# Optimizing Nutrient Management Practices for Cauliflower in Hill Zone of West Bengal: An Integrated Approach


## ABSTRACT

A set of experiments was conducted at Hill Zone of West Bengal, Kalimpong for two seasons (2019 & 2020) to standardize integrated nutrient management for optimum growth and yield of cauliflower. Different organic nutrient sources, such as farm yard manure (FYM), poultry manure (PM), and vermicompost (VC), were used to partially replace the recommended dose of chemical fertilizer. The treatments we used were as follows: $T_1$= $N_{120}$ $P_{60}$ $K_{60}$ (RDF), $T_2$= 75% RDF+25% N through FYM (FYM@ 6 t $ha^{-1}$), $T_3$= 75% RDF+25% N through VC (VC@ 2 t $ha^{-1}$), $T_4$= 75% RDF+25% N through (PM@ 1.25 t $ha^{-1}$), $T_5$= 75% RDF+25% N through FYM + Foliar spray of B, $T_6$= 75% RDF+25% N through FYM + Soil application of B, $T_7$= 75% RDF+25% N through VC + Foliar spray of B, $T_8$= 75% RDF+25% N through VC + Soil application of B, $T_9$= 75% RDF+25% N through PM + Foliar spray of B, $T_{10}$= 75% RDF+25% N through PM + Soil application of B. The treatments were set up in a randomized block design with three replication. The treatments had a significant ($P<0.05$) effect on cauliflower yield and soil-available macro and micronutrients due to integrated nutrient management. The maximum plant height (45.9 cm), curd wt. $plant^{-1}$ (537.2 g), stalk wt. $plant^{-1}$ (227.3 g), and curd yield (162.1q $ha^{-1}$) was achieved with $T_9$ treatment *i.e* 75% RDF+25% N through PM + Foliar spray of B. Therefore, application of 75 percent of RDF and 1.25 t $ha^{-1}$ poultry manure along with foliar spray of boron at 25 and 40 days after transplanting is recommended.



**Keywords:** Boron, FYM, Nutrient availability, Poultry manure, Vermicompost.


## INTRODUCTION

Indians eat a variety of vegetables every day because they contain the necessary nutrients for health and sustenance. Growing population is a challenging because our need for vegetables has increased to 143 million tonnes in 2017 in order to fulfil the minimum per capita recommended quantity of 285 g $head^{-1}day^{-1}$ compared to the current availability of 210 g $head^{-1}day^{-1}$. Vegetable productivity needs to rise by between 200 and 300 percent from its current level in order to meet the required goal. However, over the past few decades, India has made significant strides in the production of vegetables (from 125 million tonnes in 2007-2008 to 175.2 million tonnes in 2017-2018 from 11.2 million ha of land), ensuring the country's place as the second-largest producer of vegetables in the world behind China. West Bengal leads among the major vegetable-producing States with an estimated 25.47 (12%) million tonnes produced. In West Bengal's Hill Zone, encompassing the districts of Kalimpong and Darjeeling, vegetables are actually one of the key crops grown here.

Due to rising demand, commercial cauliflower cultivation has been expanding daily. Cauliflower production and yield in these regions, however, are uncertain. Poor nutrient management practices and, secondarily, the absence of a research-based nutrient management programmes for this crop were two of the main causes of this uncertainty. To boost output, cauliflower needs a steady supply of high amounts of macro- and micronutrients, which means that optimal fertilization schedules must be developed. On the other hand excessive inorganic fertilizer application poses a risk to public and environmental health. In this regard, integrated nutrient management with micronutrient B has significantly importance in recent years in the cultivation of brassica vegetables for two reasons. First, adequate nutrients are necessary for the ongoing growth in the per-hectare yield of brassica. Second, the results of multiple investigations on manures and fertilizers carried out in different countries showed that neither chemical fertilizers alone, nor sources obtained exclusively from organic materials, can sustain the productivity of soils under highly intensive cropping systems for brassica vegetables.

N fertilizer is typically used indiscriminately by cauliflower producers in large quantities, while phosphate and potassic fertilizer use is either extremely constrained or excessive. Due to insufficient application of organic manures, soil health deteriorates and secondary and micronutrients are depleted. For plants to produce high yields and high-quality products, macro and micronutrient fertilization must be balanced Swan Z. M. [18]; Ali S. [2]. The effects of macro and micronutrients on crop growth and yield parameters are, however, not well understood Islam M. [8]; May G.M [10]. Applications of NPK fertilizer do not fully compensate for the loss of boron by crops, which causes a boron shortage in the soil. According to Ouda et al. [12], boron shortage substantially inhibits plant growth. In fact, micronutrient deficiencies, especially boron, are common in high density cropping system. Low productivity, low nutrient usage efficiency, and poor quality of cauliflower and brassica are frequently caused by imbalanced fertilizer application with more N, less P, and K, as well as absence of micronutrients.

Therefore, in order to boost yield and give farmers a high income, efforts were undertaken to create fertilization schedules for cauliflower in the acidic hill region of West Bengal. Additionally, this will guarantee food security for numerous underprivileged rural areas.

## MATERIALS AND METHODS

*Experimental site description*

The experiment was carried out at Regional Research Station (Hill Zone), Uttar Banga Krishi Viswavidyalaya, Kalimpong, West Bengal (latitude 27°31' N, longitude 88°28' E, and altitude of 1097 m.a.s.l) in the years 2019–20. The climate is subtropical and humid. The soils depth ranges from fairly shallow to relatively deep (80-120 cm). Table 1 shows the soil's nutrient level prior to the start of the experiment. The area receives an average of 2231 mm of annually. The monthly mean air temperature ranges between 8 and 27 °C. Figure 1 depicts the normal monthly weather characteristics for the study area.

Table 1: Soil nutrient status before the start of the Experiment.

| **Properties** | **Characteristic value** |
|---|---|
| Soil type | Sandy loam |
| Soil pH | Acidic (Value 5.22) |
| EC (d S $m^{-1}$) | 0.012 |
| Available N (Kg $ha^{-1}$ ) | 254.4 |
| Available phosphorus (Kg $ha^{-1}$ ) | 38.5 |
| Available potassium (Kg $ha^{-1}$ ) | 158.5 |
| Soil organic carbon (%) | 1.24 |

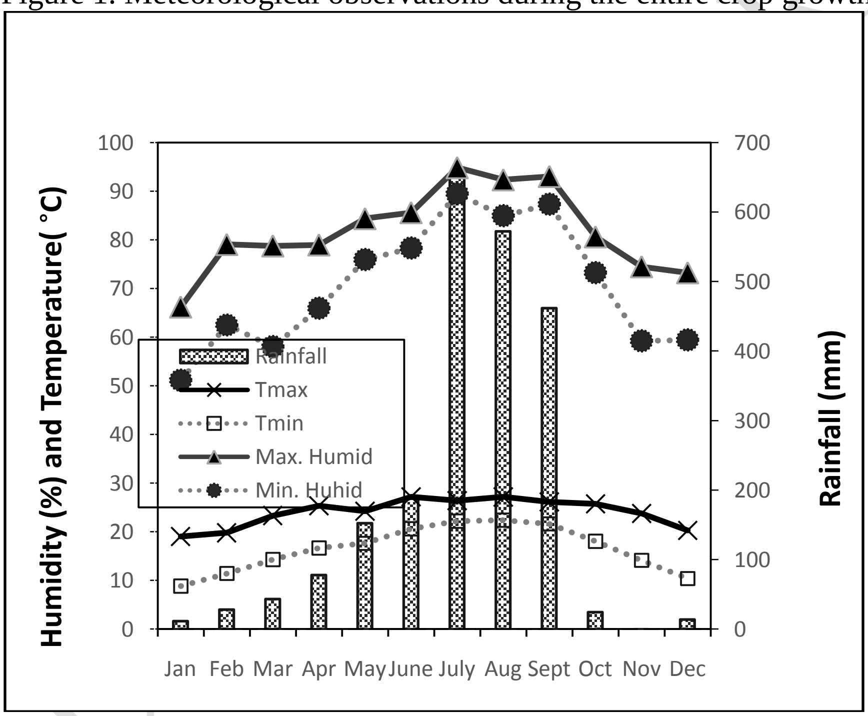
*List 1 : Treatment details*

| Abbreviation | Treatment |
|---|---|
| $T_1$ | N120 P60 K60 (RDF) |
| $T_2$ | 75% RDF+25% N through FYM (FYM@ 6 t $ha^{-1}$) |
| $T_3$ | 75% RDF+25% N through VC (VC@ 2 t $ha^{-1}$) |
| $T_4$ | 75% RDF+25% N through (PM@ 1.25 t $ha^{-1}$) |

| | |
|---|---|
| $T_5$ | 75% RDF+25% N through FYM + Foliar spray of B |
| $T_6$ | 75% RDF+25% N through FYM + Soil application of B |
| $T_7$ | 75% RDF+25% N through VC + Foliar spray of B |
| $T_8$ | 75% RDF+25% N through VC + Soil application of B |
| $T_9$ | 75% RDF+25% N through PM + Foliar spray of B |
| $T_{10}$ | 75% RDF+25% N through PM + Soil application of B |

Cauliflower variety 'madhuri' seedlings were transplanted in the field with 45*45 cm spacing, and the experimental plot was kept at a size of 10sqm (2.5 m * 4 m). Distinct organics source were used for all of these treatments. The B was applied using two distinct methods: (a) foliar spraying with boron at 1.25 g/lit; and (b) soil application with boron at 10 kg $ha^{-1}$. At 25 and 40 days after transplanting (DAT), a foliar spray was applied twice, and at 25 DAT, soil-applied boron (borax) was applied. Inorganic fertilizer was applied in two equal halves: 50% at 30 DAT and another 50% at 45 DAT. Half of the N, along with the full amounts of P and K, were applied during the final land preparation.

Figure 1. Meteorological observations during the entire crop growth period.




*Harvesting and plant data collection*

At the harvesting stage, six plants were randomly chosen from each plot, excluding the boundary area. The plant heights were measured in centimeters (cm) above the ground, and the average height was noted. Six plants were gathered at harvest, and the stalk yield and curd yield was recorded.

*Soil analysis*

After the harvesting of crop in each season, a soil sample was taken from each experimental plot (15 cm depth). Following air drying in a shed, the soil was run through a 2 mm screen for soil chemical analysis. The pH of the soil was measured using the glass electrode method in a suspension of 1:2.5 soil and water, Jackson (1973). Soil organic carbon was measured using the wet digestion method developed by Walkley and Black in 1934. With the use of the Bray and Kurtz No. 1 extractant, the soil's readily available phosphates were determined (Bray and Kurtz, 1945). The neutral normal ammonium acetate method was used to determine the potassium content of the soil (Jackson, 1973). Azomethine-H technique was used to determine the available B status in the soil sample (Bingham 1982). Micronutrients in the soil (Fe, Mn, Cu, and Zn) were identified using DTPA extraction techniques (Lindsay and Norvell, 1978). Atomic absorption spectrophotometer (AAS) was used to quantify micronutrients in the extract.

*Statistical analysis*

A randomized block design with three replications was used. The data gathered was assembled and tallied. A statistical analysis was carried out to establish the significance of variance generated by experimental treatments. The data was evaluated using the analysis of variance (ANOVA) method using SPSS 10 software.

**Results and discussion**

*Effect of INM on yield attributing characters of cauliflower*

Plant height increased with the advancement of crop age. According to the findings shown in Table 2, the treatments had a substantial impact on the height of the cauliflower plants. The highest plant height (45.9 cm) was recorded by treatment T9 (75% RDF+25% N through PM + Foliar spray of B). This treatment was statistically comparable to treatments T7 i.e. 75% RDF+25% N through VC+ foliar spray of B (45.7 cm). However, treatment T1 i.e. N120 P60 K60 had the smallest plant height (37.3 cm). It was also noted that application of half dose of NPK $ha^{-1}$ + poultry manure 3 t $ha^{-1}$ resulted in the highest plant height according to Shanta el al. [16]. The increase in plant height may be caused by the availability of more micronutrients to the plant, which increases the foliage of the plant and thereby increases photosynthesis. According to Ali and Kashen [1], the application of a half dose of NPK along with vermicompost at a rate of 5 t $ha^{-1}$ led to the highest plant height for cabbage. Similar results showed that the application of half the recommended NPK along with 2.5 t $ha^{-1}$ of vermicompost led to the highest plant height in cabbage, according to Singh et al. [17].

Table 2. Effect of sources of nutrients on yield and yield attributing characters of cauliflower.

| Treatments | Plant height (cm) | Curd wt.$plant^{-1}$ (g) | stalk wt.$plant^{-1}$ (g) | curd yield (q $ha^{-1}$) | % change of yield |
|---|---|---|---|---|---|
| T1 | 37.3 | 512.4 | 195.5 | 124.5 | |
| T2 | 41.2 | 527.2 | 206.4 | 134.1 | 7.2 |
| T3 | 41.8 | 522.7 | 204.4 | 130.2 | 4.4 |
| T4 | 41.6 | 527.1 | 209.7 | 130.2 | 4.4 |
| T5 | 45.7 | 534.1 | 225.3 | 158.1 | 21.3 |
| T6 | 44.5 | 532.1 | 220.7 | 157.2 | 20.8 |
| T7 | 45.2 | 535.3 | 221.3 | 156.8 | 20.6 |
| T8 | 44.6 | 533.3 | 223.3 | 158.8 | 21.6 |
| T9 | 45.9 | 537.2 | 227.3 | 162.1 | 23.2 |
| T10 | 45.0 | 536.5 | 225.2 | 160.6 | 22.5 |
| SEm (±) | 0.46 | 0.77 | 0.82 | 0.98 | |
| CD (P=0.05) | 1.28 | 2.51 | 2.33 | 2.23 | |

The various treatments have a substantial impact on the curd weight of cauliflowers. Treatment T9 (75% RDF+25% N through PM + Foliar spray of B) recorded the largest curd weight (537.2 g) among the various nutrient management treatments, which was noticeably higher than other treatments. The soil's physico-chemical and biological properties have been enhanced by the combined application of inorganic and organic fertilizers, which have also increased the concentration of vital nutrients in soil solution and led to improved curd weight and steady uptake of essential nutrients. These results coincide with the findings reported by Devi et al. [5], who suggested that the most effective approach for cauliflower productivity is application of 80% NPK and 20% N through FYM and vermicompost. According to Neupane et al. [11] the highest curd weight of cauliflower was obtained when 50% of the nitrogen was applied using RDF and 50% through vermicompost.

The data provided in table 2 indicated that various treatment combinations had a significant impact on the effect of INM on stalk weight per plant. T9 plants had the most (227.3 g) and T1 plants had the least (195.5 g) stalk weight per plant. Due to rapid cell division, multiplication, and elongation in the meristematic zone of the plant, which encouraged vegetative growth of the plant, the stalk weight was greatly influenced by integrated nutrient consumption [5].

The addition of organic sources of nutrients (FYM, VC, and PM) coupled with inorganic fertilizers had a substantial impact on curd yield, according to two years of field experiments (2019 and 2020). The curd production of cauliflower under the various treatments imposed ranged from 124.5 to 162.1 q ha$^{-1}$ (Table 2). The T1 (100% RDF through inorganic fertilizer) plot had the lowest curd production, while the T9 treatment (75% RDF + 25% PM+ foliar boron spray) had the highest. Hashi et al. [6] reported the maximum curd yield (36.34 q ha$^{-1}$) through 120:60:100:20 NPKS, Bo 0.6 kg ha$^{-1}$, Mo 0.54 kg ha$^{-1}$ along with 4 t ha$^{-1}$ vermicompost and 5 kg ha$^{-1}$ biofertilizer application at Dhaka, Bangladesh. A larger curd yield may be the result of improved curd compaction due to better soil and fertilizer management. This findings is also supported by Sagar et al. [14].

It was fund that the incorporation of boron fertilizer significantly affected the growth characteristics of cauliflower. This impact of micronutrient B integration may result from improvements in plant physiology that promote effective curd compaction in cauliflower. This observation was corroborated by the findings of Chongbang et al. [4], Snageeta et al [15]. The application of B considerably enhanced the vegetative growth and quality characteristics of cauliflower, according to Chattopadhyay and Mukhopadhyay [3]. Hossain et al. [7] found the response of different doses of NPK and boron on cauliflower growth and yield and revealed that maximum yield was achieved by application $N_{120}P_{120}K_{100}S_{20}B_1Mo_{0.2}$ kg ha$^{-1}$ in Bangladesh.

*Effect of INM on soil chemical properties*

The results of a two-year experiment revealed that varied fertiliser sources (FYM, VC, PM, inorganic, and B) caused significant differences in soil properties (Table 3). After two years of data collection, soil pH increased due to INM treatment. Proper fertiliser management practises had little impact on soil pH. There were highest increase in pH was found in $T_6$ and $T_8$ treatment

Table 3. Effect of sources of nutrients on some important properties of residual soils collected after each years of experiment.

| Treatment (Dose/ha) | Soil pH (1:25) | Organic carbon (%) | Available nutrients | | | Available B (mg $kg^{-1}$) | DTPA extractable micronutrient (mg $kg^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | N (kg $ha^{-1}$) | P (kg $ha^{-1}$) | $K_2O$ (kg $ha^{-1}$) | | Fe | Mn | Zn | Cu |
| T1 | 5.2 | 1.23 | 259.5 | 41.38 | 160.75 | 0.43 | 208.4 | 31.87 | 0.48 | 5.54 |
| T2 | 5.1 | 1.34 | 255.6 | 42.18 | 166.05 | 0.46 | 203.9 | 32.55 | 0.52 | 5.84 |
| T3 | 5.3 | 1.35 | 263.2 | 43.35 | 167.35 | 0.43 | 210.0 | 32.36 | 0.41 | 5.82 |
| T4 | 5.2 | 1.33 | 260.9 | 43.56 | 170.05 | 0.43 | 210.7 | 33.35 | 0.43 | 5.77 |
| T5 | 5.3 | 1.39 | 261.6 | 44.03 | 170.15 | 0.60 | 207.1 | 32.85 | 0.40 | 5.16 |
| T6 | 5.4 | 1.30 | 254.9 | 43.46 | 166.15 | 0.92 | 210.1 | 32.27 | 0.51 | 5.48 |
| T7 | 5.3 | 1.40 | 266.1 | 43.34 | 171.45 | 0.55 | 205.9 | 33.18 | 0.42 | 8.44 |
| T8 | 5.4 | 1.32 | 262.7 | 43.60 | 168.35 | 0.94 | 210.0 | 33.54 | 0.31 | 5.71 |
| T9 | 5.3 | 1.44 | 258.4 | 43.13 | 175.45 | 0.74 | 208.5 | 33.77 | 0.43 | 8.86 |
| T10 | 5.2 | 1.46 | 258.7 | 43.43 | 161.45 | 0.89 | 208.6 | 32.57 | 0.41 | 5.70 |
| SEm (±) | 0.03 | 0.01 | 1.24 | 0.19 | 1.26 | 0.02 | 0.64 | 0.25 | 0.005 | 0.02 |
| CD (P=0.05) | 0.09 | 0.05 | 3.78 | 0.56 | 4.45 | 0.04 | 1.76 | 0.73 | 0.007 | 0.05 |

(5.4). This increase in pH could be due to the proper usage of N fertiliser and the addition of organics that contain a high amount of calcium and magnesium. The organic carbon content in the soil was found maximum (1.46 %) with $T_{10}$ (75 % RDF+ 25% N through PM+ soil application of B). Availability of major plant nutrients like N, $P_2O_5$, $K_2O$, was also affected by the treatments imposed. On an average, available N, $P_2O_5$ and $K_2O$ content of the soil increased over the initial values. The contents of available N, $P_2O_5$ and K2O ranged from 254.9 to 266.1, 41.38 to 44.03 and 160.75 to 175.45 kg $ha^{-1}$. The highest (266.1 kg $ha^{-1}$) and lowest (254.9 kg $ha^{-1}$) N content in soil after harvesting were obtained from $T_7$ (75 % RDF+ 25 % N through VC+ foliar application of boron) and $T_6$ (75% RDF+

25 % N through FYM + soil application of B) treatments respectively. The highest (44.03 kg $ha^{-1}$) and lowest (41.38 kg $ha^{-1)}$ value of $P_2O_5$ was obtained from $T_5$ (75% RDF+ 25% N through FYM+ foliar application of B) and $T_1$ (100% RDF) treatments. However the highest (175.45 kg $ha^{-1}$) and lowest (160.75 kg $ha^{-1}$) value of $K_2O$ was obtained from $T_9$ (75% RDF+25% N through PM + Foliar spray of B) and $T_1$ (100% RDF) treatment respectively. Higher soil available P and K were found after application of organic manure source as it reduces the P and K absorption sites.

Sharma *et al*. (2005) studied the response of cauliflower (B. oleracea var. botrytis) in Himachal Pradesh, to integrated use of chemical fertilizers and farmyard manure. The use of 150% NPK+20 t $ha^{-1}$ farmyard manure resulted in the largest increase in organic carbon, accessible N, P, and K content over baseline values. The treatments also influenced the availability of micronutrients in the soil, including B, Fe, Mn, Zn, and Cu. In contrast, after two years of continuous treatment of boron (10 kg $ha^{-1}$) in the same plot area, there was a small increase in accessible boron concentration in soil. Parmar et al. [13] evaluated the nutrient content of Chinese cabbage and reported that utilizing B fertilizers in addition to the recommended NPK and FYM significantly increased the availability of B in the soil. Other micronutrients extracted with DTPA showed a small increase in content from their starting levels.

**Conclusion**

Total biomass yield, curd yield and yield attributing parameters viz., plant height, average curd weight per plant, stalk weight of cauliflower were significantly influenced by different levels and sources of nutrients. Combined application of organic and inorganic sources of nutrients produced the highest yield (162.1 q $ha^{-1}$). So, 75% RDF+25% N through PM along with B @ 1.25% sprayed twice at 25 and 40 days after transplanting was found to be the best treatment.

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