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Growth of BGA on different types of soil, effect of BGA on physical and chemical properties of soil for paddy plants

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Abstract
BGA (Blue Green Algae) are reported to ubiquitous in distribution and are reported in all the latitudes and longitude from the Antarctic and Arctic regions to the tropical dry deserts perhaps showing their beginning pioneering habitation of the ancient earth. They are also unique in their potentiality to simultaneously complete oxygenic photosynthesis and oxygen helpful in nitrogen fixation. By these processes such organisms particularly in the deeper habitat make significant contributions to the nitrogen bio – geochemical and Carbon cycle. The ability to fix nitrogen of these organisms either independently or in association with other organisms not only helpful to maintain natural ecosystems but also used in many countries particularly for production of rice cultivation. Their capability to grow in highly polluted habitat is also used to treat sewage and polluted effluents of various industries. From the foregoing this is evident that although BGA are prokaryotic and microscopic organisms and they are also ubiquitous in their distribution and play roles in the maintenance of various ecosystems. Their important contributions to the maintenance of global bio-geochemical and carbon cycle are quite significant. Some of them mostly use cyanobacteria for biofertilizer. This is therefore very important and too useful.

Keywords: Blue Green Algae, ubiquitous, photosynthesis, nitrogen, Carbon cycle, biofertilizer, prokaryotic and microscopic etc.

Introduction
The paddy field ecosystem provides a favorable environment with the respect to their requirement for the growth of cyanobacteria for many factors such as water, light, nutrient availability and high temperature. It might due to better micro climate for the BGA abundance in paddy soils as compared to other cultivated soils. Gallon, *et al.* (1991) [1] & Kulasooriya (2008) [2] has reported that these mechanisms as physical barriers, behavioral adaptations, biochemical and physiological strategies treated algae as a special group. Thajuddin & Subramanian (2005) [3] published review for focus on the biodiversity of algae in various habitat, recent application and new developments that are diversifying the directions for commercial exploitation.
Bhattacharya & Ray (2013) [4] have completed canonical correspondence analysis (CCA) and showed that the occurrence of algae species was influenced mostly by ammonium, organic carbon, available iron, available nitrogen and pH. Biological soil-crusts composed of eukaryotic algae, BGA, mosses, liverworts, fungi and lichens cover the uppermost soil surface and studied mostly from arid and semi arid regions of the world (Belnap and Lange, 2003) [5, 6]. Among the autotrophic organisms, cyanobacteria are one of the most important components of biological soil-crust (Belnap and Eldridge, 2003) [6]. Algae are key organisms in the long term control of resources and productivity in N poor environment, such as boreal forest. Algal crusts significantly alter uptake by plants of many bioessential elements like Cu, K, Mg, Zn and increase the N content of associated seed plants (Harper and Belnap, 2001) [7].
Soil-crust algae from forest soil of Nandapur, Koraput and Soil-crust BGA from brown soils in the forest of Salboni and Raniganj were studied and reported by Tirkey and Adhikary (2005, 2006) [8, 9]; Sethi, *et al.* (2012) [10]. Soil-crust BGA from adjoining areas of Santiniketan located in Birbhum has been recently studied by Bhattacharya, *et al.* (2012) [11].
A contribution on certain sheathed BGA residing in upper layers of arid soils add a large quantity of organic matter through carbon fixation has been reported by Tirkey and Adhikary (2005) [8]. Nain, *et al.*, (2010) [12] showed the positive association of algal strains can enhance plant growth and productivity.

Prasanna, *et al.* (2012) [13] used various combinations of strains of *Anabaena* sp. and Calothrix sp. to betterise nitrogen fixing potential which affect productivity of crop positively. A study was conducted on four BGA isolates, such as *Aulosira*, *Tolypothrix*, *Anabaena & Nostoc* of Village Mawai, District-Sidhi (M.P.). For which their nutrient requirement, growth behavior, biomass production and seasonal influence throughout the year crop were thoroughly studied. The parameters mainly included biomass productivity, chlorophyll-a, total chlorophyll content, total N-content, and seasonal growth. Among various strains of BGA, *Aulosira*, *Tolypothrix*, *Anabaena & Nostoc* were reported the better strain in terms of biomass, total chlorophyll content, total N content, subsequently, as a result of composite culture of these four isolates of BGA in the condition of field and as a most suitable combination non sterile soil was identified when taken as substrate. During the summer season their best growth showed by the All of the strain. The modern day requires for intensive crop cultivation huge the use of nitrogen fertilizers. However, nitrogen fertilizers are in short supply and very expensive in poor developing countries. Supplementing nitrogen fertilizer possibility with biofertilizers of microbial origin reported by the Ellora, *et al.*, (2012) [14].

In the comparison of industrial process the microbial process are fast and consume. Many studies have proved that BGA improve the soil structure by betterise the soil aeration, aggregation, water holding capacity, and it is, therefore, application is widely useful for the reclamation of soils already have been studied by a large number of workers such as Rogers & Burns (1994) [15]; De-Caire, *et al.* (1997) [16]; Hegde, *et al.*, (1999) [17].

Role of BGA in agriculture is well known. Nitrogen is an essential part of nucleic acids, proteins, enzymes, chlorophylls and also other physiological in green plants especially. Nitrogen is the major nutrient required in huge amounts by green plants and availability of nitrogen may change substantially in relatively short time of interval in the soil (Cameron and Haynes, 1986) [18]. Probably, nitrogen is the most common limiting factor for a rapid growth of green plants. Therefore, in agriculture a adequate supply of nitrogen is very important as stated by Chuang (1984) [19].

3. Material and Methods

The soils used in the experiment were collected from different natural conditions to assess the algal biodiversity and changes in morphology of algae. The effect of blue-green algae (BGA) on soil nitrogen was carried out from 2010 to 2012. The BGA inoculum (*Nostoc, Anabaena, Aulosira and Tolypothrix*) was used after paddy transplantation. After paddy harvest, the soil nitrogen was then estimated. The present study is on biological soil-crust samples collected from upper surface of site-I & II located in the district of Sidhi (M.P.). Various species of cyanobacteria were isolated from these biological soil-crust samples and identified. Results of relative abundance of various cyanobacterial taxa showed that Aulosira, *Tolypothrix*, *Anabaena* & *Nostoc* were the most predominant taxon.

The soil sample was analyzed with regard to pH, EC, organic carbon, total N_2, available nitrogen, available P and physical properties parameters such as porosity, density, moisture, infiltration rate and hydraulic conductivity, water holding capacity and field capacity analysed. The effect of BGA on different soil also has been analysed as per standard methods. A two dimensional Plexus diagram showed the nature of inter-specific association between the isolated cyanobacterial taxa. Standard methods have been taken for analysis of porosity, density, moisture %, infiltration rate and hydraulic conductivity as per methods suggested by Misra (1968) [20].

Hydrogen Ion Concentration (pH)

pH is a measure of the acid base equilibrium achieved by various dissolved compounds. Concentration of carbon dioxide, carbonate and bicarbonate affects the pH of water. It is determined with the help of portable standard gun type grip pH meter (Systronics) which contains indicator electrode i.e., Glass electrode which helps to measure the hydrogen ion concentration. Before operation, electrode was standardized by buffer solution of 4 and 9.2 pH.

Electric Conductivity

The specific conductivity was determined with the help of conductivity meter. The result was express as (mmhos).

Estimation of Organic carbon (%)

Organic carbon is estimated in the collected soil to follow the standard methods referred in the reference resources and also calculated the value of organic matter by multiplying the organic carbon value with standard factor of 1.334 (Misra, 1968) [20].

4. Results

The physico-chemical properties of soil samples collected from paddy fields showed that soil pH was alkaline and ranging from 7.30±0.13 to 8.62±0.18, electrical conductivity varied from 106.00±2.01 to 136.80±3.69, organic carbon content (%) varied from 0.53±0.008 to 0.96±0.026, total nitrogen content varied from 0.053±0.0010 to 0.083±0.0018. Similarly, available nitrogen and phosphorus varied from 1.66±0.02 to 7.52±0.16 and 2.58±0.03 to 9.24±0.26 respectively. The results are tabulated in Table 4.1.

Effect of BGA on Physical properties in controlled soil have been studied on various parameter i.e. porosity, density, moisture, infiltration rate, hydraulic conductivity, water holding capacity, & field capacity. Porosity (%) in controlled soil was recorded minimum & maximum i.e. 42.26±0.93% & 48.34±1.31%, Density of soil recorded minimum & maximum i.e. 1.20±0.026 g/cm^3 & 1.50±0.039 g/cm^3, Moisture(%) recorded minimum 11.23±0.27% and maximum 11.98±0.32%, Infiltration rate maximum recorded 0.99±0.027 cm/day and minimum recorded 0.88±0.018 cm/day, Hydraulic Conductivity recorded maximum 0.91±0.025 cm/day and minimum recorded 0.78±0.019 cm/day, Water Holding Capacity (%) was recorded maximum 49.93±1.35% and minimum value recorded 41.68±0.83%. Field Capacity (%) recorded maximum 7.98±0.22% and minimum 7.83±0.19%. Porosity, Density, Moisture, Hydraulic conductivity, Water Holding capacity, Field Capacity shown increasing trend in controlled soil when algal biomass is increased whereas Density showed different trend. The results are presented in Table 4.2. The results are in conformity with the finding of so many earlier workers.

Effect of BGA on Physical properties in Black Soil have been studied on various parameter such as porosity, density, moisture, infiltration rate, hydraulic conductivity, water holding capacity, & field capacity. Porosity (%) in black soil was recorded minimum & maximum i.e. 40.13±0.72% & 45.18±1.13%, Density of soil recorded minimum & maximum i.e. 1.23±0.028 g/cm^3 & 1.80±0.049 g/cm^3, Moisture(%) recorded minimum 10.40±0. 21% and maximum

10.86±0.25%, Infiltration rate maximum recorded 0.86±0.25 cm/day and minimum recorded 0.79±0.014 cm/day, Hydraulic Conductivity recorded maximum 0.73±0.017 cm/day and minimum recorded 0.65±0.013 cm/day, Water Holding Capacity (%) was recorded maximum 47.17±1.23(%) and minimum value recorded 39.55±0.67%. Field Capacity (%) recorded maximum 7.31±0.17% and minimum 6.62±0.13%. While Porosity(%), Moisture(%), Hydraulic conductivity, Water Holding capacity(%), Field Capacity(%) shown increasing trend in black soil when algal biomass is increased whereas Density, infiltration rate showed different trend in black soil. The result are tabulated in table 4.3.

Table 4.1: Comparison of physico-chemical analysis of soil samples collected from paddy fields

No. Soil Sample	Comparison of Physico-chemical analysis of soil samples collected from paddy fields					
	Ph	EC (mm/hos)	Organic Carbon (%)	Total Nitrogen (%)	Available Nitrogen (ppm)	Available Phosphorus (ppm)
	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE
01	8.16 ±0.20	121.00 ±2.42	0.76 ±0.013	0.083 ±0.0018	6.60 ±0.13	9.24 ±0.26
02	8.42 ±0.20	113.20 ±2.60	0.68 ±0.014	0.075 ±0.0012	5.68 ±0.14	7.48 ±0.13
03	7.42 ±0.09	106.00 ±2.01	0.76 ±0.014	0.065 ±0.0012	4.54 ±0.07	5.48 ±0.10
04	7.54 ±0.14	110.60 ±2.10	0.67 ±0.011	0.073 ±0.0018	6.50 ±0.16	4.56 ±0.08
05	7.42 ±0.10	107.00 ±1.61	0.86 ±0.023	0.075 ±0.0014	5.50 ±0.09	6.52 ±0.14
06	7.30 ±0.13	112.20 ±2.02	0.83 ±0.020	0.067 ±0.0013	3.52 ±0.07	3.58 ±0.07
07	7.56 ±0.14	111.80 ±2.80	0.93 ±0.021	0.055 ±0.0010	7.42 ±0.19	5.56 ±0.09
08	8.62 ±0.18	131.60 ±3.82	0.65 ±0.012	0.065 ±0.0010	5.40 ±0.09	4.70 ±0.08
09	8.58 ±0.22	130.40 ±3.65	0.54 ±0.011	0.065 ±0.0008	4.66 ±0.09	2.58 ±0.03
10	7.60 ±0.14	117.60 ±2.59	0.96 ±0.026	0.083 ±0.0021	7.52 ±0.16	6.50 ±0.12
11	8.60 ±0.22	136.80 ±3.69	0.53 ±0.008	0.056 ±0.0011	1.66 ±0.02	4.54 ±0.08
12	7.60 ±0.15	112.40 ±2.14	0.63 ±0.013	0.066 ±0.0012	6.54 ±0.10	7.40 ±0.11
13	7.70 ±0.14	116.00 ±1.74	0.57 ±0.011	0.076 ±0.0017	5.32 ±0.07	5.48 ±0.10
14	8.44 ±0.21	126.00 ±2.65	0.66 ±0.011	0.053 ±0.0010	7.48 ±0.20	6.38 ±0.16
15	7.42 ±0.10	109.60 ±1.75	0.77 ±0.018	0.065 ±0.0010	5.12 ±0.09	4.48 ±0.05
16	7.56 ±0.15	108.00 ±1.94	0.57 ±0.011	0.076 ±0.0017	6.54 ±0.11	8.30 ±0.21
17	7.58 ±0.11	106.00 ±1.27	0.65 ±0.013	0.045 ±0.0006	4.30 ±0.06	6.66 ±0.11
18	7.50 ±0.12	106.00 ±1.17	0.75 ±0.017	0.066 ±0.0013	5.46 ±0.11	8.42 ±0.25
19	7.52 ±0.13	107.60 ±1.18	0.83 ±0.021	0.062 ±0.0012	7.34 ±.0.18	4.56 ±0.09
20	7.40 ±0.08	106.00 ±1.91	0.73 ±0.017	0.075 ±0.0013	7.40 ±0.18	8.36 ±0.22
AVERAGE	7.80 ±0.13	121.00 ±2.42	0.72 ±0.014	0.067 ±0.0010	5.73 ±0.11	6.04 ±0.10

Table 4.2: Effect of BGA on Physical Properties in Controlled Soil

Amount of Algal Biomass (gm)	Amount of Soil (Kg)	Porosity (%)	Density (g/cm^3)	Moisture (%)	Infiltration Rate (cm/day)	Hydraulic Conductivity (cm/day)	Water Holding Capacity (%)	Field Capacity (%)
05	50	42.26±0.93	1.34±0.034	11.23±0.27	0.88±0.018	0.78±0.019	41.68±0.83	7.83±0.19
10	50	44.69±1.07	1.25±0.030	11.87±0.30	0.93±0.022	0.82±0.021	43.96±1.01	7.89±0.20
15	50	45.78±1.19	1.20±0.026	11.91±0.31	0.96±0.025	0.87±0.023	46.98±1.17	7.94±0.21
20	50	48.34±1.31	1.50±0.039	11.98±0.32	0.99±0.027	0.91±0.025	49.93±1.35	7.98±0.22

Table 4.3: Effect of BGA on Physical Properties in Black Soil

Amount of Algal Biomass (gm)	Amount of Soil (Kg)	Porosity (%)	Density (g/cm^3)	Moisture (%)	Infiltration Rate (cm/day)	Hydraulic Conductivity (cm/day)	Water Holding Capacity (%)	Field Capacity (%)
5	50.00	40.13±0.72	1.23±0.028	10.40±0. 21	0.89±0.020	0.65±0.013	39.55±0.67	6.62±0.13
10	50.00	42.20±0.89	1.18±0.025	10.62±0.22	0.79±0.014	0.67±0.014	41.47±0.79	6.98±0.15
15	50.00	43.96±1.01	1.10±0.021	10.73±0.24	0.83±0.016	0.69±0.015	44.16±1.06	7.20±0.16
20	50.00	45.18±1.13	1.80±0.049	10.86±0.25	0.87±0.017	0.73±0.017	47.17±1.23	7.31±0.17

Table 4.4: Effect of BGA on Physical Properties in Red Soil

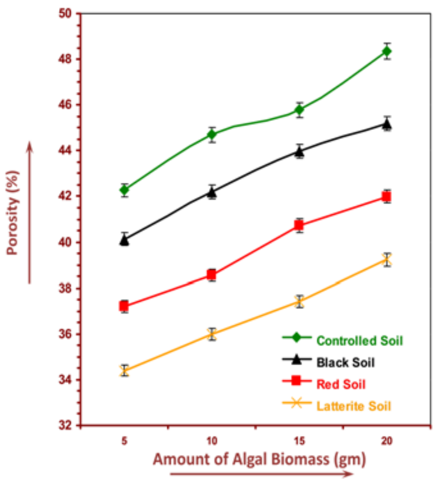
Amount of Algal Biomass (gm)	Amount of Soil (Kg)	Porosity (%)	Density (g/cm^3)	Moisture (%)	Infiltration Rate (cm/day)	Hydraulic Conductivity (cm/day)	Water Holding Capacity (%)	Field Capacity (%)
5	50.00	37.21±0.48	1.13±0.023	8.04±0.13	0.68±0.010	0.52±0.008	38.22±0.54	5.9±0.09
10	50.00	38.56±0.62	1.07±0.018	8.46±0.14	0.71±0.012	0.55±0.009	39.96±0.72	6.2±0.11
15	50.00	40.72±0.77	1.07±0.019	8.85±0.16	0.89±0.020	0.59±0.011	41.70±0.88	6.5±0.12
20	50.00	41.99±0.84	0.99±0.014	9.09±0.17	0.96±0.024	0.63±0.012	41.92±0.92	6.7±0.13

Table 4.5: Effect of BGA on Physical Properties in Laterite Soil

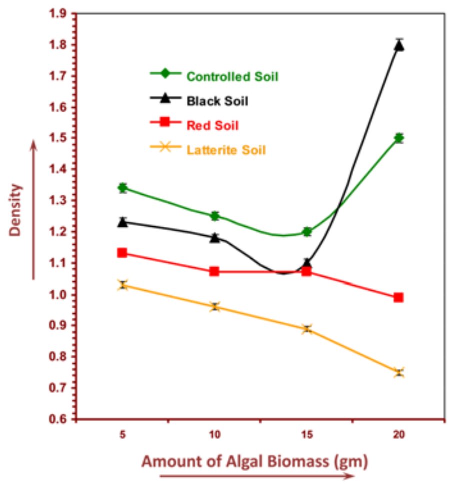
Amount of Algal Biomass (gm)	Amount of Soil (Kg)	Porosity (%)	Density (g/cm^3)	Moisture (%)	Infiltration Rate (cm/day)	Hydraulic Conductivity (cm/day)	Water Holding Capacity (%)	Field Capacity (%)
5	50.00	34.39±0.38	1.03±0.016	6.49±0.07	0.61±0.007	0.42±0.005	34.47±0.38	5.03±0.06
10	50.00	35.99±0.43	0.96±0.012	6.81±0.08	0.63±0.008	0.43±0.005	36.40±0.44	5.32±0.06
15	50.00	37.42±0.52	0.89±0.011	7.13±0.09	0.66±0.009	0.46±0.006	37.88±0.49	5.48±0.07
20	50.00	39.23±0.67	0.75±0.008	7.33±0.10	0.71±0.011	0.50±0.007	38.73±0.62	5.66±0.08

Effect of BGA on physical properties in red soil have been studied on various parameter i.e. porosity, density, moisture, infiltration rate, hydraulic conductivity, water holding capacity, & field capacity. Porosity (%) in red soil was recorded minimum & maximum i.e. 37.21±0.48% & 41.99±0.84%, Density of soil recorded minimum & maximum i.e. 0.99±0.014 g/cm^3 & 1.13±0.023 g/cm^3, Moisture(%) recorded minimum 8.04±0.13% and maximum 9.09±0.17%, Infiltration rate maximum recorded 0.96±0.024 cm/day and minimum recorded 0.68±0.010 cm/day, Hydraulic Conductivity recorded maximum 0.63±0.012 cm/day and minimum recorded 0.52±0.008 cm/day, Water Holding Capacity (%) was recorded maximum 41.92±0.92% and minimum value recorded 38.22±0.54%. Field Capacity (%) recorded maximum 6.7±0.13% and minimum 5.9±0.09%. Porosity, Moisture, Infiltration Rate, Hydraulic conductivity, Water Holding capacity and Field Capacity shown increasing trend in red soil when algal biomass is increased whereas density in red soil showed decreasing trend. The value are noted in Table 4.4.

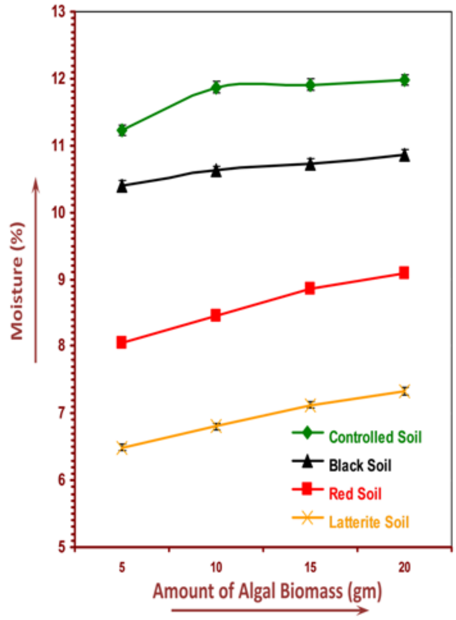
Effect of BGA on physical properties in Laterite soil have been studied on various parameter i.e. porosity, density, moisture, infiltration rate, hydraulic conductivity, water holding capacity, & field capacity. Porosity (%) in Laterite soil was recorded minimum & maximum i.e. 34.39±0.38% & 39.23±0.67%, Density of soil recorded minimum & maximum i.e. 0.75±0.008 g/cm^3 & 1.03±0.016 g/cm^3, Moisture(%) recorded minimum 6.49±0.07% and maximum 7.33±0.10%, Infiltration rate minimum recorded 0.61±0.007 cm/day and maximum recorded 0.71±0.011 cm/day, Hydraulic Conductivity recorded maximum 0.50±0.007 cm/day and minimum recorded 0.42±0.005 cm/day, Water Holding Capacity (%) was recorded maximum 38.73±0.62% and minimum value recorded 34.47±0.38%. Field Capacity (%) recorded maximum 5.66±0.08% and minimum 5.03±0.06%. Porosity, Moisture, Infiltration Rate, Hydraulic conductivity, Water Holding capacity and Field Capacity shown increasing trend in Laterite soil when algal biomass is increased whereas density in Laterite soil showed decreasing trend when algal biomass is increased. The results are tabulated in table No. 4.5. The results are in conformity with the findings of many workers.



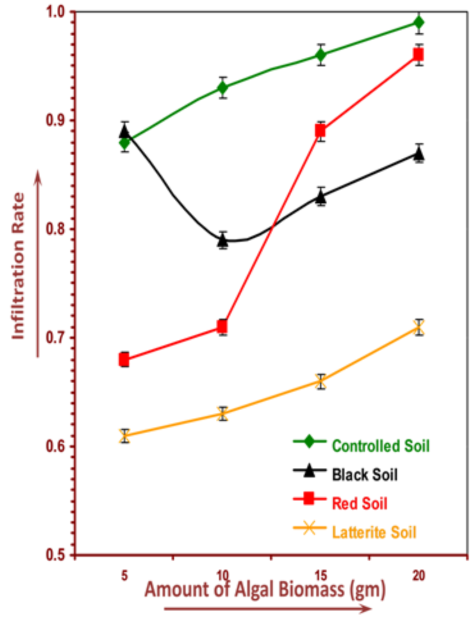
Fig–4a (Table 4.2,4.3,4.4 & 4.5) Line diagram of Porosity of soil mixed with different quantity of Algal Biomass



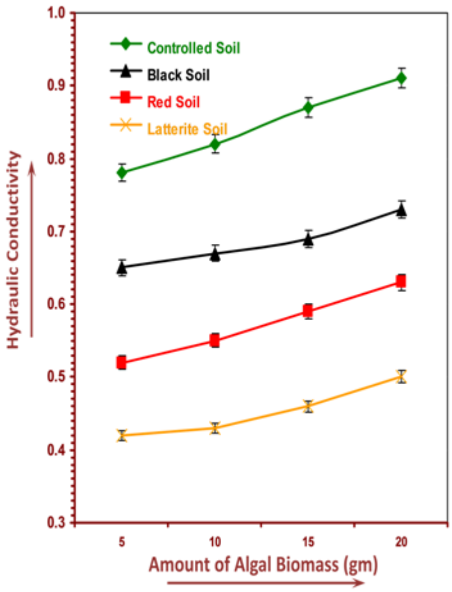
Fig–4b (Table 4.2,4.3,4.4 & 4.5) Line diagram of Density of soil mixed with different quantity of Algal Biomass



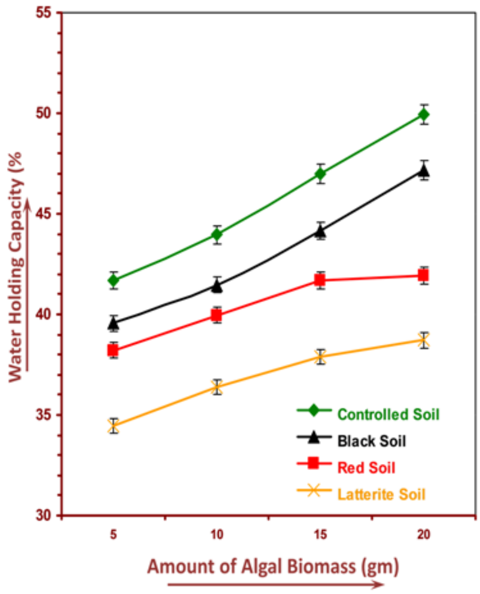
Fig–4c (Table 4.2,4.3,4.4 & 4.5) Line diagram of Moisture of soil mixed with different quantity of Algal Biomass



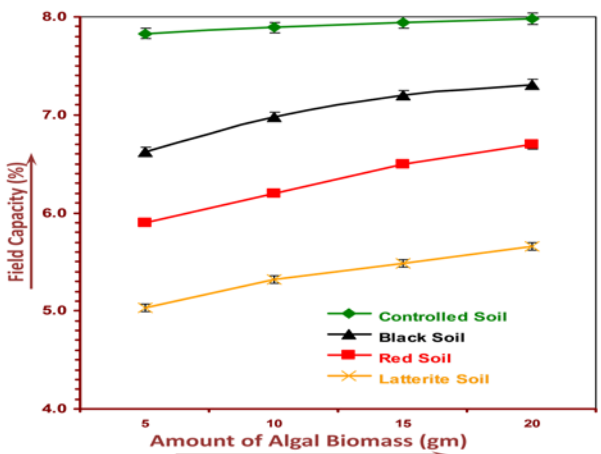
Fig–4d (Table 4.2,4.3,4.4 & 4.5) Line diagram of Infiltration of soil mixed with different quantity of Algal Biomass



Fig–4e (Table 4.2,4.3,4.4 & 4.5) Line diagram of Hydraulic conductivity of soil mixed with different quantity of Algal Biomass



Fig–4f (Table 4.2,4.3,4.4 & 4.5) Line diagram of Water holding capacity of soil mixed with different quantity of Algal Biomass



Fig–4g (Table 4.2,4.3,4.4 & 4.5) Line diagram of Field capacity of soil mixed with different quantity of Algal Biomass

5. Discussion

BGA are possessing activity like - plant hormone and, therefore, they clearly influence the growth of paddy crop through the release of these substances as noted by Bradley (1991) [21]. Many BGA produce various types of secondary metabolites such as auxin like substances or auxins, and other such as gibberellins-like substances, cytokinins and abscisic acid have been studied by large numbers of workers such as Serdyuk, *et al.* (1992) [22]; Marsalek, *et al.* (1992) [23]. To determine the natural conditions effects, study was carried out on the nitrogen fixation and growth by BGA that is isolated from the various different soils. Islam, *et al.* (2007) [24] studied and reported effect of pesticides in eighteen taxa of BGA which has been brought in the selected soil type under the unialgal culture. It has been observed that, on the other hand in heterotrophically grown culture nitrogen fixation was at higher rate. But, the result was observed satisfactory in both of the cases when the dose of pesticide applied practically in the field. With the respect to nitrogen fixation and pesticides the heterotrophically grown culture were more tolerant in this case it have been observed Islam, *et al.* (2007) [24].

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