



Effect of bio-pesticides and nitrogen on quantitative and qualitative characters of red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*)

DIKSHA THAKUR¹, DINANTER PAL KAUR², GURBAKSH KAUR¹, SAGAR KUMAR^{1*}
and NEHA SHARMA³

Mata Gujri College, Fatehgarh Sahib, Punjab 140 407, India

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ABSTRACT

Red cabbage (*Brassica oleracea* L. var. *capitata* f. *rubra*) belongs to Brassicaceae family, is an important exotic and cool season vegetable. The experiment was conducted during the winter (*rabi*) seasons 2019–2020 and 2020–2021 at the Experimental Farm, Mata Gujri College, Fatehgarh Sahib, Punjab to assess the effect of different doses of nitrogen with various bio-pesticides. Various nitrogen doses along with *Trichoderma harzianum*, *Pseudomonas fluorescens*, and neem cake were used as bio-pesticides. *Trichoderma harzianum* and *Pseudomonas fluorescens* multiplied very well in gunny bags on farm yard manure in the shade. Water was sprinkled on the gunny bags on a daily basis for 15 days and the microbial population had grown to the point where it was ready for soil application. The treatment N₂B₂ (125 kg N/ha + *Pseudomonas fluorescens* @10 g/kg FYM) gave maximum equatorial diameter (15.48 cm), polar diameter (17.80 cm), head yield/plant (1.50 kg), head yield/plot (36.08 kg), biological yield (2.27 kg/plant), harvest index (67.01%), total soluble solids (7.64°B), titratable acidity (0.299%), vitamin A (277.82 mg/100 g), vitamin C (52.25 mg/100 g), shelf life (19.86 days), physiological loss in weight (8.83%), anthocyanin content (34.50 mg/100 g) and moisture content (97.66%). Thus, it was rated as the best treatment resulting in maximum head yield/ha (146.18 q/ha).

Keywords: *Brassica oleracea* L. var. *capitata* f. *rubra*, Neem cake, Nitrogen, *Pseudomonas fluorescens*, *Trichoderma harzianum*

Red cabbage (*Brassica oleracea* L. var. *capitata* f. *rubra*) is one of the most crucial cool season vegetables belonging to the family Cruciferae. It is widely cultivated for its vibrant purple-red leaves, high antioxidant content (particularly anthocyanins), and significant nutritional value, including vitamins C, K, and dietary fibre. Due to the presence of indole-3-carbinol, it has an anticancer property (Shama *et al.* 2012). Higher yield of cabbage is related to appropriate application of fertiliser, proper cultural management, etc. Nitrogen can play an important role in the vegetative growth of every plant. A nitrogen-deficient plant will grow slowly, with little pale leaves that are often frail and thin. Therefore an optimized level of nitrogen is essential for better production in red cabbage. However, its production is often threatened by a range of insect pests such as aphids, caterpillars, and flea beetles, which can significantly reduce yield and quality. In addition to nutrient management, control of diseases and insects is also

a crucial step, and bio-pesticides can act as an alternative for chemical pesticides.

Bio-pesticides are the micro-organisms which are used to control pests, ailment, unwanted plant, and soil borne pathogens. They also enhance plant growth by improving root development (Viterbo *et al.* 2002), nutrient uptake, and inducing systemic resistance. Similarly, *Pseudomonas* spp., particularly fluorescent strains, act as plant growth-promoting rhizobacteria (PGPR).

Area under cole crop cultivation is limited and at the same time the demand of vegetables are increasing constantly both in Indian and as well as in international market. The greatest problem facing the nation in the forthcoming years is to provide safe food for the increasing population in the country. There is a crucial need to increase food production globally under degrading land resources. There is great need of research required to improve the yield of cole crops along with sustainability and certain bio-pesticides should be applied either alone or in combination with synthetic fertilizers to increase their growth and yield. *Trichoderma harzianum*, *Pseudomonas fluorescens* and neem cake are well known bio-pesticides and can be used in cole crop cultivation to increase the yield and productivity.

¹Mata Gujri College, Fatehgarh Sahib, Punjab; ²Chandigarh Group of Colleges, Jhanjeri, Mohali, Punjab. ³School of Management, CGC University, Mohali, Punjab. *Corresponding author email: sagarsukhija65@gmail.com

Although *Trichoderma* and *Pseudomonas* are well researched for their disease suppression properties, their use in the improvement of quality and yield parameters in red cabbage is not extensively studied. There is a lack of information on their combined or interaction effects on the growth, yield, and quality of red cabbage. Understanding this practice is important to develop sustainable practices. Therefore, the study aimed to investigate combined effect of nitrogen and bio-pesticides for synergistic effects on qualitative and quantitative parameters.

MATERIALS AND METHODS

The experiment was conducted during the winter (*rabi*) seasons of 2019–2020 and 2020–2021 at the Experimental Farm, Mata Gujri College, Fatehgarh Sahib (30°36'–30°39' N, 76°22'–76°46' E; at an elevation of 279 m amsl), Punjab. Fatehgarh Sahib pertains to subtropical and semi-arid climatic conditions, having a temperature range of minimum temperature recorded up to 4°C in December–January month and maximum go as high as 45°C in the month of May–June.

The experiment consisted of 16 treatments with combinations of four levels of nitrogen and four levels of bio-pesticides and three replications carried out by factorial randomized block design (FRBD). The treatments were T₁, N₀B₀: 0 kg N/ha + No bio-pesticide; T₂, N₀B₁: 0 kg N/ha + *Trichoderma harzianum* @10 g/kg FYM; T₃, N₀B₂: 0 kg N/ha + *Pseudomonas fluorescens* @10 g/kg FYM; T₄, N₀B₃: 0 kg N/ha + Neem cake @50 g/m²; T₅, N₁B₀: 75 kg N/ha + No bio-pesticide; T₆, N₁B₁: 75 kg N/ha + *Trichoderma harzianum* @10 g/kg FYM; T₇, N₁B₂: 75 kg N/ha + *Pseudomonas fluorescens* @10 g/kg FYM; T₈, N₁B₃: 75 kg N/ha + Neem cake @50 g/m²; T₉, N₂B₀: 125 kg N/ha + No bio-pesticide; T₁₀, N₂B₁: 125 kg N/ha + *Trichoderma harzianum* @10 g/kg FYM; T₁₁, N₂B₂: 125 kg N/ha + *Pseudomonas fluorescens* @10 g/kg FYM; T₁₂, N₂B₃: 125 kg N/ha + Neem cake @50 gm²; T₁₃, N₃B₀: 175 kg N/ha + No bio-pesticide; T₁₄, N₃B₁: 175 kg N/ha + *Trichoderma harzianum* @10 g/kg FYM; T₁₅, N₃B₂: 175 kg N/ha + *Pseudomonas fluorescens* @10 g/kg FYM; T₁₆, N₃B₃: 175 kg N/ha + Neem cake @50 g/m².

Cabbage hybrid 'Ruby Ball' was used in the present study. It has high nutritional value and an early season cultivar that is ready within 65–70 days after transplanting with medium-sized, compact round heads, red-purplish in colour. Average head yield was found 400–500 q/ha. The FYM was inoculated with bio-pesticides, viz. *Pseudomonas fluorescens* and *Trichoderma harzianum* @10 g/kg FYM, 15 days before the transplanting of seedlings. The treated composts were packed in the gunny bags till transplanting. The composts were watered daily. There was spore formation within 10–15 days. As the process of field preparation was over, the inoculated composts were incorporated treatment wise in the soil, one day before the transplanting.

RESULTS AND DISCUSSION

Quality: In red cabbage the maximum TSS content (7.64°Brix) was observed in treatment N₂B₂ (125 kg N/

ha + *Pseudomonas fluorescens* @10 g/kg FYM) (Table 1). This is because inorganic nitrogen fertilisers enhance the amount of glucose and fructose in the soil (Hiwale *et al.* 2010). Total soluble contents are a measure of mineral nutrition in fruits, and their levels have risen as a result of nitrogen fertiliser (Krezel and Kolota 2008). The increase in TSS could be attributed to the fact that organic manure is capable of giving appropriate macro and micronutrients to plants, which play a key role in quality improvement via beneficial enzymatic changes during growth (Bhandari *et al.* 2012). The maximum vitamin A was 277.82 mg/100 g. The fact that nitrogen is the major ingredient of all amino acids, proteins, and lipids, as well as a structural compound of the chloroplast, may aid to promote the production of more vitamin A (Yadav *et al.* 2016) and the addition of organic or inorganic fertiliser boosted vitamin A (Qureshi *et al.* 2014).

The maximum ascorbic acid content of red cabbage was (52.25 mg/100 g) observed in treatment N₂B₂ (125 kg N/ha + *Pseudomonas fluorescens* @10 g/kg FYM) (Table 1). This could be due to nitrogen stimulates meristematic activity, which increases the assimilation surface, resulting in more photosynthetic product synthesis and accumulation (Vishwakarma *et al.* 2017). Erturk *et al.* (2012) discovered that the presence of auxin and gibberellic acid increased ascorbic acid production, implying that PGPB treatment increases phytohormone synthesis, resulting in increased ascorbic acid production (Kazemi 2014) and also phosphorus aids in carbohydrate assimilation and, as a result, ascorbic acid synthesis (Jaipaul *et al.* 2011).

The highest shelf life (19.86 days) and lowest physiological loss in weight (8.83) (Table 1) was observed due to lesser rate of respiration and transpiration, resulting in lower ethylene production and longer shelf life (Patil *et al.* 2004). Chatterjee R and Paul (2014) found that combining FYM, *Azospirillum*, and phosphobacteria with inorganic fertilisers improves keeping quality by reducing cumulative physiological weight loss, compared to using inorganic fertilizer alone.

Maximum anthocyanin was 34.50 mg/100 g and this could be due to the fact that nitrogen aids in the production of carotenoids-rich chloroplasts (Qureshi *et al.* 2014) and PGPB enhanced the level of phenols and flavonoids in cluster beans when compared to the control group (Singh *et al.* 2015). The observed increase in phenolic content in biopesticides -inoculated plants suggests that the increases were generated by strain of bacteria as a result of plant hormone synthesis, i.e. IAA (Cisternas-Jamet *et al.* 2020). Following the application of FYM, increased carotenoid concentration might be attributed to an increase in the content and activity of chlorophyll and associated light-absorbing pigments (including carotenoids) (Qureshi *et al.* 2014).

The maximum moisture content was (97.66%) observed in N₂B₂ due to the ability of organic manure to deliver appropriate macro and micronutrients to plants, which play a key role in improving quality through favourable enzymatic changes throughout growth (Bhandari *et al.* 2012).

Table 1 Effect of nitrogen and bio-pesticides on TSS, titrable acidity, vitamin A and vitamin C, shelf life, moisture content, anthocyanin and physiological loss in weight in red cabbage cv. Ruby Ball

Treatments	TSS (°Brix)	Titrable acidity (%)	Vitamin A (mg/100 g)	Vitamin C (mg/100 g)	Shelf life (days)	Moisture content (%)	Anthocyanin (mg/100 g)	PLW
N ₀ B ₀	5.41	0.426	202.13	41.92	15.85	77.01	23.47	13.82
N ₀ B ₁	5.61	0.424	214.29	43.00	16.40	78.17	23.68	13.48
N ₀ B ₂	5.68	0.417	243.48	43.19	16.48	78.67	24.68	13.42
N ₀ B ₃	5.49	0.426	208.52	42.94	16.36	78.23	23.67	13.61
N ₁ B ₀	5.88	0.407	260.52	43.55	16.51	82.87	26.36	13.38
N ₁ B ₁	6.20	0.377	261.58	44.23	17.22	84.29	29.71	12.48
N ₁ B ₂	6.28	0.374	263.32	45.85	17.25	85.61	30.54	11.87
N ₁ B ₃	6.17	0.387	261.50	44.05	17.20	84.15	29.60	12.57
N ₂ B ₀	6.16	0.390	261.18	44.04	17.16	83.84	29.21	12.61
N ₂ B ₁	7.58	0.338	272.37	49.98	19.46	89.20	34.10	9.97
N ₂ B ₂	7.64	0.299	277.82	52.25	19.86	97.66	34.50	8.83
N ₂ B ₃	6.77	0.353	264.84	47.10	18.22	87.01	32.73	10.80
N ₃ B ₀	6.00	0.397	261.11	43.87	17.11	83.70	27.28	12.62
N ₃ B ₁	7.03	0.344	269.89	47.86	19.03	89.17	33.01	10.40
N ₃ B ₂	7.61	0.317	274.23	51.22	19.57	93.83	34.14	9.75
N ₃ B ₃	6.35	0.360	264.44	47.06	17.78	86.69	31.14	11.32
SEM±	0.202	NS	4.882	0.590	0.347	1.329	0.747	0.264
CD (p=0.05)	0.584		14.101	1.704	1.002	3.839	2.158	0.764

PLW, Physiological loss in weight. Treatment details are given under Materials and Methods.

Yield: Maximum equatorial diameter of 15.48 cm and polar diameter of 17.80 cm were observed (Table 2). This could be due to rapid mineralisation of low C: N ratio resulting in the continuous availability of increased quantities of nutrients, improvements in soil physical properties, and ultimately enhanced equatorial and polar diameter (Bahadur *et al.* 2004). *Pseudomonas* spp. Secrete acids and enzymes that help turn phosphates into a form that plants can use. It also produces acids, vitamins and substances that promote growth, which help plants grow well (Wani *et al.* 2007).

The maximum head weight was (1.50 kg), head yield/plot (36.08 kg) and head yield/ha (496.18 q) were observed (Table 2). This could be due to nitrogen fertilisers promoting plant growth by promoting optimal vegetative growth and, as a result, increasing the fresh weight of curd (Boroujerdnia and Ansari 2007). According to Ahmad *et al.* (2014), *Pseudomonas fluorescens* increases yield, this could be due to PGPR's multiple growth-promoting features, as well as the beneficial impacts of organic sources of nutrients (farmyard manure) on soil nutritional status and physico-chemical properties, the most important of which is water holding capacity. Similar results were reported by Zaidi and Singh (2004) and Khakipour (2008). The use of organic and chemical fertilisers in combination with *P. fluorescens* add in available nitrogen and increase soil fertility and nutrient availability in soil solution (Mouty *et al.* 2001).

The favourable benefits of an inorganic nutrition supply

on head size could be linked to higher photosynthetic activity, quicker transport, and efficiency of utilising photosynthetic products, which result in cell elongation and rapid cell division in the leaves of heads (Joshi *et al.* 2018). Bahadur *et al.* (2004) reported that organic manures treated with *Pseudomonas fluorescens* had larger and heavier heads. The increased head weight could be ascribed to the leaves' higher chlorophyll content, which leads to higher photosynthetic activity and more efficient photosynthate usage (Thapliyal 2005).

The maximum biological yield (2.27 kg) was observed in N₂B₂. Better root proliferation, more nutrient and water intake, increased photosynthesis, and increased food accumulation could all contribute to an increase in biological yield (Chatterjee 2012). The combined influence of plant growth and yield characteristics such as plant height, number of leaves per plant, and diverse head characteristics such as average head weight, diameter, and length was primarily responsible for the increase in biological yield (Upadhyay *et al.* 2012).

The highest harvest index was (67.01 %) observed in treatment N₂ (125 kg N/ha). This could be due to inorganic fertiliser application, which increased root proliferation, allowing for more nutrient absorption from the deeper layers of soil, resulting in a large rise in yield and harvest index. It is critical to use the right mix of organic and bio-fertilizers to maximise their potential and efficiency.

Table 2 Effect of nitrogen and bio-pesticides on equatorial diameter, polar diameter, average head weight, head yield and head yield in red cabbage cv. Ruby Ball

Treatments	Equatorial diameter (cm)	Polar diameter (cm)	Average head weight (kg/plant)	Head yield (kg/plot)	Head yield (q/ha)
N ₀ B ₀	11.45	11.09	0.84	20.24	281.09
N ₀ B ₁	12.26	12.79	0.96	23.12	321.09
N ₀ B ₂	12.40	14.93	0.98	23.60	327.76
N ₀ B ₃	11.55	12.67	0.94	22.64	314.42
N ₁ B ₀	12.49	15.10	1.01	24.32	337.76
N ₁ B ₁	13.30	15.55	1.16	27.92	387.75
N ₁ B ₂	13.37	15.82	1.18	28.32	393.31
N ₁ B ₃	12.97	15.40	1.12	26.96	374.42
N ₂ B ₀	12.80	15.34	1.05	25.20	349.98
N ₂ B ₁	14.69	17.24	1.46	35.12	487.75
N ₂ B ₂	15.48	17.80	1.50	36.08	496.18
N ₂ B ₃	13.77	16.37	1.24	29.76	413.31
N ₃ B ₀	12.55	15.29	1.02	24.56	341.09
N ₃ B ₁	13.86	16.56	1.29	30.88	428.86
N ₃ B ₂	15.31	17.35	1.48	35.52	493.30
N ₃ B ₃	13.61	15.88	1.20	28.88	401.09
SEM±	0.275	0.365	0.042	1.013	14.075
CD (p=0.05)	0.791	1.056	0.122	2.972	23.54

Treatment details are given under Materials and Methods.

It can be concluded that 125 kg N/ha + *Pseudomonas fluorescens* @10 g/kg FYM produced the best yield and quality in terms of equatorial diameter, polar diameter, head yield/plant, head yield/plot, biological yield, harvest index, total soluble solids, titratable acidity, vitamin A, vitamin C, shelf life, physiological loss in weight, anthocyanin content and moisture content and head yield/ha. Thus following field trials, N₂B₂- 125 kg N/ha + *Pseudomonas fluorescens* @10 g/kg FYM can be recommended to commercial red cabbage growing growers for getting high head yield and maximum net returns per unit.

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Table 3 Effect of nitrogen and bio-pesticides on biological yield and harvest index in red cabbage cv. Ruby Ball

Treatments	Biological yield (kg/plant)	Harvest index (%)
	Pooled	Pooled
N ₀ B ₀	1.32	52.85
N ₀ B ₁	1.49	64.37
N ₀ B ₂	1.45	67.61
N ₀ B ₃	1.44	64.31
N ₁ B ₀	1.52	64.55
N ₁ B ₁	1.61	70.63
N ₁ B ₂	1.62	71.30
N ₁ B ₃	1.60	65.19
N ₂ B ₀	1.55	65.68
N ₂ B ₁	2.03	70.96
N ₂ B ₂	2.27	67.01
N ₂ B ₃	1.74	70.21
N ₃ B ₀	1.53	65.91
N ₃ B ₁	2.00	63.03
N ₃ B ₂	2.19	66.44
N ₃ B ₃	1.63	72.16
SEM±	0.047	2.069
CD (p=0.05%)	0.136	5.976

Treatment details are given under Materials and Methods.

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