



RESPONSE OF RED CABBAGE (*Brassica oleracea* var. *capitata* f. *rubra*) TO THE INTEGRATED USE OF CHEMICAL FERTILIZERS, BIOFERTILIZERS AND BORON

Rajib Das*, U. Thapa**, A.R. Mandal, Y.A. Lyngdoh, S.K. Kulshreshtha and S. Debnath

Department of Vegetable Crops, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia - 741 252, West Bengal, India

*e-mail: rajib_bckv@yahoo.co.in, **drumesh.thapa@gmail.com

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ABSTRACT

Present research work was conducted during 2009-2010 and 2010-2011 at Horticulture Research Station, Mondouri, BCKVV, Nadia, West Bengal (India) to study the influence of integrated nutrient management using chemical fertilizers, bio-fertilizers and micro-nutrient (boron) on growth, yield and quality of red cabbage. The study revealed that growth attributing characters viz., plant height and spread were higher (42.83 and 48.63 cm, respectively) with application of recommended NPK [120:60:60 kg ha⁻¹] + *Azotobacter chroococcum* [@ 10 kg ha⁻¹] + boron [@ 1 kg ha⁻¹]. Higher head weight, head diameter and projected yield of 1375 g, 52.47 cm and 37.02 tonnes ha⁻¹, respectively, was achieved with the use of recommended NPK + *A. chroococcum* + phosphate solubilizing bacterium *Bacillus polymyxa* + boron. The dry matter, vitamin C, total sugar and anthocyanin contents in red cabbage also improved when integrated nutrient management was followed.

Key words: Anthocyanin, *Azotobacter chroococcum*, *Bacillus polymyxa*, boron, chemical fertilizers, growth, red cabbage, yield

INTRODUCTION

Red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*) is the modern multi-tasker's dream food, delivering double photochemical benefit by combining the promising compounds from cruciferous vegetables with polyphenols anthocyanin, more commonly associated with grapes and berries. The popularity of red cabbage as a natural colorant for products with a slightly alkaline or neutral reaction is on the rise (Majkowska-Gadomska, 2006). As it is a newly introduced crop to India red cabbage is yet to gain enough popularity among majority of Indians and its consumption is still lower than that of white cabbage. Less research has been conducted on nutrient management of this crop, especially under Indian condition. Alam (2005) reported the improvement of growth and yield of white cabbage with the application of boron along with other major nutrients, whereas the beneficial effects of nitrogen fixing bio-fertilizer in cabbage cultivation have been reported by Bashyal (2008). From the above instances, it may be suggested that the judicious application of combined doses of chemical fertilizers, bio-fertilizer and micro-nutrient would also have potentiality to improve the overall performance of red cabbage as in case of white cabbage and red

cabbage, both belong to the same species (*B. oleracea*). So, the present investigation was conducted with the objective to assess the influences of combined use of chemical fertilizers (NPK), bio-fertilizers (*Azotobacter chroococcum* and *Bacillus polymyxa*) and micro-nutrient (boron) on the growth, yield and quality attributes of red cabbage.

MATERIALS AND METHODS

The present experiment was conducted at Horticulture Research Station, Mondouri, BCKVV, Mohanpur, Nadia, West Bengal (India) for two consecutive winter seasons during the years 2009-2010 and 2010-2011. The soil of experiment site was sandy loam with organic matter 0.97%, organic carbon 0.45% and pH 6.9. The experiment was conducted in a randomized block design with each treatment replicated three times. The treatments consisted of various combinations of chemical fertilizers (N:P:K), bio-fertilizers [*Azotobacter chroococcum* and PSB (*Bacillus polymyxa*) – procured from BCKVV, Mohanpur, Nadia] and micro-nutrient (boron - applied in the form of borax at 30 days after transplanting). The recommended NPK [120:60:60 kg ha⁻¹] was applied in all the treatment. *A. chroococcum* and/or PSB, as per treatments, were applied @ 10 kg ha⁻¹ each whereas boron was applied @ 1 kg ha⁻¹. Four weeks old red cabbage seedlings were transplanted to the main field in the month of November at a plant spacing of 60 cm x 60 cm in 3.0 m x 2.5 m plots. Normal cultural practices and plant protection measures were followed during the cultivation process.

Observations were taken with respect to the head weight, head diameter, plant height, plant spread, projected yield and number days for head maturity from 10 randomly selected plants from each treatment replication. Projected yield was measured from all the plants and converted into tonnes ha⁻¹ (20% of the actual conversion figure has been reduced to consider various losses cause yield reduction). The number of days for head maturity was counted from the day of seedling transplantation to the day of 1st harvest of mature heads. The dry matter content in plants was estimated by drying the whole plant material at 105°C till constant weight (Ladonski and Gospodarec, 1986). The vitamin C was estimated as per Tillman's method modified by Pijanowski *et al.* (1973) and sugars as per Luff-Schoorl's method (Ladonski and Gospodarec, 1986). Anthocyanin content was measured spectrometrically (Sukwattanasinit *et al.*, 2007). The data was statistically analyzed methods suggested by Panse and Sukhatme (1989) and 'F' values calculated as per Fisher and Yates (1963) and critical differences determined at the probability of 0.05.

RESULTS AND DISCUSSION

Growth and yield attributes

The treatments wherein chemical fertilizers, bio-fertilizers and micro-nutrient boron were applied in combination gave better growth and yield in red cabbage (Table 1). Plant height and plant spread showed significant increase in combined applications as compared to control (chemical fertilizers alone). Highest plant height (42.83 cm) and plant spread (51.27 cm) was observed in recommended NPK + *A. chroococcum* + boron and recommended NPK + *A. chroococcum* treatments. The yield attributes such as head weight, head diameter and projected yield were maximum in treatment wherein recommended NPK + *A. chroococcum* + PSB + boron was used (1375 g, 52.47 cm and 37.02 t ha⁻¹, respectively). This was followed by treatment wherein recommended NPK + *A. chroococcum* + boron was applied. These values were significantly higher than control (recommended

Table 1: Effect of integrated use of chemical fertilizers (NPK), *Azotobacter chroococcum*, PSB (*Bacillus polymyxa*) and boron on growth and yield of red cabbage

Treatments	Plant height (cm)	Plant spread (cm)	Head weight (g)	Head diameter (cm)	Projected yield (t ha ⁻¹)	No. of days for head maturity
Recommended NPK* (control)	36.57	35.73	891.67	40.11	24.38	100.33
NPK + PSB @ 10 kg ha ⁻¹	34.63	39.80	960.00	41.03	24.88	101.67
NPK + boron @ 1 kg ha ⁻¹	34.33	37.80	1083.33	46.23	28.79	101.00
NPK + <i>A. chroococcum</i> @ 10 kg ha ⁻¹	37.10	51.27	1310.00	50.80	34.80	103.33
PSB + <i>A. chroococcum</i>	36.80	44.53	908.33	46.03	25.40	101.00
NPK + <i>A. chroococcum</i> + boron	42.83	48.63	1341.67	51.08	35.42	106.00
NPK + PSB + boron	36.70	39.33	1101.67	46.57	30.37	100.67
NPK + <i>A. chroococcum</i> + PSB + boron	39.47	48.07	1375.00	52.47	37.02	105.33
SEM(±)	1.209	1.328	52.918	0.953	1.383	1.357
CD _{0.05}	3.010	3.307	131.77	2.373	3.444	3.379

*Recommended NPK applied in all treatments @ 120:60:60 kg ha⁻¹

NPK alone) treatment. The results are in tune with Alam (2005), Bhat *et al.* (2006), Bashyal (2008) and Sharma and Sharma (2010) in cabbage and cauliflower who used boron, *Azotobacter*, *Azospirillum* and phosphate solubilizing bacteria. Our results are in partial agreement with the findings of Sarkar *et al.* (2003) and Bhattarai *et al.* (2005) in case of cabbage and cauliflower. The remarkable increase in growth and yield attributing characters of red cabbage under various nutrient combinations may be due the synergistic effect of chemical fertilizers, bio-fertilizer and boron. The most effective result with respect to number of days for head maturity was obtained in treatment wherein chemical fertilizer was used alone (*i.e.* 100.33 days), followed by recommended NPK + PSB + boron treatment (100.67 days). The relatively lesser time requirement for head maturity in chemical fertilizer treatment indicated the direct influence of inorganic forms of major nutrients in hastening the growth and maturity of plants, which may be the cause of comparatively lesser yield of red cabbage when N, P and K are applied alone without application of boron as well as any bio-fertilizer.

Quality attributes

The head quality of red cabbage with respect to dry matter, vitamin C, total sugar and anthocyanin contents was significantly better in combined application than the chemical fertilizer alone (Table 2). Dry matter, vitamin C content and total sugar content were maximum (5.88 g 100 g⁻¹, 33.82 mg 100 g⁻¹ and 2.61 g 100 g⁻¹, respectively) in treatment wherein recommended NPK + PSB + A.

Table 2: Effect of integrated use of chemical fertilizers (NPK), *Azotobacter chroococcum*, PSB (*Bacillus polymyxa*) and boron on the quality of red cabbage head

Treatments	Dry matter (g 100 g ⁻¹)	Vitamin C (mg 100 g ⁻¹)	Total sugar (g 100 g ⁻¹)	Anthocyanin (mg 100 g ⁻¹)
Recommended NPK* (control)	5.56	32.37	2.48	330.67
NPK + PSB @ 10 kg ha ⁻¹	5.51	29.68	2.36	322.33
NPK + boron @ 1 kg ha ⁻¹	5.33	29.81	2.42	328.33
NPK + <i>A. chroococcum</i> @ 10 kg ha ⁻¹	5.86	33.77	2.57	349.00
PSB + <i>A. chroococcum</i>	5.27	30.25	2.21	321.00
NPK + <i>A. chroococcum</i> + boron	5.84	33.00	2.58	362.00
NPK + PSB + boron	5.52	30.83	2.47	310.67
NPK + <i>A. chroococcum</i> + PSB + boron	5.88	33.82	2.61	343.33
SEM(±)	0.104	0.462	0.069	5.063
CD _{0.05}	0.259	1.150	0.171	12.607

*Recommended NPK applied in all treatments @ 120:60:60 kg ha⁻¹

chroococcum + boron was used. This was followed by recommended NPK + *A. chroococcum* + boron treatment with respect to dry matter and total sugar contents and recommended NPK + *A. chroococcum* treatment with respect to vitamin C content. Our findings are in partial agreement with Subbiah (1994). The anthocyanin content was highest (362.00 mg 100 g⁻¹) in recommended NPK + *A. chroococcum* + boron.

From the study it may be concluded that the combined use of chemical fertilizers and bio-fertilizers alongwith boron influenced positively various growth, yield and quality attributing characters of red cabbage perhaps due to better nutrient availability to the plants.

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