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**Research Article**

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# Effect of integrated nutrient management on the cauliflower yield and soil properties

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**ABSTRACT**
Cauliflower is one of the most important and preferred vegetables and effective nutrient management is essential to improve production as well as soil properties. Thus, the study was conducted to examine the impact of integrated nutrient management on cauliflower and soil at Ghorahi, Dang district of Nepal. The single-factor experiment was organized employing a Randomized Complete Block Design with three replications. In this study, nitrogen (N) was applied through different sources viz 100% N via urea, 50% N via urea + 50% N via farmyard manure, 50% N via urea + 50% N via pig manure, 50% N via urea + 50% N via vermicompost, 50% N via urea + 25% N via farmyard manure + 25% N via pig manure, 50% N via urea + 25% N via pig manure + 25% N via vermicompost, 50% N via urea + 25% N via farm yard manure + 25% N via vermicompost and 50% N via urea + 50% N via (farmyard manure + pig manure + vermicmpost in 1:1:1). Among different treatments, 50% N via urea + 50% N via vermicompost recorded the highest curd diameter (17.72 cm), curd height (11.57 cm), curd weight (0.76 kg), curd yield per hectare (31.67 t $ha^{-1}$), soil organic matter (3.31%), total nitrogen (0.157%), available phosphorus (76.78 kg $ha^{-1}$) as well as available potassium (860.20 kg $ha^{-1}$). Therefore, it is suggested to apply 50% N via urea and 50% N via vermicompost for better cauliflower production and soil properties.
**Keywords:** Integrated nutrient management, cauliflower, yield, soil properties.

## INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis* L.) belonging to the family Cruciferae is an important cole crop in many countries of the world. Cauliflower is cultivated for its white tender curd. The curd is used as salad, vegetables, curries and pickles and is also used in the preparation of fried snacks, burgers and sandwiches in restaurants (Ashraf et al., 2017). Cauliflower is considered as a vital food as 100 g of consumable cauliflower has 51 IU vitamin A, 56 mg vitamin C, 0.10 mg riboflavin, 0.04 mg thiamin, 1.0 mg nicotinic acid, 33 mg calcium, 57 mg phosphorus, 138 mg potassium, 90.8 g moisture, 4.0 g carbohydrates, 2.6 g protein, 0.4 g fat, 1.2 g fibre and 1.5 mg iron (Fageria et al., 2012). In Nepalese kitchens, cauliflower is one of the highly preferred vegetables. Nepal has diverse agroecological conditions due to which year-round cultivation of cauliflower can be done in Nepal (Neupane et al., 2020). In Nepal, cauliflower was cultivated in an area of 39,214 hectares in the period 2021/22 with a production of 611,015 tonnes (MoALD, 2023). In Dang, cauliflower was cultivated on 465 hectares of land in the period 2021/22 with a production of 8,556 tonnes (MoALD, 2023).

Cauliflower is a nutrient-demanding crop so a greater amount of nutrients is required for its better growth and yield. Nowadays the main source of nutrients is inorganic fertilizers but using only inorganic fertilizers for long periods can lead to nutritional imbalance and adverse impacts on the production, environment, soil properties and human health so it is necessary to find a sustainable and environment-friendly alternative method that improves production, environment, soil quality and human health. Thus, integrated nutrient management is a sustainable and environment-friendly option for crop production instead of relying solely on chemical fertilizer. Integrated nutrient management incorporates a combination of organic and inorganic sources of nutrients for plants, resulting in improved production of crops, soil quality and human health (Bhattarai et al., 2012). Integrated nutrient management means using inorganic, organic and biological sources of nutrients at the best level for obtaining and sustaining optimum yield without causing harm to the soil ecosystem and environment (Basnet et al., 2021). Integrated nutrient management is a vital technique that is gaining popularity as well as enhancing crop productivity by balancing soil's physical, chemical and biological characteristics for the development of the plant (Chaudhary et al., 2023).

Combining organic manures in appropriate quantity along with inorganic fertilizers boosts the growth of the crop (Kumar et al., 2009). In vegetables integrating organic manures along with NPK results in superior crop yield and macronutrient (NPK) availability (Kumar and Sharma, 2004). Chahal et al. (2019) concluded that the soil health and economic yield of cauliflower can be improved by the use of organic inputs through integrated nutrient management. Neupane et al. (2020) also concluded that integrated nutrient management has a better effect on crop growth parameters, root growth parameters and residual soil characteristics compared to the sole use of chemical fertilizers. Considering these facts, this experiment was carried out to examine the effect of different combinations of integrated nutrient management on the cauliflower yield as well as soil properties.

## MATERIALS AND METHODS

### Study site

A study was conducted in the field of a farmer at Ghorahi, Dang district of Nepal spanning from October 2022 to January 2023. Geographically, the experimental site is located at about 28° 02' N latitude and 82° 29' E longitude with an elevation of about 700 meters above sea level. The site experiences an average annual temperature of 25.03 °C, rainfall of 193.78 mm and relative humidity of 43.71%.

### Soil sampling before the experiment

Before planting cauliflower, the soil characteristics of the experimental field were assessed. For that, the soil samples of the experimental field were taken randomly in a zigzag pattern at a depth of 0-15 cm with the help of an auger. Twelve soil samples were taken from the whole experimental field and mixed in a clean bucket to form a composite soil sample. All the debris, pebbles and gravel present in the soil were removed followed by air-drying, grinding and sieving the soil through a 2 mm mesh. Then the soil was poured on the piece of clean paper, spread evenly and divided into four quarters. Among the four quarters, the two quarters positioned opposite were excluded, while the remaining two were mixed again and the same process was conducted repeatedly until there was only half a kilogram of soil remained. After that soil was collected in a clean bag and subjected to a soil test to analyze initial soil properties at Agricultural Technology Center Pvt. Ltd. Laboratory, Lalitpur, Nepal. Various soil properties were assessed using laboratory techniques (Table 1). The soil fertility status of the field before planting of cauliflower is given in Table 2.

### Nursery raising

Snow Mystique variety of cauliflower was used for the study. Seedlings were grown on a raised nursery bed (2 m × 1 m) on 17th October 2022. The first irrigation was applied immediately after sowing of seed by using a rose can while the rest of the irrigations were applied depending on the dryness of the soil. Weeds appearing in the nursery were eliminated by hand weeding.

**Table 1.** Laboratory techniques used to examine various soil properties

| Parameters | Analysis techniques |
|---|---|
| Soil organic matter | Walkley-Black method (Walkley and Black, 1934) |
| Total Nitrogen | Kjeldahl method (Kirk, 1950) |
| Available phosphorus | Spectrophotometer (Olsen et al., 1954) |
| Available potassium | Ammonium acetate method (Simrad, 1993) |

**Table 2.** Soil examination report of the field before planting of cauliflower

| Parameters | Value |
|---|---|
| Soil organic matter | 1.65% |
| Total Nitrogen | 0.07% |
| Available phosphorus | 127.00 kg $ha^{-1}$ |
| Available potassium | 718.00 kg $ha^{-1}$ |

### Approaches to experimentation

The study was conducted using a single-factor Randomized Complete Block Design (RCBD), with three replications and each replication comprised eight treatments. The field was ploughed using a chisel plough and levelled with a planker for the experiment. The entire experimental field covered a space of 272.25 $m^2$, with each plot measuring 6.075 $m^2$ (2.70 m × 2.25 m). The spacing of 1 m was maintained between replications while 0.5 m was maintained between treatments. Healthy seedlings that were 30 days old and in uniform condition were chosen for transplanting. In the individual plot of each replication, 30 numbers of plants were transplanted in which a distance of 0.45 m was maintained between plants and a distance of 0.45 m was also maintained between rows. Nitrogen, phosphorus and potassium were administrated at rates of 200 kg, 120 kg and 80 kg per hectare respectively based on Singh and Bhandari (2015). Single super phosphate was used to provide phosphorus, while potassium was delivered via muriate of potash. Both phosphorus and potassium were provided as a basal dose in their entirety. The nitrogen (N) was applied through chemical and various organic sources (Table 3). The entire number of organic sources of nitrogen was applied to their respective plots 15 days before seedlings transplantation while chemical sources of nitrogen were split into two doses i.e. half dose was applied initially as basal dose while the remaining half was provided after 30 days of seedlings transplantation.

### Data collection

Data related to different yield parameters like curd diameter, curd height, curd weight and curd yield per hectare were recorded. For that, five representative plants from the inner rows of each treatment of each replication were randomly labelled and tagged. Plants were only labelled from the inner rows to prevent the influence of the border. The diameter of curds of tagged plants of each treatment of each replication was measured with measuring tape and the average value of curd diameter was calculated and expressed as curd diameter in centimetres (cm). For curd height, the curds harvested from tagged plants of each treatment of each replication were cut into two halves from the centre and the vertical height of the curd was measured with measuring tape and the average value of curd height was calculated and expressed as curd height in centimetre (cm). Further, for curd weight, the weight of curds harvested from tagged plants of each treatment of each replication was weighed by digital weighing balance and the average value of curd weight was calculated and recorded as the curd weight in kilogram (kg). The average value of the curd yield of each treatment of each replication was calculated and based on that average value of the curd yield of each treatment of each replication, the average value of curd yield per hectare of each treatment of each replication was calculated and expressed as curd yield per hectare in tonnes per hectare (t $ha^{-1}$).

**Table 3.** Treatment details

| Treatments | Treatments details |
|---|---|
| T1 | 100% N via urea |
| T2 | 50% N via urea + 50% N via farmyard manure |
| T3 | 50% N via urea + 50% N via pig manure |
| T4 | 50% N via urea + 50% N via vermicompost |
| T5 | 50% N via urea + 25% N via farmyard manure + 25% N via pig manure |
| T6 | 50% N via urea +25% N via pig manure + 25% N via vermicompost |
| T7 | 50% N via urea + 25% N via farmyard manure + 25% N via vermicompost |
| T8 | 50% N via urea + 50% N via (farmyard manure + pig manure + vermicompost in 1:1:1) |

Moreover, soil characteristics were also examined after the final crop harvest. For that, five soil samples from individual treatments of each replication were taken randomly in a zigzag fashion at a depth of 0-15 cm after the final crop harvest by using an auger. Then five samples taken from individual treatments of each replication were combined in separate individual buckets to create a composite soil sample for individual treatments of each replication. Following this, air-drying, grinding and sieving of the soil through a 2 mm mesh was done. Then the soil of individual treatments of each replication was poured on the individual piece of clean paper, spread evenly and divided into four quarters. Among the four quarters, the two opposite quarters were rejected while the rest were mixed again and the same process was conducted repeatedly until there was only half a kilogram of soil remained for individual treatment of each replication. After that soil of individual treatment of each replication was collected separately in an individual clean bag with proper labelling and subjected to soil test to find out soil properties at Agricultural Technology Center Pvt. Ltd. Laboratory, Lalitpur, Nepal. Various soil properties were assessed through laboratory techniques (Table 1).

**Statistical assessment**

Data was assessed with the help of R studio. Analysis of Variance (ANOVA) in Randomized Complete Block Design (RCBD) was employed to ascertain the significance level. The treatment means were compared at probabilities of 1% and 5% following the approach outlined by Gomez and Gomez (1984).

## RESULTS AND DISCUSSIONS

### Yield parameters

#### Curd diameter

The curd diameter was significantly influenced by the different treatments (Table 4). Among various treatments, T4 (50% N via urea + 50% N via vermicompost) showed the highest curd diameter (17.72 cm) followed by 17.15 cm at T6 (50% N via urea + 25% N via pig manure + 25% N via vermicompost) and the lowest curd diameter (12.49 cm) was noted at T1 (100% N via urea). The highest curd diameter in T4 might be because both macro and micro-nutrients are present in vermicompost and the absorption of such macro and micro-nutrients has beneficial impacts on the chlorophyll levels found in leaves (Rekha et al., 2018) and thus increased chlorophyll levels produce more photosynthesis which diverts for curd growth as a result curd obtained better nutrition which ultimately increased curd diameter (Thapa et al., 2022). Further, vermicompost supplies all the necessary macro and micro elements to plants that are needed to complete their lifecycle which ensures proper source-sink relationship for better growth and development (Gyawali et al., 2022). Ali et al. (2018) in cauliflower and Kaur and Kaur (2022) in cauliflower obtained the maximum curd diameter with the combined application of chemical fertilizer and vermicompost.

#### Curd height

Different treatments showed a significant effect on curd height (Table 4). The maximum curd height (11.57 cm) was observed at T4 (50% N via urea + 50% N via vermicompost) followed by 10.39 cm at T6 (50% N via urea + 25% N via pig manure + 25% N via vermicompost) in contrast the minimum curd height (7.23 cm) was obtained in treatment T1 (100 % N via urea). The highest curd height in T4 might be because vermicompost enhances plant development by providing micro and macronutrients, vitamins, enzymes and hormones and regulating the physico-chemical properties of soil (Makulec, 2002; Sinha et al., 2009; Hazra, 2016). Similarly, essential nutrients present in vermicompost are directly taken by plants (Pathma and Sakthivel, 2012; Lim et al., 2015) which might have contributed to increasing curd height. Furthermore, it has been scientifically confirmed that vermicompost is an effective promoter of plant growth (Chaoui et al., 2003; Guerrero, 2010). Jahan et al. (2014) observed the maximum curd height of cauliflower when chemical fertilizer was combined with vermicompost.

**Curd weight**

Various treatments demonstrated a significant impact on curd weight (Table 4). In terms of curd weight, the highest curd weight (0.76 kg) was noted at T4 (50% N via urea + 50% N via vermicompost) which was followed by 0.72 kg at T6 (50% N via urea + 25% N via pig manure + 25% N via vermicompost) but the lowest curd weight (0.43 kg) was noted at T1 (100% N via urea). Here, T4 recorded the highest curd weight which might be because the application of vermicompost along with inorganic fertilizers might have enhanced the physical environment, nutrient provision and a proliferous root system leading to improved uptake of water and nutrients (Neupane et al., 2020). Neupane et al. (2020) in cauliflower and Kannaujiya et al. (2023) in cauliflower also achieved the highest curd weight through the combined use of chemical fertilizers and vermicompost.

**Curd yield per hectare**

Various treatments showed significant impacts on curd yield per hectare (Table 4). Among various treatments, T4 (50% N via urea + 50% N via vermicompost) showed the maximum curd yield per hectare (31.67 t $ha^{-1}$) which was followed by 29.81 t $ha^{-1}$ at T6 (50% N via urea + 25% N via pig manure + 25% N via vermicompost). Further, the minimum curd yield per hectare (17.87 t $ha^{-1}$) was obtained at T1 (100% N via urea). The highest curd yield in T4 might be because vermicompost contributes towards the balanced C: N ratio and improves the essential plant nutrients availability which increases the rate and efficiency of metabolic processes and high assimilation of protein and carbohydrate (Kannaujiya et al., 2023). Similarly, vermicompost provides necessary plant nutrients and plays a vital role in the growth and curd yield of cauliflower (Ali et al., 2018). Similarly, Kaur and Kaur (2022) mentioned that vermicompost acts as a natural fertilizer that does not harm soil and crops as well as improves the yield and quality of cauliflower. Further, adding vermicompost to inorganic fertilizers creates suitable chemical properties of soil for cauliflower production (Ali et al., 2018). Wani et al. (2010) in cauliflower, Mohanta et al. (2018) in broccoli, Neupane et al. (2020) in cauliflower and Kannaujiya et al. (2023) in cauliflower achieved the maximum yield by employing a combination of chemical fertilizers and vermicompost.

In this context, every treatment receiving both inorganic fertilizer and organic manure showed higher curd diameter, curd height, curd weight and curd yield per hectare than T1 which might be because organic manures help to boost the physical, chemical and biological characteristics of soil which enhance nutrient absorption by plants and give better development of the curd (Neupane et al., 2020). Further, it might be due to greater nutrient accessibility during the entire growth period and the effectiveness of chemical fertilizers is also significantly improved when chemical fertilizers are blended with organic manures (Kannaujiya et al., 2023). Further, the combination of both organic manures and chemical fertilizer enhances all yield and quality parameters of the cauliflower (Kaur and Kaur, 2022).

**Table 4.** Effects of various treatments on cauliflower yield parameters

| Treatments | Curd diameter (cm) | Curd height (cm) | Curd weight (kg) | Curd yield per hectare (t $ha^{-1}$) |
|---|---|---|---|---|
| T1 | 12.49e | 7.23d | 0.43d | 17.87d |
| T2 | 13.65de | 8.06cd | 0.45d | 18.74d |
| T3 | 15.49bc | 8.90bc | 0.60c | 25.03c |
| T4 | 17.72a | 11.57a | 0.76a | 31.67a |
| T5 | 14.46cd | 8.40cd | 0.57c | 23.85c |
| T6 | 17.15a | 10.39a | 0.72ab | 29.81ab |
| T7 | 16.83a | 10.26ab | 0.70ab | 28.89ab |
| T8 | 16.63ab | 10.19ab | 0.68b | 28.31b |
| Grand mean | 15.55 | 9.37 | 0.61 | 25.52 |
| CV% | 4.50 | 8.40 | 6.60 | 6.60 |
| F test | *** | *** | *** | *** |
| SEM (±) | 0.41 | 0.45 | 0.04 | 0.96 |

Treatments mean followed by the common letter or letters within the column are not significantly distinct from each other at a significance level of 5%. CV = Coefficient of variation, SEM= Standard error of the mean and *** = Significant at $P \leq 0.001$.

**Soil parameters**

**Soil organic matter**

Various treatments demonstrated a significant influence on soil organic matter levels (Table 5). The highest soil organic matter (3.31%) was noted at T4 (50% N via urea + 50% N via vermicompost) followed by 3.17% at T6 (50% N via urea + 25% N via pig manure + 25% N via vermicompost) and the lowest soil organic matter (2.18%) was recorded at T1 (100% N via urea). The highest soil organic matter in T4 might be because vermicompost is enriched with organic carbon and useful organisms which enhances the content of organic matter in the soil (Richards, 1954; Maamori et al., 2023). Similarly, vermicompost contributes to boosting soil's organic matter content (Gupta et al., 2011). Moreover, vermicompost provides plant nutrients, different hormones, enzymes, humic substances and mainly organic matter to the soil (Ceritoglu et al., 2018) and this could have also led to an increase in organic matter. Further, all treatments receiving both organic manure and inorganic fertilizer recorded higher soil organic matter than T1 it is because adding organic manure enhances organic matter (Sedlar et al., 2023).

**Total Nitrogen**

Different treatments showed significant effects on the total nitrogen (Table 5). In terms of total nitrogen, T4 (50% N via urea + 50% N via vermicompost) recorded the highest total nitrogen (0.157%) followed by 0.144% at T6 (50% N via urea +25% N via pig manure + 25% N via vermicompost) while T1 (100% N via urea) recorded the lowest total nitrogen (0.113%). The highest total nitrogen in T4 might be due to vermicompost's dual action of nitrogen addition to the soil and stimulation of biological nitrogen fixation (Padmavathiamma et al., 2008). Similarly, vermicompost enhances beneficial microorganisms like bacteria and aerobic fungi in the soil that play a vital role in fixing atmospheric nitrogen (Maamori et al., 2023). K.C. and Bhattarai (2011) and Chahal et al. (2019) also observed the highest nitrogen levels when chemical fertilizer was mixed with vermicompost. Further, all treatments receiving both inorganic fertilizer and organic manure demonstrated higher total nitrogen than T1 which might be because the blending of nitrogen fertilizer with organic manures potentially minimizes the nitrogen losses and boosts the efficiency of fertilizer utilization which upgrades the nitrogen availability (K.C. and Bhattarai, 2011). Despite applying 100% N through urea in T1, the highest total nitrogen was not observed in T1 which might be due to losses from leaching and volatilization, whereas in other treatments the application of organic manure retains the nutrients and minimizes losses (K.C. and Bhattarai, 2011).

**Table 5.** Effects of various treatments on soil properties after crop harvest

| Treatments | Soil organic matter (%) | Total nitrogen (%) | Available phosphorus (kg ha$^{-1}$) | Available potassium (kg ha$^{-1}$) |
|---|---|---|---|---|
| T1 | 2.18c | 0.113c | 44.64d | 497.30c |
| T2 | 2.33bc | 0.115c | 46.02d | 510.70c |
| T3 | 2.97abc | 0.134abc | 57.72b | 698.90b |
| T4 | 3.31a | 0.157a | 76.78a | 860.20a |
| T5 | 2.71abc | 0.119bc | 50.93cd | 672.00b |
| T6 | 3.17ab | 0.144ab | 72.35ab | 806.40ab |
| T7 | 3.08abc | 0.143ab | 65.23abc | 766.10ab |
| T8 | 3.06abc | 0.143ab | 63.00abc | 725.80ab |
| Grand mean | 2.85 | 0.133 | 59.58 | 692.17 |
| CV | 16.57 | 10.300 | 13.60 | 10.40 |
| F test | ** | * | ** | *** |
| SEM (±) | 0.10 | 0.014 | 8.13 | 71.80 |

Treatments mean followed by the common letter or letters within the column are not significantly distinct from each other at a significance level of 5%. CV = Coefficient of variation, SEM= Standard error of the mean, * = Significant at P≤ 0.05, ** = Significant at P≤ 0.01, and *** = Significant at P≤ 0.001

**Available phosphorus**

Available phosphorus was significantly influenced by different treatments (Table 5). Among various treatments, the maximum available phosphorus (76.78 kg ha$^{-1}$) was recorded at T4 (50 % N via urea + 50% N via vermicompost) followed by 72.35 kg ha$^{-1}$ at T6 (50% N via urea + 25% N via pig manure + 25% N via vermicompost) whereas the minimum amount of available phosphorus (44.64 kg ha$^{-1}$) was demonstrated by T1 (100% N via urea). The highest available phosphorus in T4 might be because vermicompost has more phosphorus content (Reddy et al., 1999; Mohankumar and Gowda, 2010). Further, during the decomposition process, vermicompost releases organic acids which also contribute to increased phosphorus content (Raju and Reddy, 2000; Meena et al., 2015; Khumukcham et al., 2020). Similarly, vermicompost enhances the solubility and availability of phosphorus by promoting useful microorganisms like bacteria and aerobic fungi in the soil (Maamori et al., 2023). K.C. and Bhattarai (2011), Ali et al. (2018) and Chahal et al. (2019) also observed that the highest available phosphorus was obtained when chemical fertilizer was combined with vermicompost. All treatments receiving both inorganic fertilizer and organic manure exhibited higher levels of available phosphorus than T1, potentially due to the liberation of phosphorus via organic matter after mineralization (Sur et al., 2010). Further, organic matter can enhance the phosphorus availability in the soil through abiotic processes such as decomposition and mineralization of organic phosphorus in soil or ligand exchange (Mabagala and Mngongo, 2022).

**Available potassium**

Various treatments showed a significant impact on available potassium (Table 5). The highest amount of available potassium (860.20 kg ha$^{-1}$) was observed on T4 (50% N via urea + 50% N via vermicompost) followed by 806.40 kg ha$^{-1}$ at T6 (50% N via urea +25% N via pig manure + 25% N via vermicompost) while the lowest (497.30 kg ha$^{-1}$) was noted at T1 (100% N via urea). The highest potassium content in T4 might be because vermicompost adds potassium directly to the potassium pool of the soil (Kumar et al., 2005; Sharma et al., 2009). K.C. and Bhattarai (2011) and Chahal et al. (2019) also recorded the highest available potassium levels when chemical fertilizer and vermicompost were applied together. Here all treatments receiving both inorganic fertilizer and organic manure demonstrated higher available potassium than T1 which might be because organic manures release organic acids at the time of decomposition which mobilizes the non-exchangeable forms of potassium after which potassium is easily available (Chander et al., 2010; Chahal et al., 2019).

**CONCLUSIONS**

Based on the result of the study, 50% N via urea + 50% N via vermicompost recorded the highest curd diameter, curd height, curd weight, curd yield per hectare, soil organic matter, total nitrogen, available phosphorus and available potassium. Therefore, it is suggested to apply 50% N via urea + 50% N via vermicompost for better cauliflower yield and soil quality.

**CONFLICT OF INTEREST**

The author here declares that there is no conflict of interest in the publication of this article.

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