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# Fertilizer Prescription under Chemical and INM Mode for Targeted Yield of Cauliflower [*Brassica oleracea* (L.) *var. botrytis*] in Mollisol of North India

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## ABSTRACT

On cauliflower, the effect of soil test crop response (STCR) was examined in the Mollisol region of North India. Its primary objective was to create fertilizer guidelines by utilizing chemical and integrated nutrient management (INM) practices. The trial was split into two parts: first, a preparatory test was done on maize during the *kharif* season. Then, during the *rabi* season, cauliflower was used to test different combinations of fertilizers at varying fertility levels. The experiment aimed at determining how cauliflower responded to combinations of farm yard manure, nitrogen, phosphorus, and potassium. To achieve this, a set of fertilizer prescription equations was formulated using both chemical and INM approaches. These equations took into consideration crop's nutrient requirements, soil, fertilizer and the farm yard manure (FYM) efficiency. Using these equations, ready reckoners for fertilizer prescription were created and tested in real farm situations. Ultimately, the study found that the targeted yield approach was more effective than general fertilizer recommendations.

**Key words:** Cauliflower, fertilizer prescription equation, STCR, INM

## INTRODUCTION

The modern way of farming is encountering an extraordinary obstacle in future food production, because of increasing population and the global climate change (Bhandari *et al.*, 2023). Ensuring soil health is a challenging task, particularly in the context of national food security and sustainable agricultural production.The All India Coordinated Research Project (AICRP) centers across India, which focus on soil test crop response (STCR), have created equations that incorporate organic manures and/or biofertilizers to determine the precise nutrient requirements for a particular crop yield target. Nevertheless, there is limited information available on how to use fertilizer adjustment equations to prescribe nutrients from different sources.

Vegetables are crucial to the global diet, providing essential vitamins, minerals and plant-based proteins. It was estimated that in the fiscal year of 2022, the total vegetable production would reach approximately 200 million metric tonnes. This includes among various vegetables cabbages (Statista, 2023a). China produced more than 600 million metric tonnes of fresh vegetables in 2021, making it the top producer. Meanwhile, India came in second place with an estimated yield of around 138 million metric tonnes of fresh vegetables (Statista, 2023b).

Cauliflower is one such vegetable which is a member of the Brassicaceae family, and it is cultivated for its tender, white curd, which is utilized in various dishes, such as vegetables, curries, soups and pickles. India is the world's leading producer of cauliflower, with an

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average yield of approximately 14.7 t/ha. Cauliflower is grown on 4526 thousand hectares in India, yielding a total of 86682 thousand metric tonnes. In Uttarakhand, however, cauliflower is cultivated on a smaller area of 318 thousand hectares, yielding 4197 thousand metric tonnes (National Horticulture Board, 2018).

Using fertilizer adjustment equations based on soil test results STCR recommends fertilizer application, and crop response data to determine accurate fertilizer amounts. This approach considers soil and plant factors, resulting in more precise and beneficial fertilizer recommendations for balanced nutrient supplementation of the soil. This study expands fertilizer prescription equations for cauliflower yield targets in northern India's Mollisol, where such research has not been done before.

## MATERIALS AND METHODS

In the Vegetable Research Centre of Govind Ballabh Pant University of Agriculture and Technology Pantnagar, Udham Singh Nagar (Uttarakhand), a two-phase cauliflower field experiment at 29° N latitude, 79° 27' E longitude and 217 m above sea level to study soil behaviour and applied nutrients for balanced fertilization was conducted.

In the first phase during the *kharif* season, an exhaust crop of maize was sown to create a wide variation in soil fertility. The experimental field was divided into three equal strips. Further the strip was divided into 24 plots. The second phase was a test crop experiment conducted during the *rabi* season, where soil samples were collected both at pre and post-application of fertilizers and after the test crop was harvested. The treatments comprised four levels of nitrogen 0, 50, 100 and 150 kg/ha, four levels of phosphorus 0, 30, 60 and 90 kg $P_2O_5$/ha, four levels of potassium 0, 30, 60 and 90 kg $K_2O$/ha and three levels of farm yard manure 0, 10 and 20 t FYM/ha were randomized in each of the three strips. Soil samples were collected from a depth of 0-15 cm before the application of fertilizers and after the harvesting of the test crops.

Basal doses of half N, full P, K and FYM were applied. The remainder of the N was applied 30 days after planting. The cauliflower's curd and biomass yield were measured on a per-plot basis, and plant and curd samples were collected from the test crop to analyze their total nitrogen, phosphorus and potassium content.

To conduct the study, multiple data sets were utilized, which included curd yield, nutrient uptake, initial soil available nutrients and applied fertilizer doses. These data were then used to calculate various parameters, such as nutrient requirement per unit weight of produce (kg/q), the proportion of nutrients contributed by the soil (CS), the proportion of nutrients contributed by fertilizers in the absence (CF) and presence (CF*) of farm yard manure (FYM), and the proportion of nutrients contributed by FYM. The calculations were as follows:

Plant uptake (kg/ha) = [Nutrient content (%) in plant] x [Plant dry matter yield (q/ha)].

Curd uptake (kg/ha) = [Nutrient content (%) in curd] x [Curd dry matter yield (q/ha)].

Total nutrient uptake by crop = Nutrient uptake by curd kg/ha + Nutrient uptake by plant kg/ha.

Nutrient requirement to produce one quintal of cauliflower (NR) was calculated as

NR = [Total nutrient uptake (kg/ha)]/[Curd yield (q/ha)]

The amount of N, P and K (in kilograms) needed to produce one quintal of cauliflower.

Contribution from soil for N, P and K as a percentage (CS)

CS = 100 x [(Total uptake of nutrients in control plot)/(Soil test value of that nutrient in control plot)].

Similarly, contribution of FYM to nutrients for N, P and K as a percentage (CFYM)

CYFM = 100 x [Total uptake of nutrients (kg/ha) in FYM treated plots – Soil test values of nutrients in FYM treated plots X (CS/100)]/[Amount of nutrients added through FYM (kg/ha)]

The proportion of nutrient contribution (%) from the fertilizer along with farmyard manure (FYM) for N, P and K was determined as (CF* %).

CF* = [{Total uptake of nutrients (kg/ha) in fertilizer and FYM treated plots - Soil test values of nutrients in fertilizer and FYM treated plots} X (CS/100)] / [100 X {Fertilizer dose (N/P/K) applied (kg/ha)}].

Percentage of nitrogen, phosphorus, and potassium contributed by fertilizer without FYM (CF%) = CF = [{Total uptake of nutrients (kg/

ha) in fertilizer and FYM treated plots - Soil test values of nutrients in fertilizer and FYM treated plots} X {CS/100} – {Nutrient added through fertilizer dose (kg/ha)} X {CFYM/100}] / [{Fertilizer dose (N/P/K) applied (kg/ha)} x 100].

From the above basic parameters, fertilizer doses were calculated for cauliflower as follows.

Fertilizer dose (FD) for nitrogen, phosphorus and potassium without FYM**:**

FD = [(NR/CF) X (100 T)] - [(CS/CF) X STV]

Nitrogen, phosphorus and potassium fertilizer dose with FYM:

FD = {(NR/CF*) X 100 T} - {(CS/CF*) X STV} - {(CFYM/CF*) X M}

The variables used in the study were:

NR the nutrient requirement of N, P and K in kilograms per unit weight of produce (kg/q)

CF–the percentage of nutrient contribution from fertilizer

CF*–the percentage of nutrient contribution from fertilizer along with farm yard

CS–the percentage of nutrient contribution from soil

CFYM–the percentage of nutrient contribution from FYM

T–the targeted yield in quintals per hectare (q/ha)

STV–the soil test value for available N, P and K in kilograms per hectare (kg/ha)

M–the amount of the concerned nutrient present in the FYM.

## RESULTS AND DISCUSSION

The amount of available P in the soil ranged from 15.00 to 22.11 kg of Olsen-P per hectare (kg Olsen-P/ha), with an average of 18.47 kg P/ ha. The amount of available K was determined using the neutral normal $NH_4OAc$ method and varied from 99.68 to 365.12 kg of potassium per hectare (kg K/ha), with an average of 281.82 kg K/ha. Pande and Singh (2016) reported similar pattern in soil fertility in STCR experiments.

The curd yield of cauliflower ranged from 36.67 to 413.33 q/ha with an average of 192.41 q/ ha. It indicated that the N uptake ranged from 29.27 to 298.20 kg/ha (kg/ha), with an average of 129.06 kg/ha. Similarly, the P uptake varied from 1.30 to 13.45 kg/ha, while the average was 5.89 kg/ha. The mean K uptake was 39.74 kg/ha, average range was from 6.69 to 108.26 kg/ha.

Table 1 displays the key parameters required for determining the appropriate fertilizer doses to achieve targeted yields of cauliflower. The results showed that to produce one quintal of cauliflower, 0.70 kg of N, 0.03 kg of P and 0.23 kg of K were required. These findings highlight the significance of factoring in soil and fertilizer contributions, including FYM, when determining appropriate fertilizer doses to attain specific yield targets in cauliflower production.

The percentage of N, P and K derived from the FYM applied was 45.62, 2.19 and 13.50, respectively. The authors proposed that the contribution of nutrients from fertilizers exceeded that of soil or organic sources. Comparable results were also found by Pande and Singh (2016) in the case of cabbage and by Arya and Gautam (2017) in the case of tomato. The information provided in Table 1 was utilized to formulate fertilizer adjustment equations for calculating fertilizer doses with and without FYM, as demonstrated in Table 2. Utilizing the fertilizer adjustment equations

**Table 1.** The nutrient demand with and without FYM for achieving the desired cauliflower yield

| Particular | Without FYM | | | With FYM | | |
|---|---|---|---|---|---|---|
| | N | P | K | N | P | K |
| NR (kg/q) | 0.70 | 0.03 | 0.23 | 0.70 | 0.03 | 0.23 |
| CS (%)* | 33.20 | 13.84 | 8.13 | 33.20 | 13.84 | 8.13 |
| CF (%) | 75.27 | 15.62 | 54.68 | 82.44 | 16.50 | 55.63 |
| CFYM (%) | - | - | - | 45.62 | 2.19 | 13.50 |

*Soil test values (0-15 cm): alkaline $KMnO_4$-N (kg/ha), Olsen's-P (kg/ha) and NH4OAc-K (kg/ha).

**Table 2.** Adjustment equations for fertilizer

| Fertilizer dose | Without FYM | With FYM |
|---|---|---|
| Nitrogen dose (kg N/ha) | FN = 0.93 T - 0.44 SN | FN = 0.849 T - 0.402 SN - 0.553 FYM-N |
| Phosphorus dose (kg P/ha) | F ($P_2O_5$) = 0.439 T - 2.02 SP | F (P2O5) = 0.416 T - 1.91 SP - 0.291 FYM - P |
| Potassium dose (kg K/ha) | F ($K_2O$) = 0.508 T - 0.179 SK | F (K2O) = 0.500 T - 0.176 SK - 0.293 FYM - K |

Where, T – Yield target (q/ha), SN – Soil nitrogen extracted by Alkaline $KMnO_4$ method (kg/ha), SP – Soil phosphorus extracted by Olsen's method (kg/ha), SK – Soil potassium extracted by ammonium acetate method (kg/ ha).

formulated from the fundamental data (as demonstrated in Table 1), authors had designed Tables 3 and 4, which suggested the recommended fertilizer quantities for attaining different cauliflower yield objectives, using chemical fertilizers alone and in conjunction with FYM. The fertilizer requirement decreased with an increase in test values for soil for a particular yield goal or target. However, if the soil test values remained constant, the fertilizer dose increased with an increase in the yield goal. The maximum fertilizer dose was found to be associated with higher yield levels, while it decreased with increasing test values of soil. The study findings suggested that the mixed contribution of nutrients from fertilizer and FYM was greater compared to the application of nutrients from fertilizer alone.

**Table 3.** Fertilizer prescriptions for varying cauliflower yield targets without FYM

| Soil test value (kg/ha) | Yield target of cauliflower (q/ha) | | |
|---|---|---|---|
| | 200 | 250 | 300 |
| **Alkaline $KMnO_4$- N** | | **Fertilizer–N (kg/ha)** | |
| 100 | 142 | 188 | 235 |
| 125 | 131 | 177 | 224 |
| 150 | 120 | 166 | 213 |
| 175 | 109 | 155 | 202 |
| **Olsen-P** | | **Fertilizer – $P_2O_5$ (kg/ha)** | |
| 10 | 68 | 90 | 112 |
| 15 | 58 | 80 | 102 |
| 20 | 48 | 69 | 91 |
| 25 | 37 | 59 | 81 |
| **Amm. Ac.-K.** | | **Fertilizer – $K_2O$ (kg/ha)** | |
| 100 | 83 | 108 | 134 |
| 200 | 65 | 91 | 116 |
| 300 | 48 | 73 | 98 |
| 400 | 30 | 55 | 80 |

The researchers (Rurinda *et al.* (2020), Schut and Giller (2020), Mesfin *et al.* (2021), Beneduzzi *et al.* (2022), Khan *et al.* (2022) also recommended that field specific fertilizer prescription based on a single composite sample was elusive.

**Table 4.** Fertilizer prescriptions for cauliflower yield targets using FYM and chemical fertilizers

| Soil test value (kg/ha) | Yield target of cauliflower (q/ha) | | |
|---|---|---|---|
| | 200 | 250 | 300 |
| **Alkaline $KMnO_4$- N** | | **Fertilizer – N (kg/ha)** | |
| 100 | 115 | 158 | 200 |
| 125 | 105 | 148 | 190 |
| 150 | 95 | 137 | 180 |
| 175 | 85 | 127 | 170 |
| **Olsen's P** | | **Fertilizer – $P_2O_5$ (kg/ha)** | |
| 10 | 61 | 81 | 102 |
| 15 | 51 | 72 | 93 |
| 20 | 41 | 62 | 83 |
| 25 | 32 | 53 | 73 |
| **Amm.Ac.-K** | | **Fertilizer – $K_2O$ (kg/ha)** | |
| 100 | 74 | 98 | 123 |
| 200 | 56 | 81 | 106 |
| 300 | 39 | 63 | 88 |
| 400 | 21 | 46 | 71 |

To evaluate the accuracy of the formulated equations, trials were conducted on multiple locations, each with three replications and seven treatments. The fertilizer doses were calculated using the prescription equations from Table 2 for yield targets of 250 and 300 q/ ha of cauliflower. The study also included a comparison of the recommended fertilizer doses with both the farmers' practice and general recommended doses. The treatment that resulted in the highest curd yield, net benefit and response ratio was the one where fertilizers were utilized based on the target yield of 250 q/ ha with the addition of 10 t/ha (Table 5). Ghosh *et al.* (2022) reported that combining organic and inorganic fertilizers could increase broccoli yields significantly compared to using inorganic fertilizers alone, which is consistent with the present study's findings.

Combining FYM with NPK application can enhance the chilli yield (Ahsan *et al.*, 2019). The enhanced yields observed in these studies could be attributed to the balanced nutrient supply from both the fertilizer and the effective

**Table 5.** Follow up trials at farmers' field to verify the fertilizer prescription equations in cauliflower

| Treatment | Fertilizer doses (kg/ha) | | | Fresh curd yield (q/ha) | Response ratio | Net returns (Rs.) | Yield deviation | Benefit : cost ratio |
|---|---|---|---|---|---|---|---|---|
| Control | 0 | 0 | 0 | 113.0 | - | - | - | - |
| FP | - | - | - | 166.7 | - | 53706.7 | - | - |
| GRD | 100 | 60 | 60 | 190.7 | 35.4 | 72098.9 | - | 12.7 |
| TY1 (250 q/ha) | 148 | 76 | 90 | 223.0 | 35.0 | 102169.2 | -10.8 | 13.0 |
| TY1 (250 q/ha)+FYM 10 t/ha | 120 | 67 | 80 | 298.1 | 69.4 | 163385.7 | 19.3 | 7.5 |
| TY2 (300 q/ha) | 194 | 98 | 117 | 245.9 | 32.5 | 122801.3 | -18.0 | 12.1 |
| TY2 (300 q/ha)+FYM 10 t/ha | 162 | 90 | 106 | 175.9 | 17.6 | 38859.6 | -41.4 | 1.6 |

usage of applied fertilizer nutrients along with FYM. The highest benefit : cost ratio was achieved with a yield target of 250 q/ha.

## CONCLUSION

The study suggests that using STCR-based recommendations for cauliflower, in addition to inorganic fertilizers, is more effective and economically beneficial than using inorganic fertilizers alone. Optimizing both chemical fertilizers and organic manures application is crucial for achieving optimal results. Efficient management of these resources is crucial for the long-term productivity of cauliflower crops.

## REFERENCES


Ahsan Altaf, M., Shahid, R., Asad Altaf, M., Ren, M. X., Tan, K., Xiang, W. Q., Qadir, A., Shakoor, A. and Mohsin Altaf, M. (2019). Effect of NPK, organic manure and their combination on growth, yield and nutrient uptake of chilli (*Capsicum annuum* L.). *Hortic. Int. J.* **3**. *doi.org/10.15406/HIJ.2019.03.00135.*

Arya, A. and Gautam, P. (2017). Soil test crop response-based fertilizer requirement for tomato grown on Mollisol. *Environ. Ecol.* **35**: 3009-3013.

Beneduzzi, H. M., De Souza, E. G., Moreira, W. K. O., Sobjak, R., Bazzi, C. L. and Rodrigues, M. (2022). Fertilizer recommendation methods for precision agriculture – A systematic literature study. *Eng. Agríc.* 42. *https://doi.org/10.1590/1809-4430-ENG.AGRIC.V42N1E20210185/2022.*

Bhandari, G., Dhasmana, A., Chaudhary, P., Gupta, S., Gangola, S., Gupta, A., Rustagi, S., Shende, S. S., Rajput, V. D., Minkina, T., Malik, S. and Slama, P. (2023). A perspective review on green nanotechnology in agro-ecosystems: Opportunities for sustainable agricultural practices and amp; environmental remediation. *Agric.* **13**: 668. *doi.org/10.3390/AGRICULTURE13030668.*

Ghosh, D., Brahmachari, K., Skalicky, M., Roy, D., Das, A., Sarkar, S., Moulick, D., Brestic, M., Hejnak, V., Vachova, P., Hassan, M. M. and Hossain, A. (2022). The combination of organic and inorganic fertilizers influences the weed growth, productivity and soil fertility of monsoon rice. *PLoS ONE* **17**. *https://doi.org/10.1371/journal.pone.0262586.*

Khan, A. A., Faheem, M., Bashir, R. N.,Wechtaisong, C. and Abbas, M. Z. (2022). Internet of Things (IoT) assisted context aware fertilizer recommendation. IEEE **10**. *https://doi.org/10.1109/ACCESS.2022.3228160.*

Mesfin, S., Haile, M., Gebresamuel, G., Zenebe, A. and Gebre, A. (2021). Establishment and validation of site specific fertilizer recommendation for increased barley (*Hordeum* spp.) yield, northern Ethiopia. *Heliyon* **7**. *doi.org/10.1016/j.heliyon.2021.e07758.*

National Horticulture Board (NHB). (2018). Horticultural Statistics at a Glance (2018). Horticulture Statistics Division, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India. 514 p.

Pande, J. and Singh, S. (2016). Fertilizer recommendations based on targeted yield concept for cabbage grown in a Mollisol of Uttarakhand. *J. Indian Soc. Soil Sci.* **64**: 265-270.

Rurinda, J., Zingore, S., Jibrin, J. M., Balemi, T., Masuki, K., Andersson, J. A., Pampolino, M. F., Mohammed, I., Mutegi, J., Kamara, A. Y., Vanlauwe, B. and Craufurd, P. Q. (2020). Science-based decision support for formulating crop fertilizer recommendations in sub-Saharan Africa. *Agric. Syst.* **180**. *https://doi.org/10.1016/j.agsy.2020.102790.*

Schut, A. G. T. and Giller, K. E. (2020). Soil-based, field-specific fertilizer recommendations are a pipe-dream. Geoderma 380. https://doi.org/10.1016/j.geoderma.2020.114680.

Statista. (2023a). India: Vegetable production. *https://www.statista.com/statistics/621210/vegetable-production-in-india/.*

Statista (2023b). Top producers of fresh vegetables worldwide (2021). *https://www.statista.com/statistics/264662/top-producers-of-fresh-vegetables-worldwide/.*