DOI : 10.58993/ijh/2024.81.3.10

Indian J. Hortic. 81(3), September 2024: 282-287

Impact of bio-pesticides and nitrogenous fertilizer on growth, yield contributing characters and economic attributes of red cabbage in Northern-Eastern part of Punjab

Diksha Thakur[1], Sandeep K.S.[1]*, Gurbaksh Kaur[1], Dinanter P.K.[2] and Sagar K.[3]

[1]Department of Vegetable Science, Mata Gujri College, Fatehgarh Sahib, 140407, Punjab, India

ABSTRACT

Red cabbage (*Brassica oleracea* L. var. *capitata* f. *rubra*) is an important exotic, cool-season vegetable. This research examines the impact of different nitrogen doses combined with various bio-pesticides. The study utilized *Trichoderma harzianum*, *Pseudomonas fluorescens*, and neem cake as bio-pesticides along with varying nitrogen levels. The combination of 125 kg N ha^{-1} and *T. harzianum* resulted in the highest plant height (36.50 cm), greatest plant spread (81.51 cm), and the shortest time to head initiation (41.11 days). Meanwhile, the combination of 125 kg N ha^{-1} and *P. fluorescens* produced the best equatorial diameter (15.41 cm), polar diameter (17.67 cm), and yield per hectare (501.08 quintals per hectare). The treatment with 125 kg N ha^{-1} and *P. fluorescens* at 10 g per kg of FYM (N_2B_2) also yielded the highest net return (₹383,449.65) and the best benefit-cost ratio (3.07). Based on these results, after on-farm trials, this combination is recommended to growers for improved yield, better growth, and maximum net return per unit area in red cabbage production.

Key words: *Brassica oleracea* L., nitrogen, *Trichoderma harzianum*, *Pseudomonas fluorescens*, neem cake.

INTRODUCTION

Red cabbage (*Brassica oleracea* L. var. *capitata* f. *rubra*) is an important cool season vegetable in the Cruciferae family. The red cabbage is a biennial, dicotyledonous flowering herbaceous plant distinguished by a short stem bearing a crown with a mass of red-colored leaves. It has several health-promoting properties in addition to acting as an antioxidant because of its bioactive components. Due to the presence of indole-3-carbinol, it has an anticancerous property (Shama *et al.*, 14). Red cabbage has high content of vitamin C and vitamin K, containing 44 and 72%, respectively, of the Daily Value per 100 gram (Anon, 1). Anthocyanins are phenolic compounds found in red cabbage that are more abundant than other flavanoids (Wiczkowski *et al.*, 18).

Pseudomonas and *Trichoderma* are two genus of extensively researched bio-pesticides that have the ability to stimulate plant development. *Trichoderma* can supply nutrients and phytohormones, like indole-acetic acid (IAA), that affect plant growth and balance of hormones like ethylene, gibberellic acid, and IAA, which is more likely to promote growth and in addition to indirectly impacting pathogen biocontrol and abiotic stress tolerance. Additionally, the genus *Pseudomonas* enhances the biological and chemical features of horticulture crops by directly regulating nutrient intake and phytohormone levels (Argemiro *et al.*, 2). Nitrogen can play important role on the vegetative growth of every plant. It has been found that neem is the most commonly utilised botanical biopesticide (Huang *et al.*, 10). The residue that remains after grinding neem seed kernels to obtain neem seed oil is known as neem cake. The earlier work on integrated use of pesticide had mainly focused on the production of green cabbage, with emphasis only on the yield parameters without working out the economics. Looking into this gap we conducted the research on impact of bio-pesticides and nitrogenous fertilizer on growth, yield and economics of Red Cabbage in northern-eastern part of Punjab.

MATERIALS AND METHODS

The present investigation was carried out during the winter seasons of 2019-2020 and 2020-2021 at the Experimental Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab which is situated between 76°-22'E to 76°-46'E latitude and 30°-36'N to 30°-39'N longitude with a mean elevation of 279 m above sea level on red cabbage hybrid cv. Ruby Ball.

The farm yard manure (FYM) was inoculated with bio-pesticides, *viz.*, *Pseudomonas fluorescens* and *Trichoderma harzianum* @ 10 g kg^{-1} FYM sourced from the Punjab Agricultural University, Ludhiana, 15 days before the transplanting of seedlings. The FYM

*Corresponding author: dikshaathaakurr@gmail.com

[2]Department of Floriculture & Landscaping Architecture, Mata Gujri College, Fatehgarh Sahib, Punjab, India

[3]Department of Genetics & Plant Breeding, Mata Gujri College, Fatehgarh Sahib, Punjab, India

and bio-pesticides were packed in the gunny bags till transplanting and were watered daily. There was spore formation within 10-15 days and the colonized compost of *T. harzianum* (CFU count 2 × 10^8 g^{-1}) and *P. fluorescens* (CFU count 1 × 10^8 g^{-1}) were applied 50 g $plant^{-1}$ and neem cake was applied 50 g m^{-2} just before transplanting into the main field and mixed thoroughly. The experiment includes 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 data was recorded at 30, 45, 60 and at the time of harvest. The treatments were T_1 = N_0B_0 : 0 kg N ha^{-1} + No biopesticide, T_2 = N_0B_1 : 0 kg N ha^{-1} + *T. harzianum* @ 10 g kg^{-1} FYM , T_3 = N_0B_2 : 0 kg N ha^{-1} + *P. fluorescens* @ 10 g kg^{-1} FYM, T_4 = N_0B_3 : 0 kg N ha^{-1} + Neem cake @ 50 g m^{-2}, T_5 = N_1B_0 : 75 kg N ha^{-1} + No biopesticide, T_6 = N_1B_1 : 75 kg N ha^{-1} + *T. harzianum* @ 10 g kg^{-1} FYM, T_7 = N_1B_2 : 75 kg N ha^{-1} + *P. fluorescens* @ 10 g kg^{-1} FYM, T_8 = N_1B_3 : 75 kg N ha^{-1} + Neem cake @ 50 g m^{-2}, T_9 = N_2B_0 : 125 kg N ha^{-1} + No biopesticide, T_{10} = N_2B_1 : 125 kg N ha^{-1} + *T. harzianum* @ 10 g kg^{-1} FYM, T_{11}= N_2B_2 : 125 kg N ha^{-1} + *P. fluorescens* @ 10 g kg^{-1} FYM, T_{12}= N_2B_3: 125 kg N ha^{-1} + Neem cake @ 50g m^{-2},T_{13} = N_3B_0 : 175 kg N ha^{-1} + No biopesticide, T_{14} = N_3B_1 : 175 kg N ha^{-1} + *T. harzianum* @ 10 g kg^{-1} FYM, T_{15} = N_3B_2 : 175 kg N ha^{-1} + *P. fluorescens* @ 10 g kg $^{-1}$FYM, T_{16} = N_3B_3: 175 kg N ha^{-1} + Neem cake @ 50 g m^{-2}.

RESULTS AND DISCUSSION

The study revealed significant variations in red cabbage plant height at different stages when treated with varying levels of nitrogen and bio-pesticides. The highest plant height (34.15 cm), leaf length (39.52 cm), leaf width (30.50 cm), number of jacket leaves (6.81), and plant spread (75.28 cm) were observed at all growth stages with the application of 125 kg N ha^{-1} (N_2) (Table 1). Nitrogen, a crucial component of chlorophyll, likely contributed to the increased photosynthesis and subsequent higher vegetative growth (Kaur *et al*., 11). Similarly, *Trichoderma harzianum* @10 g kg^{-1} FYM (B_1) showed the maximum plant height (33.90 cm), leaf length (38.66 cm), leaf width (29.83 cm), number of jacket leaves (6.57), and plant spread (81.51 cm). The enhanced vegetative growth may be attributed to the increased nutrient availability from organic fertilizers and the growth-promoting effects of *Trichoderma*, including improved photosynthesis and stronger root systems (Ray *et al*., 13).

The longest stalk length (8.09 cm) and maximum stalk diameter (4.18 cm) were recorded in the N_2 treatment, while B_1 resulted in stalk length and diameter of 7.77 and 4.14 cm, respectively (Table 2). This increased stalk growth might be due to an enhanced microbial community that facilitated nutrient conversion and possibly stimulated growth-promoting compounds, as suggested by Damke *et al*. (7).

Table 1. Effect of nitrogen and bio-pesticides on plant height, leaf length and leaf width in red cabbage cv. Ruby Ball.

Treatment	Plant height (cm)				Leaf length (cm)				Leaf width (cm)			
	30 DAT	45 DAT	60 DAT	At harvest	30 DAT	45 DAT	60 DAT	At harvest	30 DAT	45 DAT	60 DAT	At harvest
Factor A: Nitrogen												
N_0 - 0 kg N ha^{-1}	13.38	18.64	23.59	27.56	15.03	20.51	28.69	32.23	11.07	17.42	19.54	20.87
N_1 -75 kg N ha^{-1}	14.43	23.11	28.88	31.52	16.20	23.59	30.71	35.31	12.20	23.11	26.70	28.69
N_2 -125 kg N ha^{-1}	14.96	26.61	31.09	34.15	16.74	26.63	35.11	39.52	12.73	25.64	28.33	30.50
N_3 -175 kg N ha^{-1}	14.83	26.07	30.61	33.48	16.64	25.79	34.40	38.41	12.64	25.43	27.92	29.91
SEm (±)	0.265	0.365	0.348	0.297	0.276	0.380	0.436	0.463	0.264	0.398	0.398	0.398
$CD_{(0.05)}$	0.765	1.053	1.006	0.859	0.798	1.097	1.259	1.336	0.761	1.148	1.148	1.148
Factor B: Bio-pesticides												
B_0 -No biopesticide	13.86	20.49	25.95	28.51	15.57	21.83	29.38	32.82	11.60	19.76	22.94	24.69
B_1 -*Trichoderma harzianum* @10g kg^{-1} FYM	14.86	26.17	30.55	33.90	16.61	26.28	34.30	38.66	12.61	25.56	27.97	29.83
B_2-*Pseudomonas fluorescens* @10g kg^{-1} FYM	14.63	24.96	29.45	32.72	16.36	24.80	32.92	37.38	12.36	24.97	26.73	28.61
B_3 -Neem cake @50g m^{-2}	14.25	22.82	28.21	31.58	16.06	23.62	32.32	36.62	12.07	21.30	24.86	26.85
SEm (±)	NS	0.365	0.348	0.297	NS	0.380	0.436	0.463	NS	0.398	0.398	0.398
$CD_{(0.05)}$		1.053	1.006	0.859		1.097	1.259	1.336		1.148	1.148	1.148

Leaf area was maximized in the N_2 treatment (293.96 cm²), likely due to improved nutrient absorption, especially nitrogen, which promoted vegetative growth (Yadav *et al*., 19). B_1 also resulted in a high leaf area (289.63 cm²), possibly because *Trichoderma* promotes the uptake and transport of minerals as well as the release of nutrients from soil or organic matter. Furthermore, auxins produced by *Trichoderma* spp. have the ability to promote leaf development (Md. *et al*.,12).

The minimum days to head initiation (47.64 days) were observed in N_2, possibly due to enhanced photosynthesis and earlier head development (Chitrakar, 6). B_1 also resulted in early head initiation (47.88 days), potentially due to organic acids from FYM aiding this process (Gadge, 8).

The maximum equatorial diameter (14.17 cm) and polar diameter (16.65 cm) were found in N_2 (Table 3). Among bio-pesticides, B_2 (*P. fluorescens* @10 g kg^{-1} FYM) achieved the highest equatorial diameter (14.12 cm) and polar diameter (16.44 cm), likely due to improved nutrient availability and soil properties (Bahadur *et al*., 3). The highest head weight (1.24 kg), head yield per plot (31.54 kg), and head yield per hectare (438.03 q) were recorded in N_2, possibly due to the promotion of vegetative growth by nitrogen fertilizers, leading to increased head weight (Boroujerdnia and Ansari, 5). B_2 also showed high head weight (1.25 kg), head yield per plot (30.88 kg), and head yield per hectare (428.86 q), which could be attributed to the synthesis of amino acids, vitamins, and other growth-promoting compounds, phosphate solubilising bacteria stimulate plant development and raise crop yield (Hasani and Aminpanah, 9). In order to change insoluble phosphates into soluble form and supply plants with phosphorus, PSB also release organic acids and enzymes. Additionally, it has been found that PSB strains function as effective bio-inoculants, increasing crop output and nutritional content (Singh *et al*., 15).

The maximum biological yield (1.90 kg) was observed in N_2, with B_2 also showing high biological yield (1.88 kg) (Table 4). This increase could be due to better root proliferation, nutrient uptake, and photosynthesis. The cumulative effects of plant growth and yield characteristics were primarily responsible for the increase in biological yield (Upadhyay *et al*., 16). The economic analysis revealed that the highest net income (383449.65

Table 2. Effect of nitrogen and bio-pesticides on plant spread, No. of jacket leaves and leaf area, stalk diameter and days taken to head initiation in red cabbage cv. Ruby Ball.

Treatment	Plant spread (cm)				No. of jacket leaves	Leaf area (cm^2)	Stalk length (cm)	Stalk diameter (cm)	Days taken to head initiation
	30 DAT	45 DAT	60 DAT	At harvest	Pooled	Pooled	Pooled	Pooled	Pooled
Factor A: Nitrogen									
N_0 -0 kg N ha^{-1}	27.89	44.43	53.96	59.02	5.28	255.31	5.93	3.38	57.33
N_1 -75 kg N ha^{-1}	29.18	49.55	61.17	67.11	5.74	281.41	7.20	3.79	53.02
N_2 -125 kg N ha^{-1}	29.73	54.25	66.03	75.28	6.81	293.96	8.09	4.18	47.64
N_3 -175 kg N ha^{-1}	29.62	52.60	64.36	72.87	6.64	290.21	7.83	4.10	48.59
SEm (±)	0.302	0.599	0.617	0.750	0.072	1.854	0.092	0.049	0.625
$CD_{(0.05)}$	0.873	1.728	1.782	2.166	0.208	5.355	0.266	0.142	1.805
Factor B: Bio-pesticides									
B_0 -No biopesticide	28.44	46.58	57.84	62.51	5.51	263.36	6.66	3.49	54.93
B_1 -*Trichoderma harzianum* @ 10 g kg^{-1} FYM	29.59	53.87	64.56	73.64	6.57	289.63	7.77	4.14	47.88
B_2 -*Pseudomonas fluorescens* @ 10 g kg^{-1} FYM	29.35	51.21	62.68	70.09	6.29	287.35	7.50	3.99	50.83
B_3 -Neem cake @50 g m^{-2}	29.04	49.17	60.43	68.03	6.10	280.56	7.13	3.83	52.95
SEm (±)	NS	0.599	0.617	0.750	0.072	1.854	0.092	0.049	0.625
$CD_{(0.05)}$		1.728	1.782	2.166	0.208	5.355	0.266	0.142	1.805

Table 3. Effect of nitrogen and bio-pesticides on equatorial diameter, polar diameter, average head weight and head yield in red cabbage cv. Ruby Ball.

Treatment	Equatorial diameter (cm)	Polar diameter (cm)	Av. head weight (kg plant^{-1})	Head yield (kg plot^{-1})	Head yield (q ha^{-1})
	Pooled	Pooled	Pooled	Pooled	
Factor A: Nitrogen					
N_0 -0 kg N ha^{-1}	11.91	12.87	0.93	22.40	311.09
N_1 -75 kg N ha^{-1}	13.03	15.47	1.12	26.88	373.31
N_2 -125 kg N ha^{-1}	14.17	16.65	1.31	31.54	438.03
N_3 -175 kg N ha^{-1}	13.83	16.27	1.25	29.96	416.08
SEm (±)	0.137	0.206	0.021	0.507	7.037
$CD_{(0.05)}$	0.397	0.594	0.061	1.463	20.323
Factor B: Bio-pesticides					
B_0 -No biopesticide	12.32	14.21	0.98	23.58	327.48
B_1 -*Trichoderma harzianum* @10 g kg^{-1} FYM	13.53	15.53	1.22	29.26	406.36
B_2 -*Pseudomonas fluorescens* @10 g kg^{-1} FYM	14.12	16.44	1.29	30.88	428.86
B_3 -Neem cake @50 g m^{-2}	12.97	15.08	1.13	27.06	375.81
SEm (±)	0.137	0.182	0.021	0.507	7.037
$CD_{(0.05)}$	0.397	0.527	0.061	1.464	20.326

Rs.ha^{-1}) and benefit: cost ratio (3.15) were achieved with the N_2B_2 treatment, likely due to the increased yield and nutrient availability (Bairwa, 4) (Table 5).

Table 4. Effect of nitrogen and bio-pesticides on biological yield and harvest index in red cabbage cv. Ruby Ball.

Treatment combination	Biological yield (kg plant^{-1})	Harvest index (%)
Nitrogen		
N_0 -0 kg N ha^{-1}	1.42	62.28
N_1 -75 kg N ha^{-1}	1.59	67.92
N_2 -125 kg N ha^{-1}	1.90	68.46
N_3 -175 kg N ha^{-1}	1.84	66.88
SE(m) ±	0.024	1.034
$CD_{(0.05\%)}$	0.068	2.987
Bio-pesticides		
B_0 -No biopesticide	1.48	62.25
B_1 -*Trichoderma harzianum* @10g kg^{-1} FYM	1.78	67.25
B_2 -*Pseudomonas fluorescens* @10g kg^{-1} FYM	1.88	68.09
B_3 -Neem cake @50g m^{-2}	1.60	67.97
SE(m) ±	0.024	1.034
$CD_{(0.05\%)}$	0.068	2.987

Finally, the highest harvest index (68.46%) was observed in N_2, potentially due to enhanced nutrient absorption and yield (Verma and Maurya, 17). B_2 also showed a high harvest index (68.09%), highlighting the importance of optimizing organic and bio-fertilizer combinations to maximize their efficiency.

AUTHOR'S CONTRIBUTION

DT, SSK conducted Field experiment, DT, DPK, GK collected the data, DT did formal analysis, SSK, SK reviewed the manuscript, GK involved in implementation.

DECLARATION

There is no conflict of interest among the authors.

REFERENCES

1. Anonymous, 2019. Final area and production estimates for horticulture crops for 2018-2019. *National Horticulture Mission*, Government of India.
2. Argemiro, P.M.F., Erika, V.D.M., Jesimiel, G.B., Jorge, M.P.B., Júlia, K.S., Cristina, S.M. 2019. Combined effecty of *Pseudomona*s sp. and *Trichoderma aureoviride* on lettuce growth promotion. *Biosci. J.* **35**: 419-30.

Table 5. Effect of bio-pesticides and nitrogen treated red cabbage on economic parameters.

Treatment	Total cost (₹)	Gross return (₹)	Net return (₹)	Benefit cost ratio
N_0B_0-0 kg Nha^{-1} + No biopesticide	117512.13	249978.33	132466.20	1.13
N_0B_1-0 kg N ha^{-1} + *Trichoderma harzianum* @ 10 g kg^{-1} FYM	121662.13	318865.00	197202.87	1.62
N_0B_2-0 kg N ha^{-1} + *Pseudomonas fluorescens* @ 10 g kg^{-1} FYM	120832.13	326085.00	205252.87	1.70
N_0B_3-0 kg N ha^{-1} + Neem cake @ 50 g m^{-2}	120467.13	307755.00	187287.87	1.55
N_1B_0-75 kg N ha^{-1} + No biopesticide	119921.04	326643.33	206722.29	1.72
N_1B_1-75 kg N ha^{-1} + *Trichoderma harzianum* @ 10 g kg^{-1} FYM	124071.04	379975.00	255903.96	2.06
N_1B_2-75 kg N ha^{-1} + *Pseudomonas fluorescens* @ 10 g kg^{-1} FYM	123241.04	379415.00	256173.96	2.08
N_1B_3-75 kg N ha^{-1} + Neem cake @ 50 g m^{-2}	122876.04	347748.33	224872.29	1.83
N_2B_0-125kgN ha^{-1} + No biopesticide	121527.02	339416.67	217889.65	1.79
N_2B_1-125 kg N ha^{-1} + *Trichoderma harzianum* @ 10 g kg^{-1} FYM	125677.02	479410.00	353732.98	2.81
N_2B_2-125 kg N ha^{-1} + *Pseudomonas fluorescens* @ 10 g kg^{-1} FYM	124847.02	508296.67	383449.65	3.07
N_2B_3-125 kg N ha^{-1} + Neem cake @ 50 g m^{-2}	124482.02	404970.00	280487.98	2.25
N_3B_0-150 kg N ha^{-1} + No biopesticide	122329.96	335528.33	213198.37	1.74
N_3B_1-150 kg N ha^{-1} + *Trichoderma harzianum* @ 10 g kg^{-1} FYM	126479.96	419970.00	293490.04	2.32
N_3B_2-150 kg N ha^{-1} + *Pseudomonas fluorescens* @ 10 g kg^{-1} FYM	125649.96	484965.00	359315.04	2.86
N_3B_3-150 kg N ha^{-1} + Neem cake @ 50 g m^{-2}	125284.96	392190.00	266905.04	2.13

3. Bahadur, A., Singh, J. and Singh, K.P. 2004. Response of cabbage to organic manures and biofertilizers. *Indian J. of Hortic.* **61**: 278-79.

4. Bairwa, H. L., Mahawer, L. N., Shukla, A. K., Kaushik, R. A. and Mathur, S. R. 2009. Response of integrated nutrient management on growth, yield and quality of okra. *Indian J.* Agric. *Sci.* **79**: 381-84.

5. Boroujerdnia, M. and Ansari, N.A. 2007. Effect of different levels of nitrogen fertilizer and cultivars on growth, yield and yield components of romaine lettuce (*Lactuca sativa* L.). *Middle Eastern and Russian J. Plant Sci. Biotechnol.* **1**: 47-53.

6. Chitrakar, A.N. 2004. Effect of combined case of organic manure and chemical fertilizers on growth and quality of cabbage (*Brassica oleracea* var. *capitata* L.). M.Sc. Thesis. Marathwada Agriculture University, Parbhani (M.S.).

7. Damke, M.M., Kawarkhe, V.J. and Patil, C.U. 1988. Effect of phosphorus and potassium on growth and yield of cabbage. *PKV Res. J.* **12**: 110-14.

8. Gadge, P. M. 2003. Effect of organic and inorganic fertilizers on the growth, yield and quality of cabbage (*Brassica oleracea* var. *capitata*). M.Sc. (Agri.) thesis, Marathwada Agriculture University, Parbhani.

9. Hasani, H. and Aminpanah, H. 2015. Effect of *Pseudomonas fluorescens* inoculation on yield and yield components of rice (*Oryza sativa* L.) under different levels of phosphorus fertilizer Thai J. Agric. Sci. **48**: 157-63.

10. Huang, J., Rucker, A., Schmidt, A., Gleixner, G., Gershenzon, J., Trumbore, S. and Hartmann, H. 2020. Production of constitutive and induced secondary metabolites is coordinated with growth and storage in Norway spruce saplings. *Tree Physiol.* **40**: 928-42.

11. Kaur, P., Singh, S.K., Kaur, R. and Sidhu, M.K. 2020. Response of different levels of nitrogen and spacing on growth and yield of cauliflower grown under central region of Punjab. *Int. J. Bio-resource Stress Man.* **11**: 320-26.

12. Md, Y.R., Pronay, B., Md, I.H. and Abul, K.A. 2016. Farmers livelihood due to salinity intrusion in Morelganj Upazila of Bangladesh. *Int. J. Business Social Sci. Res.* **4**: 83-88.

13. Ray, P.K., Adarsh, A. and Chaudhary, A. 2018. Effect of organic and inorganic fertilizers on yield

and economics of cabbage (*Brassica oleracea* var. *capitata*). *J. Pharmacogn. Phytochem.* **7**: 1967-70.

14. Shama, S.N., Alekhya, T. and Sudhakar, K. 2012. Pharmacognostical and phytochemical evaluation of *Brassica oleracea* Linn var. *capitata* f. *rubra* (red cabbage). *J. Pharm. Biol.* **2**: 43-46.

15. Singh, J.S., V.C. Pandey and D.P. Singh. 2011. Efficient soil microorganisms: a new dimension for sustainable agriculture and environmental development. *Agri. Ecosyst. Environ.* **140**: 339-53.

16. Upadhyay, A.K., Bahadur, A. and Singh, J. 2012. Effect of organic manures and biofertilizers on yield, dry matter partitioning and quality traits of cabbage (*Brassica oleracea* var. *capitata*). *Indian J. Agric. Sci.* **82**: 31-34.

17. Verma, R. and Maurya, B.R. 2013. Effect of bio-organics and fertilizers on yield and nutrient uptake by cabbage. *Ann. Plant Soil Res.* **15**: 35-38.

18. Wiczkowski, W., Szawara-Nowak, D., Romaszko, J. 2016. The impact of red cabbage fermentation on bioavailability of anthocyanins and antioxidant capacity of human plasma. *Food Chem.* **190**: 730-4.

19. Yadav, V.S., Yadav, B.D. and Sharma, Y.K. 2002. Effect of NICAST (organic manure) in comparison to recommended doses of manure and fertilizer in cabbage and onion. *South Indian Hortic.* **49**: 157-59.

Received : April, 2024; Revised : September, 2024; Accepted : September, 2024