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*Original Research Paper*

# Effect of nitrogen and potassium inputs on cabbage (*Brassica oleracea* var. *capitata*) production and profitability in the terai region of West Bengal

**Golay S.[1], Jana J.C.[1], Thapa A.[2*], Dutta S.[1], Roy M.[2] and Chakraborty S.[2]**

[1]Department of Vegetable Science, Uttar Banga Krishi Viswavidyalaya, Pundibari - 736 165, West Bengal, India
[2]Seacom Skills University, Kendradangal, Birbhum - 731 236, West Bengal, India
[*]Corresponding author Email: adimangarthapa@gmail.com

## ABSTRACT

A two years field experiment was conducted during the *rabi* seasons of 2019-20 and 2020-21 in factorial randomized design with three replications, consisting five levels of nitrogen (kg/ha) (75, 100, 125, 150 and 175) and four levels of potassium (kg/ha) (50, 75, 100 and 125) encompassing twenty treatments combination. The pooled analysis revealed that different doses nitrogen and potassium significantly influenced vegetative growth, yield and quality of cabbage. The combined application of nitrogen (175 kg/ha) + potassium (125 kg/ha) recorded the maximum plant height, stem diameter, head width, head weight, yield per plots and yield per hectare. From the economic analysis, the combined application of nitrogen (175 kg/ha) + potassium (125 kg/ha), and nitrogen (175 kg/ha) and potassium (100 kg/ha) recorded highest B:C ratio (1.95). From the above findings, it can be suggest that the combination of nitrogen (175 kg/ha) + potassium (125 kg/ha) will be profitable to the cabbage growers of West Bengal, India.

**Keywords:** Cabbage, fertilizer, growth, profitability, quality, yield

## INTRODUCTION

Among horticultural crops, vegetables have higher nutritional value, higher output, increased income per unit of land, are shorter in duration, high-yielding, and intensive in nature. Cabbage, family Cruciferae, is a biennial and herbaceous crop originating in Western Europe and the Northern Mediterranean coast. In India, cabbage leads globally in production and ranks second in area and production. In fiscal year 2023, the volume of cabbage production in India is estimated to have amounted to about 9.95 million metric tons with an area of about 428 hectares. (NHB, 2023). Cabbage is embraced for its nutritional benefits which have highest contribution in vitamin A, vitamin C, carotenoids, calcium, magnesium and some other dietary fibres (Singh et al., 2018). It keeps bones healthy, and it helps to reduce the risk of cancer and aids in reducing the blood pressure. Cabbage has low fats (0.1%) and carbohydrates (4.6%). The juice of cabbage is used for the remedy against poisonous mushroom and used for the gargle against the hoarseness (Sri et al., 2021).

Excessive amount of nitrogen may cause loose head formation and internal decay if nitrogen is not in adequate amount, it would not form heads (Singh et al., 2018). Potassium also plays a crucial role in overall plant growth as it regulates essential processes like photosynthesis, water uptake, disease resistance and nutrient transport, thereby enhancing head quality, taste and shelf life (Kuree et al., 2023). Insufficient nitrogen can prevent head formation, while a lack of potassium can lead to marginal necrosis and decreased head quality. Conversely, excess potassium may cause the cabbage heads to split (Gebeyaw & Belete 2020). Modern agriculture practice has led to severe problems of soil organic matter decline and widespread soil fertility depletion which are closely associated with fertilizer nutrient imbalance, nutrient gap between plant use and fertilizer application and mining out scarce native soil nutrients to support plant growth and yield (Chaudhary et al., 2024).

NPK supply is an important input for realizing higher cabbage yield (Hasan et al., 2018) with the advancement of time, balance nutrient application becoming more negative because most of our farmers are much interested using inorganic fertilizer for more production which in turn result in poor soil fertility, depletion in soil health and effect on overall environment. Keeping all the above points in view present study aims to provide insights into the effective

**Table 1 : Chemical properties of experimental soil (0-15 cm)**

| Characteristics | Content | Method employed |
|---|---|---|
| Sand | 65% | Hydrometer method |
| Silt | 18% | Hydrometer method |
| Clay | 16.1% | Hydrometer method |
| Bulk density | 1.25 mg/m$^3$ | By using core sampler |
| | Available nutrients (kg/ha) | |
| Nitrogen | 117.6 | Modified Macro Kjeldahl Method (Jackson, 1967) |
| Phosphorus | 14.98 | Bray's Method- Brayand Kurtz, 1945 (Jackson, 1967) |
| Potassium | 104.26 | Flame photometer method (Jackson, 1967) |
| Organic carbon (%) | 0.76 | Walkley & Black, 1934 |
| pH | 5.78 | Jackson,1973 |

utilization of fertilizers which may be beneficent in increasing cabbage productivity and also help to study the different levels of nitrogen, potassium and their interactive effect on growth, yield, and profitability of cabbage.

## MATERIALS AND METHODS

The study aimed to investigate the growth, yield, and economic viability of cabbage grown under different levels of nitrogen and potassium. The experiment was carried out at the instructional farm of Uttar Banga Krishi Vishwavidyalaya, West Bengal, India (26° 19' 86" N and 89° 23' 53" E, at an elevation of 43 meters above sea level during the *rabi* seasons of 2019-20 and 2020-21. The site featured sandy loam soil, characterized by its coarse texture, low water retention, and low pH. The climate of the *Terai* zone is constituted with high rainfall (average annual rainfall 210 cm to 330 cm), high relative humidity, moderate temperatures from 7-8°C to 24-33.2°C, extended winters, and significant residual soil moisture. Prior to planting, composite soil samples from each plot were collected and analyzed (Table 1).

The experimental setup in a factorial randomized block design with three replications, encompassing twenty plots. The treatments included five levels (kg/ha) of nitrogen (75, 100 125, 150 and 175) and four levels (kg/ha) of potassium (50, 75, 100 and 125). Standard crop management practices for the region were adhered to. The ascorbic acid content (mg/100 g) was estimated using 2, 6 dichlorophenol indophenols dye using 3% metaphosphoric acid as a stabilizing agent (Association of vitamin chemist, 1966). The data for an individual year were computed and the pooled mean was worked out to determine the significance of variation using Fisher and Snedecor's 'F' Test, with a 5% significance level, as per Fisher & Yates (1963). All statistical analyses were performed using INDOSTAT software.

## RESULT AND DISCUSSION

### Effect of nitrogen levels

Application of different doses of nitrogen significantly increased the growth, yield and quality parameters *viz*., plant height, stem diameter, head width, head weight, yield/plot, yield/hectare and vitamin C content (Table 2). Highest plant height (30.12 cm), stem diameter (20.77 mm), head width (13.43 cm), head weight (1.88 kg), yield/plot (60.46 kg) and yield/ha (70.50 t) were recorded in $N_5$ (175 kg/ha). The enhanced growth and yield parameters might be due to the fact that nitrogen being an important component of chlorophyll imparts green colour to the plants and improves photosynthesis which results into more production of photosynthates and nitrogen also enhances the cytokinin production in the roots of the plants and more cytokinin carried to the leaves, resulted in more cell division increase cell size and initiate meristematic activities when applied in optimum amounts (Gebeyaw & Belete 2020; Kurre et al., 2023; Katuwal et al., 2023). The better availability of nitrogen might have also favoured the metabolic and auxin activities in the plants and ultimately resulted in increased size, weight and yield of cabbage (Kaur et al., 2020; Brahmbhatt et al., 2023).

**Table 2 : Effect of different level of nitrogen and potassium on growth, yield and quality parameters of cabbage**

| Treatment | Plant height (cm) | Stem diameter (mm) | Head width (cm) | Head weight (kg) | Yield/ plot (kg) | Yield/ hectare (kg) | Ascorbic acid (mg/100 g) |
|---|---|---|---|---|---|---|---|
| Factor A | | | | | | | |
| $N_1$ (75 kg/ha) | 27.42 | 19.7 | 12.84 | 1.37 | 47.57 | 55.43 | 29.98 |
| $N_2$ (100 kg/ha) | 28.37 | 19.23 | 13.31 | 1.49 | 52.87 | 61.3 | 26.95 |
| $N_3$ (125 kg/ha) | 28.72 | 19.63 | 13 | 1.6 | 54.72 | 63.76 | 25.44 |
| $N_4$ (150 kg/ha) | 29.07 | 19.78 | 13.01 | 1.71 | 56.58 | 65.85 | 22.39 |
| $N_5$ (175 kg/ha) | 30.12 | 20.77 | 13.43 | 1.88 | 60.46 | 70.5 | 17.27 |
| SEm± | 0.46 | 0.52 | 0.28 | 0.06 | 0.78 | 1.46 | 0.59 |
| CD at 5% | 1.33 | 1.45 | 1.13 | 1.09 | 2.24 | 4.16 | 1.7 |
| Factor B | | | | | | | |
| $K_1$ (50 kg/ha) | 28.21 | 19.69 | 13.07 | 1.43 | 53.19 | 62.04 | 23.03 |
| $K_2$ (75 kg/ha) | 28.37 | 19.6 | 12.99 | 1.54 | 54.12 | 62.78 | 23.98 |
| $K_3$ (100 kg/ha) | 28.9 | 19.31 | 13.19 | 1.63 | 54.63 | 63.69 | 24.69 |
| $K_4$ (125 kg/ha) | 29.27 | 20.72 | 13.22 | 1.75 | 55.81 | 64.97 | 25.92 |
| SEm± | 0.41 | 0.59 | 0.23 | 0.08 | 0.69 | 1.32 | 0.54 |
| CD at 5% | 1.29 | 1.51 | 1.07 | 1.17 | 2.08 | 4.07 | 1.55 |
| Interaction (N+K) | | | | | | | |
| $N_1K_1$ | 26.05 | 19.17 | 12.75 | 1.21 | 45.32 | 52.77 | 29.09 |
| $N_1K_2$ | 27.44 | 19.89 | 12.38 | 1.25 | 46.6 | 54.32 | 29.08 |
| $N_1K_3$ | 28.22 | 19.83 | 13.31 | 1.35 | 47.55 | 55.44 | 30.26 |
| $N_1K_4$ | 27.91 | 19.84 | 12.92 | 1.43 | 50.81 | 59.18 | 31.48 |
| $N_2K_1$ | 28.37 | 19.59 | 13.78 | 1.44 | 51.5 | 60.19 | 26.66 |
| $N_2K_2$ | 28.23 | 19.47 | 13.21 | 1.47 | 53.18 | 60.71 | 26.64 |
| $N_2K_3$ | 28.27 | 18.2 | 12.81 | 1.5 | 52.89 | 61.59 | 26.63 |
| $N_2K_4$ | 28.54 | 19.65 | 13.42 | 1.51 | 53.9 | 62.7 | 27.88 |
| $N_3K_1$ | 28.53 | 20.45 | 12.98 | 1.53 | 54.15 | 63.12 | 24.25 |
| $N_3K_2$ | 27.78 | 18.47 | 12.99 | 1.54 | 54.6 | 63.55 | 24.22 |
| $N_3K_3$ | 29.42 | 19.76 | 13.34 | 1.56 | 54.82 | 63.97 | 26.62 |
| $N_3K_4$ | 28.83 | 19.85 | 12.7 | 1.57 | 55.3 | 64.39 | 26.65 |
| $N_4K_1$ | 29.19 | 19.55 | 12.65 | 1.58 | 55.56 | 64.65 | 19.38 |
| $N_4K_2$ | 28.75 | 19.79 | 12.98 | 1.59 | 56.39 | 65.61 | 22.97 |
| $N_4K_3$ | 28.82 | 19.38 | 13.27 | 1.6 | 57.08 | 66.48 | 22.99 |
| $N_4K_4$ | 29.13 | 20.51 | 13.14 | 1.65 | 57.28 | 66.66 | 24.2 |
| $N_5K_1$ | 29.12 | 19.48 | 13.2 | 1.68 | 59.42 | 69.45 | 15.75 |
| $N_5K_2$ | 29.5 | 20.22 | 13.39 | 1.72 | 59.82 | 69.69 | 16.98 |
| $N_5K_3$ | 30.08 | 19.31 | 13.2 | 1.74 | 60.8 | 70.95 | 16.96 |
| $N_5K_4$ | 31.45 | 23.32 | 13.93 | 1.78 | 61.78 | 71.9 | 19.4 |
| SEm± | 0.9 | 0.95 | 0.52 | 0.07 | 1.53 | 2.9 | 1.17 |
| CD at 5% | 1.77 | 1.88 | 1.41 | 1.11 | 2.41 | 4.5 | NS |

Significant observations were recorded in quality parameters of cabbage *viz*., highest vitamin C content (29.98 mg/100 g) was observed with the application of nitrogen 75 kg/ha ($N_1$) at the time of harvest. The increase in vitamin C with a decrease in nitrogen level might be due to the increase level of nitrogen could increase the concentration of $NO_3$ (nitrate) in the plant, which may lead to the decrease of vitamin C concentration in cabbage for that reason the treatment with minimum supply of nitrogen at 75 kg/ha recorded highest vitamin C content in cabbage. Muhammad et al. (2024) also reported that ascorbic acid content decrease with increase the concentration of nitrogen in cauliflower.

Similarly, available soil nitrogen and phosphorous were significantly influenced by different dosages of nitrogen application (Table 3). The maximum available soil nitrogen (145.93 kg/ha) and phosphorous (12.52 kg/ha) was observed with nitrogen application at 175 kg/ha. Similarly, the available potassium was also significantly influenced by different levels of nitrogen application. The maximum available soil potassium (47.53 kg/ha) was recorded with nitrogen application at 75 kg/ha.

**Table 3 : Effect of different level of nitrogen and potassium on residual nutrient status**

| Treatment | Available soil nitrogen (kg/ha) | Available soil phosphorous (kg/ha) | Available potassium (kg/ha) |
|---|---|---|---|
| Factor A | | | |
| $N_1$ (75 kg/ha) | 67.59 | 10.79 | 47.53 |
| $N_2$ (100 kg/ha) | 91.59 | 11.27 | 48.02 |
| $N_3$ (125 kg/ha) | 116.71 | 12.00 | 46.28 |
| $N_4$ (150 kg/ha) | 128.19 | 12.47 | 46.95 |
| $N_5$ (175 kg/ha) | 145.96 | 12.55 | 45.73 |
| SEm± | 3.77 | 0.36 | 0.85 |
| CD at 5% | 10.80 | 1.05 | 2.23 |
| Factor B | | | |
| $K_1$ (50 kg/ha) | 109.99 | 10.20 | 38.02 |
| $K_2$ (75 kg/ha) | 110.83 | 11.51 | 44.24 |
| $K_3$ (100 kg/ha) | 107.51 | 12.28 | 49.44 |
| $K_4$ (125 kg/ha) | 111.70 | 13.27 | 55.89 |
| SEm± | 3.35 | 0.34 | 0.75 |
| CD at 5% | 10.25 | 1.03 | 2.13 |
| Interaction (N+K) | | | |
| $N_1K_1$ | 66.52 | 9.51 | 38.18 |
| $N_1K_2$ | 70.73 | 10.25 | 45.93 |
| $N_1K_3$ | 58.20 | 12.80 | 50.48 |
| $N_1K_4$ | 74.90 | 10.58 | 55.52 |
| $N_2K_1$ | 91.55 | 10.66 | 38.86 |
| $N_2K_2$ | 87.41 | 9.25 | 46.13 |
| $N_2K_3$ | 95.79 | 10.29 | 49.21 |
| $N_2K_4$ | 91.62 | 14.88 | 57.87 |
| $N_3K_1$ | 116.72 | 9.70 | 35.97 |
| $N_3K_2$ | 116.71 | 13.45 | 44.33 |
| $N_3K_3$ | 112.50 | 10.96 | 47.44 |
| $N_3K_4$ | 120.90 | 13.89 | 57.37 |
| $N_4K_1$ | 129.22 | 9.25 | 39.12 |
| $N_4K_2$ | 133.38 | 13.95 | 43.38 |
| $N_4K_3$ | 120.88 | 10.51 | 50.29 |
| $N_4K_4$ | 129.29 | 16.15 | 54.99 |
| $N_5K_1$ | 145.92 | 11.89 | 37.98 |
| $N_5K_2$ | 145.94 | 10.66 | 41.45 |
| $N_5K_3$ | 150.19 | 16.82 | 49.76 |
| $N_5K_4$ | 141.8 | 10.84 | 53.71 |
| SEm± | 7.50 | 0.71 | 1.66 |
| CD at 5% | NS | 1.98 | NS |

**Effect of potassium levels**

Application of different levels of potassium revealed a significant effect on growth, yield and quality parameters of cabbage (Table 2). The maximum plant height (29.27 cm), stem diameter (20.72 cm), and head width (13.22 cm) were observed with the application of potassium at 125 kg/ha ($K_4$). Similarly, the highest head weight (1.75 kg), yield per plot (58.81 kg) and yield per hectare (64.97 t) were recorded with potassium application at 125 kg/ha ($K_4$). Potassium is necessary for young-growing tissue cell elongation and possibly for cell division. It also has an important role in maintaining turgor pressure (Hussain et al., 2019). It also enhances plant vigor and strengthens the stalk, further synergistic effect with nitrogen and phosphorous resulted in growth and development. It also acts as an essential nutrient for plant growth and plays an important role in many metabolic processes such as uses of water, photosynthesis and synthesis of amino acids and protein and translocation of sugar and assimilation within the plant, and the accumulation of high molecular carbohydrate necessary for plant growth as well as formation and development of fruits which leads to increase growth and yield (Srivastava et al., 2018).

Maximum vitamin C content (25.88 mg/100 g) was observed under $K_4$ (potassium at 125 kg/ha). Potassium helps in the movement of nitrogen from the roots to the shoots and carbon from the shoots to the roots, fruits, and other organs. When there is an adequate supply of potassium plants uptake more nitrogen and convert the nitrogen more rapidly into protein (Singh et al., 2021). Bhattarai & Swarnima (2016) reported that vitamin C content increased with increased application of potassium fertilizer in potato tuber.

Similarly, the different potassium levels also showed significant variation in residual soil nutrient status after harvesting (Table 3). Maximum values regarding available nitrogen (111.70 kg/ha), phosphorous (13.27 kg/ha) and potassium (55.89 kg/ha) in soil were recorded with an application of potassium at 125 kg/ha ($K_4$) in both the seasons.

**Interaction effect of nitrogen and potassium**

On the perusal of data presented in Table 2, indicated that growth, yield and quality parameters were significantly affected by the combination application of different levels of nitrogen and potassium. Maximum plant height (31.42 cm), stem diameter (23.32 mm), head width (13.93 cm), head weight (1.78 kg), yield per plot (61.78 kg) and yield per hectare (71.90 t) were recorded in treatment combination of $N_5K_4$ (nitrogen at 175 kg/ha + potassium at 125 kg/ha). The appreciable effect on crop productivity was recorded due to the interactive effect of different doses of nitrogen and potassium. Combine application of nitrogen and potassium increase the growth and attributing parameters of cabbage which might be due to because of fact that plant is getting appropriate amount of nitrogen and potassium. With the increase level of nitrogen and potassium possibly helped in the expansion of leaf area and chlorophyll content which together might have accelerated the photosynthetic rates and in turn increased the supply of carbohydrate to plant. These results are also conformity with the findings of Tripathi et al. (2020) in broccoli and Hange et al. (2020) in knol khol.

Similarly, the vitamin C content of cabbage was insignificantly affected by combinations of different levels of nitrogen and potassium. The better availability of nitrogen might have also favoured the metabolic and auxin activities in the plants and ultimately resulted in increased size, weight and yield of cabbage (Verma & Nawange 2015; Kurre et al., 2023). It plays an important role in many metabolic processes such as uses of water, photosynthesis and synthesis of amino acids and protein and translocation of sugar and assimilation within the plant and the accumulation of high molecular carbohydrates (Bajpai et al., 2023). Therefore, the combined application of nitrogen and potassium at adequate levels increases the many metabolic processes which enhance vegetative growth and better development of heads. The treatment combination $N_5K_4$ (nitrogen 175 kg/ha + potassium 125 kg/ha) and $N_5K_3$ (nitrogen 175 kg/ha + potassium 100 kg/ha) recorded highest B:C ratio (1.95), followed by $N_5K_2$ (nitrogen 175 kg/ha + potassium 75 kg/ha) (1.95).

**Table 4 : Effect of different levels of nitrogen and potassium on economics**

| Treatment | Cost of cultivation (Rs.) | Gross return (Rs.) | Net return (Rs.) | B:C ratio |
|---|---|---|---|---|
| $N_1K_1$ | 134600 | 310300 | 175700 | 1.31 |
| $N_1K_2$ | 137000 | 319350 | 182350 | 1.33 |
| $N_1K_3$ | 138600 | 325950 | 187350 | 1.35 |
| $N_1K_4$ | 140200 | 348150 | 207950 | 1.48 |
| $N_2K_1$ | 135800 | 353900 | 218100 | 1.61 |
| $N_2K_2$ | 138200 | 357200 | 219000 | 1.58 |
| $N_2K_3$ | 139800 | 362150 | 222350 | 1.59 |
| $N_2K_4$ | 141400 | 368700 | 227300 | 1.61 |
| $N_3K_1$ | 136400 | 371200 | 234800 | 1.72 |
| $N_3K_2$ | 138800 | 373650 | 234850 | 1.69 |
| $N_3K_3$ | 140000 | 378650 | 238650 | 1.7 |
| $N_3K_4$ | 142000 | 378600 | 236600 | 1.67 |
| $N_4K_1$ | 137000 | 380250 | 243250 | 1.78 |
| $N_4K_2$ | 139400 | 386000 | 246600 | 1.77 |
| $N_4K_3$ | 141000 | 390950 | 249950 | 1.77 |
| $N_4K_4$ | 142600 | 391750 | 249150 | 1.75 |
| $N_5K_1$ | 137600 | 402250 | 264650 | 1.92 |
| $N_5K_2$ | 140000 | 409900 | 169900 | 1.93 |
| $N_5K_3$ | 141600 | 417300 | 275700 | 1.95 |
| $N_5K_4$ | 143200 | 423050 | 279850 | 1.95 |

## CONCLUSION

Based on the present study, it is concluded that different nutritional sources (nitrogen and potassium) significantly influenced vegetative growth, yield, and quality characteristics of cabbage. From the economic analysis, combined application of nitrogen 175 kg/ha + potassium 125 kg/ha, and nitrogen 175 kg/ha + potassium 100 kg/ha can be recommended for higher profit for the cabbage growers of West Bengal.

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