*Int.J.Curr.Microbiol.App.Sci* (2019) *8*(8): 2102-2110

*International Journal of Current Microbiology and Applied Sciences*
***ISSN: 2319-7706* Volume 8 Number 08 (2019)**
Journal homepage: http://www.ijcmas.com

**Original Research Article** https://doi.org/10.20546/ijcmas.2019.808.246

# Effect of Photosynthetic Bacteria and Bio-Char on the Growth, Development and Quality of Chinese Cabbage (*Brassica rapa* ssp. *pekinensis*) c.v. All Season No. 2

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**Keywords**

Chinese cabbage, Napa cabbage, Bio-char, Photosynthetic bacteria, Organic farming, Vermicompost, Growth parameters and Yield parameters

**Article Info**

***Accepted:***
15 July 2019
***Available Online:***
10 August 2019

**A B S T R A C T**

A field experiment was conducted during Rabi season of 2018 in Departmental Research Field of Department of Horticulture, SHUATS, Prayagraj on heading type of Chinese cabbage *(Brassica rapa ssp. Pekinensis)/ napa cabbage.* The experiment was conducted in Randomized Block Design (RBD) with ten treatments replicated thrice. The experiment consisted of Bio-char (10t/ha, 20t/ha and 30t/ha) made from rice husk and Photosynthetic bacteria, *Rhodopseudomonas paulistris* (66L/ha, 132L/ha and 198L/ha). The variety, All Season No. 2 was used for sowing. The seeds were sown at a row to row distance of 60 cm and plant to plant distance of 45 cm. In this investigation the result revealed that T5 (PSB 132L + Biochar 30t) was found to the best in respect of plant height (33.59 cm) at 60 DAT, days to head initiation (28.07 days), head net weight (2.25 kg), head size (519.63 $cm^3$), compactness (18.51), TSS content (5.27 °Brix), moisture content (96.07%) and Vitamin C content (50.30 mg/100g).

## Introduction

Biochar as defined by Lehmann and Joseph, 2009 is a carbon-rich product obtained when biomass, such as wood, manure or leaves is heated at relatively low temperature (<700°C) in a closed container with little or no available air. Use of biochar has shown to improve crop yield and soil nutrient stock (Grunwald *et al.*, 2017). Biochar also helps improve water holding capacity of the soil, nutrient retention due to increase in cation exchange capacity and provides a good habitat for soil microbes to develop and flourish (Bian *et al.*, 2016).

Photosynthetic bacteria in the recent years are being used in various agricultural applications including purification of water, bio-fertilizers, animal feed and bioremediation of chemicals among many others. They are classified into

three classes, viz., Purple sulfur bacteria, family: *Chromatiaceae*, Purple non-sulfur bacteria, family: *Rhodospirillaceae* and Green Sulfur bacteria, family: *Chlorobiaceae). Rhodopseudomonas palustris* is a phototrophic purple non-sulfur bacteria (PNSB) which belongs to the class α-proteobacteria. This bacterium is widely distributed in various aquatic ecosystems as well as in sediments, moist soils, natural wetlands, and paddy fields. They can improve soil fertility, nitrogen use efficiency, enhance plant nutrition availability, and support the health of plants (Wong *et al.*, 2014).

## Materials and Methods

The experiment was carried out during November 2018 to January 2019 at experimental field of the Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The experiment was laid out in randomized block design comprising of 10 treatments: $T_0$ (Control), $T_1$ (PSB 66L/ha + Bio-char 10t/ha), $T_2$ (PSB 132L/ha + Bio-char 20t/ha), $T_3$ (PSB 198L/ha + Bio-char 30t/ha), $T_4$ (PSB 66L/ha + Bio-char 20t/ha), $T_5$ (PSB 123L/ha + Bio-char 30t/ha), $T_6$ (PSB 198L/ha + Bio-char 10t/ha), $T_7$ (PSB 66L/ha + Bio-char 30t/ha), $T_8$ (PSB 132L/ha + Bio-char 10t/ha) and $T_9$ (PSB 198L/ha + Bio-char 20t/ha) with 3 replications. Treatments were randomly arranged in each replication, divided into 10 plots. For plant protection yellow sticky traps were used and neem cake was broadcasted around the plants @80kg per hectare. Chinese cabbage All Season No. 2, which is resistant to bolting and cold was procured from Hei Long Jiang All Lucky seed Co., Ltd and used.

The purple non-sulfur photosynthetic bacteria were procured from Japan and mass produced in the Department of Horticulture, SHUATS by mixing 60 ml of PSB with 40ml of well beaten chicken egg in 900ml of water. PSB was diluted in 88,440 L of water and applied to the root zone of the plant weekly after transplanting. Bio-char was made from rice husk by the process of pyrolysis and incorporated to the soil before transplanting. Six seedlings of 31 days old were transplanted to all the sub-plots of 1.5 $m^2$ at a spacing of 45cm x 60cm.

Growth parameters (plant height, no. of leaves and plant spread) were recorded at 15, 30, 45 and 60 DAT.

Days to head initiation was recorded at the first visible formation of head. Days were counted from the date of transplanting.

Readings for yield parameters (average head weight, yield per plot and yield per hectare) were recorded right upon harvesting for accurate analysis of different treatment combinations.

Head size was calculated by multiplying the Lateral diameter of the head with the Polar diameter of the head.

Head size = X x Y.

Where,
X= Equatorial diameter
Y= Polar diameter

Head compactness was measured using the formula given by Pearson in 1931.

$$\text{Head compactness} = \frac{C}{W^3} \times 100$$

Where,

C = Net weight of head (g)
W = Average of equatorial and polar diameter of head (cm)

Head compactness index was calculated by dividing the Polar diameter by the equatorial diameter (Pearson, 1931).

Total soluble solids (TSS $^0$Brix) was taken with the help of a Hand Refractometer and express in degree brix.

Moisture percentage of napa cabbage was estimated by taking 100 gm sample of the cabbage leaves collected from each treatment by recording fresh weight and oven dry weight at 80 $^0$C for 48 hours at harvest. It was calculated by following formula.

$$\text{Moisture \%} = \frac{\text{Fresh weight - Dry weight}}{\text{Dry weight}} \times 100$$

Ascorbic acid (mg/ 100g) content of head of selected plant samples was measured using AOAC (1968) method.

Ascorbic acid reduces oxidation-reduction indicator dye, 2, 6-dichloroindophenol, to colourless solution.

At end point, excess unreduced dye is rose pink in acid solution. The formula used for determination is given below:

(X-B) x (F/E) x (V/Y) = Vitamin C mg/100 ml of juice.

Where,

X= average ml for test solution titration.

B= average ml for test blank titration.

F= mg ascorbic acid equivalent to 1.0ml indophenol standard solution.

E = number of g, tablets, ml, etc.

V= volume initial test solution.

## Results and Discussion

### Growth parameters

The treatment $T_5$ (PSB132L + Biochar 30t) was found to have maximum growth parameters in all successive growth stages (15, 30, 45, and 60 DAT) with plant height (17.04, 26.33, 32.96 and 33.59 cm), number of leaves (8.33, 9.89, 11.09 and12.03), plant spread (36.71, 53.98, 57.74 and 60.91 cm. The earliest head initiaion in days was observed in $T_5$ (PSB 132L + Biochar 30t) (28.07 days) followed by $T_8$ (PSB 132L + Biochar 10t) (28.89 days) and $T_9$ (PSB 198L + Biochar 20t) (30.55 days).

Performance in treatments with biochar compared to control. Similar findings were recorded by Carter *et al.,* (2013) in lettuce and Chinese cabbage (*Brassica chinensis*), Upadhyay *et al.,* (2014) in lettuce, Trupiano *et al.,* (2017) in lettuce and Lee *et al.,* (2008) in tomato

### Yield parameters

The maximum head weight was observed in in $T_5$ (PSB 132L + Biochar 30t) (2.25 kg) followed by $T_8$ (PSB 132L + Biochar 10t) (1.95 kg) and $T_3$ (PSB 198L + Biochar 30t) (1.89 kg). The maximum head weight per plot was observed in in $T_5$ (PSB 132L + Biochar 30t) (13.5 kg). The maximum head weight per hectare was observed in in $T_5$ (PSB 132L + Biochar 30t) (83.85 tonnes).The maximum size was observed in in $T_5$ (PSB 132L + Biochar 30t) (519.73 cm$^2$) followed by $T_3$ (PSB 198L + Biochar 30t) (500.14 cm$^2$) and $T_8$ (PSB 132L + Biochar 10t) (472..17 cm$^2$) The maximum head polar diameter was observed in in $T_5$ (PSB 132L + Biochar 30t) (28.8cm) followed by $T_2$ (PSB 132L + Biochar 20t) (27.72), T1 (PSB 66L + Biochar 10t) (27.5 cm) and $T_3$ (PSB 198L + Biochar 30t) (27.33 cm) (Table 1–5).

**Table.1** Effects of Bio-char and PSB on growth parameters of Chinese cabbage (Plant height and no. of leaves)

| Treatment | Treatment combination | Plant height (cm) | | | | No. of Leaves | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 15DAT | 30DAT | 45DAT | 60DAT | 15DAT | 30DAT | 45DAT | 60DAT |
| $T_0$ | CONTROL | 14.03 | 16.51 | 26.01 | 27.21 | 6.33 | 7.89 | 8.70 | 9.09 |
| $T_1$ | PSB 66L + Biochar 10t | 15.34 | 18.81 | 28.83 | 29.71 | 7.47 | 8.22 | 9.40 | 9.83 |
| $T_2$ | PSB 132L + Biochar 20t | 15.28 | 17.82 | 27.15 | 29.03 | 7.60 | 8.44 | 9.55 | 9.63 |
| $T_3$ | PSB 198L + Biochar 30t | 15.77 | 21.19 | 31.29 | 31.91 | 7.73 | 9.11 | 10.31 | 10.63 |
| $T_4$ | PSB 66L + Biochar 20t | 14.42 | 16.95 | 27.03 | 28.03 | 7.33 | 8.44 | 9.64 | 9.94 |
| $T_5$ | PSB 132L + Biochar 30t | 17.04 | 26.33 | 32.96 | 33.59 | 8.33 | 9.89 | 11.09 | 12.03 |
| $T_6$ | PSB 198L + Biochar 10t | 15.59 | 20.58 | 29.04 | 30.47 | 7.33 | 8.33 | 9.50 | 10.77 |
| $T_7$ | PSB 66L + Biochar 30t | 15.23 | 18.52 | 28.18 | 29.53 | 8.07 | 9.43 | 10.60 | 11.53 |
| $T_8$ | PSB 132L + Biochar 10t | 16.98 | 21.89 | 31.62 | 32.99 | 7.53 | 9.00 | 10.20 | 10.70 |
| $T_9$ | PSB 198L + Biochar 20t | 15.93 | 19.55 | 29.71 | 31.70 | 8.00 | 9.33 | 10.53 | 11.17 |
| | **F-Test** | S | S | S | S | S | S | S | S |
| | **C.D. at 0.5%** | 1.62 | 2.20 | 1.00 | 0.96 | 0.69 | 1.04 | 1.15 | 0.88 |
| | **S.Ed. (±)** | 0.77 | 1.05 | 0.48 | 0.46 | 0.33 | 0.5 | 0.55 | 0.42 |

**Table.2** Effects of Bio-char and PSB on growth parameters of Chinese cabbage (Plant spread and head initiation)

| Treatment | Treatment combination | Plant spread (cm) | | | | Head Initiation |
|---|---|---|---|---|---|---|
| | | 15 DAT | 30 DAT | 45 DAT | 60 DAT | |
| $T_0$ | CONTROL | 29.11 | 43.03 | 45.89 | 48.06 | 43.33 |
| $T_1$ | PSB 66L + Biochar 10t | 31.04 | 47.33 | 49.88 | 53.74 | 32.33 |
| $T_2$ | PSB 132L + Biochar 20t | 29.58 | 48.04 | 48.95 | 51.51 | 35.07 |
| $T_3$ | PSB 198L + Biochar 30t | 34.50 | 51.93 | 55.03 | 57.07 | 31.26 |
| $T_4$ | PSB 66L + Biochar 20t | 29.08 | 44.73 | 47.00 | 50.09 | 42.00 |
| $T_5$ | PSB 132L + Biochar 30t | 36.71 | 53.98 | 57.74 | 60.91 | 28.07 |
| $T_6$ | PSB 198L + Biochar 10t | 31.47 | 48.99 | 52.00 | 55.61 | 31.07 |
| $T_7$ | PSB 66L + Biochar 30t | 31.44 | 46.76 | 50.31 | 54.57 | 32.26 |
| $T_8$ | PSB 132L + Biochar 10t | 35.33 | 53.11 | 55.37 | 58.53 | 28.89 |
| $T_9$ | PSB 198L + Biochar 20t | 31.51 | 49.47 | 52.02 | 56.29 | 30.55 |
| | **F-Test** | S | S | S | S | S |
| | **C.D. at 0.5%** | 1.91 | 2.68 | 1.37 | 2.91 | 1.82 |
| | **S.Ed. (±)** | 0.91 | 1.28 | 0.65 | 1.39 | 0.87 |

**Table.3** Effects of Bio-char and PSB on yield parameters of Chinese cabbage

| Treatment | Treatment combination | Average Head Yield (Kg) | Yield Per Plot (Kg) | Yield/ha (tonnes) | Head size ($cm^2$) |
|---|---|---|---|---|---|
| $T_0$ | Control | 1.22 | 7.30 | 45.06 | 397.36 |
| $T_1$ | PSB 66L + Biochar 10t | 1.73 | 10.36 | 63.95 | 461.83 |
| $T_2$ | PSB 132L + Biochar 20t | 1.64 | 9.86 | 60.86 | 460.36 |
| $T_3$ | PSB 198L + Biochar 30t | 1.89 | 11.36 | 70.13 | 500.14 |
| $T_4$ | PSB 66L + Biochar 20t | 1.51 | 9.05 | 55.83 | 420.93 |
| $T_5$ | PSB 132L + Biochar 30t | 2.25 | 13.50 | 83.35 | 519.73 |
| $T_6$ | PSB 198L + Biochar 10t | 1.84 | 11.06 | 68.26 | 465.93 |
| $T_7$ | PSB 66L + Biochar 30t | 1.61 | 9.68 | 59.75 | 446.60 |
| $T_8$ | PSB 132L + Biochar 10t | 1.95 | 11.71 | 72.27 | 472.17 |
| $T_9$ | PSB 198L + Biochar 20t | 1.86 | 11.13 | 68.73 | 464.84 |
| | **F-Test** | S | S | S | S |
| | **C.D. at 0.5%** | 0.08 | 0.47 | 1.87 | 27.28 |
| | **S.Ed. (±)** | 0.04 | 0.22 | 0.89 | 13.3 |

**Table.4** Effects of Bio-char and PSB on head size and compactness of Chinese cabbage

| Treatment | Treatment combination | Head Polar Diameter (cm) | Head Lateral Diameter (cm) | Head Compactness | Head Compactness Index |
|---|---|---|---|---|---|
| $T_0$ | Control | 26.09 | 15.23 | 13.81 | 1.71 |
| $T_1$ | PSB 66L + Biochar 10t | 27.50 | 16.79 | 15.92 | 1.64 |
| $T_2$ | PSB 132L + Biochar 20t | 27.72 | 16.61 | 15.14 | 1.67 |
| $T_3$ | PSB 198L + Biochar 30t | 27.33 | 17.57 | 15.54 | 1.62 |
| $T_4$ | PSB 66L + Biochar 20t | 27.23 | 15.45 | 15.54 | 1.76 |
| $T_5$ | PSB 132L + Biochar 30t | 28.08 | 18.51 | 17.81 | 1.52 |
| $T_6$ | PSB 198L + Biochar 10t | 26.66 | 17.46 | 17.22 | 1.53 |
| $T_7$ | PSB 66L + Biochar 30t | 26.49 | 16.86 | 15.87 | 1.57 |
| $T_8$ | PSB 132L + Biochar 10t | 27.08 | 17.43 | 17.71 | 1.55 |
| $T_9$ | PSB 198L + Biochar 20t | 26.70 | 17.42 | 17.29 | 1.53 |
| | **F-Test** | S | S | S | S |
| | **C.D. at 0.5%** | 1.33 | 0.48 | 1.65 | 0.08 |
| | **S.Ed. (±)** | 0.63 | 0.23 | 0.78 | 0.04 |

**Table.5** Effects of Bio-char and PSB on Quality parameters of Chinese cabbage

| Treatment No. | Treatment combination | T.S.S% (°Brix) | Moisture content (%) | Ascorbic acid content (mg/100g) |
|---|---|---|---|---|
| $T_0$ | (CONTROL) | 3.80 | 94.66 | 48.23 |
| $T_1$ | PSB 66L + Biochar 10t | 4.51 | 95.24 | 48.73 |
| $T_2$ | PSB 132L + Biochar 20t | 4.27 | 95.14 | 48.85 |
| $T_3$ | PSB 198L + Biochar 30t | 4.84 | 95.39 | 50.11 |
| $T_4$ | PSB 66L + Biochar 20t | 3.78 | 94.82 | 48.46 |
| $T_5$ | PSB 132L + Biochar 30t | 5.27 | 96.07 | 50.30 |
| $T_6$ | PSB 198L + Biochar 10t | 4.80 | 95.31 | 49.84 |
| $T_7$ | PSB 66L + Biochar 30t | 4.18 | 94.87 | 49.11 |
| $T_8$ | PSB 132L + Biochar 10t | 4.87 | 95.71 | 50.22 |
| $T_9$ | PSB 198L + Biochar 20t | 4.69 | 95.30 | 49.52 |
| | **F-Test** | S | S | S |
| | **C.D. at 0.5%** | 0.26 | 0.71 | 0.52 |
| | **S.Ed. (±)** | 0.12 | 0.34 | 0.25 |

The maximum head equatorial diameter was observed in in $T_5$ (PSB 132L + Biochar 30t) (18.51cm) followed by $T_3$ (PSB 198L + Biochar 30t) (17.57 cm) and $T_6$ (PSB 198L + Biochar 10t) (17.86 cm. The maximum head compactness was observed in in $T_5$ (PSB 132L + Biochar 30t) (17.81) followed by, $T_8$ (PSB 132L + Biochar 10t) (17.71 the best head compactness index was observed in in $T_5$ (PSB 132L + Biochar 30t) (1.54). Similar findings were recorded by Carter *et al.*, (2013) in lettuce and Chinese cabbage (*Brassica chinensis*), Upadhyay *et al.*, (2014) in lettuce, Baiga *et al., (*2017) in Chinese cabbage and Gu. (2002) in tomato and cucumber.

## Quality parameters

The highest TSS was observed in $T_5$ (PSB 132L + Biochar 30t) (5.27 brix) followed by $T_8$ (PSB 132L + Biochar 10t) (4.87 brix) and $T_3$ (PSB 198L + Biochar 30t) (4.84 brix) The highest moisture content was observed in in $T_5$ (PSB 132L + Biochar 30t) (96.07%) followed by $T_8$ (PSB 132L + Biochar 10t) (95.71).The highest ascorbic acid content was observed in in $T_5$ (PSB 132L + Biochar 30t) (50.30 mg/100g) followed by $T_8$ (PSB 132L + Biochar 10t) (50.22 mg/100g) and $T_3$ (PSB 198L + Biochar 30t) (50.11 mg/100g).

For all the parameters $T_0$ (Control) showed the least favourable results as compared to the rest. Bio-char and PSB significantly influenced the growth, yield and quality of Chinese cabbage.

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**How to cite this article:**

Tzudikumzuk Lemtur, Vipin M. Prasad, Samir E. Topno and Vijay Bahadur. 2019. Effect of Photosynthetic Bacteria and Bio-Char on the Growth, Development and Quality of Chinese Cabbage (*Brassica rapa* ssp. *pekinensis*) c.v. All Season No. 2.*Int.J.Curr.Microbiol.App.Sci.* 8(08): 2102-2110. doi: https://doi.org/10.20546/ijcmas.2019.808.246