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Vimal Kumar
Agro Climate Research Centre Tamil Nadu Agricultural University, Coimbatore – 641 003, India

S Panneerselvam
Agro Climate Research Centre Tamil Nadu Agricultural University, Coimbatore – 641 003, India

Jeetendra Kumar Soni
Department of Agronomy Tamil Nadu Agricultural University, Coimbatore – 641 003, India

A Lakshmanan
Department of Microbiology, Tamil Nadu Agricultural University, Coimbatore – 641 003, India

P Arun Kumar
Agro Climate Research Centre Tamil Nadu Agricultural University, Coimbatore – 641 003, India

Correspondence
Vimal Kumar
Agro Climate Research Centre Tamil Nadu Agricultural University, Coimbatore – 641 003, India

Response of blue green algae on rice (*Oryza sativa*) crop production at elevated temperature

Vimal Kumar, S Panneerselvam, Jeetendra Kumar Soni, A Lakshmanan and P Arun Kumar

Abstract
An investigation to "Assess the crop productivity of rice crop under current and elevated temperature with application of Blue Green Algae" was carried out at Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore, during Rabi season (November 2014 – March 2015). This experimentation was carried out with two temperature levels *viz.*, current temperature at open environment and +2ºC elevated temperature at temperature controlled chamber. During the experimentation, crop productivity, and yield potentials of rice crop were evaluated. The impact of photosynthetic diazotroph, Blue Green Algae on enhancing the crop yield under different temperature level of rice soil ecosystem was evaluated. The study revealed that crop raised under ambient temperature showed superior performance on growth parameters and yield. Blue green algal inoculation also promoted crop growth and yield under both environmental conditions. With enhancement in temperature, the photosynthetic rate of plants reduced gradually. The photosynthetic rate of plant increased due to the application of Blue Green Algae at both temperature levels and algal inoculation favored the photosynthetic rate at all the stages of crop growth.

Keywords: Blue Green Algae, Current temperature, Elevated temperature, Crop yield

Introduction
Rice crop (*Oryza sativa* L.) is the most common staple food for large number of populations living on the earth than any other crops (Sheila Bhalla, 2014) [4]. Rice crop grows between 55^0N and 36^0S latitudes under diverse climate and weather conditions in different ecosystems. India has the largest area among the rice growing countries and ranks second in production. To meet the demands of increasing population and maintain self-capability, present production level in India needs to be increased to 120 million tonnes by 2020 (Veeramani, 2010) [5]. Prakash, 2014 [3] suggested that a robust and significant non-linear relationship between maximum daily temperature and rice yields. Optimum temperature for batter rice production is 30 °C during day time and 20°C during night time. Increases in maximum temperature during the ripening phase contribute to an increase in rice yield up to a critical threshold of 32 °C. When maximum temperature goes beyond this threshold, rice yield declines sharply.
The global average surface temperature has been going to increase over the time, with several observations indicating that it has increased by 0.74 °C for the last century. Worldwide, the warmest decade on record was 2001-2010 bases on thermometer-based observations. The global surface temperature during 2012 was (+) 0.56 °C warmer than the 1951-1980 base period average, despite much of the year being affected by a strong La Nina. The rice crop growth and production are dependent on the availability of sufficient nutrients and climatic conditions. Several studies have indicated that high air temperature can reduce grain yield. As a general rule, yield will decrease by 0.6 tonnes per hectare for every 1 °C increase in temperature reported by Desiraju *et al*. 2008 [1]. The photosynthetic systems such as Blue Green Algae and *Azolla* are capable of increasing the rice production due to increasing the nutrients availability to plants according to Geetha Lakshmi *et al*., 2011 [2]. In view of the above, an investigation was undertaken to assess the effect of elevated temperature with and without application of blue green algae on rice (*Oryza sativa*) crop production.

Materials and Methods
The present investigation was carried out to know the response of blue green algae on rice production at elevated temperature. The experiment was conducted at Agro Climate Research Centre, TNAU, Coimbatore, during R*abi* season (November 2014 – March 2015) with rice

variety CO-51 in randomized block design. The experiment had four treatments and five replications. Experiment was conducted under four environmental condition likewise (T_1) growing of rice under elevated temperature at +2^{0}C with the application of blue green algae (BGA), (T_2) growing of rice under elevated temperature at +2 ^{0}C without BGA, (T_3) growing of rice under current temperature with BGA, (T_4) growing of rice under current temperature without BGA. Plants were grown in standard tubs size (1.5 X 1.0 m) under open environment as well as under Temperature Control Chamber (TCC). Inside of Temperature Control Chamber, the temperature was set at +2 ^{0}C more than open condition.

The experiment location, having the climate of Semi-Arid Tropics with mean maximum temperature 35 ^{o}C and mean minimum temperature 22.7 ^{o}C and inside of Temperature Control Chamber the temperature was set at +2 ^{0}C. The relative humidity ranged from 80-90 per cent under open environment and inside of Temperature Control Chamber, it was 75-85 percent. Biometric observations as per the guidelines of All India Coordinated Rice Improvement Project were recorded at 15 DAT, 30 DAT, 45 DAT, 60 DAT and at harvest stage. The randomize selected five plants mean value was observed for plant height measurement in centimetre, number of tillers per plant at15 DAT, 30 DAT, 45 DAT, 60 DAT and harvest stage. The number of filled grain per panicle was recorded by randomize selected five plants panicle and mean value at harvesting stage. The weight of 1000 grain was recorded for the calculation of grain yield per hectare.

Table 1: Effect of temperature and blue green algae on plant height (cm), number of tiller/plant at different growth stages and grain yield of rice crop

Treatment	Plant Height (cm)					No of tillers/plant					Grain yield (kg ha^{-1})
	15 DAT	30 DAT	45 DAT	60 DAT	At harvest	15 DAT	30 DAT	45 DAT	60 DAT	At harvest	
T_1- Rice crop under elevated temperature at +2^{0}C with BGA	39.8	55.5	83.1	90.2	91.7	3.1	6.2	13.2	16.2	19.1	6053
T_2- Rice crop under elevated temperature at +2^{0}C without BGA	35.4	50.5	74.6	87.5	88.8	2.7	5.6	10.4	15.3	18.3	5440
T_3- Rice crop under current temperature with BGA	33.2	48.2	72.1	85.7	86.9	4.8	11.3	18.6	21.2	24.6	7448
T_4- Rice crop under current temperature without BGA	27.7	44.3	65.0	83.9	85.1	3.7	8.6	16.9	19.3	21.4	6733
CD (P=0.05)	1.7	1.3	8.8	1.2	2.4	0.2	0.3	0.9	1.1	1.5	339

DAT: days after transplanting

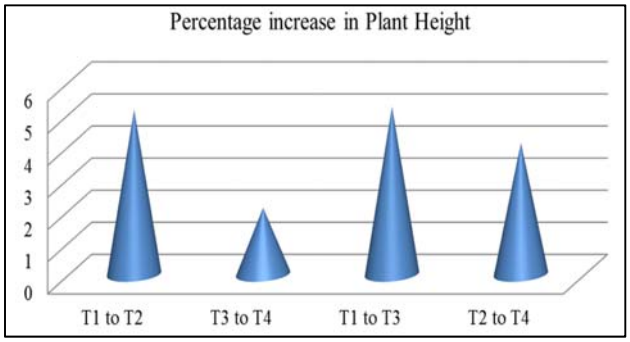

Fig 1: Effect of temperature and blue green algae on plant height of rice crop (See table 1 for treatment details)

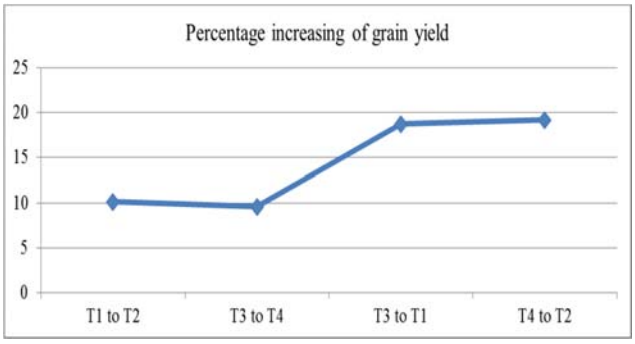

Fig 3: Effect of temperature and blue green algae on grain yield of rice crop (See table 1 for treatment details)

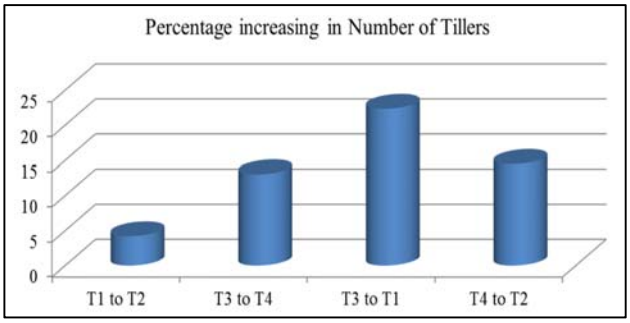

Fig 2: Effect of temperature and blue green algae on number of tillers/plant in rice crop (See table 1 for treatment details)

Plate 1: Difference in plant height at both temperatures.

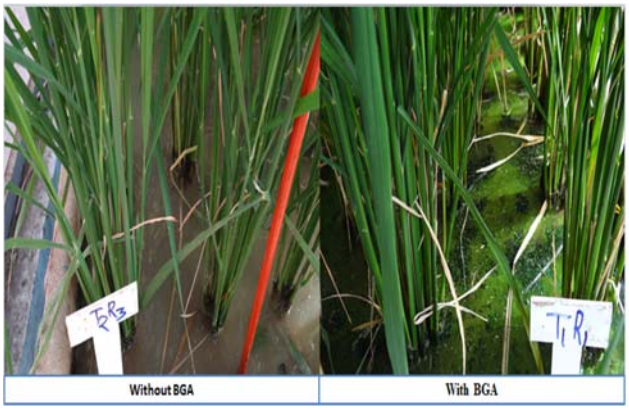

Plate 2: Difference in number of tillers at inside of temperature control chamber at with and without application of Blue Green Algae.

Results and Discussion

The mean values of biometric parameters recorded under open environmental conditions as well as controlled conditions in Temperature Controlled Chamber (TCC) at different stages of rice crop are presented in Table 1. The plant height gradually increased with age of the crop and maximum height was recorded at maturity stage. The plants grown under +2 ^{0}C elevated temperature with and without application of Blue Green Algae recorded higher in all stage of crop growth compared to plants grown in current temperature level with and without application of Blue Green Algae (Table1 and Figure 1). The height of the rice plants grown under +2 ^{0}C elevated temperature with application of Blue Green Algae (T_1) was recorded 5.13 percent higher at harvesting stage compared to plants grown under +2 ^{0}C elevated temperature without application of Blue Green Algae at harvest stage (T_2). The rice crop grown under current temperature with application of Blue Green Algae (T_3) recorded 2.07 percent more height than rice crop grown under current temperature without application of Blue Green Algae (T_4). The plant grown under current temperature with application of Blue Green Algae recorded 5.23 percent lower height (T_3) compared to plant grown under +2 ^{0}C elevated temperature with application Blue Green Algae (T_1). The plant grown under current temperature without application of Blue Green Algae (T_4) recorded 4.12 percent lower height compared to plant grown under +2 ^{0}C elevated temperature without application Blue Green Algae (T_2) Figure1.

The number of tillers per plant was more when crop grown under current temperature (T_3 and T_4) as compared to +2^{0}C elevated temperature (T_1 and T_2). The number of tillers per plant was 13 percent higher in rice crop grown under an open condition with application of Blue Green Algae (T_3) then crop grown under open condition without application of Blue Green Algae (T_4). The number of tillers per plant was 4.2 percent higher in rice crop grown under +2 ^{0}C elevated temperature with application of Blue Green Algae (T_1) then crop grown under +2 ^{0}C elevated temperature without application of Blue Green Algae (T_2). The number of tillers per plant was 23 percent higher in rice crop grown under an open environmental condition with application of Blue Green Algae (T_3) then crop grown under +2 ^{0}C elevated temperature with application of Blue Green Algae (T_1), so the algal effect was more at current temperature. The number of tillers per plant was 14.48 percent higher in rice crop grown under open condition without application of Blue Green Algae (T_4) then crop grown under +2 ^{0}C elevated temperature without application of Blue Green Algae (T_2). The number of tillers per plant was more at open condition then control condition and it was increased by the application of Blue Green Algae at both control condition and +2 ^{0}C elevated temperature. The sequence of a number of tillers per plants was recorded according to data was (T_4>T_3>T_1>T_2). The application of Blue Green Algae response positive at both current temperature and +2 ^{0}C elevated temperature level but more response at current temperature level (Figure 2).

The interaction between temperature levels and Blue Green Algae indicated that open environment with application of Blue Green Algae recorded higher grains yield than elevated temperature with and without application Blue Green Algae. The yield of rice was 10 percent more at +2 ^{0}C elevated temperature with application of Blue Green Algae (T_1) than rice grain yield at +2 ^{0}C elevated temperature without application of Blue Green Algae (T_2). The rice grain yield was 9.59 percent more at open environmental condition with application of Blue Green Algae (T_3) than rice grain yield at open environmental condition without application of Blue Green Algae (T_4). The rice grain yield was 18.72 percent more at open environmental condition with application of Blue Green Algae (T_3) than rice grain yield at +2 ^{0}C elevated temperature with application of Blue Green Algae (T_1). The production of rice was 19.20 percent more at open environmental condition without application of Blue Green Algae (T_4) compared to +2 ^{0}C elevated temperature without application of Blue Green Algae (T_2). The application of Blue Green Algae increase crop grain yield due to increasing of nitrogen availability to crop at both open environmental condition and +2 ^{0}C elevated temperature, Figure 3.

In this study, the crop growth and production was found to be high in current temperature with application of Blue Green Algae followed by current temperature without application of Blue Green Algae, elevated temperature with Blue Green Algae and elevated temperature without Blue Green Algae (T_3>T_4>T_1>T_2).

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