



Effect of Integrated Nutrient Management on Growth and Yield of Cauliflower

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

With the use of integrated nutrient management, cauliflower the growth and yield can be boosted. Due to their complementing effects, the ideal combination of different organic and inorganic sources of nutrients may significantly boost cauliflower growth and yield. The experiment consisted of 13 treatments viz. T₁= N₁₂₀P₆₀K₁₀₀S₂₀ kg/ha (Recommended dose of NPKS as control), T₂= N₁₂₀P₆₀K₁₀₀S₂₀ kg/ha + CD (5 t/ha), T₃= N₁₂₀P₆₀K₁₀₀S₂₀ kg/ha + VC (4 t/ha), T₄= N₁₂₀P₆₀K₁₀₀S₂₀ kg/ha + MSC (4 t/ha), T₅= N₁₂₀P₆₀K₁₀₀S₂₀B_{0.6}Mo_{0.54} kg/ha + CD (5 t/ha), T₆= N₁₂₀P₆₀K₁₀₀S₂₀B_{0.6}Mo_{0.54} kg/ha + VC (4 t/ha), T₇= N₁₂₀P₆₀K₁₀₀S₂₀B_{0.6}Mo_{0.54} kg/ha + MSC (4 t/ha), T₈= N₁₂₀P₆₀K₁₀₀S₂₀ kg/ha + CD (5 t/ha) + Bio. (5 kg/ha), T₉= N₁₂₀P₆₀K₁₀₀S₂₀ kg/ha + VC (4 t/ha) + Bio. (5 kg/ha), T₁₀= N₁₂₀P₆₀K₁₀₀S₂₀ kg/ha + MSC (4 t/ha) + Bio. (5 kg/ha), T₁₁= N₁₂₀P₆₀K₁₀₀S₂₀B_{0.6}Mo_{0.54} kg/ha + CD (5 t/ha) + Bio. (5 kg/ha), T₁₂= N₁₂₀P₆₀K₁₀₀S₂₀B_{0.6}Mo_{0.54} kg/ha + VC (4 t/ha) + Bio. (5 kg/ha) and T₁₃=

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$N_{120}P_{60}K_{100}S_{20}B_{0.6}Mo_{0.54}$ kg/ha + MSC (4 t/ha) + Bio. (5 kg/ha). The experiment was laid out in a Randomized Complete Block Design (RCBD) having single factor with three replications. Data were recorded on growth, yield components of cauliflower and significant variation was observed for most of the studied characters. Under this investigation, it was revealed that the highest yield (36.34 t/ha) with net return (Tk. 524202) and BCR (3.59) was obtained from T_{12} ($N_{120}P_{60}K_{100}S_{20}B_{0.6}Mo_{0.54}$ kg/ha + VC (4 t/ha) + Bio. (5 kg/ha) treatment. On the other hand, the lowest yield (13.50 t/ha) with net return (Tk. 137869) and BCR (2.04) was obtained from T_1 ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment. So, economic analysis revealed that T_{12} ($N_{120}P_{60}K_{100}S_{20}B_{0.6}Mo_{0.54}$ kg/ha + VC (4 t/ha) + Bio-fertilizer (5 kg/ha) treatment appeared to be the best for achieving the higher growth, yield and economic benefit of cauliflower.

Keywords: Cauliflower; growth; yield; INM.

1. INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is the most important cole crop belongs to the family Cruciferae in the tropic and temperate regions of the world [1]. Cauliflower was introduced and widely in India [2]. Cauliflower is a very tasty and much popular vegetable in Bangladesh as well as all over the world. 100 g cauliflower contain 25 kcal energy, 89.25 g water, 2.38 g protein, 0.41 total lipids, 7.18 g carbohydrates, 3.3 g fiber, 1.39 g sugar, 40 mg calcium [3]. But the total cauliflower production is far below the requirement. Due to its economic importance, growers are not in a position to produce good quality cauliflower having low production with high productivity due to various biotic (Pest and diseases), abiotic (rainfall, temperature, relative humidity and light intensity) stresses and crop factors. To fulfill the nutritional requirement of people, total production as well as number of vegetables should be increased.

The increase use of fertilizers no doubt increases production of commodities very remarkably but it has a long-term detrimental impact on soil health. The Escalating prices of chemical fertilizers and its detrimental impacts had forced farmers to adopt alternative source of nutrients for vegetable production [4]. Therefore, reduced dependence on chemical fertilizers along with the maintenance of sustainable production is vital issues in modern agriculture which is only possible through integrated plant nutrient [5]. Long term studies on crops indicated that the balanced use of NPK fertilizers could not maintain the higher yields due to emergence of secondary and micro-nutrient deficiencies and deterioration of soil physical properties but uses of organic manures in INM (Integrated Nutrient Management) help in mitigating multiple nutrient deficiencies [6]. An integrated approach involving organic manures, biological resources and chemical fertilizers can

go a long way to improve crop productivity and to maintain soil fertility.

Cowdung contains a number of nutrients that can improve physical, chemical and biological properties of soil [7]. Vermicompost is a very good organic fertilizer and powerful growth promoter over the conventional composts and a protective farm input, which increases the physical, chemical and biological properties of soil. Vermicompost promotes growth from 50-100% over conventional compost and 30-40% over chemical fertilizers and the production cost will be low [8]. Mushroom spent compost (MSC) which is free from *E. coli* and *Salmonella spp.* promotes the quality of soil that improves the crop yield [9]. The use of bio-fertilizers in combination with chemical fertilizers and organic manures offers a great opportunity to increase the production as well as quality of cauliflower [10]. The role of bio-fertilizers is perceived as growth regulators besides biological nitrogen fixation collectively leading to much higher response on various growth and yield attributing characters [11]. Therefore, it is clear that the growth and yield of cauliflower can be increased by judicious application of integrated nutrient management. The purpose of this study is to investigate the effect of integrated nutrient management on vegetative growth and yield of cauliflower along with comparing the suitability of different integrated nutrient management practices on growth and yield attributes of cauliflower. It also helps to find out the economic performance of different integrated nutrient management practices on cauliflower production.

2. MATERIALS AND METHODS

2.1 Description of the Site

The research work was conducted at Horticulture Farm, Sher-e-Bangla Agricultural University,

Sher-e-Bangla Nagar, Dhaka, from October 2020 to February 2021. The location of the site was 23°74' N Latitude and 90°35' E Longitude with an elevation of 8.2 meters from the sea level [12]. The experimental site was under the subtropical climate with three distinct seasons: winter from November to February, pre-monsoon or hot season from March to April, and monsoon season from May to October [13]. Site of study has cold winter and hot summer. The yearly average precipitation (30- years long term period) which is mostly occurred during the monsoon months is 490 mm. The mean annual average maximum and minimum temperature was 28 and 19°C respectively.

2.2 Soil Sampling and Analysis

Prior to the beginning of experiment, soil samples were taken in order to determine the physical and chemical properties. The texture of the soil in the experimental field was silty loam. The soil in the experimental area is part of the Modhupur Tract [14] and belongs to Agroecological zone No. 28. The soil sample from the experimental plot was obtained from a depth of 0-30 cm and examined at the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka. It was air dried, crushed, and tested for physical and chemical properties.

2.3 Field Preparation and Treatment Allocation

The plot selected for the experiment was opened with a power tiller in the last week of October 2020 and left exposed to the sun for a week. To achieve good tilth, the land was harrowed, ploughed, and cross-ploughed several times after one week, followed by laddering. The experiment was laid out in a Randomized Complete Block Design (RCBD) having single factor with three replications. The treatments involved were, $T_1 = N_{120}P_{60}K_{100}S_{20}$ kg/ha (Recommended dose of NPK as control), $T_2 = N_{120}P_{60}K_{100}S_{20}$ kg/ha + CD (5 t/ha), $T_3 = N_{120}P_{60}K_{100}S_{20}$ kg/ha + VC (4 t/ha), $T_4 = N_{120}P_{60}K_{100}S_{20}$ kg/ha + MSC (4 t/ha), $T_5 = N_{120}P_{60}K_{100}S_{20}B_{0.6}Mo_{0.54}$ kg/ha + CD (5 t/ha), $T_6 = N_{120}P_{60}K_{100}S_{20}B_{0.6}Mo_{0.54}$ kg/ha + VC (4 t/ha), $T_7 = N_{120}P_{60}K_{100}S_{20}B_{0.6}Mo_{0.54}$ kg/ha + MSC (4 t/ha), $T_8 = N_{120}P_{60}K_{100}S_{20}$ kg/ha + CD (5 t/ha) + Bio. (5 kg/ha), $T_9 = N_{120}P_{60}K_{100}S_{20}$ kg/ha + VC (4 t/ha) + Bio. (5 kg/ha), $T_{10} = N_{120}P_{60}K_{100}S_{20}$ kg/ha + MSC (4 t/ha) + Bio. (5 kg/ha), $T_{11} =$

$N_{120}P_{60}K_{100}S_{20}B_{0.6}Mo_{0.54}$ kg/ha + CD (5 t/ha) + Bio. (5 kg/ha), $T_{12} = N_{120}P_{60}K_{100}S_{20}B_{0.6}Mo_{0.54}$ kg/ha + VC (4 t/ha) + Bio. (5 kg/ha) and $T_{13} = N_{120}P_{60}K_{100}S_{20}B_{0.6}Mo_{0.54}$ kg/ha + MSC (4 t/ha) + Bio. (5 kg/ha). Each block was divided into 13 plots where 13 treatments combination were distributed randomly and 39 unit plots altogether in the experiment. The size of each plot was 1.80 m × 1.60 m. The distance maintained between two blocks were 1.00 m and two plots were 0.50 m. The plots were raised up to 10 cm and maintaining spacing 60 cm × 40 cm, respectively. Each unit plot had 3 rows and with 4 plants. So, there were 12 plants per unit plot.

2.4 Planting Materials

The seeds of cauliflower cv. BARI fulkopi-1 variety were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur.

2.5 Manuring and Fertilization

Urea, Triple Super Phosphate (TSP) and Murate of Potash (MoP) were used as the source of nutrient elements N, P, K that was applied in all treatments. Total urea was applied in three installments. 1st installment was applied 10 days after planting, 2nd installment and 3rd installment was applied 25 days and 40 days respectively after planting. TSP was applied in two installments where 1st installment was applied at land preparation and 2nd installment was applied just before transplantation of the plants. MoP was also applied in two installments where 1st installment and 2nd installment was applied 15 days and 35 days respectively after planting. Gypsum, Borax and Ammonium Molybdate were used as the source of S, B and Mo with a standard dose of 111.11, 3.53 and 1 kg/ha respectively and the total amount were applied at the final land preparation. Organic manures like Cowdung, Vermicompost and Mushroom Spent Compost and Bio-fertilizer were applied fully applied at final land preparation. The fertilizers and manures were thoroughly mixed with the soil.

The above doses of fertilizers were converted into manure and fertilizer mixed per treatment of the experiment and supplied by each type of manure and fertilizer. NPKS were applied in each treatment. B and Mo were used in 6 treatments. After conversion the doses of each manure used in the experiment was as.

Table 1. Doses of manure and fertilizer

Fertilizer	Doses ha ⁻¹
Urea	260.87 kg
TSP	300 kg
MoP	200 kg
Gypsum	111.11 kg
Borax	3.53 kg
Ammonium molybdate	1 kg
Manures	Doses ha ⁻¹
Cowdung	5 t
Vermicompost	4 t
Mushroom spent compost	4 t
Bio-fertilizer	5 kg

Table 2. Doses of fertilizer and manure in each plot

Treatment	Urea (g/plot)	TSP (g/plot)	MoP (g/plot)	Gypsum (g/plot)	Borax (g/plot)	Ammonium Molybdate (g/plot)	VC (kg/plot)	MSC (kg/plot)	BIO. (g/plot)
T ₁	75.13	86.4	57.6	31.9	-	-	-	-	-
T ₂	75.13	86.4	57.6	31.9	-	-	-	-	-
T ₃	75.13	86.4	57.6	31.9	-	-	1.15	-	-
T ₄	75.13	86.4	57.6	31.9	-	-	-	1.15	-
T ₅	75.13	86.4	57.6	31.9	1.01	0.29	1.15	-	-
T ₆	75.13	86.4	57.6	31.9	1.01	0.29	-	-	-
T ₇	75.13	86.4	57.6	31.9	1.01	0.29	1.15	1.15	-
T ₈	75.13	86.4	57.6	31.9	-	-	-	-	1.44
T ₉	75.13	86.4	57.6	31.9	-	-	1.15	1.15	1.44
T ₁₀	75.13	86.4	57.6	31.9	-	-	1.15	1.15	1.44
T ₁₁	75.13	86.4	57.6	31.9	1.01	0.29	-	-	1.44
T ₁₂	75.13	86.4	57.6	31.9	1.01	0.29	1.15	1.15	1.44
T ₁₃	75.13	86.4	57.6	31.9	1.01	0.29	1.15	1.15	1.44

Here, CD = Cowdung, VC = Vermicompost, MSC = Mushroom spent compost
Bio. = Bio-fertilizer

2.6 Statistical Analysis

The collected data were compiled and tabulated. Statistical analysis was done on various plant characters to find out the significance of variance resulting from the experimental treatments. Data were analyzed using analysis of variance (ANOVA) technique with the help of the computer package program MSTAT-C (software) and the mean differences were adjudged by least significant difference test (LSD) as laid out by [15].

3. RESULT AND DISCUSSIONS

3.1 Growth Parameters

The data revealed that the effect of integrated nutrient management of synthetic fertilizers along with organic manures affected different growth parameters like plant height, number of leaves, spread of canopy and stem diameter of cauliflower as shown in (Table 1). Significant difference was observed in the plant height, number of leaves, spread of canopy and stem diameter due to integrated management of nutrients. The treatment T₁₂ recorded the maximum plant height (50.20 cm), number of leaves (23.73) and spread of canopy (55.47 cm) followed by T₁₃ (48.30 cm), (22.47) and (53.17 cm) and T₁₁ (47.10 cm), (22.40) and (52.33 cm) which were statistically similar to T₁₃ of plant height, number of leaves and spread of canopy respectively and the maximum stem diameter was on T₁₂ (3.33 cm), which was as par as T₁₃ (3.13 cm) and T₁₁ (3.03 cm).

The higher plant height might be attributed to the availability of greater amount of nutrients along with the efficiency of the plants of receiving proper nutrients resulting in larger leaf surface as well as prolonged greenness at both vegetative and reproductive stages. The results were in close agreement with the findings of [16], [17]. The plant height due to the enhancement of auxine biosynthesis and accessibility of macro nutrients specially nitrogen and also micro nutrients from chemical fertilizers and organic manures the significantly lower growth parameter was noticed on the treatment T₁ = N₁₂₀P₆₀K₁₀₀S₂₀ kg/ha (Recommended dose of NPKS as control) because providing only chemical fertilizers might not have fulfilled the crop demand. The application of INM was found better than only use of chemical fertilizers as it provides proper amount of nutrients for plant growth and improvement with the conservation of soil health.

INM refers to integration of organic, inorganic and biological components to increase crop productivity and maintenance of soil fertility for future use [18]. The results were in close agreement with the findings of [19-21].

3.2 Reproductive Parameters

The data revealed that the effectiveness of integrated nutrient management of chemical fertilizers along with organic manures affected the different reproductive stages like curd weight, curd diameter, quality and also the yield of cauliflower production as shown in (Table 2). Significant differences in curd weight, curd diameter, quality and yield were recorded due to application of chemical fertilizer along with organic manure in integrated management method. The treatment T₁₂ recorded maximum curd weight (956.33 g), curd diameter (17.43 cm) and yield (36.34 t/ha) followed by T₁₃ (926.30 g), (16.93 cm) and (31.68 t/ha) and T₁₁ (886.30 g), (16.47 cm) and (28.10 t/ha) which differed significantly from each other. This difference was shown due to balanced levels of fertilizer and manure application.

The treatment T₁₂ was maximum in all diameters because of having vermicompost as organic manure which contains more nutrients than mushroom spent compost and cowdung in T₁₃ and T₁₁ respectively. Vermicompost along with chemical fertilizer and biofertilizer enhance the availability of essential nutrients for the plants which increase the crop production with better quality rather than MSC and cowdung. Similar result was observed by Sharma and Sharma [22]. The qualitative traits like maximum TSS(°b) and ascorbic acid content of cauliflower curd was recorded highest with the application of treatment of T₁₂ (N₁₂₀P₆₀K₁₀₀S₂₀B_{0.6}Mo_{0.54} kg/ha + VC 4 t/ha + Bio. 5 kg/ha) followed by T₁₃ (N₁₂₀P₆₀K₁₀₀S₂₀B_{0.6}Mo_{0.54} kg/ha + MSC 4 t/ha + Bio. 5 kg/ha). It might be due to increased photosynthetic activity and other mineral resulted improved levels of carbohydrates and other quality parameters of cauliflower curd through the way of enzymatic activity that stimulated by plant growth substances produced by application of bio-fertilizers and other nutrients. Similar findings were reported by [23], [12] and [24].

3.3 Total dry Matter Accumulation in Cauliflower

The data revealed that the efficiency of integrated nutrient management method affected

the total dry matter production and its accumulation (Table 3). The treatment T₁₂ recorded the maximum total dry matter accumulation (21.73 g plant⁻¹), followed by T₁₃ (21.08 g plant⁻¹) which was statistically similar and T₁₁ (19.65 g plant⁻¹) which differed significantly from T₁₂ and T₁₃ but statistically similar to T₆ (19.20 g plant⁻¹). Significantly lower total dry matter accumulation (12.90 g plant⁻¹) was recorded with T₁ (N₁₂₀P₆₀K₁₀₀S₂₀ kg/ha (Recommended dose of NPKS as control). This

difference was observed due to balanced application of fertilizers and manures and proper consumption of macro and micro nutrients along with other essential elements by the plants for their advancement in case of growth and yield. The increased total dry matter accumulation in T₁₂ may be attributed to greater accumulation of photosynthates by vegetative parts in the plants having micronutrient application. Similar results found by [22], [25,26].

Table 3. Effect of integrated nutrient management methods on vegetative growth parameters of cauliflower

Treatment	Plant height (cm)	No. of leaves	Spread of canopy(cm)	Stem Diameter (cm)
T ₁	35.90 i	13.60 f	39.63 j	1.90 j
T ₂	37.90 h	15.30 e	42.03 i	2.23 i
T ₃	39.20 g	16.20 e	44.50 h	2.43 h
T ₄	37.60 h	16.20 e	42.93 i	2.33 hi
T ₅	45.30 d	19.90 c	49.73 ef	2.73ef
T ₆	47.90 b	20.60 c	51.37 cd	2.93cd
T ₇	46.20cd	20.50 c	50.40 de	2.83 de
T ₈	40.90 f	17.50 d	45.63 gh	2.60 g
T ₉	43.90 e	18.20 d	48.27 f	2.66fg
T ₁₀	41.80 f	17.60 d	46.50 g	2.56 g
T ₁₁	47.10 bc	22.40 b	52.33 bc	3.03 bc
T ₁₂	50.20 a	23.73 a	55.47 a	3.33 a
T ₁₃	48.30 b	22.47 b	53.17 b	3.13 b
LSD _(0.05)	1.2458	1.0515	1.4982	0.1061
CV%	3.71	3.32	4.78	2.36

Table 4. Effect of integrated nutrient management on reproductive parameter, quality, yield and total dry matter accumulation of cauliflower

Treatment	Curd weight (g)	Curd diameter (cm)	Total Solids soluble of curd (°B)	Ascorbic acid of curd (mg/100g)	Yield (ton)	Total dry matter accumulation (g plant ⁻¹)
T ₁	517.20 m	13.73 h	3.84 h	59.20 g	13.50 j	12.90 i
T ₂	577.22 l	15.07 g	4.20 g	59.85 f	17.00 ij	15.03 h
T ₃	647.33 j	15.60 f	4.23 g	59.91 ef	21.44 g	16.20 fgh
T ₄	617.23 k	15.13 g	4.25 g	59.82 f	18.50 hi	15.67 gh
T ₅	780.70 f	16.17 cde	4.60 e	60.30 cdef	24.44 ef	17.86 de
T ₆	850.33 d	16.30 c	4.76 bcd	60.78 bc	29.60 bc	19.20 c
T ₇	820.70 e	16.23 cd	4.68 cde	60.55 bcd	26.60 de	18.53 cd
T ₈	677.33 i	15.77 ef	4.42 f	60.10 def	20.40 gh	16.75 efg
T ₉	747.33g	16.03 cdef	4.62 de	60.45 bcde	25.50 de	17.46 de
T ₁₀	717.30 h	15.83 def	4.54 ef	60.33 bcdef	22.60 fg	17.03 ef
T ₁₁	886.30 c	16.47 c	4.82 bc	60.89 b	28.10 cd	19.65 bc
T ₁₂	956.33 a	17.43 a	5.63 a	61.55 a	36.34 a	21.83 a
T ₁₃	926.30 b	16.93 b	4.87 b	60.20 def	31.68 b	20.54 b
LSD _(0.05)	16.013	0.2163	0.1570	0.5609	2.7051	1.2139
CV%	5.28	6.31	1.13	1.25	6.59	3.25

4. CONCLUSION

On the basis of present study, it can be concluded that the application of $N_{120}P_{60}K_{100}S_{20}B_{0.6}Mo_{0.54}$ kg/ha + Vermicompost (4 t/ha) + Bio-fertilizer (5 kg/ha) resulted in maximum plant height, number of leaves, spread of canopy and stem diameter in vegetative stage and curd weight, curd diameter and yield in reproductive stage. Also, TSS(°b) and ascorbic acid content of cauliflower and total dry matter accumulation were highest in treatment T₁₂. Therefore we can conclude that plant which received nutrients from chemical fertilizers along with organic manures and bio-fertilizer that plant showed significant results as compared to other treatments. Besides, availability of these elements in the soil and the ability of the plant to acquire them was another reason for getting significant results in these treatments. For the absorption of proper nutrients by the plant, application of micronutrient is crucial which was mostly found in T₁₂. The treatments containing vermicompost always showed better results as compared to other treatments due to having higher amount of micronutrients. Moreover, the results of mushroom spent compost were always very close to vermicompost. On the other hand, cowdung also played better role rather than only use of chemical fertilizers. However, response of other plants were different to application methods of fertilizers such as lacking of some important elements or only chemical fertilizers could not fulfill the needs. In this case, application of integrated nutrient management system in plants is suitable for cauliflower production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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