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Effect of Integrated Nutrient Management on LAI and Yield Formation of Cauliflower in Bhaktapur

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ABSTRACT

This study was conducted to assess the effect of different combinations of NPK fertilizer and organic manure on the growth and yield of cauliflower (Brassica oleracea var. botrytis). The main objective of the study was to identify the most suitable combination of integrated nutrients for improving cauliflower growth, yield attributes, and yield under local field conditions. The experiment was carried out on a field at Bhaktapur from 8 Jan to 24 April 2026 using the cauliflower variety **Snow Mystique**. The experiment was laid out in RCBD with four treatments and five replications. The treatments included T1 (0 nutrients added), T2, T3 and T4 with equal amount of OM @ kg/ha but different N:PK: amounts (N: . FYM was applied uniformly to all plots. Data were collected on plant height, number of leaves, leaf area index, curd weight, curd diameter, biomass, number of curds per plot, and yield per plot. The collected data were analysed using Analysis of Variance (ANOVA). The results showed that T3 produced the best performance in yield parameters and recorded the highest curd weight of 896.0 g, curd diameter of 13.88 cm, biomass of 1755.6 g, and yield of 17.47 kg per plot. Although T4 showed higher vegetative growth in some stages, it produced lower yield than T3, indicating that excessive fertilizer application was not beneficial. Therefore, the recommended NPK dose of 200-120-100 kg ha^{-1} with organic manure is concluded to be the most suitable combination for cauliflower production in Chittapol, Bhaktapur.

Keywords: Biomass, curd, LAI, plant height, Snow Mystique

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis*) is one of the most important vegetable crops grown in Nepal and many other parts of the world. It belongs to the family Brassicaceae, which also includes cabbage, broccoli, mustard, radish, and other important vegetables. Cauliflower is mainly grown for its edible white curd, which is used as a vegetable in daily meals. It is popular among consumers because of its good taste, soft texture, nutritional value, and wide use in different food preparations. Cauliflower is not only important as food but also as a source of income for farmers. In Nepal, many small and medium farmers grow cauliflower commercially because it gives better economic return compared to some traditional cereal crops. In peri-urban areas near large cities, such as Kathmandu Valley, cauliflower farming is especially important because farmers can easily sell their produce in nearby markets. Fresh cauliflower has regular demand in markets, hotels, restaurants, and households. Therefore, cauliflower cultivation plays an important role in improving farmers' income, employment opportunities, and livelihood.

Although NPK fertilizers are important for increasing cauliflower yield, their improper use can create problems. Many farmers apply fertilizers without testing soil or following scientific recommendations. Some farmers use too much urea because they believe that more fertilizer always gives more yield. However, excessive use of chemical fertilizers can damage soil health, increase production cost, reduce fertilizer efficiency, and cause environmental pollution. It may also disturb the balance of soil nutrients. On the other hand, using too little fertilizer cannot fulfil crop nutrient requirements and results in poor growth and low yield. Therefore, the main challenge is to find the right combination of fertilizer that gives better growth, higher yield, and good economic return without harming soil health. Organic manure is also very important in cauliflower production. Organic manure includes farmyard manure, compost, animal manure, and other decomposed organic materials. It improves soil structure, water-holding capacity, aeration, microbial activity, and nutrient availability. Unlike chemical fertilizers, organic manure releases nutrients slowly and improves the long-term fertility of the soil. It also helps to increase organic matter content in the soil. Soil organic matter is very important because it improves soil quality and supports sustainable crop production. In areas where farmers grow vegetables continuously, the use of organic manure is necessary to maintain soil fertility. The combined use of NPK fertilizers and organic manure is often better than using chemical fertilizer or organic manure alone. Chemical fertilizers provide nutrients quickly to meet the immediate need of the crop, while organic manure improves soil health and provides nutrients slowly over time. This combined approach is known as integrated nutrient management (INM). It helps to increase nutrient use efficiency, improve soil fertility, reduce dependence on chemical fertilizers, and support sustainable agriculture. For a crop like cauliflower, which needs high nutrients, integrated use of NPK and organic manure can be very useful. It can improve plant growth, curd size, curd weight, and total yield.

Chittapol, Bhaktapur, is a suitable area for vegetable cultivation. Farmers in this area grow different vegetables both for household consumption and commercial purposes. Cauliflower is one of the important vegetables grown in this region because of its good market value. The use of organic manure in Chittapol is common because many farmers have access to animal manure and compost materials. However, the nutrient content of organic manure is often low and variable. Therefore, a balanced combination of NPK fertilizer and organic manure can be a practical solution for farmers higher yield and income.

Another important issue is sustainability. Modern agriculture should focus not only on increasing yield but also on protecting soil and environment. Excessive use of chemical fertilizers can lead to soil degradation, nutrient imbalance, water pollution, and reduced microbial activity. Organic manure can help reduce these problems by improving soil organic matter and biological activity. However, organic manure alone may not supply enough nutrients for high-yielding crops like cauliflower. Therefore, combining organic manure with NPK fertilizer is a balanced and sustainable approach. It can support both productivity and soil conservation. Several studies have shown that balanced use of NPK fertilizer and organic manure improves the growth and yield of cauliflower and other vegetable crops. Adhikari and Sharma (2019) reported that soil fertility management is one of the major factors affecting vegetable productivity in Nepal. Pant et al. (2018) also found that proper application of nitrogen, phosphorus, and potassium improves crop growth and yield when applied in balanced form. However, farmers need simple and practical recommendations that are suitable for their local conditions. Research conducted in the local area can provide more useful information for farmers than general recommendations. This study was conducted to identify the appropriate combination of plant nutrients for good growth and higher yield of cauliflower in Chittapol, Bhaktapur.

MATERIALS AND METHODSS

The study area

The experiment was conducted at Surya Binayak 10, Chittapol area of Bhaktapur. The experimental site lies at 27°39”11′N latitude and 85°28” 26 ′E longitude, at an altitude of approximately 1523 meters above sea level (mask). It is located approximately 12 to 15 kilometers east of Kathmandu city, in the eastern corner of the Kathmandu Valley. The area experiences a monsoon-influenced humid subtropical climate, characterized by hot, wet summers and mild, dry winters. The soils at the experimental site are silty clay loam to loam in texture, well-drained, and moderately fertile.

Experimental materials

The cauliflower variety used was Snow Mystique, a well-known high-yielding and widely grown variety in the Bhaktapur district. Snow Mystique was therefore selected as a suitable variety for optimizing the integrated nutrients to harvest the highest possible yield.

Soil type of experimental field

The soil of the experimental field was tested before field lay out. The soil had pH of 5.0, with good drainage and aeration facilities. The soil test results, confirmed by the Soil and Fertilizer Testing Laboratory, Hetauda, Makawanpur (2082/09/08), The soil had the following properties: organic matter (OM) 2.96%, available nitrogen 0.15%, available phosphorus 96 kg/ha, and available potassium 390 kg/ha (SFTL, 2082/09/08). This indicates that the soil was moderately deficient in nitrogen and phosphorus, justifying the need for NPK fertilizer application.

Experimental design and treatments

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four treatments and five replications, giving a total of 20 experimental plots. The layout of the experiment was carried out to fit five blocks (replications) of four plots each in the field, as per the Randomized Complete Block Design (RCBD). The total experimental field measured 21.3 m × 7.8 m (166.14 sq. m.). Each individual plot measured 3.85 m × 1.6 m (6.16 sq. m.), with 45 cm spacing between plots within the same block and 45 cm buffer on each side. The row-to-row spacing within each plot was 60 cm, and the plant-to-plant spacing was 45 cm. Each plot contained 4 rows of 7 plants, giving 28 plants per plot. Five plants were selected from the inner rows as sample plants for observation.

The four treatments had different levels of the NPK + OM as shown in Table 1. In the experiment, various mixture of the Urea (46% N), Di-ammonium Phosphate (DAP, 18% N + 46% P_2O_5), Muriate of Potash (MOP, 60% K_2O) and well-decomposed farmyard manure (FYM) were used as sources of nutrients.

Table 2. Treatment and NPK doses used in the experiment.

Treatments	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	FYM (t/ha)
T1(control)	0	0	0	39.3
T2	150	90	75	39.3
T3	200	120	100	39.3
T4	250	150	125	39.3

Transplanting and harvesting

The cauliflower seedlings were transplanted on 8 Jan 2026, at a row-to-row spacing of 60 cm and plant-to-plant spacing of 45 cm, with one seedling per hill. Transplanting was done in the afternoon to reduce transplanting shock. Curd formation was observed at 80 DAT. The crop was harvested on 24th April 2026 (106 DAT) , when the curds reached marketable size and before they started to become loose or discolored.

Weeding and intercultural operations

In the experimental plots, weeding was done manually as per need after 30 DAT. The soil was also loosened to provide proper aeration, and earthing up was carried out at the time of second weeding operation. The second split dose of nitrogen (25% as top dressing) was also applied during earthing-up operation.

Irrigation

Irrigation was provided by the Ring shape / furrow method at regular intervals based on the moisture requirement of the crop and the prevailing weather conditions. During the early establishment phase after transplanting, irrigation was given every 3 days. During the active vegetative growth phase and curd development phase, the irrigation interval was adjusted to every 4 days. Irrigation was stopped one week before harvest to allow the soil to dry and to make harvesting easier.

Biometric parameters

* **Plant height (cm**): Measured from the base of the plant at ground level to the tip of the tallest leaf using a Scale/ measuring tape.
***Number of leaves per plant:** All fully expanded leaves per plant were counted and the average of five plants was recorded.

*** Leaf area index (LAI, cm^2):** Calculated by multiplying the length and breadth of the largest leaf on each of five randomly selected plants per plot, and taking the average.

Yield parameters

At harvest, the following yield parameters were recorded:

- **Curd weight (g/ plot):** The fresh weight of the marketable curd from each plot was measured using an electronic balance.
- **Curd diameter (cm)**: Measured across the widest part of the curd using a Vernier caliper.
- **Biomass (g / plant):** Total above-ground biomass per plant was recorded.
- **Number of curds per plot:** All marketable curds from the net plot area were counted.
- **Yield per plot (kg):** Calculated as Yield/Plot (kg) = Curd Weight (g) × Number of Curds per Plot ÷ 1000.

Data collection, measurement and analysis

The growth parameters were recorded at 15, 30, 45, 60, and (DAT) from five randomly selected plants per plot. Yield and related data were measured during harvest. All data collected from the experiment were analysed using Analysis of Variance (ANOVA) for the Randomized Complete Block Design (RCBD), following the method described by Cochran and Cox (1963). The analysis was performed using Microsoft Excel (version 13). The significance of treatment differences was tested at the 5% level of probability. Treatment means were compared using the Critical Difference (CD) test at the 5% level. The Coefficient of Variation (CV%) was calculated to assess the reliability and precision of the experimental data.

RESULTS AND DISCUSSION

Leaf Area Index

Leaf area index (LAI) is used to measure the total leaf surface available for photosynthesis, which is the basis for yield formation. The data on LAI at different growth stages are presented in Table 2. The LAI increased continuously from 15 DAT to 75 DAT in all treatments revealing that cauliflower plants developed larger leaf area as the crop advanced towards curd formation and maturity. The effect of all IPN levels on LAI was significant at 30 DAT and 75 DAT, while it was non-significant at other DAT (Table 2). The T4 recorded the highest LAI value of 78.08 cm², followed by T3 with 56.24 cm². The better performance of the crop in T4 may be due to higher nutrient availability, especially nitrogen, which promotes vegetative growth.

Table 2. Effect of IPN levels on LAI of cauliflower at different growth stages (DAT)

Treatments	15 DAT (cm²)	30 DAT (cm²)	45 DAT (cm²)	60 DAT (cm²)	75 DAT (cm²)
T1(control)	18.30	31.37b	59.08c	269.36a	484.16b
T2	21.08	29.24b	76.20a	235.48a	571.92ab
T3	17.39	56.24ab	117.04a	394.24a	625.24ab
T4	21.84	78.08a	198.40a	349.34a	710.28a
LSD (0.05)	—	36.12	134.22	226.90	137.95
Sem	—	5.86	21.78	36.81	22.38
F-probability	NS	*	NS	NS	*
CV%	19.78	53.80	86.44	52.76	16.74
Grand Mean	—	48.73	112.68	312.10	597.90

*Means in the same column followed by different letters are significantly different at 5% level. NS = Not Significant; * = Significant at 5% level (CD: 30 DAT = 36.12, 75 DAT = 137.95).*

At 45 DAT, the result was statistically non-significant, although clear numerical differences were observed among treatments. At 75 DAT, the LAI had significant difference among treatments at the 5% level. The T4 recorded the highest LAI of 710.28 cm², followed by T3 with 625.24 cm². The difference between T4 and T1 (control) was 226.12 cm², which was higher than the LSD value by 137.95. It should, however, be noted that T4 was statistically at par with T2 and T3 indicating that although T4 had the highest numerical value, its advantage over T2 and T3 was not statistically strong enough.

Higher leaf area alone may not always ensure higher curd yield, because excessive vegetative growth can sometimes reduce curd development if the plants do not receive optimum nutrients. The result suggests that nutrients combinations (NPK+OM) had a positive effect on LAI in cauliflower. The higher leaf area under T4 may therefore be due to the combined effect of optimum level of the nutrients.

The coefficient of variation was highest at 45 DAT with 86.44%, followed by 30 DAT with 53.80% and at 60 DAT with 52.76%. The lowest CV was recorded at 75 DAT with 16.74%, showing more reliable and uniform data at the later stage. Since the treatment effect was significant at 75 DAT and the CV was comparatively low, the result at this stage can be considered more dependable.

Yield and yield attributes

Yield is a biological parameter resulted from the combined effect of environment, genetic factor (variety) and plant nutrients. Yield attributes are the most important parameters for evaluating the economic performance of any crop in a given environment.. The data on yield and yield attributes of cauliflower under four IPN levels are presented in Table 3.

Curd weight was significant different and varied largely among all treatments (F = 21.283, CD = 171.53). T3 recorded by far the highest mean curd weight of 896.0 g, followed by T4 (523.2 g). That difference showed that applying higher levels of IPNs did not improve and actually reduced curd weight. This finding agreed with those reported by Singh and Yadav (2019) and Adhikari and Sharma (2019).

.**Table 3. Effect of NPK levels on yield and yield attributes of cauliflower.**

Treatments	Curd Wt. (g)	Curd Dia. (cm)	Biomass (g / plant)	No. Curds/ Plot	Curd yield (kg / plot)	Curd yield (kg / ha)
T1(control)	284.4c	9.48c	945.6c	23.4a	6.66b	10811.71b
T2	465.6b	11.06b	1528.6ab	18.8b	8.76b	14220.81b
T3	896.0a	13.88a	1755.6a	19.4b	17.47a	28360.45a
T4	523.2b	11.22b	1101.0bc	20.4ab	10.58b	17175.36b
Grand Mean	**542.3**	**11.41**	**1332.7**	**20.5**	**10.87**	**17646.14**
CD (5%)	171.53**	0.986**	517.44*	NS	4.36**	**
CV (%)	22.95	6.27	28.17	12.18	29.13	-

*Means in the same column followed by different letters are significantly different at 5% level. ** = Highly significant at 1% level; * = Significant at 5% level; NS = Not Significant.*

Curd diameter showed the strongest treatment effect (F = 32.507, CD = 0.986). T3 recorded the largest curd (13.88 cm), followed by T4 (11.22 cm). The very low CV of 6.27% confirmed the reliability of this result. Biomass was significantly different (F = 4.973, CD = 517.44), with T3 having the highest one (1755.6 g / plant). This trait had directly positive relationship with the cord yield. The cord yield per plot and ha was significantly different among the treatments. The treatment T3 gave the highest cord yield of 17.47 kg/plot (28360.45 kg/ ha. These results were consistent with the results of Thapa and Poudel (2017); Pant, Bhattarai and Regmi (2018); Bhattarai and Thapa (2020); and Rana and Subedi (2021).

CONCLUSION

This study clearly showed that the integrated nutrient management had a significant and positive effect on the growth, yield and yield attributes of cauliflower at Chittapol, Bhaktapur. Among the four tested integrated nutrient levels, the T3: 200-120-100 kg N-P_2O_5-K_2O / ha^{-} + (OM) 39.3 t/ha gave the best results for all important yield parameters, including curd weight, curd diameter, biomass per plant, and curd yield per plot and hectare. Therefore, this treatment was found to be most suitable for cauliflower production under the conditions of this study site.

SUGGESTIONS

- Farmers in Chittapol, Bhaktapur and similar agro-ecological zones of Nepal should apply integrated nutrients with NPK fertilizers (200-120-100 kg/ha) in co9mbination with organic manure (39.3) kg ha^{-1} for best cauliflower yield.

- Nitrogen should be applied in split doses (50% basal, 25% at 30 DAT, and the rest 25% at 45 DAT) to reduce nitrogen loss through leaching and volatilization and to improve nutrient use efficiency.

AUTHORS' CONTRIBUTIONS

Pushpa Goit: Literature review, field lay out and experimentation, data measurement, analysis and draft report writing,
Binayak P Rajbhandari: Overall supervision including technical and academic guidance in experimentation, data interpretation and report writing.

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