CLYBIO CONCENTRATION ON GROWTH AND YIELD OF CABBAGE UNDER DIFFERENT COLORED SHADE NETS

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Most surely in the creation of the heavens and the earth and the alternation of the night and the day, there are signs for men who understand.
(Surah Al Zumar 3:190)

DEDICATED TO
MY BELOVED DAUGHTER AND MY HUSBAND

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CERTIFICATE

This is to certify that thesis entitled, **"CLYBIO CONCENTRATION ON GROWTH AND YIELD OF CABBAGE UNDER DIFFERENT COLORED SHADE NETS"** was submitted to the Faculty of Agriculture, Sher-e- Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE,** embodies the result of a piece of bona fide research work carried out by **BENJIR HOSNE JAHAN BARI, Registration No. 19-10359** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during this investigation has duly been acknowledged.

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- The author

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ABSTRACT

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the growth and yield of cabbage as influenced by two different factors such as factor-A: Colored shade nets *viz.* without a net (N_0), white net (N_W), pink net (N_P), and blue net (N_B), and factor B: Clybio concentration *viz.* no Clybio application (C_0), Clybio concentration at 1000-fold (C_{1000}), and Clybio concentration at 500-fold (C_{500}). The experiment was set up in Split Plot Design with three replications. Data on different growth, physiological and yield parameters were taken in which all the treatments showed significant variations. The use of white shade nets (Nw) provided with better head length (16.0 cm), head diameter (55.7cm), single head weight (1.1 kg), and yield of 45.8 t/ha in comparison to other nets or no net use. Alongside, the sole application of Clybio to cabbage as a 1000-fold liquid solution (C_{1000}) resulted in maximum single head weight (0.8 kg), and yield of 33.3 t/ha while the maximum head length (14.8 cm) was from 500-fold Clybio solution (C_{500}), and head diameter was statistically insignificant between C_{1000} and C_{500}. Maximum yield per hectare (62.5 t) was found from N_WC_{1000} and minimum (20.8 t) was from N_0C_0. In consideration to the overall performances, white shade net (N_W) along with the application of 1000-fold Clybio solution (C_{1000}) has the potential for better cabbage production.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
Agric.	=	Agricultural
Agron.	=	Agronomy
ANOVA	=	Analysis of Variance
BADC	=	Bangladesh Agricultural Development Corporation
BARI	=	Bangladesh Agricultural Research Institute
Biol.	=	Biology
cm	=	Centimeter
DAT	=	Days after transplanting
Dec.	=	Decimal
et al.	=	And others
FAO	=	Food and Agriculture Organization
Hort.	=	Horticulture
Init.	=	Initial
Int.	=	International
Irr.	=	Irrigation
J.	=	Journal
LSD	=	Least Significance Difference

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.) which belongs to the Brassicaceae family, is famous for its nutritional values, medicinal effects, and other therapeutic properties. It is distinguished by its swollen heads which are formed by the thickening of edible buds with tightly packed overlapping leaves manifesting a large head. The cabbage generally grows in the Rabi season in Bangladesh. It is consumed throughout the country by every class of people as fresh vegetables or raw salad. It is believed that cabbage originated in Western European countries. Before cultivation and use as food, cabbage was mainly used for medicinal purposes (Silva, 1986). However, cabbage contains a good amount of vitamin C along with vitamin B, and some supplies of potassium and calcium to the diet.

It also contains a range of essential vitamins and minerals as well as a small amount of protein and some caloric values. Present years consumption of this vegetable has increased. However, the productivity of cabbage per unit area is quite low as compared to the developed countries of the world (Anon, 2006).

The growth and yield of cabbage are significantly influenced by the excessive use of chemical fertilizers which ultimately increase the production cost as well as the impact on the environment. It is a fact that the use of inorganic fertilizer for crops is not so good for health because of residual effects but in the case of organic fertilizer such a problem does not arise and on the other hand, it increases the productivity of soil as well as crop quality and yield (Tindall, (2000).

Several authors reported in different research nationally and globally that the use of different colored shade nets and effective microorganisms has demonstrated significant responses to crop growth and production rate. It also impacted its yield and its nutritional quality to meager in local climatic conditions.

Clybio is unique and complex microbes that contain bacteria like *Lactobacilli* bacteria (Lactic acid bacteria), *Bacillus natto* bacteria, and yeast fungus.

Lactobacillus bacteria are biocontrol agents against bacterial diseases and have a bio-stimulating effect to promote growth, yield as well as quality. Lactic acid bacteria act as plant growth-promoting bacteria (Shrestha *et al.* 2014). It also creates antibacterial antibody activity in the plant to fight against bacterial disease. *Bacillus natto* bacteria have been known to have a potent antibacterial function (Tiwari *et al.*, 2019) Yeast promotes different essential amino acids, vitamins, and phytohormones that led to the growth and improve the chlorophyll content (Taha *et al.*, 2020). Yeast Fungus can promote plant growth and health and increases the root-to-shoot ratio. Brewers' yeast is a cost-effective biofertilizer and acts against fungal diseases as a bio-control agent. The application of effective microorganisms (EM) has positive influences on leaf chlorophyll content, yield, and micronutrient content of plants (Iriti *et al.* 2019).

Due to their safe and environment-friendly nature, bio-fertilizer applications are increasing day by day. Bio-fertilizer application is very efficient for organic and safe crop production (Uddin *et al.*, 2019). The use of organic fertilizer increases plants vegetative growth and yield (Rakibuzzaman *et al.*, 2019b).

The net-covering was found to mitigate extreme climatic fluctuations, reduce heat and wind stresses, and improve canopy vitality. A colored net is an emerging approach, which introduces additional benefits, on top of the various protective functions of nettings. These nets are unique in that they both spectrally modify, as well as scatter the transmitted light. The photo selective nets include "colored nets" (e.g., red, yellow, green, blue, and white net products) as well as color nets absorbing spectral bands shorter, or longer than the visible range. The spectral manipulation is aimed at specifically promoting physiological responses, while light scattering improves light penetration into the inner canopy (Shahak, 2008). Silva *et al.*, (2018) found that the use of colored shading nets allows manipulating the light spectrum, and thus supplying the appropriate quantity and quality of light for each species and maximizing production.

Considering the above factors, the experiment has taken place with the following objectives:

Objectives:

- To identify the effect of using Clybio on the growth and yield of cabbage.
- To identify the effect of different color shade nets on the growth and yield of cabbage.
- To identify the combined effects of using Clybio concentration and color shade nets on the growth and yield of cabbage.

REVIEW OF LITERATURE

Cabbage is one of the most familiar, leafy, and commonly available vegetables in Bangladesh, as well as in the world. Research on various aspects of its production technology has been carried out worldwide. Among these researches, a limited number of works have been done on color shade netting and the use of Clybio concentration in different controlled or uncontrolled treatment manners. Very few numbers of works were reported where the effect of the application of Clybio in different concentrations and use of colored shade nets on cabbage were studied. However, some of the research and their findings related to the present study carried out at home and abroad are reviewed in this chapter under the following headings.

A study was conducted by Kodippili and Nimalan (2018), to evaluate the effect of homemade EM combined with compost on chili growth and yield characteristics (*Capsicum annuum*). The experiment was designed using three replications in a Randomized complete block design (RCBD). The following were the treatments: T_1: Control, T_2: Compost, and T_3: EM + Compost (T_3). The EM + Compost treated crops had significantly higher plant height (29.76 cm), number of leaves per plant (176.40), number of branches per plant (44.67), number of flowers per plant (15.47), and number of chili pods per plant (10.60), but no significant differences in pod length, pod width, or total chili pod weight per crop were observed between the EM + compost and compost treatments. This study concluded that the growth and yield of the chili crops were increased by the application of EM with compost compared to the application of compost only.

Akter *et al.* (2021) studied the impact of seed priming and Clybio on spinach growth and yield. A significant result was found from treatment 2, by the application of Clybio at 4 ml/L. Treatment 2 performed better in all aspects of growing parameters such as germination percentage, plant height, number of leaves per plant, leaf diameter, chlorophyll percentage, root length, and leaf fresh weight, while the control treatment performed lowest in all parameters.

The highest yield of spinach (14.33 t/ha) was obtained from treatment 2, followed by treatment 1 (8.87 t/ha). The result suggested that the application of Clybio at 4 ml/L increased spinach growth and yield significantly.

Karawi *et al*. (2018) conducted a study on the effect of spraying dry yeast (*Saccharomyces cerevisiae*) and boron and their interaction on the growth and production of the strawberry plant. The study included 9 treatments: spraying the plants with two concentrations of dry yeast (1, 2 gL^{-1}) in addition to distilled water only with three concentrations of boron (0, 2, 4 gL^{-1}). The results showed that spraying the plants with dry yeast led to a significant increase in the plant height and the number of leaves at the concentration of (1 gL^{-1}), while the spraying treatment with concentration (2 gL^{-1}) gave a significant increase in the dry weight of the total vegetative, the leaves content of chlorophyll and the fruits content of total sugars, the average production of one plant. The spraying with boron showed a significant increase in the traits of vegetative growth and the yield traits at a concentration of (2 gL^{-1}).

An experiment was conducted by Abdel-Gawad and Youssef (2019) to evaluate the response of Faba bean to foliar application of yeast extract, bio-fertilizer, and humic acid. Results showed that foliar application of yeast extract (10 g/L) increased growth and yield significantly.

Anuradha *et al*. (2020) experimented to study the co-inoculation effect of effective rhizospheric bacteria on the growth, yield, and quality of strawberry cv. Chandler. They treated the strawberry plants with rhizospheric bacteria i.e., *Pseudomonas* strains namely, CP109 and CPS67, and *Bacillus* strains namely HCA61, RCA3, and SYB101, whereas untreated soil served as control. The growth, yield, and quality of fruits were significantly influenced by rhizospheric bacteria. Among different treatments, treatment T_4 (CP109 + HCA61) recorded the significantly highest fruit yield per plant (257.92 g). The growth parameters, *viz.* plant height (14.11 cm), number of leaves per plant (12.34), crown diameter (13.21 mm), fresh weight (45.89 g), and dry weight (13.11 g) of plant maximum in treatment combination CP109+ HCA61.

However, concerning TSS (%), Ascorbic acid and anthocyanin content (mg 100 g^{-1}) of fruits *Bacillus* HCA61+ *Pseudomonas* CP109 was found best. The co-inoculation with *Bacillus* and *Pseudomonas* strains could be an eco-friendly and cost-effective technology for improving the growth, yield, and quality of strawberries.

Anushma *et al.* (2014) had investigated on effect of coloured shade nets on softwood grafting success in jamun was undertaken at Kittur Rani Channamma College of Horticulture, Arabhavi, U.H.S., Bagalkot (Karnataka), India; during 2010-12. The influence of different colored shade nets *viz.*, white, red, black, green, and blue on graft take after 3 months after grafting was significant. The grafts kept under red colored shade nets recorded highest graft success (72.50%). Significantly least graft success was recorded in grafts under the blue shade net (47.50%). No significant difference was found for graft survival at four months after grafting under different colored shade nets. The survival percentage recorded under different colored shade nets varied from 92.71 per cent (white) to 96.87 per cent (red). There was no significant difference for graft height under different colored shade nets during the period of investigation. There was no significant difference for number of sprouts of grafts under different colored shade nets. At 30 DAG and 60 DAG, significantly higher number of leaves per graft was recorded in grafts kept under white shade net (5.6 and 8.96, respectively). At 90 DAG, significantly maximum number of leaves was recorded in grafts under red shade net (12.00). Minimum number of leaves was recorded in grafts under blue shade net (8.22). Thus, colored shade nets showed significant influence on graft take and graft growth parameters.

B.B. Mekki *et al.* (2005) experimented the effect of application of organic manure, biofertilizer, and yeast *(Candida tropical)* on growth, yield, and seed quality of soybean *(Glycine max L.)*. The results indicated that the application of organic manure at a rate of 20 tons / acre as a sole treatment and also when it was associated with biofertilizer as one treatment had more plant height and dry weight/plant. In contrast plant height was reduced at the treatment had a sole biofertilizer and also when it was associated with yeast, also the number of branches/plants was decreased at the treatment received bio. or yeast singly. Seed yield (g/plant), pods weight (g/plant), as well as the number of pods/plants, seeds/pod and 1000-seed weight were decreased by adding biofertilizer singly, but when it was associated with organic manure showed the highest seeds and pods weights. Application of organic manure+yeast as one treatment increasing yield and yield attributes of soybean plants. Seed oil % was increased in the plants that were treated by biofertilizer singly and also at the treatment received organic manure+yeast as one treatment, whereas protein % was increased at the treatment had organic singly or when it was associated with biofertilizer, then this increase in protein percentage due to the increase in N% at the same treatments. P concentration was only increased at the plants that received yeast only and also when yeast was associated with biofertilizer. Zn concentration tended to increase in the plants treated by bio.+organic manure+yeast followed by bio.+organic as one treatment. Mn concentration was high when plants received yeast singly or when it was associated with biofertilizer, while Fe concentration tended to increase due to adding bio.+organic manure+yeast followed by bio.+organic as one treatment.

Botha (2011) discussed his research on how soil yeasts interact with biotic and abiotic variables in their environment. Soil yeasts may have a role in the development of soil aggregates and the preservation of soil structure, in addition to affecting microbial and plant growth. Soil yeasts contributed to critical ecological processes such as the mineralization of organic matter and the dissipation of carbon and energy across the soil ecosystem by serving as a nutrition supply for bacterial, faunal, and protistan predators. Some soil yeasts had the potential to solubilize insoluble phosphates, making them more easily accessible to plants, and may play a role in both the nitrogen and sulfur cycles. Recently, the potential of soil yeasts as plant growth promoters and soil conditioners has been studied to use them in the field of sustainable agriculture.

Chowdhury *et al.* (1991) conducted a series of studies in the research filed of the Institute of Post-Graduation Studies in Agriculture (IPSA), salna, Gazipur during 1992-1993 to evaluate the effect of EM on the growth and yield of some selected crops. Onion (*Allium cepa* L.) and String bean (*Vigna sesquipedalian* L.) were cultivated in the field and chili pepper (*Capsicum fulctescens* L.) was in at pot. Four treatments were used with EM and without EM (T_1: Control, T_2: Cowdung @ 10 t/ha, T_3: Rice straw @ 10 t/ha, T_4: Recommended N-P-K fertilizer rate). The highest onion yield (7.2 t/ha) was obtained by T_2 with EM and was greater than that produced by T_4 (6.3 t/ha)). EM increased leaf chlorophyll and yield of string bean significantly. The highest yield of chili peppers was obtained with EM but was not significantly different than the other treatments.

Chowdhury *et al.* (1994) reported that a series of four experiments were conducted in the experiment field of Rice Research Institute, Joydevpur, Gazipur, and Institute of Postgraduate Studies in Agriculture (IPSA), Salna, Gazipur to evaluate the effect of organic amendments and Effective Microorganisms (EM) on crop production. Four crops (string bean, rice, red pepper, and Indian spinach) and four treatments T_1: control, T_2: recommended chemical fertilizer application, T_3: cow dung at 10 t/ha, T_4: rice straw at 10 t/ha used. EM was used with treatment. The result showed that string bean T_4 with EM give the highest fruit per plant (21.7), yield (12.1 t/ha), and yield increase (146%) than the control. For rice plant height (71 cm) at T_4 with EM and yield (4.2 t/ha) at T_2 with EM were highest. For red pepper fruit per plant (75.7), fruit weight (76.7 g), and yield increase (73%) at T_4 with EM. For Indian spinach, EM showed no significant effect on Harvested shoots/plant, leaves/plant, weight of stems/plant (g), and yield (t/ha).

Díaz-Pérez *et al.* (2020) carried out a study to determine the effects of colored shade nets on bell pepper fruit yield, postharvest transpiration, color, chemical composition, and antioxidant capacity. The experiment was conducted in Tifton, GA, during the spring of 2015 and 2016. The experimental design was a randomized complete block with four replications and five colored shade net treatments (black, red, silver, and white nets, and an unshaded control). The nets were placed on the top of rectangular wooden structures (15m wide, 36m long and 35m high), leaving the sides of the structures uncovered. Results showed that in both 2015 and 2016, marketable and total fruit number, yield, and individual fruit weight were reduced under the unshaded treatment. There were inconsistent differences in marketable and total fruit number, yield, and individual fruit weight among colored shade nets. Postharvest fruit transpiration and skin permeance were also reduced in unshaded conditions, and no differences were found among colored shade nets. Fruit color L* and b* values were highest, and a* value was lowest in unshaded conditions. Fruit soluble solids, total phenols, flavonoids, and antioxidant capacity [Cupric Reducing Antioxidant Capacity (CUPRAC) and Trolox Equivalent Antioxidant Capacity (TEAC)] responded differently among colored shade nets in the 2 years. Total phenols, flavonoids, and TEAC, however, were among the highest in unshaded conditions.

Dursun *et al.* (2010) observed the effects of spraying a growth-promoting bacterium on chemical contents, yield, and growth of tomato (*Lycopersicon esculentum* L.) and cucumber (*Cucumis sativus* L.) vegetable species. Different strains of bacteria, *Bacillus subtilis* BA-142, *Bacillus megatherium- GC subgroup A.* MFD-2, *Acinetobacter baumannii* CD-1, and *Pantoea agglomerans* FF, were used. The effects of the bacterial treatments on the plant nutrient elements of tomato and cucumber fruit were determined. Its effects on average fruit weight, fruit number per plant, fruit weight per plant, plant length, fruit width and length, and total soluble solid and dry matter in tomato and cucumber fruit were also determined. The effects of bacterial application on plant mineral contents were significant. Bacterial applications increased the mineral contents of tomato and cucumber fruit as compared to the control treatment. All bacterial applications particularly affected on improving the N, P, Mg, Ca, Na, K, Cu, Mn, Fe, and Zn contents of the fruit. Growth promoting effects of bacterial application on the plant growth parameters except for TSS

(Total soluble solid) were significant. The highest average fruit weight, fruit weight per plant, and plant length were obtained from *Pantoea agglomerans* FF applications in tomatoes as compared to that of the other applications. Fruit number per plant was high in *Acinetobacter baumannii* CD-1 application and fruit width, fruit length and dry matter were highest in *Bacillus megaterium-GC subgroup A.,* MFD-2 application than that of the other application in tomato. The highest fruit number per plant, fruit weight per plant, plant length, fruit width, fruit length, and dry matter was obtained from *Pantoea agglomerans* FF applications in cucumber as compared to that of the other applications and the highest average fruit weight was found in *Bacillus megatherium-GC subgroup A.* MFD-2 application when compared to the other applications. The results of this study showed that *Pantoea agglomerans* FF, *Acinetobacter baumannii* CD-1, and *Bacillus megaterium-GC subgroup A.* MFD-2 have a great potential to increase the yield, growth, and mineral contents of tomato and cucumber vegetable species.

Fawzy *et al.* (2012) conducted two field experiments at Wady Elmollak, Ismailia Governorate, Egypt in two successive seasons of 2009 to 2010 and 2010 to 2011 to evaluate the foliar effect of EM, amino acids, and yeast on the growth and yield of onion. Two cultivars Giza 20 and Super X were used. There was ten treatments control (spray with tap water), EM_1 (1 cm/L), EM_2 (2 cm/L), EM_3 7 (3 cm/L), AG_1 (1 cm/L), AG_2 (2 cm/L), AG_3 (3 cm/L), Y_1 (1 gm/L), Y_2 (2 gm/L) and Y_3 (3 gm/L). Results showed that Giza 20 gave the highest amount of vegetative growth plant height (51.23 cm: 42.23 cm) in the two seasons. About foliar application treatments, the results indicated that using EM, amino acids, and yeast had positive promoting effects by providing supplemental doses of these components on growth, yield, and quality as well as all chemical composition compared with control plants. It may be concluded that using yeast at rates of Y_3 gives the highest growth parameters. However, using EM at rates of EM_3 gives the highest yield (15.69 t/ha).

Idris *et al.* (2008) conducted field experiments at Research Farm in Wad

Medani, University of during 2004-05 to find out the response of tomato (*Lycopersicon esculentum* Mill) to the application of effective microorganisms (EM). Effective microorganisms (EM) were applied at three rates of 0.01%, 0.02% and 0.05% either alone or in combinations with chicken manure or urea. Chicken manure (6 ton/ha) was added to the soil and urea (0.10 ton/ha) was applied. Spraying intervals were 7 and 14 days and application methods were soil and foliar application. Findings showed that significant differences between the different treatments. EM sprayed at a dilution rate 10 of 0.05% every seven days in combination with chicken manure gave significant increases in plant height, number of branches/plants, number of fruits/cluster and total yield.

Iljovski *et al.*, (2015), conducted a study to observe the effect of colored shade nets on tomato yield grown in open field in Skopje region in 2014. Two tomato hybrids for summer production (Optima f_1 and Lzmir F_1) were used in the field experiment. The follow treatment in the experiment were evaluated: I. red shade net with 40% of shading intensity, II. White shade net with 40% of shading intensity, III. Greed shade net were installed after 35 days of transplanting. Height of plants, diameter of fruits, pericarp size and total yields were measured during the vegetation. According to the obtained results of tomato yield, there were significant different between the treatment with color shade nets and control treatment. Namely the treatment with red shade net showed the highest yield of 77.8 t/ha, then comes the treatment with white shade net (69.7 t/ha) and then the treatment with green shade net (55.7 t/ha), while the lowest yield (43.1 t/ha) was achieved in control treatment.

Iriti *et al.* (2019) carried out an experiment conducted in Hunumulla agricultural farm to found that effective microorganisms (EM) treatments had an influence on leaf chlorophyll content, yield, and micronutrient content of bean plants cultivated in various substrates (nutrient rich substrate vs. nutrient low sandy soil). Two weeks longer than control plants, EM treated plants maintained maximum leaf photosynthetic performance and increased yield.

Javaid (2006) carried out an experiment to evaluate the effect of foliar and soil application of beneficial microorganisms on growth and yield of pea (*Pisum sativum* L.). Soil amended NPK fertilizer; farmyard manure and green manure were used with foliar application of EM. Results showed that foliar application of significantly increased shoot biomass by 70% in NPK treated soil. Similarly foliar application of EM increased the number of pods and pod biomass by 157% and 266%; 126% and 145% in NPK fertilizers and green manure amended soil.

Javaid and Bajwa (2011) conducted a field experiment to find out the effect of EM on mung bean cultivation. Experiment field soil was amended with farmyard manure at 20 t/ha, *Trifolium alexandrinum* green manure at 20 t/ha, Recommended (NPK) and half (½ NPK) doses of chemical fertilizers. EM was applied in the form of a dilute solution in water (1:1000) at fortnight intervals throughout the experiment period. EM application significantly enhanced shoot biomass in farmyard manure, ½ NPK and NPK amendments. Similarly, EM significantly increased grain yield by 24% and 46% in farmyard manure and NPK fertilizers amendments, respectively. By contrast, in green manure amendment, EM application resulted in a significant decline of 23% in grain yield. In ½ NPK amendments, the effect of EM application on grain yield was insignificant. However, in NPK amended soil, EM application markedly enhanced plant nutrition at later growth stage only.

Karunarathna and Seran (2016) evaluated the effect of effective microorganisms (EM) in combination with cow dung on capsicum (*Capsicum annuum* L.) growth and yield. A Randomized Complete Block Design was used to organize six treatments with three replications. T_1: Inorganic fertilizer application, T_2: No fertilizer application, T_3: Cattle manure 5 t/ha + EM, T_4: Cattle manure 10 t/ha + EM, T_5: Cattle manure 15 t/ha + EM, T_6: Cattle manure 20 t/ha + EM, T_7: Cattle manure 20 t/ha + EM, T_8: Cattle manure 20 t/ha + EM Up to 20 DAT, the data indicated no significant change in canopy height across the treatments At 10, 20, and 30 DAT, there were significant differences in the number of leaves per plant, as indicated by P values of 0.197, 0.700, and 0.075, and chi-square values of 7.33, 3.00, and 10.00, respectively. In majority of the treatments, the diameter of the pod was increased until the third plucking, after which it was reduced. The number of pods per plant rose when cow manure was increased from T_3 to T_4. T_4 had high fresh pod weights, number of seeds per pod, and dried pod and seed weights.

Khalid and Jin (2011) conducted a study to find the effects of bacterial and fungal effective microorganisms (EM) on the growth of Chinese cabbage *(Brassica rapa*) were evaluated. This investigation was carried out parallel with conventional NPK chemical fertilizer and a commercial sold microbial fertilizer to compare between each of their effect. Sterile water and molasses were served as controls. *Azotobacter chroococcum* effect also was studied either alone or in combination with the effective microorganisms on the growth parameters. In contrast to the bacterial EM, the fungal EM alone without *A. chroococcum* had a more stimulating effect than fungal EM combined with *A. chroococcum*. Results showed that seedling inoculation significantly enhanced *B. rapa* growth. Shoot dry and fresh weight, and leaf length and width significantly were increased by both bacterial and fungal inoculation. The results indicated that the NPK chemical fertilizer deteriorates the microflora inhabiting the soil, while the effective microorganisms either fungal or bacterial ones increased the microbial density significantly. This study implies that both of fungal and bacterial EM are effective for the improvement of the Chinese cabbage growth and enhance the microorganisms in soil. The results showed antagonism occurred between *A. chroococcum* and each of *Penicillium* sp and Trichoderma sp in both agar and plant assays.

Kleiber *et al.* (2013) has conducted research in a dedicated greenhouse within the boundaries of the Experimental Station of the Faculty of Horticulture and Landscape Architecture of the University of Life Sciences in Poznan, Poland to see how the chemical composition of nutrient solutions (NS I, NS II), seed inoculation with Effective Microorganisms (EM), and assimilation illumination

(AI) of plants affected lettuce (*Lactuca sativa* L.) growth, development, and nutritional status in hydroponic cultivation, as well as microbiological changes in the medium. The following measurements were made- number of leaves per plant (LQ), surface area of the largest leaves (SBL), relative chlorophyll content (SPAD units), and total fresh weight (TFW). Results showed that application of NS II and EM-A had a positive influence on the development of leaves, relative chlorophyll content on the plant.

Mazzini-Guedes and Pivetta, (2014) conducted an experiment to observe the influence of different colored shade nets and light conditions on the initial growth of *B. variegata* and *B. variegata* var. *candida*. The influence of six light conditions (red net with 50% shading; blue net with 50% shading; black net with 70% shading; black net with 50% shading; black net with 30% shading; and full sun) on the initial growth of *B. variegata* and *B. variegata* var. *candida* were evaluated along 160 days, and growth relationships were calculated. Seedlings showed more efficiency on the use of photoassimilated compounds when grown under full sun. Such condition is the most appropriate for seedling production of *B. variegata* and *B. variegata* var. *candida*, contradicting what has been performed in practice.

Ncube *et al.* (2011) conducted a field experiment during the 2004-2005 summer season to evaluate the agronomic suitability of effective microorganism (EM) on tomato (*Lycopersicon esculentum* Mill). Treatments included: Control (T_1), Effective microorganism (T_2), Mineral fertilizer (T_3), Effective microorganism (EM) + Mineral fertilizer (T_4), Compost + Effective microorganism (T_5), Compost + Mineral fertilizer (T_6) and Compost + Mineral fertilizer +Effective microorganism (T_7). Results showed that application of EM significant effect on tomato production. Number of fruited 8 tomato plants at T_5 resulted in 33.3% increase in the number of fruited plants relative to the T_1. Highest Yield (36.3 t/ha) was at T_4 and lowest yield (17.5 t/ha) at T_7.

Olle and Willians (2013) collected data from various scientific papers and reported that effective microorganisms (EM) had positive effect on the growth of vegetables while in other 30% they had no significant influence. Investigation among 22 reports on the effect of effective microorganisms (EM) on vegetables 84 % showed positive effect. 4 % negative effect and 12 % showed no significant effect.

Pii *et al.* (2018) conducted research to evaluate and compare the effects of beneficial microorganisms, supplied either as pure culture (*Azospirillum brasilense*) or as a commercial mixture (Effective Microorganisms-EM), on the growth and quality of strawberry fruits. Strawberry plants were hydroponically grown either in a complete nutrient solution or in a nutrient solution inoculated with *A. Brasiliense* or with EM for 10 weeks. Fruits obtained from PGPR inoculated plants also had a higher sweetness index in comparison to control fruits. The concentration of flavonoids and flavanols was higher in fruits harvested from *A. Brasiliense*-inoculated plants. In addition, PGPRs also influenced the uptake and allocation of nutrients in fruits, in particular increasing the concentration of micronutrients.

Pinheiro *et al.* (2020), conducted a study to analyze changes in density and stomatal morphometry and the concentration of leaf pigments in lettuce cultivars grown in protected environments under different photo selective nets (40% shading). Cultivars of lettuce (Vera, Vanda, and Solaris) were grown in a hydroponic system with a laminar flow of nutrients using red, blue and silver nets to provide shading coverage (treatments) in addition to a control with no shading nets. At the end of the production cycle, it was observed that the lettuce cultivars grown under a red net and without a net showed greater stomatal densities and chlorophyll contents. The concentration of photosynthetic pigments (chlorophyll and carotenoid content) showed variations dependent upon the cultivar, demonstrating that the genotypes respond differently to environmental conditions.

Q. Y. Yan *et al.* (2012) conducted a study to know the effects of shading on growth and quality of flowering Chinese cabbage (*Brassica campestris* L. ssp. *chinensis* var. *utilis* Tsen et Lee) were studied by different color shading-nets (red, grey, black, and blue net) from November to December in Guangzhou, China. Under grey, blue, red, and black net at 12 am, temperature decreased 5.81, 1.27, 3.93 and 8.58°C, and the relative humidity increased 18.75, 18.32, 26.69 and 2.48%, respectively. Plant fresh weight increased 41.71 and 5.36% under red and blue net, while decreased 14.66 and 49.55% under grey and black net, respectively. And shoot fresh weight increased 43.80 and 9.00% under red and blue net, while decreased 12.81 and 48.62% under grey and black net, respectively. Plant height increased 16.25% under red net, however decreased 12.73, 33.01 and 47.50% under blue, grey, and black net. Leaf area increased 41.44, 23.05 and 15.70% under red, grey, and blue net, respectively. Under shading net, soluble protein and vitamin C concentration in leaf and flower stalk decreased, the reduction under red net was the least.

Rakibuzzaman *et al.* (2019b) accomplished a pot experiment to study the influence of Pest Exclusion Net (PEN) and organic leachates on Aloe Vera production. Pest exclusion net, *viz.*, No use of PEN (open), 32 mesh net and 20 mesh net; and organic leachates *viz.* no use organic leachates (con.), Cowdung leachates (Cd), vermicompost leachates (Vm), Mustard oil cake leachates (Mc) were used as treatment following spilt plot design with three replications. vermicompost leachates showed maximum number of leaves (12.6), no. of pups (2.9), gel brix (1.94%) whereas minimum (1.57%) from control treatment and 32 mesh gave better performance where minimum no. of black spot (13.8), maximum plant height (33.3 cm) while maximum black spot (23.0), plant height (23.6 cm) in open field. Maximum skin wt. per leaf (55.5 g) and gel wt. (62.5 g) recorded in 32 mesh Vm treatment. In view of overall performances, 32 mesh Pest exclusion net and vermicompost leachates had the potentiality for quality Aloe vera production.

Rakibuzzaman *et al.* (2019a) conducted an experiment to evaluate the effect neem oil and natura one for brinjal production. The experiment conducted with four treatments *viz.* Control (T_0), Natura-one (T_1), Neem oil (T_2) and Neem oil+ Natura one (T_3) following Randomized Complete Block Design (RCBD) with three replicates. This study was carried out to examine different characters like plant height, number of branches, infested branch, branch infestation (%), number leaves/plant, chlorophyll percentage, number of flower/plants, number of fruit/plants, infested fruit, fruit infestation (%), yield/plant (kg), yield/ha (ton) and yield increase (%) over control of brinjal. Lower infested shoot and fruits (0.2 and 0.2 plant-1, respectively) and percentage (11.9 and 16.9, respectively) were found in T_3. Highest yield (57.3 tha^{-1}) and increased yield percentage over control (13.47%) were also found in T_3 treatment.

Rakibuzzaman *et al.* (2021a) carried out a field experiment to study the performance of potato germplasm with the bio-stimulating effect of Trichoderma application on potato production. Potato germplasm *viz.*, G_1 (Sokal), G_2 (Bijita), G_3 (JP Blue yellow), G_4 (JP Blue white), G_5 (Burma-1), G_6 (Burma-2), G_7 (Cardinal as check), and Trichoderma application: T_0 (No application), T_1 (Once application), T_2 (Twice application) were used in this experiment arranged in Randomized Complete Block Design with three replications. Data on different growth and yield attributes were showed significant variations. Among them, the highest plant height, maximum leaf number, SPAD value, stem number, tuber length, tuber weight observed in germplasm Sokal with twice application of Trichoderma. Maximum yield per hectare (38.92 t) were found in G_1T_2 and minimum (21.7 t) in G_4T_0.

Rodrigues *et al.* (2017) set an experiment to examine the photosynthetic pigments content and chloroplast characteristics of tamarind (*Tamarindus indica*) plants grown under colored shade nets. Under greenhouse, tamarind seeds were sown in polypropylene trays containing Plantmax® substrate. When the seedlings reached 10 cm long (approximately 60 d old), they were placed inside of structures covered with blue, red, white, and black shade nets, with 50% of shading. After 150 days, the leaves were collected and chlorophyll and carotenoids content as well as chloroplast features were assessed. Plants grown under black net showed higher values for chlorophyll a and chlorophyll b content as well as for total chlorophyll and a/b ratio. The black net was also responsible for providing the highest density of chloroplasts and area of starch grains, while the chloroplast area was greater under blue and black nets. These results made the use of black net, a cultivation practice suitable for commercial purposes.

Rueda *et al*. (2016) carried out an investigation with isolated and identified *Azotobacter* spp. and *Azospirillum* spp. through macromorphologically and micromorphologically to assess its effect on growth and yield of strawberry (*Fragaria vesca*) in hydroponic system. The inoculation and coincubation of bacterial culture were performed in combination with three nitrogen levels (50, 100 and 150 ppm). It was observed that in T_8 (co-inoculation in 100 ppm N) group showed significantly increase in plant height (18.57 cm), chlorophyll content (48.57 Soil Plant Analysis Development-SPAD), fresh root weight (25.82 g) and dry root weight (5.93 g), while in treatment group T_5 (*Azotobacter* spp. 100 ppm of Nitrogen) and T_6 (*Azotobacter* spp. 150 ppm of Nitrogen) showed significant increase in root length, leaf area, dry and fresh weights of aerial parts. *Azotobacter* and Nitrogen treatment has growth related benefits in strawberries under hydroponic system.

Silva *et al.* (2018), conducted an experiment to evaluate the effects of shade nets on fruit production and qualitative parameters of four species belonging to genus *Physalis*. The experimental design was random blocks with a 4 x 5 factorial scheme, four species of *Physalis* (*P. peruviana*, *P. pubescens*, *P. minima* and *P. ixocarpa*) and four colors of shade nets (white, blue, red, and black), besides the control treatment under full sun exposure. Fruits were collected weekly and evaluated for longitudinal and transversal diameter and biomass with and without a calyx. Finally, the percentage of calyx biomass compared to the total fruit biomass, number of fruits per plant and production were determined. A differentiated response was found among the species regarding the coloring of the converter shade nets. Plants of *P. peruviana* had the best productive and qualitative parameters of fruits when cultivated in full sunlight or under white shade nets, *P. pubescens* and *P. minima* when cultivated in full sunlight or under white and blue shade nets, and *P.ixocarpa* under red or black shade nets.

Shah *et al.* (2001) conducted study at Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan during the period of autumn 1998 to investigate the effect of different fertilizers and EM on growth, yield and quality of maize. Nine treatments were applied as follows T_0: (Control), T_1: (12.5 t FYM + 60 L/ha EM), T_2: (75 kg N + 60 L/ha EM), T_3: (37.50 kg P + 60 L/ha EM), T_4: (75 kg N + 37.50 P + 60 L/ha EM), T_5: (25 t FYM + 30 L/ha EM), T_6: (150 kg N + 30 L/ha EM), T_7: (75 kg P + 30 L/ha EM) and T_8: (150 kg N + 75 kg P +30 L/ha EM). Results showed that Plant height (244.5 cm) at T_5 and (243.50 cm) at T_8 are statistically similar. Number of grain/cob (572.40) and grain yield (4.72 t) are highest at T_8. Increase of yield was recognized to increased leaf number and a greater number of grains per cob.

Shahak *et al*. (2004) reported that a series of color net products was produced, each net differentially modifying the spectrum (in the visible, and/or UV, FR, or IR regions) of the incident radiation, and at the same time enriching the relative content of scattered light. The spectral manipulation promotes physiological responses, while light scattering improved light penetration into the plant canopy. The approach aimed at combining as many benefits as possible in one technology. The color net approach was evaluated during the past seven years in numerous ornamentals, edible field crops, fruit trees and vineyards. The benefits of the colored-netting approach, include extending the harvest season (early and late maturation), and improving the yield, product quality and the overall agroeconomic performance of agricultural crops.

Shaheen *et al.* (2014) studied the influence of organic manure and complex chemical fertilizer (NPK) with or without effective microorganism (EM) on the agronomic performance of spinach crop in a two-year pot experiment at Gomal University from 2009 to 2011. Bio-Aab, a commercial product, was employed as an EM source. T_1 (no N or EM), T_2 (FYM applied at 10 t/ha), T_3 (press mud applied at 20 t/ha), T_4 (compost applied at 0.7 t/ha), and T_5 (poultry manure applied at 5 t/ha) were the treatments. In 2009-10, the use of EM in combination with Press mud at a rate of 20 t/ha resulted in greater average spinach plant height (35 cm), number of leaves (16.4), fresh foliage yields (330 g/pot), and dry foliage yields (32 g/pot) and leaf length (40.5 cm) relative to poultry manure, compost or FYM treatments. Similar result was observed during 2010-11. Press mud with EM was more efficient in improving soil quality and enhancing spinach growth and quality followed by FYM and poultry manure.

Singh *et al*. (2009) conducted a field experiment to study the response of nitrogen fixing bacteria with chemical fertilizers in conjunction with plant bioregulators on growth, yield and nutrient status of strawberry cv. Sweet Charlie. The maximum growth in terms of plant height, number of leaves, leaf area, crowns/plant and total biomass were observed in the treatment consisting of *Azotobacter* + *Azospirillium* + 60 kg N ha^{-1} + 100 ppm GA_3. This treatment also contains highest chlorophyll content in leaves. Highest fruit set, yield and optimum fruit quality was recorded in plants inoculated with *Azotobacter* and *Azospirillum* along with 60 kg N ha^{-1} (50% N of the standard dose) and 100 ppm GA_3. The plant nutrient status was much influenced by combined use of biofertilizer and bioregulators.

Sood *et al*. (2018) undertook a study to monitor the interactive effects of bio-fertilizers and plant growth regulators on performance of strawberry. Three different bio-fertilizers *viz. Azotobacter* (10 kg/ha), PSB (6 kg/ha) and VAM (12 kg/ha) and three plant growth regulators *viz.* GA_3 (100 ppm), Triacontanol (5 ppm) and NAA (50 ppm) were tested individually and in combinations. The combined application of bio-fertilizers and growth regulators (i.e., PSB@6 kg/ha + GA_3@100 ppm) helped to improve the plant growth with least time to produce first flower. The physical characteristics, anion and cation content of strawberry fruit were positively affected by treating the plants with PSB@6 kg/ha) + Triacontanol@5 ppm. The plants treated with PSB (6 kg/ha) + Triacontanol (5 ppm) registered a 33.0% higher yield compared to control treatment. An appropriate combination of bio-fertilizers and plant growth regulators (e.g., PSB@ 6 kg/ha) + Triacontanol@ 5 ppm) significantly improved the fruit yield and quality of strawberry.

Tafoya *et al.* (2018), carried out a study to evaluate light quality transmitted by gray, aluminized, pearl, blue, red, and black (control) nets with 30% shade, as well as its effects on photosynthetic properties and fruit production of cucumber plants. Treatments (shade nets) were established under a randomized complete block design with four repetitions. The red net transmitted 23.7 and 40.3% more photosynthetic photon flux density (400 to 700 nm) and red light (600 to 700 nm), and the blue net transmitted 36% more blue light (400 to 500 nm) in comparison with the respective transmissions of black net. All nets increased the photosynthetic responses: transpiration, stomatal conductance, and CO2 assimilation, observed in plants grown under the black net. Leaf greenness (41.6 SPAD units) and foliar area (90 dm^2) increased 22.8 and 38.9% with the red net, while the dry weight of leaf (52.5g) increased by 21.9% with the pearl net. Pearl, red, aluminized, and blue nets showed to be viable alternatives because the production of fruit increased by 71, 48, 46, and 46%, respectively, in comparison with the conventional black net (52 tha^{-1}).

To determine if lactic acid bacteria, when inoculated into soil amended with organic materials, could enhance decomposition and the release of plant nutrients, and increase soil humus formation, Higa *et al*., 1989, set an experiment. The addition of EM 4 to soil amended with fresh green grass increased the growth of cucumber over that of the unamended and fertilized controls, while woodchips appeared to suppress growth. The yield of mustard and radish (tops and roots) were significantly higher with EM 4 at all dilution levels than either of the controls. However, mustard yield was highest at the 1:500 dilution, while there was little difference in radish yield for the dilutions used. Populations of fungi, *Lactobacilli*, aerobic bacteria, and actinomycetes were generally higher in soil treated with EM 4 than for the unamended controls. Results indicate that EM 4 can accelerate the decomposition of organic amendments in soils and the release of their nutrients for plant growth. The soil humus content, even from addition of woodchips, was increased considerably from treatment with EM 4.

To explore the potential relevance and practical application of rhizophagy, Lonhienne *et al*. (2014) investigated brewers' yeast (*Saccharomyces cerevisiae*), a waste product of the brewing industry, for its role as biofertilizer. The addition of live or dead yeast to fertilized soil substantially increased the nitrogen (N) and phosphorus (P) content of roots and shoots of tomato (*Solanum lycopersicum*) and young sugarcane plants. Yeast addition to soil also increased the root-to-shoot ratio in both species and induced species-specific morphological changes that included increased tillering in sugarcane and greater shoot biomass in tomato plants. These findings support the notion that brewers' yeast is a cost effective biofertilizer that improves not only plant nutrition but also plant vigor during the early growth phase.

Tomic *et al.* (2015) investigated the effects of biofertilizer and cultivar on the vegetative potential, leaf mineral composition, yield potential, fruit features, and chemical attributes of Clery, Joly, and Dely strawberry plants' fruits. Biofertilizer 1 (inoculums of a mixture of liquid bacteria cultures from the genera *Azotobacter*, *Derxia*, and *Bacillus*) and Biofertilizer 2 (inoculums of a mixture of liquid bacteria cultures from the genera *Azotobacter*, *Derxia*, and *Bacillus*) were used (inoculums of liquid culture of diazotrophic bacteria belonging to the genus *Klebsiella*). The biofertilizers used had a substantial influence on the leaf's vegetative potential, as well as the contents of several macro and microelements, as well as the values of titratable acidity, vitamin C, total anthocyanins, total phenolic content, and total antioxidant capacity.

Uddin *et al.* (2021) conducted a study to investigate the influence of organic bio stimulator on growth and yield attributes of strawberry. The experiment was consisted of four treatments, T_0: Control; T_1: Neem oil; T_2: Bordeaux mixture; T_3: Clybio; and arranged in Randomized Complete Block Design (RCBD) with three replications. The effects on vegetative growth, yield attributes and fruit quality (Brix %) were investigated and they showed significant variation. Furthermore, strawberry fruit color (fruit skin and flesh) measured and expressed through L* (lightness), a* and b* (two Cartesian coordinates) including C* and hab (Chroma & Hue angle) based on CIELab scale. The results showed that, Clybio (T_3) and Bordeaux mixture (T_2) treatment more prominently enhanced vegetative growth (crown height, SPAD value, runner number) and yield attributes (flower number, fruit length); maximum fruit number (26.3), fruit weight (25.3 g), Brix value (7.1) recorded in T_3 treatment, and Clybio led to greater improvement in fruit yield (69.6%) over control treatment. So, it can be concluded that Clybio can be recommended as a bio-fertilizer that had the bio-stimulating impact to improve vegetative growth as well as higher yield.

Uddin *et al.* (2020) accomplished an experiment to evaluate the bio efficacy of spore concentration of *Trichoderma harzianum* on tomato. Three tomato varieties *viz.* Roma-VF (V_1), BARI Tomato-2 (V_2), Apple Netherland (V_3), and *Trichoderma harzianum*: No Trichoderma applications (T_0), 106spores/ml (T_1), 107spores/ml (T_2) were used in this study with three replications following Randomized Complete Block Design. Data on different growth and yield attributes parameters were taken in which all the treatment showed significant variations. Among varieties, Roma VF variety had prominent yield (90.3 t/ha) and among Trichoderma treatment 107spores/ml application had a synergistic effect on yield/ha (89.8 t). The combination of variety (V_1) and Trichoderma (T_2) application increased growth and yield attributes significantly and influenced higher yield than other treatment.

Verma *et al.* (2017), conducted a field experiment during 2014-15 to study the performance of different levels of inorganic fertilizers with combination of bio-fertilizers. It comprised application of different level of inorganic and bio-fertilizers with thirteen treatments. Among these, overall minimum plant height was obtained (14.18 cm) at 90 days after transplanting in T_1 - Control and maximum plant height (18.67 cm) in T_2 - (100 kg N ha^{-1}+ *Azotobacter*). The maximum number of leaves was recorded highest (18.67) in T_2 - (100 kg N ha^{-1}+ *Azotobacter*) with followed by (17.67) in T_4 - (75 kg N ha^{-1} + *Azotobacter*). The minimum spreading of plant in North- South direction (15.63 cm) was recorded in case of control. The highest yield per plant observed in T_2 (173.42 g). Among the thirteen treatments T_2 - (100 kg N ha^{-1}+ *Azotobacter*) showed best performance in terms of maximum fruit yield of strawberry.

Widdiana and Higa (1998) conducted a field plot experiment during 1993 at crop production center for horticultural Crops, Lembang, West Java to determine the effects of foliar applied EM on the production of garlic, onion, tomato, and watermelon. T_1: Control (fertilizer + manure only), T_2: EM (0.1%) applied weekly, T_3: EM (0.5%) applied weekly, T_4: EM (1.0%) applied weekly, T_5: EM (0.1%) applied biweekly, T_6: EM (0.5%) applied biweekly and T_7: EM (1.0%) applied biweekly treatments were used. The highest garlic yield (98.4 kg/ha) was obtained at T_2 the highest yield of onion (167.4 kg/ha) at T_4; and the highest yield of tomato (265.0 kg/ha) at T_4. Yield increase percentage of garlic, onion, and tomato (from EM) of 12.5, 11.5 and 19.5% compared with the fertilized (no EM) controls. There was no significant increase in watermelon yields from foliar application of EM at any treatment.

Xiaohou *et al.* (2001) conducted various studies in China to investigate the effect of foliar application of beneficial microorganisms on yield and quality of various crops. He reported that in field trials, sprinkling of 0.1% beneficial microorganisms' solution improved the quality and enhanced yields of tea, cabbage, and sugar corn by 25%, 14%, and 12.5%, respectively.

Yousaf *et al.* (2000) investigated the effect of seed treatment and foliar application of beneficial microorganisms on growth and yield of two varieties of groundnut (*Arachis hypogaea* L.). Two varieties ICG-2261 and ICGV-86550 and three treatments T_1: Control, T_2: Seed inoculation with EM, T_3: Seed inoculation with EM + EM spray. Result showed that root length and plant height range from 13.4 cm and 83.0 cm to 13.1 cm and 79.8 cm. Maximum root length, plant height, number of branch (29.13) 13 and weight (198.1 gm) were at T_3, while minimum number of branch (21.3) and weight (144.4 gm) were at in T_1.

Zareen *et al.* (2012) carried out a study on endophytic associations with plants have a beneficial effect for many different plant species with some of them being host specific. Several endophytes isolated from poplar and willow were screened for their effects on commercially important crops including corn, tomato, pepper, squash, sunflower, and grasses. Most of these endophytes produce growth hormones such as indoleacetic acid (IAA) and have the nitrogenase gene required for nitrogen fixation. The effects of these isolates on plant growth and yield were evaluated under greenhouse conditions. We found that inoculated plants not only had better viability and earlier flowering and fruiting, and they also had increased plant growth and fruit yields when grown in nitrogen-limited soil. In a particular variety of perennial rye grass, the endophytes increased the total nitrogen content of the plants, indicative of nitrogen fixation, in addition to promoting plant growth. The use of specific endophytes may be preferable to the use of chemical fertilizers because of the monetary and environmental costs, contributing to more sustainable agricultural systems.

Zehra *et al.* (2009) brought about a study to evaluate the yield response of potato to inoculation with *Bacillus* sp. OSU-142 at three levels of N fertilization (0, 120, and 240 kg ha^{-1}) under field conditions in Ahlat District of Eastern Anatolia Region of Turkey in 2006 and 2007. Tuber inoculation with *Bacillus* sp. OSU-142 significantly affected yield and yield components in both years. Tuber yields and yield components were higher at all levels of nitrogen fertilizer in the inoculated plots as compared to the control. However, the beneficial effect of *Bacillus* sp. OSU-142 on tuber yield was noted at 120 kg N ha-1, possibly indicating either more effective of inoculation in the low-N input agriculture or interaction of *Bacillus* sp.OSU-142 with higher yielding seasonal conditions. In general, more response to inoculation was observed in the absence of major crop growth limitations, suggesting the complementary contribution of the *Bacillus* sp.OSU-142 treatment to develop higher-yielding potato more efficiently.

Zoran *et al.* (2017) experimented the concept of photo-selective netting in a sweet pepper *(Capsicum annuum* L.) cultivar 'Cameleon' from summer cultivation in south Serbia (under high solar radiation 910 Wm^{-2}, with a photosynthetic photon flux density of 1661 $\mu molm^{-2}s^{-1}$), under four different colored shade-nets (pearl, red, blue, and black) with 40% relative shading. The aim of the study was to determine how different environmental control technologies, colored shade-nets as net house or plastic-house integrated with colored shade-nets, could influence plant parameters, production, and quality traits in pepper fruits. Shade-grown leaves generally have higher total chlorophyll and carotenoid content than control leaves. Pericarp fruit thickness was significantly higher in peppers grown under red net house (4637.10 µm) and black net house (4609.32 µm) compared to the open field – control (3116.19 µm). The highest concentration of total soluble solids (TSS) was detected in pepper fruits grown under the open field conditions (8.03%). Pepper fruits grown in plastic tunnels had significantly lower TSS content (6.58%). Total acid (TA) content was 0.19 in the control and 0.25 in pepper fruits grown under red nets. The highest concentration of vitamin C was detected in peppers grown in plastic tunnels integrated with red-colored nets (175.77 mg 100 g^{-1}). The results showed that red and pearl photo-selective nets create optimal growing conditions and increase the total fruit yield as well as the number of fruits with fewer physiological disorders and with thicker pericarp. Photo selective pearl and red nets can be recommended for sweet pepper 'Cameleon' with respect to quality and bioactive compound and can furthermore be implemented in protected cultivation practices.

Zoran *et al.* (2018) stated that the photo selective, light-dispersive shade nets can be used as an alternative to protect crops from adverse environmental conditions such as: excessive solar radiation, heat and drought stress, wind and hail, birds, flying pests, thus improving crop's production, yield and quality.

The physiological parameters discussed in the review include vegetable growth parameters (leaf area, leaf chlorophyll), tissue structure, fruit ripening, physiological disorders, pest and disease incidence, fruit quality parameters (soluble solids content and titratable acidity), bioactive compounds (antioxidant activity, ascorbic acid, carotenoid and flavonoid contents) and aroma volatile compounds at harvest. Also, it is evident in the reviewed literature that light quality influences the biosynthesis, accumulation, and retention of vegetable phytochemicals, as well as the decay development during storage. These new strategies to modulate light quality should be conveyed to vegetable producing farmers, thus allowing them to preserve the freshness and post-harvest quality of vegetables for an extended period of time, and to meet the consumers demand for vegetables with high nutritional value all year round. Research on light manipulation in horticultural systems is necessary for sustainable and market-oriented open field and greenhouse vegetable production in the future.

Zoran *et al.* (2012) conducted a study to observe the photo selective netting concept in a tomato 'Vedeta' cultivation in the south part of Serbia (Aleksinac) under high solar radiation, using four different colored shade-nets (pearl, red, blue and black) with different relative shading (40% and 50% PAR). Exposure to full sunlight was used as a control. Red and pearl nets with 40% shade significantly increased the total yield. Shading reduced the appearance of tomato cracking and eliminated sunscalds on tomato fruits and accordingly, increased the marketable tomato production by about 35% compared to non-shading conditions. Changing the light intensity by color shade nets affected the biosynthesis of lycopene and β-carotene in tomatoes. Thus, significantly higher lycopene content was observed in greenhouse tomato integrated with red shade netting technologies (64.9 μg g^{-1}) than in field-grown tomatoes (48.1 μg g^{-1}). By contrast, shaded fruits have lower content of carotene. The photo-selective, light-dispersive shade nets appear as interesting tools that can be further implemented within protected cultivation practices.

MATERIALS AND METHODS

The chapter illustrates a brief outline of the location of the experiment, climatic conditions as well as the materials used for experimenting. It demonstrates the information regarding the methodology that was utilized during the accomplishment of the experiment. This chapter also incorporates the treatments of the experiment as well as procedures for data collection and analysis.

3.1 Experimental site

The experiment was brought about at the Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from October 2019 to January 2020. The site lies within 23074' N latitude and 90035' E longitude and at an elevation of 8.2 m from sea level (Anon., 1989) in the Agro-Ecological Zone of Madhupur Tract (AEZ No. 28). In Appendix I, the trial location was depicted on a map of Bangladesh's AEZ.

3.2 Climatic conditions

The experimental site was in the subtropical monsoon climatic zone, which is characterized by heavy rainfall from April to September (Kharif season) and minimum rainfall for the rest of the year (Rabi season). Rabi season of the year (October to March) experiences adequate sunshine and moderately low temperatures prevail during this period, which is appropriate for the cabbage growing in Bangladesh.

3.3 Soil Characteristics

The soil of the experimental site falls under the Modhupur Tract (UNDP, 1988) under AEZ No. 28. It had shallow red brown terrace soil. The selected plot was medium-high land, and the soil series was Tejgaon (FAO, 1988). Organic matter content was 0.84%. Soil pH ranged from 6.0-6.6. The experimental area was flat having a good drainage system and available irrigation and it is above the flood level. Soil samples were taken from the experimental field at depths ranging from 0 to 15 cm. Soil Resource and Development Institute (SRDI) Dhaka conducted the analysis. Appendix II contains the soil's physicochemical characteristics.

3.4 Experimental Materials

3.4.1 Planting Materials

BARI badhakopi-1 (Provati) was used as planting material. 30-35 days old seedlings were collected from local nursery of Dhaka.

3.4.2 Clybio

Clybio is the unique and complex blend of useful microbes (EM) that contains bacteria like *Lactobacilli* bacteria, lactic acid bacteria, *Bacillus natto* bacteria, as well as yeast fungus with the power of enzyme (indigenous microbial nutrient such as amino acid and peptide-based hormone substances). The liquid solution of Clybio was collected from the agricultural service providers of Conpass corporation in Dhaka. The Clybio solution was prepared as below:

C_{500}: 8ml Clybio in 1 liter of water

C_{1000}: 4ml Clybio in 1 liter of water

3.4.3 Colored shade nets

Three different colored nylon shade nets with 60 mesh (white, pink, and blue) were collected from the local nursery and market. The light intensity of the different colored shade nets was measured by using the Lux meter device which is shown in table 1.

Table 1: Light intensity under different shade net condition

Shade net color	Light Intensity (lux)
Control	12000
White	10860
Blue	9800
Pink	9800

3.4.3 Treatments of the experiment

The experiment was conducted to find out the growth and yield of cabbage as influenced by colored shade nets and Clybio. The experiment consisted of two factors.

Factor A: Colored shade net

(i) N_0: Control (without net)

(ii) N_W: White net

(iii) N_P: Pink net

(iv) N_B: Blue net

Factor B: Clybio Concentration

(i) C_0: No Clybio application

(ii) C_{1000}: 1000-Fold

(iii) C_{500}: 500-Fold

12 treatment combinations are as follows:

N_0C_0	N_WC_0	N_BC_0	N_PC_0
N_0C_{1000}	N_WC_{1000}	N_BC_{1000}	N_PC_{1000}
N_0C_{500}	N_WC_{500}	N_BC_{500}	N_PC_{500}

3.5 Application of Clybio

Application of Clybio was carried out as both foliar and soil application. The first application of Clybio was done at 10 days after transplanting and the frequency was maintained and carried out for seven more times afterward.

3.6 Shade net installation

Seedlings of cabbage were transplanted into four blocks in a random plotting. Within four blocks three were shaded with three different colored nets (white, pink, and blue) but one without.

3.7 Design and layout of the experiment

The two factorial experiment was laid out following Split Plot Design with three replications. An area of 19.8 m × 6.8 m was divided into four equal blocks which acted as plots. Each block was divided into 3 split plots, and 12 treatment combinations were allotted randomly in the blocks. Size of each plot was 6.6 m × 1.2 m. There were 36-unit plots, and the size of each split unit was 2.2 m × 1.2 m. The distance maintained between two blocks was 0.5 m. The seeds were sown maintaining a distance of row to row of 60 cm and plant to the plant of 40 cm. The layout of the experiment is shown in **Figure 1.**

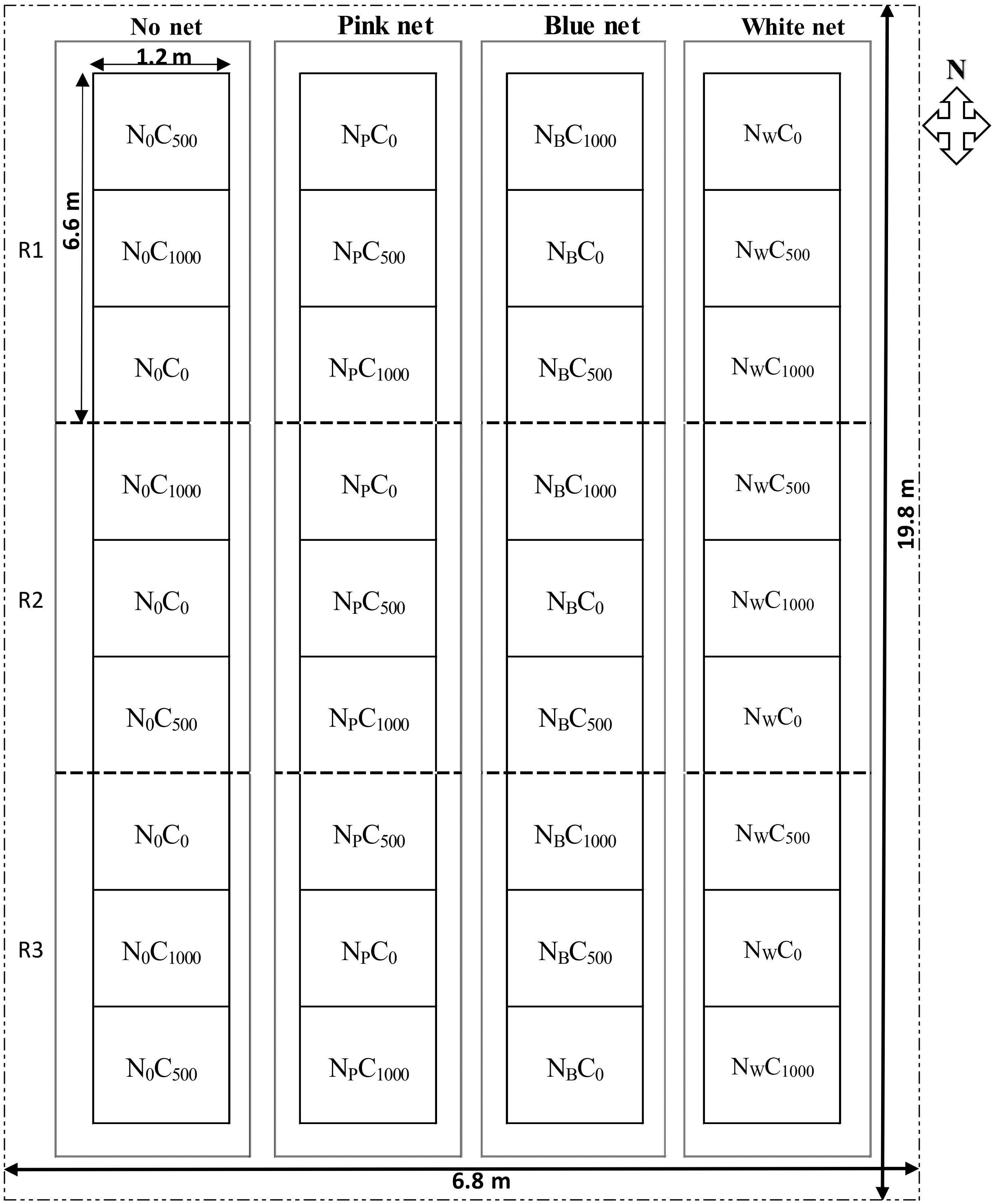


Figure 1. The layout of the experiment field

3.8. Production methodology

3.8.1 Preparation of the main field

In the third week of September 2019, the selected experimental plot was prepared by ploughing and cross ploughing, followed by laddering and harrowing with a tractor and power tiller to get a good tilth. Weeds and stubbles were carefully removed from the experimental area before it was leveled. Finally, the experimental plot was partitioned into the unit plots following the experimental design.

3.9 Application of manure and fertilizers

During final land preparation, all cow dung, one third of urea, half of TSP, and half of the MOP of the recommended dose were put in the field. Remaining TSP, MOP, and Urea were applied to the plots as basal dose. Table 2 shows the manureand fertilizer doses utilized in the study.

Table 2. Manures and fertilizer used as per BARI (2019) recommend action

Manures/ Fertilizers	Recommended Dose/ha
Urea	300 kg
TSP	200 kg
MOP	250 kg
Cowdung	5 ton

3.10 Transplanting of seedlings in the main field

Healthy and uniform-sized seedlings were brought and transplanted into the main field. Transplanting was done in the afternoon maintaining appropriate cautions. A considerable number of seedlings were also planted on the border of the experimental plots for gap filling.

3.10.1 Spacing

Row-to-row distance and plant-to-plant distance were maintained at 60 cm and 40 cm, respectively.

3.11 Intercultural operations

Various intercultural operations *viz.* irrigation and drainage, gap filling, weeding, etc. were accomplished for better growth and development of cabbage seedlings.

3.11.1 Irrigation and drainage

Overhead irrigation was provided with a watering can to the plots once immediately after transplanting every alternate day in the evening up to 1st harvest. Further irrigation was done as and when needed. Excess water was effectively drained out at the time of irrigation.

3.11.2 Gap filling

Gap filling was done after 6 days of transplanting from the border side transplanted plant.

3.11.3 Weeding

Weeding was done to keep the plots free from weeds, and easy aeration of the soil, which ultimately ensured better growth and development. Breaking the crust of the soil was done when needed.

3.12 Plant Protection

No pesticides and fungicides were used during this experiment.

3.13 Harvesting

All cabbage heads were not matured at the same time, that is why harvesting was carried out in two batches.

3.14 Parameters of the experiment

1. Growth parameters
    a. Plant height (cm)
    b. Number of leaves
    c. Days to 80% head initiation
    d. Leaf length (cm)
    e. Leaf breadth (cm)
    f. Shoot length (cm)
    g. Root length (cm)
2. Physiological parameters
    a. SPAD value
3. Yield attributing parameters
    a. Head length (cm)
    b. Head diameter (cm)
    c. Single head weight (kg)
    d. Yield per plot (kg)
    e. Yield per hectare (t)

3.15 Data collection

Three plants were randomly selected from each unit of the plot for the collection of data. The plants in the outer rows and the end of the middle rows were excluded from the random selection to avoid the border effect. However, the yield of all plants was considered as per plot yield. Data have been collected based on three attributes *viz.* growth parameters, physiological parameters, and yield attributing parameters. Yield attributing data have been recorded from the mean of three harvested plants which were selected at random for each unit plot of every harvesting stage.

3.15.1 Plant height (cm)

The height of the plant was recorded in centimeters (cm) at 15, 30, 45, and 60 days after transplanting (DAT) in the experimental plots. The height was measured from the attachment of the ground level up to the tip of the growing point.

3.15.2 Number of leaves per plant

Total number of leaves per plant was recorded from each unit plot starting from 30 to 90 DAT at 20 days intervals.

3.15.3 Days to 80% head initiation

Data on days to 80% of head initiation of cabbage were recorded when 80% of cabbage started to initiate heads.

3.15.4 Leaf length with petiole at harvest (cm)

The length of a mature leaf (fourth leaf from the top) with petiole was measured by using a meter scale at harvest. The measurement was taken from the base of the leaf to the tip of the petiole. The mean was expressed in centimeters (cm).

3.15.5 Breadth of the leaf at harvest (cm)

The breadth of mature leaves (fourth leaf from the top) was measured with a meter scale at harvest. The mean was recorded and expressed in centimeters (cm).

3.15.6 Root length at harvest (cm)

Root length was measured by a meter scale when it was harvested. Thus, the mean was recorded and expressed in centimeters (cm).

3.15.7 Stem length at harvest (cm)

Stem length at harvest was measured from base to top of stem at the time of harvest with a meter scale. Thus, the mean was recorded and expressed in centimeters (cm).

3.15.8 SPAD value

At 80 DAT, SPAD value of cabbage leaves was measured. The fourth wrapper leaves from the top were measured. Using a portable SPAD Meter (SPAD-502, Minolta, Japan), three mature plants from each unit plot were assessed. (SPAD-502) is a simple and portable diagnostic equipment for determining the greenness of leaves or their relative chlorophyll content.

3.15.9 Diameter of the head (cm) at harvest

The diameter of the head was measured with a meter scale when it was harvested and then the mean was recorded and expressed in centimeters (cm).

3.15.10 Single head weight (kg)

Head weight was measured by electronic precision in grams (Plate 1).

3.15.11 Yield per plot (kg)

The yield of cabbage head per block was recorded from the mean weight of a single head found from the total harvested plants of each plot and expressed in Kilogram (kg).

3.15.12 Yield per hectare (t)

The yield obtained from the unit plot was converted into per hectare yield expressed in tons (t).

3.16 Statistical Analysis

The data recorded for different parameters were statistically analyzed using the "Statistix-10" computer package program (Gomez *et al.* 1984).

a)

b)

c)

d)

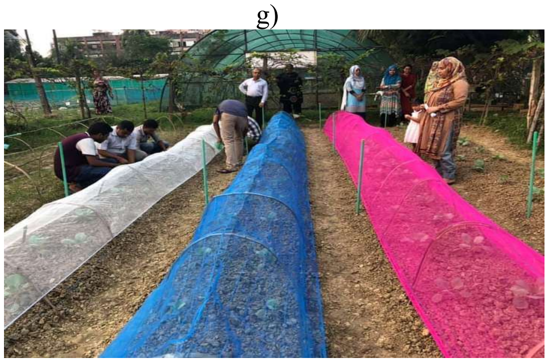
e)

f)

Plate 1. Pictorial presentation a) Colored shade nets at cabbage plots; b) Clybio; c) Field measurement and data collection; d) Application of Clybio; e) Arrangement of cabbages according to different treatment combinations; f) Harvesting of cabbage

g)

h)



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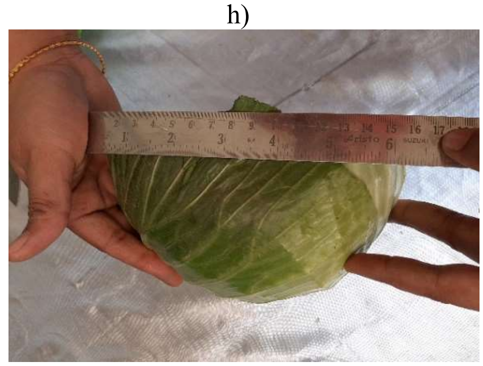

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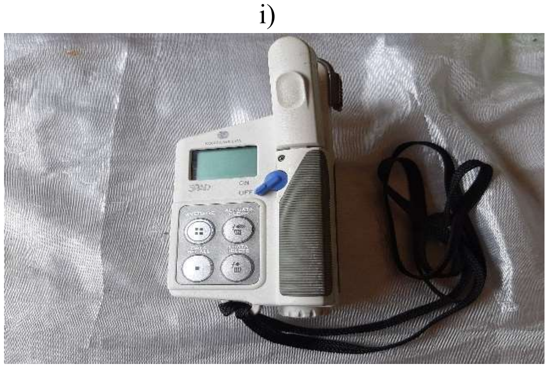

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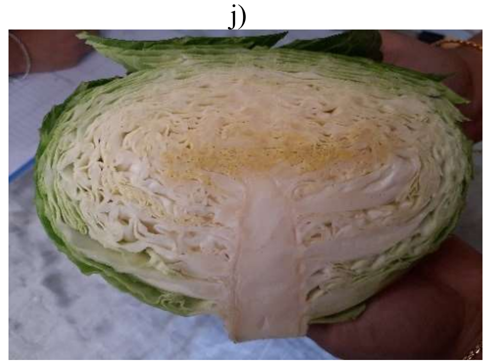

l)

Plate 2. Pictorial presentation g) Measurement of the head length of cabbage using meter scale in cm; h) Measurement of single head weight in gram using an electric balance machine; i) Shade net installation; j) Measurement of head diameter in cm using meter scale; k) SPAD meter; l) Longitudinal section of cabbage

RESULTS AND DISCUSSION

The experiment was conducted on "Clybio concentration on growth and yield of cabbage under different colored shade nets" and the results on the effectiveness of various treatments combined in consideration of two factors colored shade nets and Clybio concentration. Findings of the research work have been presented and discussed in this chapter. This chapter's illustration has focused on tables and figures to enhance their parallel and dissimilar traits through discussion, comprehension, and perception. A summary of the analysis of variances regarding all parameters has been arrayed in the appendix. Results have been presented and discussed and possible interpretations are given under the following headings.

4.1 Growth parameters

4.1.1 Plant height (cm)

Plant height is a significant growth parameter that is positively correlated with the yield. However, this trait was significantly influenced by the use of different colored shade nets on different days after transplanting (DAT) (Figure 2 and Appendix II). In the case of all net conditions, a significant increase in plant height (cm) was observed at 15 days, 30 days, 45 days, and 60 days after transplanting. The mean plant height ranged from 13.3 cm to 26.8 cm, the maximum plant height was recorded at 60 after transplanting. The tallest plant was found from N_W (26.2 cm), whereas the shortest was from N_0 (21.5 cm) at 60 days after transplanting. There was also a significant difference among the treatments N_0 (21.5 cm), N_B (23.7 cm), and N_P (24.8 cm) in this respect (Figure 2). Red nets have been found to reduce the red/far-red ratio resulting in enhanced vegetative growth in various crops (Oren-Shamir *et al*., 2001; Shahak, 2008). Plant height and stem diameter were reduced in the unshaded treatment (Díaz-Pérez *et al*., 2020).

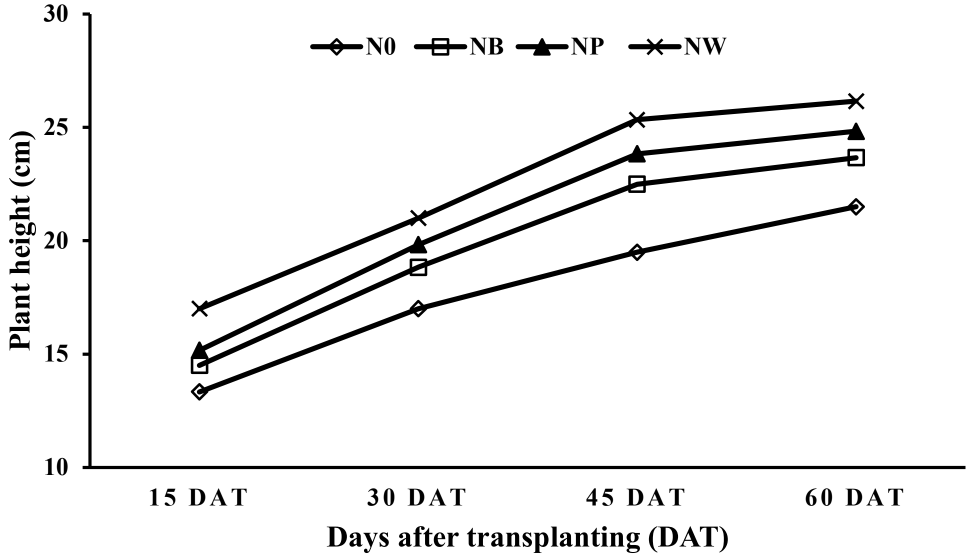

Figure 2. Effects of different colored shade net on plant height (cm) at different days after transplanting of cabbage (Here, $N_{0:}$ No net; N_w: White net; N_B: Blue net and N_P: Pink net)

Plant height was significantly affected by different concentrations of Clybio (Appendix II). Plant height of cabbage exposed statistically significant inequality among no application (C_0), 1000-fold application (C_{1000}), and 500-fold application (C_{500}) of Clybio at 15, 30, 45, and 60 days after transplanting (Figure 3). The tallest plant (24.7 cm) was found was recorded at C_{1000} and the shortest plant (21.5 cm) was found from C_0 treatment at 60 DAT (Figure 3). Plant height showed significant variations with different Clybio treatments. According to a study by Akter *et al.* (2021) reported that the application of Clybio at 1000 folds performed better at the plant height of spinach. Karawi *et al*. (2018), found that spraying the strawberry plants with dry yeast led to a significant increase in the plant height.

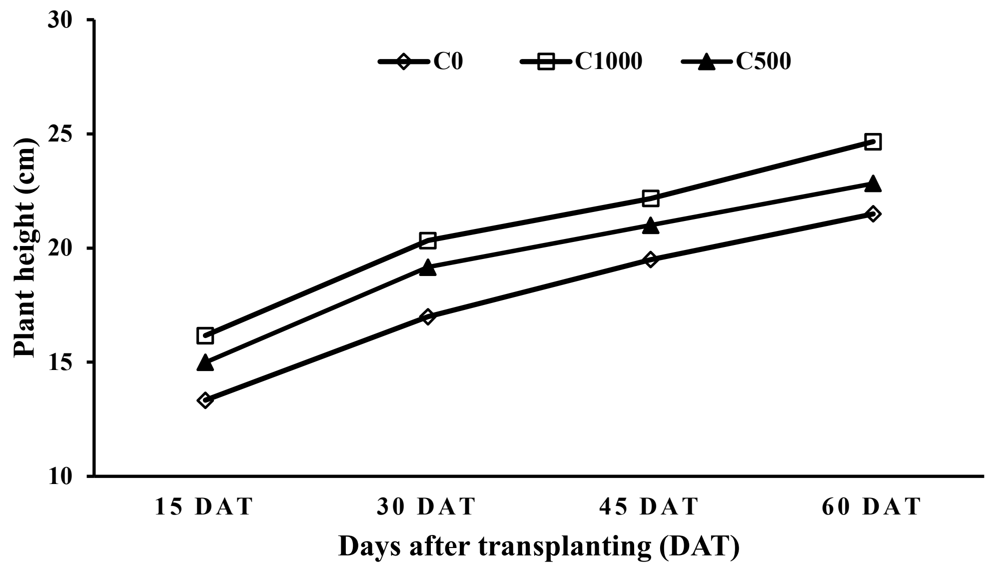

Figure 3. Effects of Clybio concentration on plant height (cm) at different days after transplanting of cabbage (Here, C_{0}: No Clybio application (control); C_{1000}: Clybio concentration 1000-fold; C_{500}: Clybio concentration 500-fold)

The combined effect of different shade net treatments and different concentrations of Clybio in the terms of plant height also exposed significant variation (Table 3 and Appendix IV) at 15 days, 30 days, 45 days, and 60 days after transplanting. The tallest plant was obtained from $N_{W}C_{1000}$ (29.0 cm) and the shortest was obtained from $N_{0}C_{0}$ (21.5 cm) at 60 DAT (Table 3).

Table 3. Combined effects of colored shade net and Clybio concentration on plant height (cm) of cabbage at different days after transplanting**

Plant height (cm)				
Treatment*	**15 DAT**	**30 DAT**	**45 DAT**	**60 DAT**
N_0C_0	13.3 h	17.0 h	19.5 g	21.5 h
N_0C_{1000}	16.2 e	20.3 de	22.2 e	24.7 e
N_0C_{500}	15.0 fg	19.2 fg	21.0 f	22.8 g
N_WC_0	17.0 d	21.0 d	25.3 b	26.2 c
N_WC_{1000}	19.5 a	24.5 a	26.8 a	29.0 a
N_WC_{500}	17.7 bc	22.7 b	25.8 b	27.2 b
N_BC_0	14.5 g	18.8 g	22.5 e	23.7 f
N_BC_{1000}	17.3 cd	21.8 c	24.5 c	25.5 d
N_BC_{500}	16.0 e	19.8 ef	23.8 d	24.8 e
N_PC_0	15.2 f	19.8 ef	23.8 d	24.8 e
N_PC_{1000}	18.0 b	23.0 b	25.5 b	27.5 b
N_PC_{500}	17.0 d	21.0 d	24.7 c	26.0 cd
CV%	6.5	8.1	5.7	6.1
LSD (0.05)	3.2	3.9	2.8	2.9

***Here**, N_0: No net; N_w: White net; N_B: Blue net; N_P: Pink net; C_0: No Clybio application; C_{1000}: Clybio concentration 1000-fold; and C_{500}: Clybio concentration 500-fold

** **In** a column, means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

4.1.2 Number of leaves per plant

The leaf is one of the plants' most important organs, accommodating various physiological processes, photosynthesis, and transpiration. Thus, leaves influence greatly in enhancing yield. The number of leaves per plant of cabbage significantly varied among different shade net treatments (Figure 4 and Appendix V). Highly significant differences exist among different shade net at 30 days, 50 days, 70 days, and 90 days after transplanting. In the colored shade net application, maximum number of leaves (59.0) was found from N_w and minimum (49.0) number was from N_0 at 90 days after transplanting (Figure 4). R. H. Stamps (2009) found out that the black net treatments were the main effectors of vegetative growth increasing widths compared with the no net control. The other colored nets (gray, red, white) affected some other vegetative parameters (increased leaf length with gray 50%, increased leaf number with all three at 50% and gray at 35%).

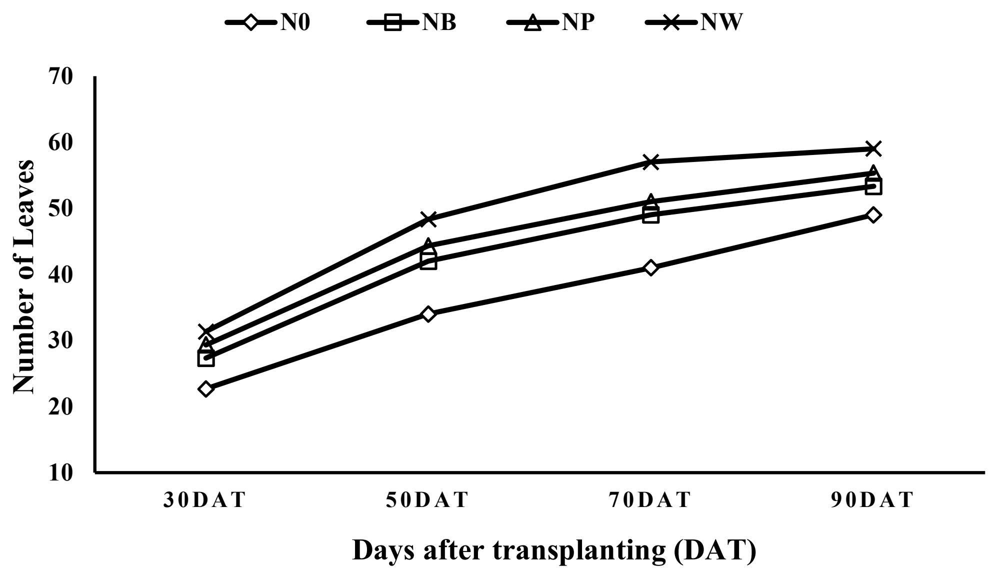

Figure 4. Effect of shade nets on number of leaves per plant of cabbage at different days after transplanting (Here, $N_{0:}$ No net; N_w: White net; N_B: Blue net and N_P: Pink net)

In case of different Clybio concentration application, significant variation in number of leaves per plant was observed at 30, 50, 70 and 90 days after transplanting (Figure 5 and Appendix Table 4). The maximum number of leaves (54.7) was found from C_{1000}, and the minimum (49.0) was from C_0 at 90 days after transplanting (Figure 5). Akter *et al.*, (2021), found significantly better result on number of leaves per plant (spinach) due to the application of Clybio at 8ml/l.

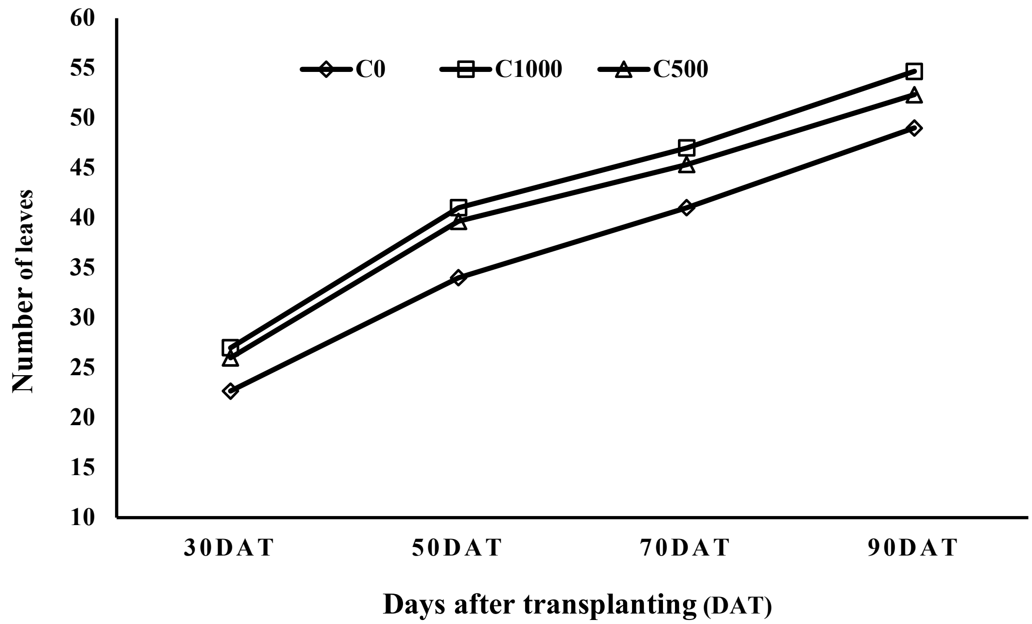

Figure 5. Effects of Clybio concentration on number of leaves per plant of cabbage at different days after transplanting (Here C_0: No Clybio application; C_{1000}: Clybio concentration 1000-fold; and C_{500}: Clybio concentration 500-fold)

In case of the combined effect of different shade nets treatments and different concentrations of Clybio, significant variation was observed in the number of leaves per plant (Table 4 and Appendix IV). Maximum number of leaves (66.0) was found from N_WC_{1000}, and minimum number (49.0) was from N_0C_0 at 90 days after transplanting (Table 4).

Table 4. Combined effects of different colored shade net and Clybio concentration on the number of leaves per plant of cabbage at different days after transplanting**

	Number of leaves per plant			
Treatment*	30 DAT	50 DAT	70 DAT	90 DAT
N_0C_0	22.7 g	34.0 h	41.0 j	49.0 h
N_0C_{1000}	27.0 ef	41.0 fg	47.0 h	54.7 ef
N_0C_{500}	26.0 f	39.7 g	45.3 i	52.3 g
N_WC_0	31.3 c	48.3 c	57.0 cd	59.0 d
N_WC_{1000}	36.0 a	54.7 a	62.0 a	66.0 a
N_WC_{500}	33.0 b	51.3 b	60.0 b	63.7 b
N_BC_0	27.3 ef	42.0 f	49.0 g	53.3 fg
N_BC_{1000}	29.3 d	48.0 cd	57.0 cd	61.7 c
N_BC_{500}	27.7 e	46.3 d	55.0 e	59.7 d
N_PC_0	29.3 d	29.3 d	51.0 f	55.3 e
N_PC_{1000}	32.0 bc	51.0 b	58.0 c	64.0 b
N_PC_{500}	31.0 c	48.3 c	55.7 de	61.7 c
CV %	1.5	1.9	1.4	1.8
LSD 0.05	0.7	0.9	0.7	0.9

***Here**, N_0: No net; N_w: White net; N_B: Blue net; N_P: Pink net; C_0: No Clybio application; C_{1000}: Clybio concentration 1000-fold; and C_{500}: Clybio concentration 500-fold

** **In** a coloumn, means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

4.1.3 Leaf length (cm)

The result analysis of the data measured from the sole application of colored shade nets gave significant variations in leaf length. Maximum leaf length was found from N_W (19.8 cm) and the lowest leaf length was from N_0 (17.5 cm). (Figure 6 and Appendix VI). Q.Y. Yan *et al.* (2012) reported that under shading-net, the leaf length of flowering Chinese cabbage increased compared to no shade conditions. Díaz-Pérez *et al.* (2020) studied that leaf length, plant height, and stem diameter were reduced in the unshaded treatment.

Figure 7 showed that maximum leaf length was from C_{1000} (19.5 cm) and minimum leaf length (17.5 cm) was from C_0, in case of the application of different concentrations of Clybio in cabbage. Khalid and Jin (2011) conducted a study to find the effects of bacterial and fungal effective microorganisms (EM) on the growth of Chinese cabbage *(Brassica rapa*) where leaf length and width significantly increased by both bacterial and fungal inoculation.

In the combined effects of colored shade nets and Clybio concentration, it was found that in N_WC_{1000} the leaf length was maximum (24.5 cm) while the lowest result was from N_0C_0 (17.5 cm) (Table 5).

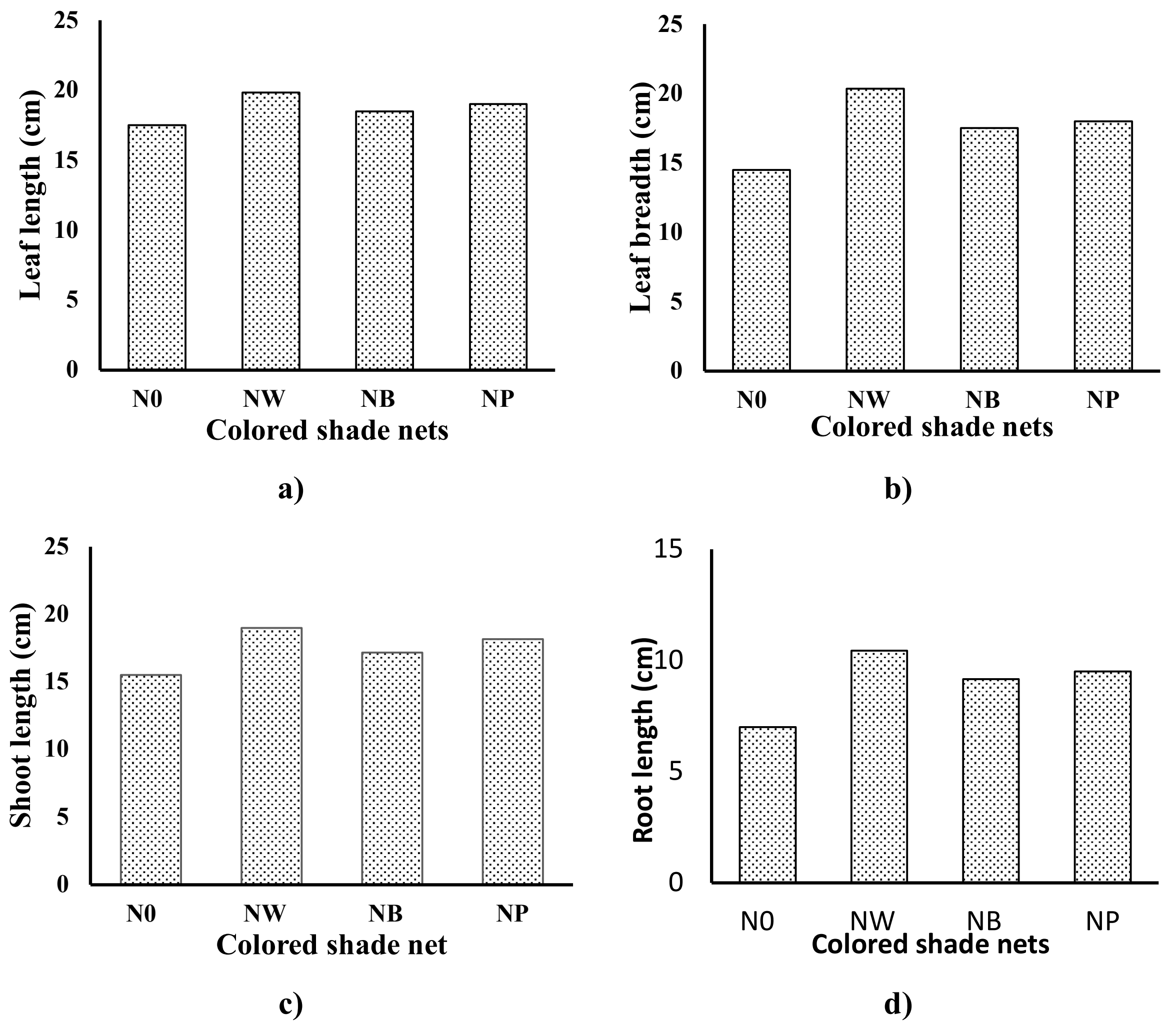

Figure 6. Effects of different colored shade net on a) leaf length (cm), b) leaf breadth (cm), c) stem length (cm), and d) root length (cm) of cabbage (Here, N_0: No net; N_w: White net; N_B: Blue net and N_P: Pink net)

4.1.4 Leaf breadth (cm)

In case of sole usage of colored shade nets, significant variations were found in leaf breadth. The treatment N_W gave maximum leaf breadth (20.3 cm) while N_0 showed the lowest (14.5 cm) of all (Figure 6 and Appendix VI). Q.Y. Yan *et al.* (2012) reported that in comparison to no netting, leaf width under red, grey, and blue net increased, while under black net this decreased.

In case of the application of different concentration of Clybio in cabbage, it was observed that maximum leaf breadth (16.5 cm) was from C_{1000}, and minimum leaf breadth (14.5 cm) was found from C_0 (Figure 7). Akter *et al.* (2021), found significantly better result on leaf breadth of spinach on the application of Clybio at 1000 folds.

The combined effects of colored shade nets and use of Clybio concentration, it was noticed that in N_WC_{1000} the leaf breadth was maximum (25.3 cm) while the lowest result was from N_0C_0 (14.5 cm) (Table 5). Moreover, the result shows that the average growth rate of leaf breadth is slightly higher in white shade net with Clybio concentration compared to other colored nets like blue, pink or no shade net (Table 5).

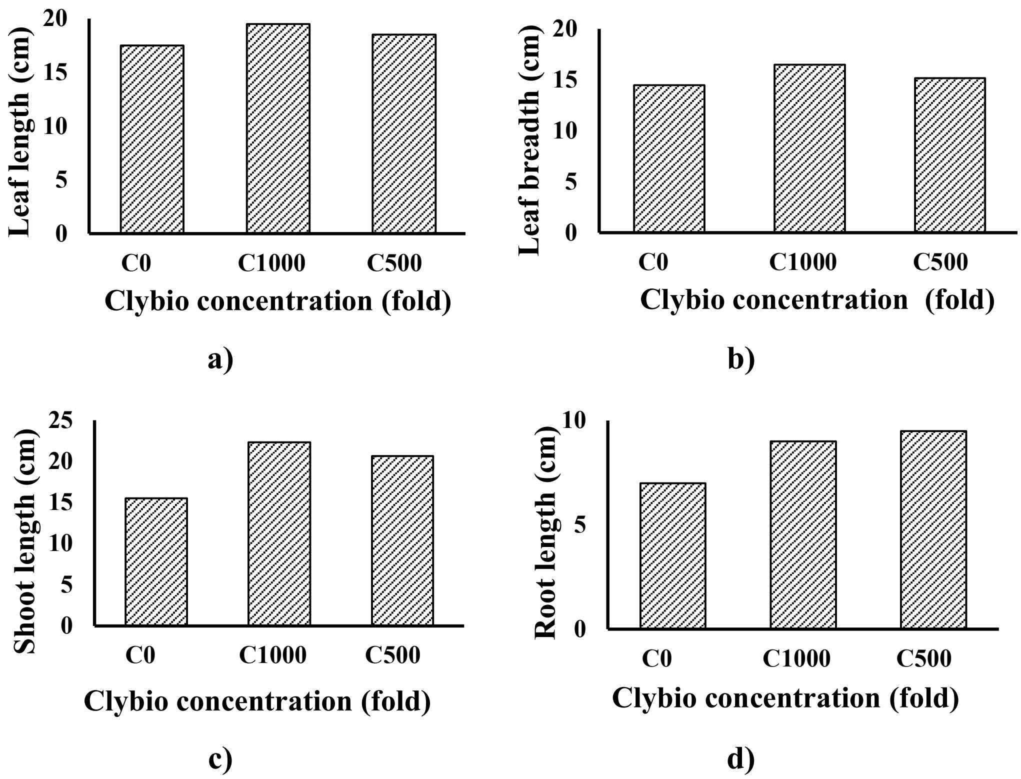

Figure 7. Effects of Clybio concentration on a) leaf length (cm), b) leaf breadth (cm), c) stem length (cm), and d) root length (cm) of cabbage (Here, $C_{0:}$ No Clybio application (control); $C_{1000:}$ Clybio concentration 1000-fold; $C_{500:}$ Clybio concentration 500-fold).

4.1.5 Stem length (cm)

The sole application of colored shade nets gave significant variations in stem length results and data analysis. Maximum stem length (19.0 cm) was found from N_W and the lowest stem length (15.5 cm) was from N_0. (Figure 6 and Appendix VI). Zoran *et al.* (2018) reported that lower light intensities increased stem elongation. Franklin (2008) noted that a low R/FR ratio can promote shoot elongation.

In the case of the different applications of Clybio concentration in cabbage, maximum stem length (22.3 cm) was from C_{1000} and minimum (15.5) from C_0 (Figure 7). Khalid and Jin (2011) conducted a study to find the effects of bacterial and fungal effective microorganisms (EM) on the growth of Chinese cabbage *(Brassica rapa*) where stem length and width significantly increased by both bacterial and fungal inoculation.

In the combined effects of colored shade nets and use of Clybio concentration, it was found that in N_WC_{1000} the stem length was maximum (25.8 cm) while the lowest result was from N_0C_0 (15.5 cm) (Table 5).

4.1.6 Root length (cm)

For the sole application of colored shade nets, the significant variations were found in root length (cm). The treatment N_W gave maximum root length (10.4 cm) while N_0 (7.0 cm) showed the lowest (Figure 6 and Appendix VI). Mazzini-Guedes and Pivetta, (2014) reported that *B. variegata* var. *candida* (Orchid) seedlings cultivated under the black net had greater root growth and dry matter increase than in open field conditions.

It was found that maximum root length (9.5 cm) was from C_{500}, and minimum root length (7.0 cm) was found from C_0, in case of Clybio application in different concentrations (Figure 7). Akter *et al.* (2021), found substantially better results on root length of spinach plants by the application of Clybio at 1000 folds.

In the case of combined effects of colored shade nets and the use of Clybio concentration, it was identified that in N_WC_{500} the root length was maximum (14.0 cm) while the lowest was from N_0C_0 (7.0 cm) (Table 5).

Table 5. Combined effects of different colored shade net and Clybio concentration on leaf length (cm), leaf breadth (cm), stem length (cm), root length (cm) and SPAD value of cabbage **

Treatment*	Leaf length (cm)	Leaf breadth (cm)	Stem length (cm)	Root length (cm)	SPAD value
N_0C_0	17.5 g	14.5 j	15.5 h	7.0 f	54.0 d
N_0C_{1000}	19.5 de	16.5 i	22.3 bcd	9.0 e	58.3 a
N_0C_{500}	18.5 f	15.2 j	20.7 e	9.5 de	56.3 b
N_WC_0	19.8 de	20.3 cd	19.0 f	10.4 d	54.3 d
N_WC_{1000}	24.5 a	25.3 a	25.8 a	13.0 bc	57.0 b
N_WC_{500}	22.5 b	23.5 b	21.5 de	14.0 a	55.3 c
N_BC_0	18.5 f	17.5 h	17.2 g	9.2 e	48.0 h
N_BC_{1000}	21.5 c	19.5 de	23.5 b	12.2 c	50.7 f
N_BC_{500}	19.5 de	18.5 fg	22.0 cd	12.8 bc	49.3 g
N_PC_0	19.0 ef	18.0 gh	18.2 fb	9.5 de	50.7 f
N_PC_{1000}	22.5 b	20.5 c	22.8 bc	12.2 c	53.7 d
N_PC_{500}	20.2 d	19.2 ef	21.2 de	13.2 ab	52.3 e
CV%	2.8	2.6	3.3	5.1	1.0
LSD (0.05)	1.0	0.8	1.2	1.0	0.9

*Here, N_0: No net; N_w: White net; N_B: Blue net; N_P: Pink net; C_0: No Clybio application; C_{1000}: Clybio concentration 1000-fold; and C_{500}: Clybio concentration 500-fold

** In a column, means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

4.1.7 Days to 80% head initiation

Days required to initiate 80% of the cabbage head is an important growth parameter. The use of colored shade nets over the cabbage plants showed that it took the least time (30.0 days) to form 80% of cabbage heads when there was no shade net whereas under a blue net it took the highest (36.7) days for head initiation (Figure 8). However, pink, and white color shade nets represented almost similar types of results in this parameter (Figure 8). No data from any other literature was found regarding this topic.

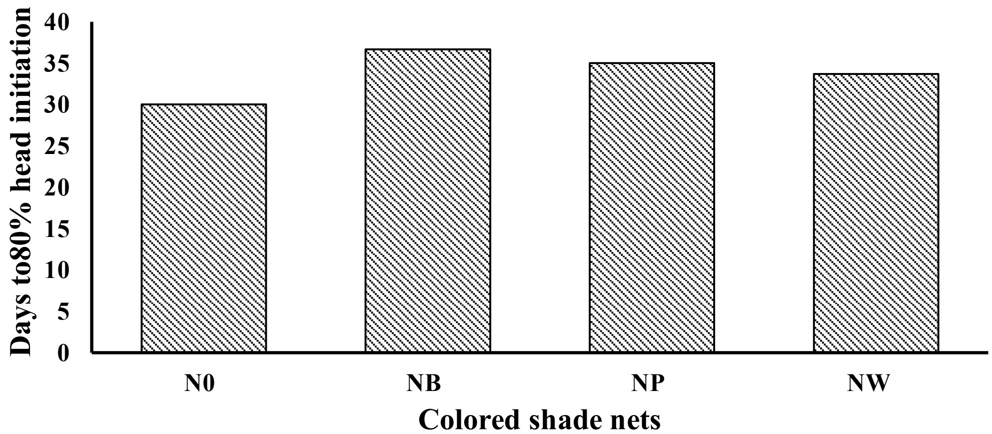

Figure 8. Effects of different colored shade net on days to 80% head initiation of cabbage (Here, N_0: No net; N_w: White net; N_B: Blue net and N_P: Pink net).

The least days (30.0) were required to initiate 80% of the cabbage head under the C_0 (control) treatment while C_{500} showed the slowest initiation of the head (33.0 days) (Figure 9 and Appendix VII). No data on this parameter were found from any other literatures.

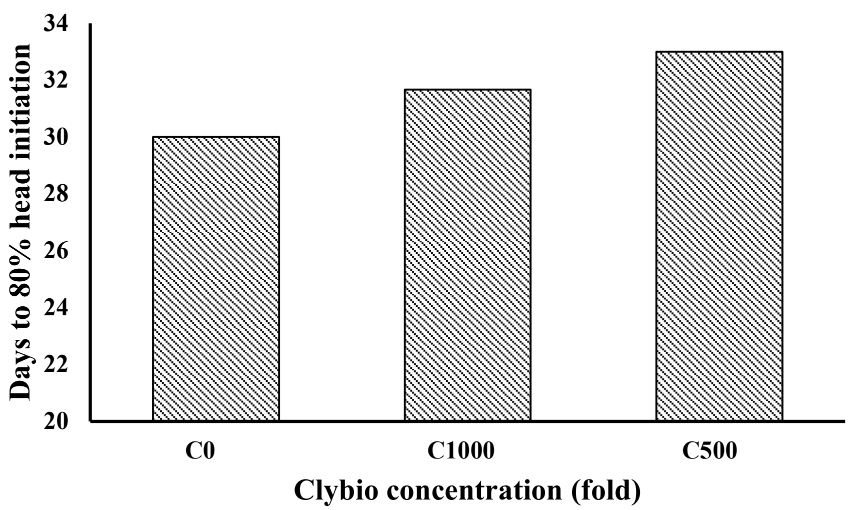

Figure 9. Effects of Clybio concentration on days to 80% head initiation of cabbage (Here, C_0: No Clybio application (control); C_{1000}: Clybio concentration 1000-fold; C_{500}: Clybio concentration 500-fold)

In the case of treatment combinations, maximum days to 80% head initiation (41.0) was found from N_BC_{500}, and minimum days to head initiation (30.0) was from N_0C_0 (Table 8 And Appendix VII)

4.2 Physiological parameters

4.2.1 SPAD Value

SPAD value is a very important physiological parameter for cabbage which indicates the greenness of leaves and is positively correlated with the yield. SPAD value showed significant variation among the treatments of different shade nets (Figure 10 and Appendix VIII). The SPAD Values in N_W (54.3) and N_0 (54.0) are statistically insignificant but highest in value. Whereas the N_B (48.0) showed the lowest SPAD value (Figure 9). Pinheiro *et al.* (2020) observed that the lettuce cultivars grown under a red net and without a net showed greater stomatal densities and chlorophyll contents. The chlorophyll content of pepper fruits grown under the pearl net was significantly higher than the chlorophyll of fruit grown under the black net (Alkalai-Tuvia *et al.*, 2014).

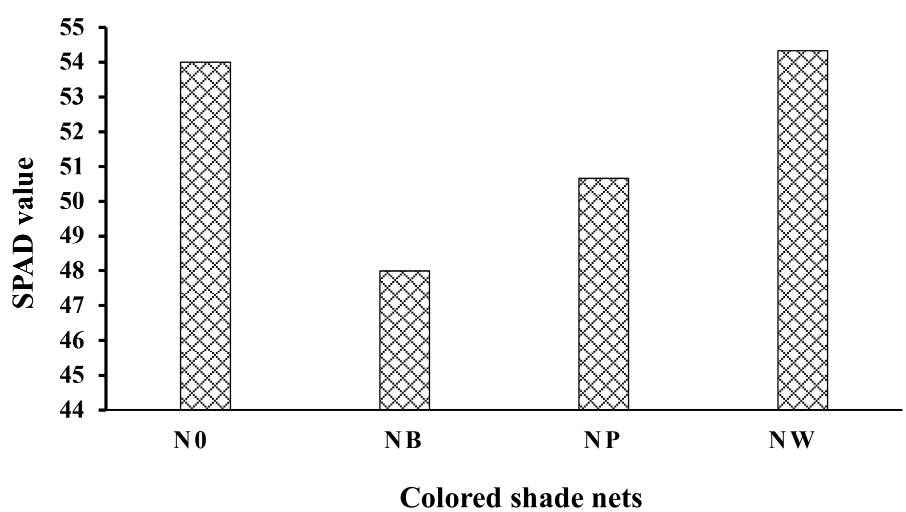

Figure 10. Effects of different colored shade nets on SPAD value of cabbage (Here, N_0: No net; N_w: White net; N_B: Blue net and N_P: Pink net).

In the case of different Clybio concentration treatments, C_{1000} shows the highest

SPAD value (58.3) while C_0 (54.0) is the lowest (Figure 11 and Appendix VII). According to the study conducted by Uddin *et al.* (2021) found that Clybio and Bordeaux mixture treatment more prominently enhanced vegetative growth (crown height, SPAD value, runner number) and yield attributes (flower number, fruit length) in strawberry over control treatment. Chowdhury *et al.* (1991) conducted a study and found the application of EM increased leaf chlorophyll and the yield of string beans significantly.

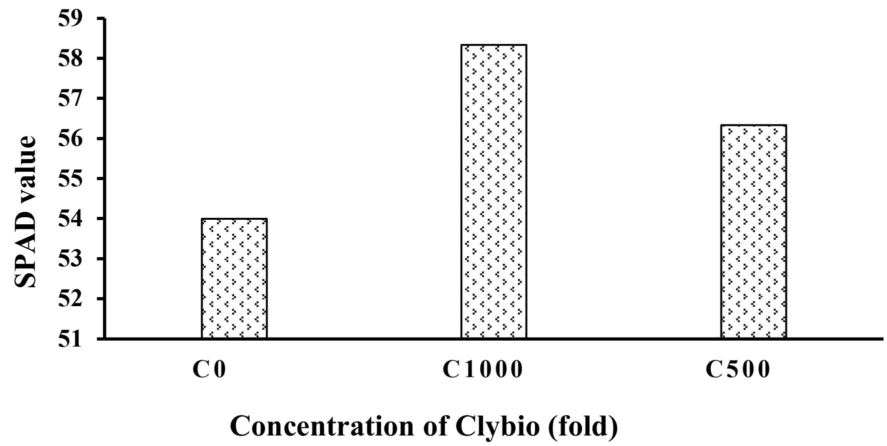

Figure 11. Effects of Clybio concentration on SPAD value of cabbage (Here, C_{0}: No Clybio application (control); C_{1000}: Clybio concentration 1000-fold; C_{500}: Clybio concentration 500-fold).

Combined effects of shade nets and Clybio concentration treatment were found significant in cabbage leaves. The highest SPAD value was found from N_0C_{1000} (58.3) which was followed by N_WC_{1000} (57.0) and the lowest result for the SPAD value (48.0) was found from the N_BC_0 (Table 5).

4.3 Yield parameters

4.3.1 Head length (cm)

Head length is a very crucial yield parameter of cabbage. In case of the use of different colored shade nets, it was noticed that the head length of cabbage was the same (16.0 cm) in both N_W and N_P which was statistically insignificant. On the other hand, N_0 (11.5 cm) showed the lowest result (Table 6 and Appendix

IX). Iljovski *et al.* (2015), studied that the height of plants, the diameter of fruits, pericarp size, and total yields were measured during the vegetation. According to the obtained results of tomato yield, there was a significantly different between the treatment with color shade nets and the control treatment. Namely the treatment with red shade net showed the highest yield, then comes the treatment with white shade net and then the treatment with green shade net, while the lowest yield was achieved in control treatment.

In the case of application of different concentrations of Clybio on cabbage plants, it was found that C_{500} showed the highest result (14.8 cm) which was followed by C_{1000} (13.8 cm). At the same time, C_0 (Control) gave the lowest value (11.5 cm) on head length (Table 7 and Appendix IX). Akter *et al.* (2021) reported that Clybio at 4 ml/L performed better in all aspects of growing parameters in spinach, such as germination percentage, plant height, number of leaves per plant, leaf diameter, chlorophyll percentage, root length, and leaf fresh weight compared to the control treatment. The result suggested that the application of Clybio at 4 ml/L increased spinach growth and yield significantly.

The effects of combined treatment of using shade net and different Clybio concentration application, it was found that N_WC_{500} gave the utmost result (21.0 cm) while the minimum one was from N_0C_0 (11.5 cm) regarding cabbage head length, (Table 8 and Appendix IX).

4.3.2 Head diameter (cm)

Head diameter is one of the important yield parameters of cabbage. In the case of using different colored shade nets, it was observed that the head diameter of cabbage was found statistically insignificant among N_W (55.7 cm), N_B (53.0 cm) and N_P (54.5 cm). On the other hand, N_0 (47.7 cm) showed the lowest result (Table 6 and Appendix IX). In the study done by Iljovski *et al.*, (2015), the diameter of fruit head, pericarp size, and total yields were measured during the vegetation of tomato yield, there was a significantly different between the treatment with color shade nets and control treatment. Namely, the treatment with a red shade net showed the highest yield, then comes the treatment with a white shade net, and then the treatment with a green shade net while the lowest yield was achieved in the control treatment.

In the case of different Clybio concentration applications, it was found that C_{500} (50.8 cm) and C_{1000} (52.2 cm) showed a statistically insignificant value. Nevertheless, C_0 (Control) gave the lowest value (47.7 cm) on head diameter (Table 7 and Appendix IX). Abdel-Gawad and Youssef (2019) reported that the response of Faba bean to foliar application of yeast extract, bio-fertilizer, and humic acid. Results showed that foliar application of Yeast extract increased growth and yield significantly.

The combined effects of using shade net and different Clybio concentration applications, it was detected that N_WC_{500} gave the utmost result (62.5 cm) on head diameter while the minimum one was from N_0C_0 (47.7 cm), (Table 8 and Appendix IX).

4.3.3 Single head weight (kg)

Head weight for each cabbage is very important to have clear information on the yield of cabbage cultivation. In the case of the use of different colored shade nets, it was noticed that the single head weight of cabbage was 1.7 kg in N_W which was followed by N_B and N_P. On the other hand, N_0 showed the lowest result (0.5 kg) per head (Table 6 and Appendix IX). Marketable and total fruit number and yield and individual fruit weight of bell pepper were reduced under unshaded treatment compared to all shade nets (Díaz-Pérez *et al*., 2020)

In case of different concentrated Clybio applications on cabbage plants, it was found that C_{500} (0.7 kg) and C_{1000} (0.8 kg) showed the insignificant result while

C_0 (Control) gave the lowest result (0.5 kg) per head, (Table 7 and Appendix IX). Fawzy *et al.* (2012) concluded that using EM gave the higher yield.

The effects of combined treatment of using shade net and different Clybio concentration application, it was found that N_WC_{1000} gave the utmost result (1.5 kg) on head weight which is followed by N_WC_{500} and N_PC_{1000}. On the other hand, the lowest was from N_0C_0 (0.5 kg) per head, (Table 8 and Appendix IX).

4.3.4 Yield per plot (kg)

Under the treatment of different colored shade nets, it was noticed that the yield per plot of cabbage was maximum in N_W (36.3 kg) which was followed by N_P and N_B whereas, N_0 showed the lowest result with the value of 16.5 kg (Table 6 and Appendix IX). Anusiya *et al.* (2019) stated that the lettuce grown in shade net situation favored plant growth attributes and gave higher production as compared to open field situation.

In the case of different concentrated Clybio applications on cabbage plants, it was found that C_{1000} showed the highest result (33.3 kg) while C_0 (Control) gave the lowest value (16.5 kg) for yield per plot of cabbage (Table 7 and Appendix IX). Uddin *et al.* (2021) found that in strawberry Clybio and Bordeaux mixture treatment more prominently enhanced vegetative growth (crown height, SPAD value, runner number) and yield attributes (flower number, fruit length); maximum fruit number, fruit weight, Brix value recorded in Clybio treatment, and Clybio led to greater improvement in fruit yield over control treatment.

With the combined effects of using shade nets and different Clybio concentrations, it was observed that N_WC_{1000} gave the utmost result for yield per plot (49.5 kg) while minimum one (16.5 kg) was from N_0C_0 (Table 8 and Appendix IX).

4.3.5 Yield per hectare (t)

The treatment of different colored shade nets revealed that the yield per hectare of cabbage was maximum in N_W (45.8 t) which was followed by N_P and N_B. On the other hand, minimum one (20.8 t) was from N_0 (Table 6 and Appendix IX). In case of netting, spinach production was found higher under colored shade nets than control condition (Meena and Vashisth, 2014), which support the result of the present study. Zoran *et al.* (2012) also found that red and pearl shade nets combined with greenhouse technologies significantly increased the total yield.

Under the application of different concentrations of Clybio on cabbage plants, it was detected that C_{1000} showed the highest result (33.3 t) while C_0 (Control) provided the lowest (20.8 t) for yield per hectare of cabbage (Table 7 and Appendix IX). According to the study conducted by Uddin *et al.* (2021), Clybio and Bordeaux mixture treatment more prominently enhanced vegetative growth (crown height, SPAD value, runner number) and yield attributes (flower number, fruit length) in strawberry; maximum fruit number, fruit weight, Brix value recorded in Clybio treatment, and Clybio led to greater improvement in fruit yield over control treatment. Karawi *et al*. (2018), found that spraying yeast with boron on strawberry plants showed a significant increase in the traits of vegetative growth and yield.

In case of the combined effects of the usage of different colored shade nets and different Clybio concentrations, it was found that N_WC_{1000} treatment gave the maximum result for yield per plot (62.5 t) while minimum (20.8 t) was from the N_0C_0 treatment (Table 8 and Appendix IX)

Table 6. Effects of colored shade net on head length (cm), head diameter (cm), single head weight (kg), yield per plot (kg) and yield per hectare (t) of cabbage**

Treatment*	Head length (cm)	Head diameter (cm)	Single head weight (kg)	Yield/Plot (kg)	Yield/ha (t)
N_0	11.5 c	47.7 d	0.5 d	16.5 d	20.8 d
N_W	16.0 a	55.7 a	1.1 a	36.3 a	45.8 a
N_B	14.5 b	53.0 bc	0.7 c	23.1c	29.2 c
N_P	16.0 a	54.5 ab	0.9 b	29.7b	37.5 b
CV%	3.5	2.22	6.7	6.7	6.7
LSD (0.05)	1.0	2.1	0.1	1.1	4.2

*Here, N_0: No net; N_w: White net; N_B: Blue net; and N_P: Pink net
** In a column, means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

Table 7. Effects of Clybio concentration on head length (cm), head diameter (cm), single head weight (kg), yield per plot (kg) and yield per hectare (t) of cabbage **

Treatment*	Head length (cm)	Head diameter (cm)	Single head weight (kg)	Yield/Plot (kg)	Yield/ha (t)
C_0	11.5 c	47.6 c	0.5 c	16.5 c	20.8 c
C_{1000}	13.8 b	52.1 ab	0.8 a	26.4 a	33.3 a
C_{500}	14.8 a	50.8 b	0.7 b	23.1 b	29.2 b
CV%	3.5	2.2	6.7	6.7	6.7
LSD (0.05)	1.0	2.1	0.1	1.1	4.2

*Here, C_0: No Clybio application; C_{1000}: Clybio concentration 1000-fold; and C_{500}: Clybio concentration 500-fold
** In a column, means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

Table 8. Combined effects of different colored shade net and Clybio concentration on head length (cm), head diameter (cm), single head weight (kg), yield per plot (kg), and yield per hectare (t) of cabbage **

Treatment*	Head length (cm)	Head diameter (cm)	Single head weight (kg)	Yield/ Plot (kg)	Yield/ha (t)	80% Head initiation (Days)
N_0C_0	11.5 j	47.7 g	0.5 g	16.5 g	20.8 g	30.0 l
N_0C_{1000}	13.8 i	52.2 ef	0.8 de	26.4 de	33.3 de	31.6 k
N_0C_{500}	14.8 gh	50.8 f	0.7 f	23.1 f	29.2 f	33.0 j
N_WC_0	16.0 ef	55.7 c	1.1 c	36.3 c	45.8 c	33.6 ij
N_WC_{1000}	18.5 b	59.2 b	1.5 a	49.5 a	62.5 a	35.0 h
N_WC_{500}	21.0 a	62.5 a	1.3 b	42.9 b	54.2 b	36.0 fg
N_BC_0	14.5 hi	53.0 de	0.7 f	23.1 f	29.2 f	36.6 ef
N_BC_{1000}	15.6 fg	56.2 c	1.1 c	36.3 c	45.8 c	38.6 c
N_BC_{500}	16.7 de	59.0 b	0.9 d	29.7 d	37.5 d	41.0 a
N_PC_0	16.0 ef	54.5 cd	0.9 d	29.7 d	37.5 d	35.0 f
N_PC_{1000}	17.3 cd	56.3 c	1.3 b	42.9 b	54.2 b	37.0 de
N_PC_{500}	18.2 bc	60.2 b	1.1 c	36.3 c	45.8 c	39.0 bc
CV%	3.5	2.2	6.7	6.7	6.7	3.0
LSD (0.05)	1.0	2.1	0.1	1.1	4.2	1.8

*Here, N_0: No net; N_w: White net; N_B: Blue net; N_P: Pink net; C_0: No Clybio application; C_{1000}: Clybio concentration 1000-fold; and C_{500}: Clybio concentration 500-fold

** In a column, means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability.

SUMMARY AND CONCLUSION

5.1 Summary

Cabbage (*Brassica oleracea* var. *capitata* L.) is a widely found vegetable which belongs to the family Brassicaceae and is famous for its nutritional values, medicinal effects, and other therapeutic properties. The growth and yield of cabbage are significantly influenced by the excessive use of chemical fertilizers which ultimately increase the production cost as well as the impact on the environment. Several authors reported in different research nationally and globally that the use of different colored shade nets and effective microorganisms has demonstrated significant responses to crop growth and production rate. It also impacted its yield and its nutritional quality to meager in local climatic conditions.

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from October 2019 to January 2020 to identify the effect of using Clybio and different color shade nets on the growth and yield of cabbage as well as examine the combined effects of using Clybio concentration and color shade nets on cabbage production. Two factorial experiment includes colored shade nets *viz.* without a net (N_0), White net (N_W), Pink net (N_P), and blue net (N_B) as well as Clybio concentration which comprises no Clybio application (C_0), Clybio concentration at 1000-Fold (C_{1000}), and Clybio concentration at 500-Fold (C_{500}). The experiment was set up in Split Plot Design with three replications.

Collected data were statistically analyzed for the assessment of treatments to identify the best treatments among different colored shade nets and different Clybio concentrations for safe cabbage production. The findings and conclusion have been described in this section.

Among the treatments of different colored shade nets and different Clybio concentrations, significant variations were observed in all parameters which are as follows:

The tallest plant was found from N_W (26.2 cm) and C_{1000} (24.7 cm) whereas the shortest (21.5 cm) was from N_0 and C_0 at 60 days after transplanting. In case of treatment combination, maximum plant height was obtained from N_WC_{1000} (29.0 cm) and minimum was obtained from N_0C_0 (21.5 cm) at 60 days after transplanting.

Maximum number of leaves was found from N_w (59.0) and C_{1000} (54.7) while minimum number of leaves (49.0) was from N_0 and C_0 at 90 days after transplanting. In case of treatment combination, maximum number of leaves (66.0) was found from N_WC_{1000}, and minimum number (49.0) was from N_0C_0 at 90 days after transplanting.

Maximum leaf length was found from N_W (19.8 cm) and the lowest leaf length was from N_0 (17.5 cm). In case of Clybio application, maximum leaf length was found from N_W (19.8 cm) and the lowest leaf length was from N_0 (17.5 cm). Combined effect of colored shade net and Clybio concentration showed that in N_WC_{1000} the leaf length was maximum (24.5 cm) while the lowest result was from N_0C_0 (17.5 cm).

In case of sole usage of colored shade nets, N_W gave maximum leaf breadth (20.3 cm) while N_0 showed the lowest (14.5 cm). For different concentration of Clybio in cabbage, it was observed that maximum leaf breadth (16.5 cm) was from C_{1000}, and minimum leaf breadth (14.5 cm) was found from C_0. The combined effects of colored shade nets and use of Clybio concentration, it was noticed that in N_WC_{1000} the leaf breadth was maximum (25.3 cm) while the lowest result was from N_0C_0 (14.5 cm).

In colored shade netting, maximum stem length (19.0 cm) was found from N_W and the lowest stem length (15.5 cm) was from N_0 while for Clybio concentration, maximum stem length (22.3 cm) was from C_{1000} and minimum (15.5 cm) from C_0.

From the treatment combinations in N_WC_{1000} the stem length was maximum (25.8 cm) while the lowest result was from N_0C_0 (15.5 cm).

Under colored shade net treatment, N_W gave maximum root length (10.4 cm) while N_0 showed the lowest (7.0 cm). In case of Clybio concentration, maximum root length (9.5 cm) was from C_{500}, and minimum root length (7.0 cm) was found from C_0. Among the treatment combinations, in N_WC_{500} the root length was maximum (14 cm) while the lowest was from N_0C_0 (7.0 cm).

The use of colored shade nets over the cabbage plants showed that it took the least time (30.0 days) to initiate 80% of cabbage heads when there was no shade net whereas under a blue net it took the highest (36.7) for head initiation. The least days (30.0) were required to initiate 80% of the cabbage head under the C_0 (control) treatment while C_{500} showed the slowest initiation of the head (33.0 days). In case of treatment combinations, maximum days to 80% head initiation (41.0) was found from N_BC_{500} and minimum days to head initiation (30.0) was from N_0C_0.

The SPAD values in N_W (54.3) and N_0 (54.0) are statistically insignificant but highest in value. Whereas the N_B (48.0) showed the lowest SPAD value. In the case of different Clybio concentration treatments, C_{1000} shows the highest SPAD value (58.3) while C_0 (54.0) is the lowest. The highest SPAD value (58.3) was found from N_0C_{1000} and the lowest result for the SPAD value (48.0) was found from the N_BC_0.

In case of the use of different colored shade nets, it was noticed that the head length of cabbage was the same (16.0 cm) in both N_W and N_P which was statistically insignificant. On the other hand, N_0 (11.5 cm) showed the lowest result. From the application of Clybio concentration, maximum head length was observed from C_{500} (14.8 cm) and minimum was from C_0 (11.5 cm). From the combination of treatments N_WC_{500} gave the utmost result (21.0 cm) while minimum one was from N_0C_0 (11.5 cm).

Head diameter of cabbage was found statistically insignificant among N_W (55.7 cm), N_B (53.0 cm) and N_P (54.5 cm) On the other hand, N_0 showed the lowest result (47.7 cm). In the case of different Clybio concentration applications, C_{500} (50.8 cm) and C_{1000} (52.1 cm) showed a statistically insignificant value C_0 gave the lowest value (47.7 cm) on head diameter. In case of combined treatments, N_WC_{500} gave the utmost result (62.5 cm) on head diameter while minimum one was from N_0C_0 (47.7 cm).

In the case of the use of different colored shade nets, it was noticed that the head weight of cabbage was 1.7 kg per head in N_W and N_0 showed the lowest result 0.5 kg per head. In Clybio concentration, C_{1000} (0.8 kg) showed the height single head weight while C_0 gave the lowest result (0.5 kg). From the treatment combinations, N_WC_{1000} gave the utmost result (1.5 kg) on single head weight and the lowest was from N_0C_0 (0.5 kg).

Under the treatment of different colored shade nets, yield per plot of cabbage was maximum in N_W (36.3 kg) and was minimum in N_0 (16.5 kg). In the case of Clybio applications at different concentration, C_{1000} showed the highest result (26.4 kg) while C_0 gave the lowest value (16.5 kg) for yield per plot of cabbage. With the combined effects of using shade nets and different Clybio concentrations, N_WC_{1000} gave the utmost result for yield per plot (49.5 kg) while the minimum one (16.5 kg) was from N_0C_0.

The treatment of different colored shade nets revealed that the yield per hectare of cabbage was maximum in N_W (45.8 t) and minimum was in N_0 (20.8 t). Under the application of different concentrations of Clybio on cabbage plants, C_{1000} showed the highest result (33.3 t) while C_0 provided the lowest value (20.8 t) for yield per hectare of cabbage. Among the treatment combinations, N_WC_{1000} treatment gave maximum result for yield per plot (62.5 t) while minimum value (20.8 t) was from N_0C_0 treatment.

5.2 Conclusion

In respect to the above analysis, it can be concluded that colored shade nets and Clybio concentrations showed a significant impact on growth and yield of cabbage. According to the result, N_W (white colored shade net) provided with maximum plant height, number of leaves, leaf length, leaf breadth, stem length, root length, SPAD value, head diameter and yield per hectare. On the other hand, when Clybio was applied to the cabbage at a concentration of 1000 fold, was excellent among the Clybio concentration treatments applied in terms of all parameters. In case of treatment combination, when white colored shade net was used along with the application of 1000 fold solution of Clybio (C_{1000}), performed as the best combination. To sum up, it can be articulated that white colored shade net (N_W) was the best colored shade net as well as application of Clybio at 1000-fold (C_{1000}) was outstanding among all the treatments of Clybio concentration and combination treatment N_WC_{1000} was the best for growth and yield attributes of cabbage.

5.3 Recommendation

Based on the findings of the research, these recommendations can be made:

1. White colored shade net (N_W) could be recommended for production in farmers' field.
2. Clybio could be recommended as an effective bio stimulator for production farmers' field.

5.4 Suggestion

Similar type of study needs further trial in different contexts and locations in Bangladesh to justify the outcome.

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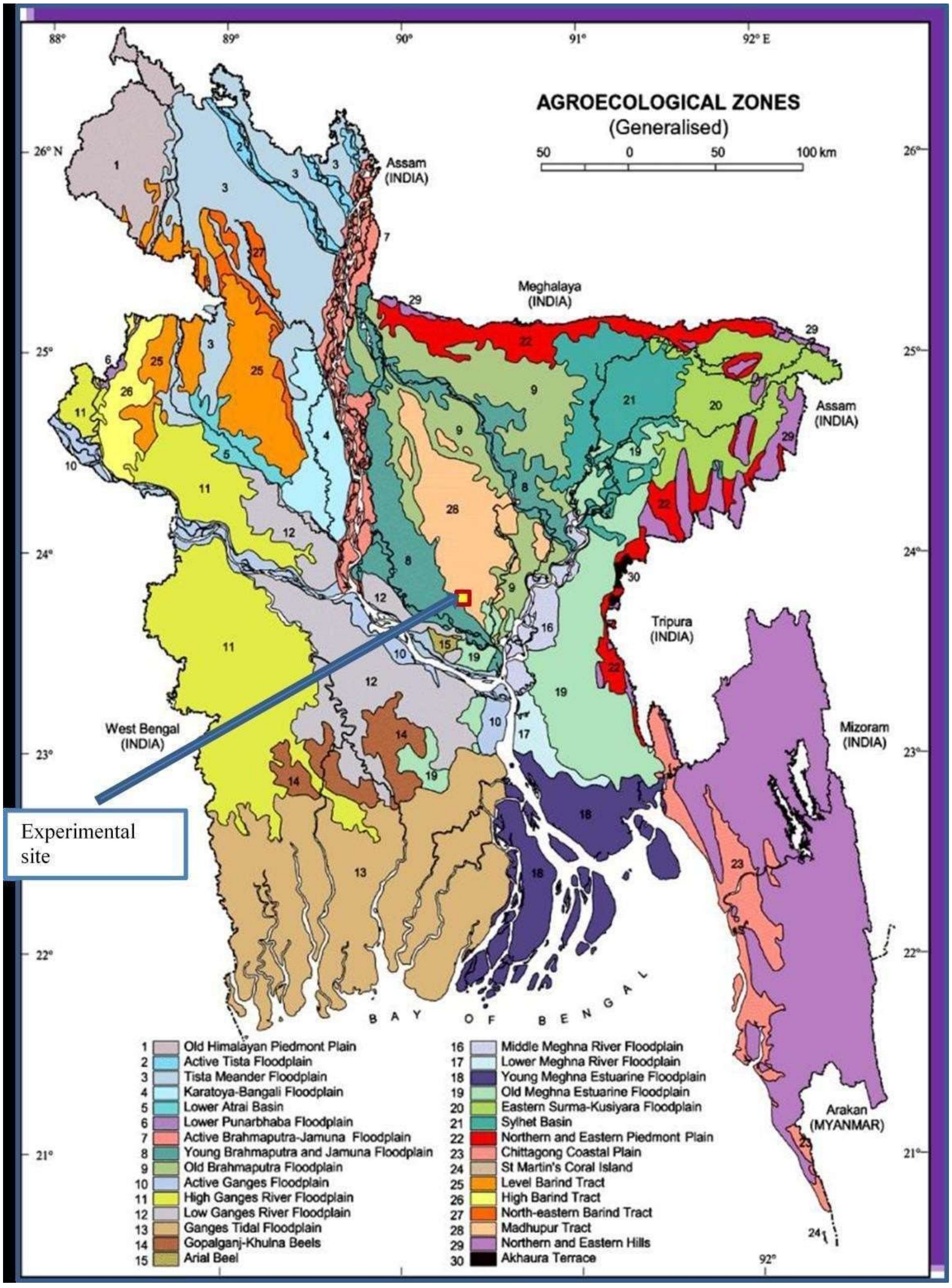
APPENDICES

Appendix I. Map showing the experimental site



Appendix II: Characteristics of the soil of Sher-e-Bangla Agricultural University soil were analyzed by Soil Resources Development Institute (SRDI), Khamar Bari, Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University
AEZ	Madhupur Tract (28)
General soil type	Shallow Red Brown Terrace Soil
Land Type	High land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Fellow-Tomato

B. Physical and chemical properties of initial soil

Characteristics value	Partial Size Analysis
% Sand	27
% Silt	43
% Clay	30
Textural Class	
p^H	6.0 – 6.6
Organic carbon (%)	0.46
Organic matter (%)	0.83
Total N (%)	0.05
Available P (ppm)	20.00
Exchangeable K (me/100 gm soil)	0.12
Available S (ppm)	46

Appendix III: Monthly record of air temperature, relative humidity, and total rainfall of the experimental site during the period from August 2019 to January 2020.

Month	Air temperature (ºC)		RH (%)	Rainfall (mm)
	Maximum	Minimum		
August	29.5	19.2	73.4	316.5
September	29.0	18.8	72.3	300.4
October	28.4	15.6	72.0	172.3
November	27.0	14.9	71.2	34.4
December	25.8	14.2	68.3	12.8
January	25.0	13.5	69.5	7.7

Source: Bangladesh Meteorological Department (Climate division), Agargaon,Dhaka-1207.

Appendix IV: Analysis of variance on plant height at different days after transplanting of cabbage.

Source of variation	Degrees of freedom	Mean Square for plant height (cm)			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	0.778	0.063	0.333	0.424
Treatment	11	8.747*	12.599*	13.7746*	12.907*
Error	22	0.149	0.229	0.114	0.128
***Significant at 0.05 level of probability**					

Appendix V: Analysis of variance on the number of leaves at different days after transplanting of cabbage.

Source of variation	Degrees of freedom	Mean Square of number of leaves			
		30DAT	50DAT	70DAT	90DAT
Replication	2	0.194	0.750	4.750	5.861
Treatment	11	38.051*	101.098*	124.515*	85.725*
Error	22	0.801	1.235	0.720	1.164
*Significant at 0.05 level of probability					

Appendix VI: Analysis of variance on leaf length (cm), leaf breadth (cm), shoot length (cm) and root length (cm) of cabbage.

Source of variation	Degrees of freedom	Mean Square			
		Leaf length (cm)	Leaf breadth (cm)	Shoot length (cm)	Root length (cm)
Replication	2	0.0833	0.3958	0.4844	1.0803
Treatment	11	12.6231*	29.8201*	25.2844*	14.1708*
Error	22	0.3258	0.2443	0.4799	0.3136
*Significant at 0.05 level of probability					

Appendix VII: Analysis of variance on days to 80% head initiation of cabbage.

Source of variation	Degrees of freedom	Mean Square of number of days
		Days to 80% head initiation
Replication	2	1.194
Treatment	11	30.384
Error	22	1.104
*Significant at 0.05 level of probability		

Appendix VIII: Analysis of variance on SPAD value on cabbage.

Source of variation	**Degrees of freedom**	**Mean Square of SPAD value**
Replication	2	3.083
Treatment	11	30.727
Error	22	0.2652
***Significant at 0.05 level of probability**		

Appendix IX: Analysis of variance on head length (cm), head diameter (cm), single head weight (kg), yield per plot (kg) and yield per hectare (t) of cabbage.

Source of variation	**Degrees of freedom**	**Mean Square**				
		Head length (cm)	**Head diameter (cm)**	**Single head weight (kg)**	**Yield/plot (kg)**	**Yield (t/ha)**
Replication	2	0.771	0.424	0.047	4.690	67.326
Treatment	11	18.136	54.280	0.257	25.654	368.031
Error	22	0.316	1.545	0.004	0.436	6.242
***Significant at 0.05 level of probability**						