# EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH AND YIELD OF CAULIFLOWER

**SAMSUN NAHAR HASHI**

**DEPARTMENT OF HORTICULTURE**

**SHER-E-BANGLA AGRICULTURAL UNIVERSITY**

**DHAKA-1207**

**DECEMBER, 2021**

# EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH AND YIELD OF CAULIFLOWER


**By**

**SAMSUN NAHAR HASHI**

**REGISTRATION NO.: 19-10266**

**Mobile No. 01757638141**

**Email. hashi.agri08@gmail.com**


*A Thesis*
*Submitted to the Faculty of Agriculture,*
*Sher-e-Bangla Agricultural University, Dhaka-1207,*
*In partial fulfillment of the requirements*
*for the degree of*

**MASTER OF SCIENCE (MS)**

**IN**

**HORTICULTURE**

**SEMESTER: JULY-DECEMBER, 2021**

**APPROVED BY:**

| | |
|---|---|
| ………..…...………………………. | …..………………………………… |
| **Prof. Dr. Tahmina Mostarin** | **Prof. Dr. Khaleda Khatun** |
| **Designation** | **Designation** |
| **Supervisor** | **Co-supervisor** |

……..……………………………………

**Prof. Dr. Khaleda Khatun**
**Chairman**
**Examination Committee**

**DEPARTMENT OF HORTICULTURE**
Sher-e-Bangla Agricultural University
**Sher-e-Bangla Nagar, Dhaka-1207**

*Ref:-.................................* *Date: 30/01/2023*

# *CERTIFICATE*

*This is to certify that the thesis entitled* ***'EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH AND YIELD OF CAULIFLOWER'*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS)*** *in* ***HORTICULTURE****, embodies the result of a piece of bona fide research work carried out by* ***SAMSUN NAHAR HASHI****, Registration No.:* ***19-10266,*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

*I further certify that any help or source of information, received during the course of this investigation has duly been acknowledged.*

**Dated:**
**Place: Dhaka, Bangladesh**

**Prof. Dr. Tahmina Mostarin**
Department of Horticulture
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka- 1207
**Supervisor**

***Dedicated***

***to***

***My Beloved***

***Parents***

# ***ACKNOWLEDGEMENTS***

*The author seems it a much privilege to express her enormous sense of gratitude to the Almighty Allah for there ever ending blessings for the successful completion of the research work.*

*The author wishes to express her gratitude and best regards to her respected Supervisor, **Dr. Tahmina Mostarin**, Professor, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for her continuous direction, constructive criticism, encouragement and valuable suggestions in carrying out the research work and preparation of this thesis.*

*The author wishes to express her earnest respect, sincere appreciation and enormous indebtedness to her reverend Co-Supervisor, **Dr. Khaleda Khatun**, Professor, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for her scholastic supervision, helpful commentary and unvarying inspiration throughout the research work and preparation of the thesis.*

*The author feels to express her heartfelt thanks to the honorable Chairman, **Prof. Dr. Khaleda Khatun**, Department of Horticulture along with all other teachers and staff members of the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for their co-operation during the period of the study.*

*The author feels proud to express her deepest and endless gratitude to all of her course mates and friends to cooperate and help her during taking data from the field and preparation of the thesis.*

*The author expresses her heartfelt thanks to her beloved parents, sister and all other family members for their prayers, encouragement, constant inspiration and moral support for her higher study. May Almighty bless and protect them all.*

*The Author*

# EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH AND YIELD OF CAULIFLOWER


## ABSTRACT

The experiment was carried out at the "Horticulture Farm" of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during October 2020 to February 2021 to study the effect of integrated nutrient management on the growth and yield of cauliflower. The experiment consisted of 13 treatments *viz.* $T_1 = N_{120}P_{60}K_{100}S_{20}$ kg/ha (control), $T_2 = T_1$ + Cowdung (5 t/ha), $T_3 = T_1$+ Vermicompost (4 t/ha), $T_4 = T_1$ + Mushroom spent compost (4 t/ha), $T_5 = T_2 + B_{0.6}Mo_{0.54}$ (kg/ha), $T_6 = T_3 + B_{0.6}Mo_{0.54}$ (kg/ha), $T_7 = T_4 + B_{0.6}Mo_{0.54}$ (kg/ha), $T_8 = T_2$ + Bio-fertilizer (5 kg/ha), $T_9= T_3$ + Bio-fertilizer (5 kg/ha), $T_{10}= T_4$ + Bio-fertilizer (5 kg/ha), $T_{11}= T_5$ + Bio-fertilizer (5 kg/ha), $T_{12}= T_6$ + Bio-fertilizer (5 kg/ha) and $T_{13}= T_7$ + Bio-fertilizer (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 and yield 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 $T_{12}$ ($T_6$ + Bio-fertilizer (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 $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment appeared to be the best for achieving the highergrowth, yield and economic benefit of cauliflower.

## LIST OF CONTENTS


| Chapter | Title | Page No. |
|---|---|---|
| | **ACKNOWLEDGEMENTS** | **i** |
| | **ABSTRACT** | **ii** |
| | **LIST OF CONTENTS** | **iii** |
| | **LIST OF TABLES** | **vi** |
| | **LIST OF FIGURES** | **vii** |
| | **LIST OF PLATES** | **viii** |
| | **LIST OF APPENDICES** | **ix** |
| | **LIST OF ACRONYMS** | **x** |
| **I** | **INTRODUCTION** | **1** |
| **II** | **REVIEW OF LITERATURE** | **5** |
| **III** | **MATERIALS AND METHODS** | **20** |
| 3.1 | Description of the experimental site | 21 |
| 3.2 | Soil characteristics | 21 |
| 3.3 | Climate and weather | 21 |
| 3.4 | Crop/planting material | 22 |
| 3.5 | Experimental treatments | 22 |
| 3.6 | Experimental design and layout | 22 |
| 3.7 | Seedbed preparation | 22 |
| 3.8 | Seed treatment | 23 |
| 3.9 | Seed sowing | 23 |
| 3.10 | Raising of seedlings | 23 |
| 3.11 | Land preparation | 23 |
| 3.12 | Application of manures and fertilizers | 24 |
| 3.13 | Transplanting of seedlings | 24 |
| 3.14 | Intercultural operations | 25 |
| 3.14.1 | Gap filling | 25 |
| 3.14.2 | Weeding | 25 |
| 3.14.3 | Irrigation | 25 |
| 3.14.4 | Pest control | 25 |
| 3.14.5 | General observation | 25 |
| 3.15 | Harvesting | 25 |

## LIST OF CONTENTS (Cont'd)


| Chapter | Title | Page No. |
|---|---|---|
| 3.16 | Collection of data | 26 |
| 3.16.1 | Plant height | 26 |
| 3.16.2 | Number of leaves per plant | 26 |
| 3.16.3 | Largest leaf length | 26 |
| 3.16.4 | Largest leaf breadth | 26 |
| 3.16.5 | Spread of plant canopy per plant | 26 |
| 3.16.6 | Root length | 26 |
| 3.16.7 | Stem length | 26 |
| 3.16.8 | Stem diameter | 27 |
| 3.16.9 | Diameter of curd per plant | 27 |
| 3.16.10 | Total weight of curd per plant | 27 |
| 3.16.11 | Dry weight percentage of leaves per plant | 27 |
| 3.16.12 | Dry weight percentage of curd per plant | 27 |
| 3.16.13 | Yield per plot | 28 |
| 3.16.14 | Gross yield per hectare | 28 |
| 3.17 | Economic analysis | 28 |
| 3.18 | Statistical analysis | 28 |
| **IV** | **RESULTS AND DISCUSSION** | **29** |
| 4.1 | Plant height | 30 |
| 4.2 | Number of leaves per plant | 32 |
| 4.3 | Largest leaf length | 33 |
| 4.4 | Largest leaf breadth | 33 |
| 4.5 | Spread of canopy per plant | 34 |
| 4.6 | Root length | 34 |
| 4.7 | Stem length | 36 |
| 4.8 | Stem diameter | 36 |
| 4.9 | Curd diameter | 37 |
| 4.10 | Curd weight per plant | 39 |
| 4.11 | Dry matter (%) of leaves | 40 |
| 4.12 | Dry matter (%) of curd | 40 |
| 4.13 | Yield per plot | 41 |

## LIST OF CONTENTS (Cont'd)


| Chapter | Title | Page No. |
|---|---|---|
| 4.14 | Yield per hectare | 42 |
| 4.15 | Economic analysis | 43 |
| 4.15.1 | Gross return | 44 |
| 4.15.2 | Net return | 44 |
| 4.15.3 | Benefit cost ratio | 44 |
| **V** | **SUMMARY AND CONCLUSION** | **46** |
| | **REFERENCES** | **50** |
| | **APPENDICES** | **56** |

## LIST OF TABLES


| Table | Title | Page No. |
|---|---|---|
| 1 | Effect of different integrated nutrient management on plant height at different days after transplanting of cauliflower | 31 |
| 2 | Effect of integrated nutrient management on largest leaf length, largest leaf breadth and spread of canopy of cauliflower | 35 |
| 3 | Effect of integrated nutrient management on root length, stem length and stem diameter of cauliflower | 37 |
| 4 | Effect of integrated nutrient management on dry matter (%) of leaves and dry matter (%) of curd of cauliflower | 41 |
| 5 | Effect of integrated nutrient management on yield per plot and yield per hectare of cauliflower | 43 |
| 6 | Cost and return of cauliflower using different integrated nutrient management | 45 |

# LIST OF FIGURES


| Figure | Title | Page No. |
|---|---|---|
| 1 | Effect of integrated nutrient management on number of leaves at different days after transplanting of cauliflower | 32 |
| 2 | Effect of integrated nutrient management on curd diameter of cauliflower | 38 |
| 3 | Effect of integrated nutrient management on curd weight of cauliflower | 39 |

## LIST OF PLATES


| Plate | Title | Page No. |
|---|---|---|
| 1 | Photograph of seedbed | 65 |
| 2 | Photograph of transplanting of seedlings in the main field | 65 |
| 3 | Photograph of fertilization on the plot | 66 |
| 4 | Photograph of vegetative stage of cauliflower | 66 |
| 5 | Photograph of general view of the experimental plot | 67 |
| 6 | Photograph of curd of cauliflower | 67 |
| 7 | Photograph of harvested curds of cauliflower | 68 |

## LIST OF APPENDICES


| Appendix | Title | Page No. |
|---|---|---|
| I | Agro-Ecological Zone of Bangladesh showing the experimental location | 58 |
| II | Monthly records of air temperature, relative humidity (RH) and rainfall during the period from November 2020 to March 2021 | 59 |
| III | Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka | 59 |
| IV | Layout of the experimental field | 60 |
| V | Mean square values of plant height at different days after transplanting of cauliflower | 61 |
| VI | Mean square values of number of leaves plant$^{-1}$ at different days after transplanting of cauliflower | 61 |
| VII | Mean square values of largest leaf length plant$^{-1}$, largest leaf breadth plant$^{-1}$ and spread of canopy per plant of cauliflower | 61 |
| VIII | Mean square values of root length, stem length, stem diameter and curd diameter of cauliflower | 62 |
| IX | Mean square values of curd weight per plant, dry matter (%) of leaves and dry matter (%) of curd per plant of cauliflower | 62 |
| X | Mean square values of yield per plot and yield per hectare of cauliflower | 62 |
| XI | Production cost of cauliflower per hectare | 63 |

## LIST OF ACRONYMS

| **Acronym** | | **Full meanings** |
|---|---|---|
| AEZ | = | Agro-Ecological Zone |
| % | = | Percent |
| °C | = | Degree Celsius |
| BARI | = | Bangladesh Agricultural Research Institute |
| cm | = | Centimeter |
| CV% | = | Percentage of coefficient of variance |
| cv. | = | Cultivar |
| DAS | = | Days after sowing |
| *et al.* | = | And others |
| FAO | = | Food and Agriculture Organization |
| g | = | Gram |
| $ha^{-1}$ | = | Per hectare |
| kg | = | Kilogram |
| LSD | = | Least Significant Difference |
| MoP | = | Muriate of Potash |
| N | = | Nitrogen |
| No. | = | Number |
| NPK | = | Nitrogen, Phosphorus and Potassium |
| SAU | = | Sher-e-Bangla Agricultural University |
| SRDI | = | Soil Resources and Development Institute |
| t | = | Ton |
| TSP | = | Triple Super Phosphate |
| viz. | = | Videlicet (namely) |
| Wt. | = | Weight |

# CHAPTER I

# INTRODUCTION

# CHAPTER I

# 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 (Siddique, 2004). Cauliflower was introduced and widely in India (Saha *et al.*, 2015). Edible part of cauliflower is commonly known as 'Curd'. Cauliflower is a very tasty and much popular vegetable in Bangladesh as well as all over the world. The nutritional value per 100 g edible part of fresh cauliflower contains 89% moisture, 8.0 g carbohydrate, 2.3 g protein, 40 IU carotene, 0.13 mg B1, 0.11 mg B2, 50 mg vitamin C, 30 mg calcium and 0.8 mg iron and also contains 30 calorie (Rashid, 1999). In the year 2019-2020 cauliflower covers an area 21963.56 hectares with a total production of 283157 tons (BBS). The total cauliflower production is far below the requirement. To fulfill the nutritional requirement of people, total production as well as number of vegetables should be increased.

Cauliflower is a heavy feeder of nutrients and it responds very well to all bulky nutrient addition through FYM, bio-fertilizers, green manures and chemical fertilizers. Among various factors of production, nutritional requirement play a vital role in measuring the production of the crop. Long term studies on crops indicated that the balanced use of NPKS fertilizers could not maintain the higher yields over years because of emergence of secondary and micro-nutrient deficiencies and deterioration of soil physical properties. The increase use of fertilizers no doubt increases production of commodities very remarkably but it has a long-term detrimental impact on soil health. Therefore, reduced dependence on chemical fertilizers along with maintenance of sustainable production is vital issues in modern agriculture which is only possible through integrated plant nutrient (Chumyani *et al.*, 2012). The results of a large number of experiments on manures and fertilizers conducted in several parts of the country revealed that neither chemical fertilizers alone, nor organic sources used extensively, can sustain the productivity of soils under highly intensive cropping. The cost of chemical fertilizers is also increasing day by day; hence, adoption of integrated plant nutrient offers scope for sustainable crop production and improves soil fertility. Uses of organic manures in Integrated Nutrient Management (INM) help in mitigating multiple nutrient deficiencies (Devi *et al.*, 2018).

An integrated approach involving organic manures, biological resources and chemical fertilizers can go a longway to improve crop productivity and to maintain soil fertility.

Cowdung can restore the soil nutrients and improve the structure of the soil. Cowdung contains a number of nutrients that can improve physical, chemical and biological properties of soil (Suparman and Supiati, 2004). The use of cowdung (N=1.0-1.1%, P=0.3-0.33%, K=0.46-0.51%) can improve the growth and yield some crops such as maize, soybean, cucumber, and some vegetable crops (Mucheru-Muna and Mugendi, 2007; Ghorbani *et al.*, 2008; Mahmoud *et al.*, 2009; Jahan *et al.*, 2014). Vermicompost (N=1.7-2.7%, P=1.25-2.25%, K=1.2-1.6%) is a very good organic fertilizer and powerful growth promoter over the conventional composts and a protective farm input, which increases the water holding capacity in soil. Vermicompost treated soil has better aeration,porosity and bulk density, which enhances soil fertility. The use of compost and vermicompost improves plant growth and quality. The vermicompost promote growth from 50-100% over conventional compost and 30-40% over chemical fertilizers and the production cost will be low (Sinha *et al*., 2010). Mushroom spent compost (N=1.5%, P=0.5%, K=1.09%) improves soil water infiltration, water retention, permeability and aeration. It is a good organic fertilizer which is free from *E. coli* and *Salmonella spp.* Mushroom spent compost promote the qualityof soil that improves the crop yield (Ashrafi *et al.*, 2014).

Systematic approach to nutrient management by tapping all possible sources of organic and inorganic in a judicious manner to maintain soil fertility and crop productivity is the essence of integrated nutrient management (INM). In addition, bio-fertilizers increase the growth of microorganisms in soil, which act a growth promoter and also play a vital role in magnifying nitrogen fixation. They work as nitrogen fixers, potassium and phosphorus solubilizers and phosphorus mobilizers. Among bio-fertilers, *Azospirillum* fixes nitrogen from 10 to 40 kg/ha and found to colonize the root system of many vegetable plants. *Azospirillum* inoculation helps the plants in better vegetative growth and also in saving input of nitrogenous fertilizers by 10%-20%. So, utilization of bio-fertilizers which have an ability to enrich the soil with beneficial microorganisms as well as to mobilize the nutritionally important elements from non- usable to usable forms through biological processes resulting in enhanced production of fruits and vegetables offer an alternative (Purkayastha *et al.*, 1998).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 (Mondal *et al.*, 2003). 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 (Yeptho *et al.*, 2012). Integrated use of fertilizer, manure and bio-fertilizers improve soil fertility and crop growth. INM refers to integration of organic, inorganic and biological components to increase crop productivity and maintenance of soil fertility for future use (Gruhn *et al.*, 2000).

Therefore, it is clear that the growth and yield of cauliflower can be increased by judicious application of integrated nutrient management. But only a little information on cauliflower research regarding integrated nutrient management is available in Bangladesh.

Keeping the above facts in view the present experiment was undertaken with following objectives:

i. To investigate the effect of integrated nutrient management on vegetative growth and yield of cauliflower.

ii. To compare the suitability of different integrated nutrient management practices on growth, yield attributes and yields of cauliflower.

iii. To find out the economic performance of different integrated nutrient management practices on cauliflower production.

# CHAPTER II

# REVIEW OF LITERATURE

# CHAPTER II

## REVIEW OF LITERATURE

Yield and yield contributing characters of cauliflower are considerably depended on integration of different nutrients management practices for obtaining higher production. Different integrated nutrient management practices are more responsible for the growth and yield of cauliflower. The available relevant reviews related to application of integrated nutrient on growth and yield of crops in the recent past have been presented and discussed:

Kumar *et al.* (2021) conducted a field experiment at the Horticulture Research Center (HRC) of Sardar Vallabhbhai Patel University of Agriculture and Technology Meerut during 2019-20. The experiment consists of eleven treatment combinations with integrated sources of nutrients and mulching (Black and Paddy straw) in Randomized Block Design with three replications. The results showed that plants fortified and mulched with $T_8$ 50% RDF + 15 t/ha VC + *Azotobacter* (5 kg/ha) + PSB (5 kg/ha) + Black mulch (2.5 mm) had been significantly registered for largest leaf plant$^{-1}$ (16.73 cm$^2$) and maximum average specific gravity of the curd (1.17), polar diameter of curd (17.87 cm), curd size index (19.13 cm$^2$) and maximum marketable curd yield (179.09 q ha$^{-1}$). The same treatment was also found superior in terms of minimum days taken to first curd initiation (47.62), days taken to 50% curd initiation (64.57), days taken to 50% curd maturity (99.35) and days taken to first curd maturity duration from initiation to harvest (18.67).

Rabindra *et al.* (2021) carried out an experiment at horticulture field of Rama University, Department of Horticulture Faculty of Agriculture and Allied Industries during October 2020 to February 2021 to assess the growth and yield attributes of cauliflower (*Brassica oleracea*, var. *botrytis* L) cultivar variety, snow crown under various Integrated Nutrient Management (INM). The experiment was carried out in randomized complete block design. There were 8 treatments comparing $T_1$ (control), $T_2$ (recommended dose of NPK @150:100:80 kg/ha), $T_3$ (half dose of NPK/ha + FYM @15 tons/ha), $T_4$ (half dose of NPK/ha + *Azospirillum* @ 5 kg/ha), $T_5$ (half dose of NPK/ha + FYM @15 tons/ha + *Azospirillum* @ 5 kg/ha), $T_6$ (half dose of NPK/ha + vermicompost @ 2.5 tons/ha), $T_7$ (half dose of NPK/ha + Vermicompost @ 2.5 tons/ha + FYM @ 15 tons/ha), $T_8$ (half dose of NPK/ha + Vermicompost @ 2.5

tons/ha + *Azospirillum* @ 5 kg/ha) which was replicated three times. The result revealed that the highest plant height (60.50 cm), number of leaves (16.33), plant spread (44.50 cm), curd diameter (20 cm), curd weight per plant (1006.7 g), curd yield per plot (9.3 kg) and curd weight per hectare (32 tons/ha) were observed in half dose of NPK/ha + Vermicompost @ 2.5 tons/ha + *Azospirillum* @ 5 kg/ha ($T_8$). INM treatments showed lesser result on growth and yield of cauliflower in $T_1$ (control). Thus, farmers are suggested to apply half dose of NPK/ha + Vermicompost @ 2.5 tons/ha + *Azospirillum* @ 5 kg/ha to increase growth and yield of cauliflower.

Islam *et al.* (2020) conducted a field experiment was at two locations to evaluate integrated management of different organic manures with chemical fertilizers for cauliflower production. The experiment consisted of seven treatments $T_0$: control, $T_1$: 75% recommended fertilizer dose (RFD), $T_2$: 100% RFD, $T_3$: 75% RFD + Kazi compost (5 t $ha^{-1}$), $T_4$: 75% RFD + Kazi compost (3 t $ha^{-1}$), $T_5$: 75% RFD + poultry manure (3 t $ha^{-1}$) and $T_6$: 75% RFD + cow dung (5 t $ha^{-1}$). Combined application of organic manures and inorganic fertilizers significantly increased growth parameters, yield attributes and yield of cauliflower and exerted significant positive effects on nutrient [nitrogen (N), phosphorus (P), potassium (K) and sulfur (S)] uptakes by curds compared to the unfertilized control. There was no considerable effect of integrated nutrient management on the occurrence of seed-borne fungi in curds and leaves. Among different treatment combinations, the performance of $T_3$ was the best which was statistically similar with $T_4$. Next to Kazi compost (70% poultry manure composted with 30% rice and/or saw dust), poultry manure performed well followed by cow dung in association with chemical fertilizers. In both of the locations, the performance of integrated nutrient management was better (compensating up to 25% of RFD) compared to sole application of inorganic fertilizers. Therefore, Kazi compost @ 5 t $ha^{-1}$ combined with 75% RFD should be recommended for better growth, yield and nutritional improvement in cauliflower.

Neupane *et al.* (2020) conducted an experiment in the farmer's field at Ajagadhawa, Gadhawa-4, Dang, Nepal to evaluate the effect of integrated nutrient management on growth and yield of cauliflower as well as their residual effects on soil properties. The cauliflower variety silvercup-60 was grown under eight different treatments; $T_1$: 50% N through RDF + 50% N through FYM; $T_2$: 50% N through RDF + 50% N through PM; $T_3$: 50% N through RDF + 50% N through VC, $T_4$: 50% N through RDF + 25%

N through FYM + 25% N through PM; $T_5$: 50% N through RDF + 25% N through VC + 25% N through PM; $T_6$: 50% N through RDF + 25% N through VC + 25% N through FYM; $T_7$: 50% N through RDF + 25% N through VC +25% N through FYM; $T_8$: 50% N through RDF + 50% N through FYM, VC and poultry manure. The experiment was laid out in RCB design with three replications. The result revealed that the highest plant height (36.40 cm), number of leaves (15), plant spread (31.72 cm), leaf area (526.5 $cm^2$), curd weight (207.3 g) and curd yield (12.85 t/ha) were found under 50% N through RDF +50% N through VC. The root length, root diameter and root density were better under all INM treatments as compared to100% N through RDF. INM treatments showed lesser bulk density, lesser particle density, greater infiltration rate and greater organic matter content than application of 100% N through RDF. Soil total nitrogen was increased in all INM treatments while soil available phosphorus decreases in all treatments except 100% N trough RDF and 50% N through RDF + 50%N through PM. Thus, farmers are suggested to apply 50% N through VC along with 50% N through RDF to increase cauliflower yield.

Bhadra *et al.* (2019) conducted an experiment to study the effects of cowdung and boron on growth and yield of broccoli. The experiment consisted of two factors; Factor A: cowdung - 4 levels such as $C_0$: no cowdung (control), $C_1$: cowdung 10 ton/ha, $C_2$: cowdung 15 ton/ha and $C_3$: cowdung 20 ton/ha. Factor B: boron- 4 levels, such as $B_0$- no boron (control), $B_1$: boron 1 kg/ha, $B_2$: boron 2 kg/ha and $B_3$: boron 3 kg/ha. In case of cowdung the maximum plant height at 60 DAT (61.47 cm), spread of plant at 60 DAT (50.00 cm), number of leaves per plant at 60 DAT (11.39), length of the largest leaf at 60 DAT (57.69 cm), primary curd weight (374.58 g), yield per hectare (15.74 t/ha) were recorded from $C_3$ (cowdung 20 ton/ha) treatment and the lowest was recorded from the control ($C_0$) treatment. Regarding combination of cowdung and boron the maximum plant height at 60 DAT (63.11 cm), spread of plant at 60 DAT (52.33 cm), number of leaves per plant at 60 DAT (12.97), length of the largest leaf at 60 DAT (60.25 cm), primary curd weight (399.33 g), yield per hectare (16.71 t/ha) and the minimum days required for curd initiation (50.10 DAT), were recorded from $C_3B_2$ (cowdung 20 t/ha and boron 2 kg/ha) treatment and the lowest was recorded from $C_0B_0$ (no cowdung and no boron) treatment. The highest production of broccoli is obtained from 20 ton/ha cowdung and 2 kg/ha boron.

Salwa and Kashem (2019) conducted an experiment in the Dekarhaor of Noagaon village under South Sunamganj Upazila of Sunamganj district during November 2017 to February 2018 to observe the effect of nutrients management on growth and yield of cauliflower hybrids. Two Hybrids namely ShiraGiku ($V_1$) and Rupali ($V_2$), and four combinations of nutrients, viz. (i) recommended rate of N-P-K-S-Zn-B @ 180-80-180-28-4.5-2.1 kg ha-1($F_1$), (ii) $F_1$ + 25% N-P-K-S-Zn-B of $F_1$ ($F_2$), (iii) $F_1$ – 25% N-P-K-S-Zn-B of $F_1$ ($F_3$), and (iv) cow dung @ 10 t $ha^{-1}$ ($F_4$) was conducted in a factorial randomized complete block design (RCBD) and replicated thrice. Plant height (cm), numbers of leaves $plant^{-1}$, leaf length (cm) and leaf breadth (cm), and spreading diameter (cm) were collected at 15 days intervals, while the yield data were recorded at harvest. The parameters were significantly varied due to hybrids and fertilizers packages. Higher gross yield (42.52 t $ha^{-1}$) was found in Shira Giku and lower (42.12 t $ha^{-1}$) from Rupali. Higher curd yield of 25.17 t $ha^{-1}$ was obtained in Shira Giku than Rupali (9.61 t $ha^{-1}$). The highest gross yield of 44.45 t $ha^{-1}$ was obtained when the crop was treated with cowdung @ 10 t $ha^{-1}$ followed by recommended fertilizer rate ($F_1$). The curd yield of 18.19 t $ha^{-1}$ was obtained with 25% less than recommended fertilizer rate of application ($F_3$). The highest gross yield of 52.93 t $ha^{-1}$ was obtained in $V_1F_1$ combination and the lowest of 30.10 t $ha^{-1}$ in $V_2F_1$. Results revealed that the Hybrid Shira Giku with recommended dose of fertilizer (180-80-180-28-4.5-2.1 kg $ha^{-1}$ of N-P-K-S-Zn-B) performed the best in comparison to other treatment combinations.

Ali *et al.* (2018) conducted a field experiment at South Surma upazila of Sylhet district to evaluate the effect of vermicompost, cowdung and inorganic fertilizers on the growth and yield of cauliflower (*Brassica oleracea* var. *botrytis* L.) in acid soil. The experiment comprised of four treatments viz. $T_1$= 135-60-135-21-3-1.5 kg $ha^{-1}$ of N-P-K-S-Zn-B, $T_2$= $T_1$ + Cowdung (5 t $ha^{-1}$), $T_3$= $T_1$ + Vermicompost (5 t $ha^{-1}$) and $T_4$= Vermicompost (10 t $ha^{-1}$). The experiment was laid out in a randomized complete block design with three replications. The results on growth parameters recorded at 15, 30 and 45 DAT showed significant variation in different growth and yield contributing characters. The tallest plant (24.47 cm) was recorded at 45 DAT in $T_3$ treatment. The same treatment at 30 DAT produced the highest number of leaves $plant^{-1}$ (8.33) while $T_4$ had the lowest number of leaves $plant^{-1}$ (5.93). The longest length and breadth of the largest leaf and spreading of plants were recorded 19.60, 10.03 and 16.53 cm at 45 DAT in $T_3$, respectively. The maximum curd yield (29.72 t $ha^{-1}$) was recorded in $T_3$ treatment. Post-harvest soil analysis showed higher amount of organic matter, total N, available P, exchangeable K and available S contents than in initial soil. This might be due to residual effect of vermicompost. The results revealed that vermicompost addition with recommended dose of chemical fertilizers $T_3$ performed better compared to only inorganic fertilizers.

Devi *et al.* (2018) conducted a field experiment laid out at the experimental farm of Department of Soil Science and Water Management, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP) in two consecutive years (2015 and 2016) to evaluate effect of integrated nutrient management (INM) on yield of cauliflower (*Brassica oleracea* var. *botrytis* L.) and soil fertility. Studies employed integrated use of organic and inorganic fertilizers with PGPR strains (*Bacillus* spp.). The nine treatments, $T_1$- Absolute control, $T_2$- 70% NPKM + 30% N through FYM and VC (50:50), $T_3$- 80% NPKM + 20% N through FYM and VC (50:50), $T_4$- 90% NPKM + 10% N through FYM and VC (50:50), $T_5$- 100% NPK + FYM, $T_6$- 100% NPK + Vermicompost, $T_7$- 110% NPKM (50:50 of FYM and VC as per N content), $T_8$- 120% NPKM (50:50 of FYM and VC as per N content), $T_9$- 130% NPKM (50:50 of FYM and VC as per N content). PGPR applied to all treatments except $T_1$, $T_5$ and $T_6$. Experimental set up was laid down in a randomized block design (RBD) with three replicates. Results revealed that treatment $T_3$- 80% NPKM + 30% N through FYM and VC (50:50) with PGPR, significantly increased the cauliflower yield by 22.91% as compared to treatment $T_5$- 100% NPK + FYM (RDF). Soil status was assessed after harvest and concentration of nutrients increased in soil with the combined use of fertilizers and PGPR.

Meena *et al.* (2018) carried out an experiment in order to study the effect of biofertilizers and growth regulators on growth attributes of cauliflower. The experiment consisting 15 treatments combination with two factors i.e. biofertilizers with three levels (control, PSB and mycorrhiza) and growth regulators with five levels (control, NAA 50 ppm, NAA 100 ppm, $GA_3$ 50 ppm and $GA_3$ 100 ppm) in Factorial Randomized Block Design with three replications. The individual application of biofertilizer treatment $B_2$ (*mycorrhiza*) recorded maximum plant height (63.02 cm), numbers of leaves per plant (22.83), length of stem (8.96 cm), minimum days taken to 50% curd initiation (33.20), days taken to 50% marketable curd size (59.35) and maximum chlorophyll content in leaves at 45 DAT (0.45 mg $g^{-1}$). Similarly, the individual application growth regulator treatment $G_3$ ($GA_3$ 50 ppm) found maximum plant height (64.58 cm), number of leaves per plant (24.05), length of stem (9.39 cm), minimum days taken to 50% curd initiation (32.48), days taken to 50% marketable curd size (58.32) and maximum chlorophyll content in leaves at 45 DAT (0.45 mg $g^{-1}$) compared to control. Further, the interaction effect due to application of biofertilizer and growth regulator had significant increased growth and yield over the control. The maximum plant height (65.91 cm), number of leaves per plant (24.45), stem length (9.78 cm), minimum days taken to 50% curd initiation (31.57), days taken to 50 per cent marketable curd size (55.85) and maximum chlorophyll content in leaves at 45 DAT (0.48 mg $g^{-1}$) with application treatment $B_2G_3$ (mycorrhiza + $GA_3$ 50 ppm) compared to control.

Mishra *et al.* (2018) conducted a field experiment in the research farm of All India Coordinated Research Project on Vegetable, Orissa University of Agriculture and Technology, Bhubaneswar during 2014-15 to study the integrated nutrient management in Sprouting Broccoli cv. Shayali for growth, yield, quality and economics in a randomized block design with 10 treatments. The soil test based recommended fertilizer dose applied was NPK @ 200: 50: 150 kg/ha. The Treatment, $T_7$ i.e., 50% NPK + Vermicompost @ 2.5 t/ha recorded maximum values for plant height (51.56 cm), plant spread N-S (61.63 cm) and E-W (64.91 cm), number of leaves per plant (22.27), leaf area (405.45 $cm^2$), leaf length (23.15 cm), leaf width (18.18 cm), days to 50% head initiation (50.67 days) and days to first harvest (51.00). The treatment, $T_7$ also recorded highest head girth (42.76 cm), head diameter (14.16 cm), terminal head weight (327.57 g), head volume (595.67 cc), gross yield (233.56 q/ha), marketable yield (163.63 q/ha), vitamin C (80.24 mg/g), dry matter (11.77%), gross returns (Rs. 700680.00/ha), net returns (Rs. 525510.00/ha) and benefit cost ratio (4.0). This was followed by treatment $T_9$ (50% NPK + poultry manure @ 2.5 t/ha). Among all the treatments, the treatment $T_7$ i.e., application of 50% recommended dose of NPK/ha with 2.5 tons of vermicompost in sprouting broccoli was found to be the best for obtaining better growth, optimum yield, better quality produce, highest net returns as well as cost benefit ratio and is recommended for Odisha condition.

Changkija *et al.* (2017) carried out a field experiment at the Experimental Farm, Department of Horticulture, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus, during 2012-2013 and 2013-2014 to find out the response of integrated nutrient management on growth, yield and quality of broccoli cv. Calabrese under the foothill condition of Nagaland. Results revealed that integrated application of 50% NPK + 50% vermicompost + Biofertilizers recorded significantly higher plant height (70.33 cm), number of leaves (20.45), stem diameter (3.25 cm), plant spread (74.25 cm), equilateral head diameter (16.97 cm), polar head diameter (18.37 cm), head size (310.59 $cm^2$), gross head weight (956.0 g), net head weight (330.86 g), yield $ha^{-1}$ (11.96 t $ha^{-1}$), protein content (3.77%), vitamin C content (132.50 mg 100 $g^{-1}$), total soluble solids (5.52) and pH of the head (5.12). While treatment T16- 50% NPK + 50% Pig manure + Biofertilizers gave the highest net return (Rs. 260450) and cost benefit ratio (1:3.48) and was found to be significantly at par for all growth, yield and quality parameters with treatment $T_{18}$ (50% NPK + 50% vermicompost + biofertilizers). Latha *et al.* (2017) conducted an experiment and revealed that Integrated Nutrient Management (INM) recorded significant increase in broccoli curd yield. Application of poultry manure @ 2.5 t $ha^{-1}$ + Half RDF of chemical fertilizers (40-30-30 kg N, $P_2O_5$ and $K_2O$ $ha^{-1}$) treatment recorded highest average curd weight of 285.17 g with an yield of 104.37 q $ha^{-1}$ which was 15% yield increase to the treatment applied with 100% RDF of chemical fertilizers (80-60-60 kg N, $P_2O_5$ and $K_2O$ $ha^{-1}$). Treatment $T_9$ (poultry manure @ 2.5 t $ha^{-1}$ + Half RDF of chemical fertilizers) recorded highest net returns of Rs. 222,820/- with benefit-cost ratio of 2.9 and production cost of Rs. 76,700/- among all the treatments. The treatments applied with chemical fertilizers or organic manures alone could not increase the yield of broccoli than the treatments integrated with both of organic and inorganic sources. The treatments $T_7$ (Vermicompost @ 2.5 t $ha^{-1}$ + Half RDF of chemical fertilizers) and $T_3$ (FYM @ 10 t $ha^{-1}$ + Half RDF of chemical fertilizers) recorded on par curd yields of 98.93 q $ha^{-1}$ and 95.21 q $ha^{-1}$, respectively with the treatment $T_9$, and with benefit-cost ratio of 2.59 and 2.52, respectively. Lowest benefit-cost ratio of 1.59 was recorded in the treatmentapplied with Vermicompost @ 5 t $ha^{-1}$.

Simarmata *et al.* (2016) experimented that 50% of recommended dose of mineral fertilizer along with compost of trailing-daisy weeds at 10 ton $ha^{-1}$ increased the plant height and shoot fresh weight in cauliflower. Mineral fertilizer at 50% of the recommended dose and cowdung at 20 t $ha^{-1}$ can increase the curd fresh weight of cauliflower.

Solaiman *et al.* (2016) conducted an experiment to find out the effect of organic manures and spacing on the growth and yield of cauliflower in summer season. In this study, the treatment consisted of three organic manures *viz.* $F_0$: no organic manure, $F_1$: cowdung, $F_2$: vermicompost and three spacing *viz.* $S_1$ (60 × 30) cm, $S_2$ (60 × 40) cm, $S_3$ (60 × 50) cm. Two factorial experiments were laid out in the RCBD with three replications. Significant variations in all parameter were observed due to organic manure and spacing at different days after transplanting. For organic manure, highest yield of cauliflower (12.98 t $ha^{-1}$) was obtained from $F_2$ and lowest (8.24 t $ha^{-1}$) from $F_0$. For spacing, highest yield of cauliflower (11.25 t $ha^{-1}$) was obtained from $S_1$ and lowest (10.57 t $ha^{-1}$) from $S_3$. For combined effect, highest yield of cauliflower (13.33 t $ha^{-1}$) was obtained from $F_2S_1$ and the lowest (7.91 t $ha^{-1}$) from $F_0S_3$. The highest BCR (3.79) was found from $F_2S_1$ and lowest (2.70) from $F_0S_3$. It is found from theexperiment that growth and yield of summer cauliflower were positively correlated with organic manure and spacing. However, white beauty cultivars can be cultivated in summer season and use of vermicompost with 60 × 50 cm spacing would be beneficial for the farmers.

Chaudhary *et al.* (2015) conducted an experiment on effect of integrated nutrient management on cabbage (*Brassica oleracea* var. capitata L.) under middle Gujarat conditions out during rabi season of the year 2013-2014 at Agronomy Farm, Department of Agronomy, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. The treatments consisted of 10 treatments, viz. 100 % RDN + FYM @ 20 t $ha^{-1}$ ($T_1$), 100 % RDN + FYM @ 20 t $ha^{-1}$ + *Azotobacter* +PSB ($T_2$), 100 % RDN + vermicompost @ 10 t $ha^{-1}$ ($T_3$), 100 % RDN + vermicompost @ 10 t $ha^{-1}$ + *Azotobacter* + PSB ($T_4$), 100 % RDN + FYM @ 10 t $ha^{-1}$ ($T_5$), 100 % RDN + FYM @ 10 t $ha^{-1}$ + *Azotobacter* + PSB ($T_6$), 75 % RDN + FYM @ 10 t $ha^{-1}$ ($T_7$), 75 % RDN + FYM @ 10 t $ha^{-1}$ + *Azotobacter* + PSB ($T_8$), 75 % RDN + vermicompost @ 5 t $ha^{-1}$ ($T_9$) and 75 % RDN + vermicompost @ 5 t $ha^{-1}$ + *Azotobacter* + PSB ($T_{10}$). Result revealed that treatment ($T_4$) 100 % RDN + vermicompost @ 10 t $ha^{-1}$ + *Azotobacter* + PSB increased growth attributes i.e. plant height and leaf area index except number of open leaves $plant^{-1}$ at harvest that remained non-significant and yield and yield attributes i.e. weight of cabbage head, volume of cabbage head and diameter of cabbage head and yield of cabbage head were obtained from the treatment ($T_4$) 100 % RDN + vermicompost @ 10 t $ha^{-1}$ + *Azotobacter* + PSB. Nitrogen influenced all growth and yield attributes significantly and it increased gradually with increasing levels of nitrogen up to 200 kg N $ha^{-1}$.

Prabhakar *et al.* (2015) conducted a field experiment to study the effect of different levels of organic manures and conventional practices on growth, yield and quality of cauliflower. The trial included five levels of organic manure nutrient and two inorganic nutrient supplies. The treatment which received recommended dose of farm yard manure along with recommended NPK produced the highest mean curd yield (21.23 t/ha) followed by the treatments, which received 100 and 75% recommended dosage of nitrogen (RDN) through organics (19.36 and 18.42 t/ha). The same treatment also recorded higher values for growth and yield parameters like number of leaves, leaf area, leaf area index, curd diameter and curd weight. Quality parameters in terms of total antioxidant capacity, radical scavenging ability, total flavonoids and vitamin C were better with integrated nutrient management as compared to chemical fertilizers only.

Tekasangla *et al.* (2015) carried out a field experiment during 2011-12 at the Experimental Farm of School of Agricultural Sciences and Rural Development, Medziphema Campus, Nagaland University to study the effect of integrated nutrient management on growth, yield and quality of cauliflower under foothills condition of Nagaland. The experiment was laid out in a randomized block design with three replications. Results revealed that application of different levels of fertilizers, organic manures and biofertilizers either alone or in combination significantly increased the growth, yield and quality of cauliflower as compared to control. The maximum plant height (49.26 cm), stalk length (19.60 cm), number of leaves (24.45), plant spread (68.13 cm), curd diameter (12.73 cm), curd size (108.18 $cm^2$), gross curd weight (866.67 g), net curd weight (351.33 g), curd yield per hectare (13.00 t), curd compactness (24.45) and ascorbic acid content (25.15 mg 100 $g^{-1}$) were recorded with the combined application of 50% NPK + 50% FYM + Biofertilizers. There was a significant buildup of organic carbon in the soil after harvest of the crop with 50% NPK + 50% FYM + Biofertilizers. The same treatment also produced the highest net return of Rs. 187,750/- along with cost benefit ratio of 1:2.59. This result suggested that 50% chemical fertilizers can be reduced without any compromise on yield, quality and fertility status of soil.

Verma *et al.* (2015) carried out two field experiments to study the impact of integrated nutrient management (INM) on plant growth, head yield, quality and its economics in cabbage at Main Experiment Station, Department of Vegetable Science, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad, Uttar Pradesh during rabi season of 2009-2010 and 2010-2011. Among the treatments, the highest yield 471.99 q/ha and 466.08 q/ha and vitamin-C content 117.38 mg/100 g and 115.57 mg/100 g were recorded from treatment ($T_8$) comprises of 50% recommended dose of fertilizers (RDF) + poultry manure (3 t/ha) + *Azotobacter* (seedling root dip for 20 min in 10% solution) during both the years 2009-2010 and 2010-2011, respectively followed by ($T_9$) 50% RDF + vermicompost (3 t/ha) + *Azotobacter* (seedling root dip for 20 min in 10% solution). Hybrid cultivar Kranti showed maximum values for most of the growth, yield and quality attributes for all the treatments over cultivar Golden Acre during both the years of investigation. From economic analysis, highest net return was observed with the cultivation of hybrid Kranti followed by Golden Acre. Vegetable growers can get higher yield and net return by the application of 50% RDF + poultry manure (3 t/ha) + *Azotobacter* with hybrid Kranti.

An experiment was conducted by Rahman *et al*. (2014) to investigate the effect of foliar fertilization on growth and yield of cauliflower under poultry manure condition at farmer's field Marghazar, Mansehra. The experimental treatments were $T_0$= Control (Urea) 123.5 kg ha$^{-1}$, $T_1$= N + Mo + Mg foliar spray [4% N + (Mo) 50 mg L$^{-1}$ + (B) 80 mg L$^{-1}$], $T_2$= Urea + N foliar spray (123.5 kg ha$^{-1}$ + 2% N), $T_3$= foliar spray 4% N and $T_4$= foliar spray 8% N. The results revealed that treatment $T_1$ [4% N + (Mo) 50 mg L$^{-1}$ + (B) 80 mg L$^{-1}$] significantly increased the root length, leaf length, plant fresh weight, curd weight, circumference of curd and curd yield. From these results it could be suggested and recommended that nitrogen in combination with micronutrients (Mo and B) are the most essential plant mineral nutrients in foliar fertilization method for growth and curd yield of cauliflower under poultry/chicken manure condition.

Sangeeta *et al.* (2014) carried out an experiment with cauliflower cv. Poosi in a randomized block design with three replications. The experiment comprised of 15 different combinations of five different sources of nutrients including organic, inorganic and bio fertilizers alone and in combinations which were applied following the proper procedures as per treatment. The effect of different treatments were observed and noted that maximum plant height (66.75 cm), plant spread (58.64 cm), curd diameter (16.09 cm), depth of curd (11.76 cm), curd volume (702.00 cc), weight of curd (568.00 g), yield per hectare (252.48 q) and ascorbic acid (63.19 mg/100g) was noted by application of ½ N:P:K (recommended dose) + FYM @ 5 t/ha + poultry manure @ 2 t/ha+ *Azospirillum* ($T_{14}$). Hence it can be said that the application of ½ recommended dose of NPK along with FYM @ 5 t/ha + poultry manure @ 2 t/ha as well as seedling inoculation with *Azospirillum* was found to be the most effective treatment combination for getting enhanced yield and quality.

Farahzety and Aishah (2013) conducted an experiment to assess the potentiality of organic fertilizers in replacing the chemical fertilizer for cauliflower production under protected structure. Three composts and two vermicomposts used were oil palm empty fruit bunches compost (EFBC), chrysanthemum residue compost (CRC), soybean waste compost (SWC), green waste vermicompost (GWV) and vegetable waste vermicompost (VWV). A chemical fertilizer (N: $P_2O_5$: $K_2O$; 12:12:17) was used as control. The amount of fertilizer applied was calculated based on 180 kg/ha of N. It was observed that VWV and EFBC were comparable to the chemical fertilizer based on their effects on the growth and yield performance of cauliflower. VWV and EFBC indicated promising results and can be used to replace chemical fertilizers in fulfilling the nutrient requirements of cauliflower. The yield and curd size of VWV and EFBC treated cauliflower were similar to chemically fertilized plants. Besides, curds of VWV treated plants can be harvested 7 days earlier than chemically fertilized plants. The use of compost and vermicompost have positive effects on the growth and crop yield of cauliflower, and have great potential to improve vegetable production in Malaysia.

Isaac and Manu (2013) carried out an experiment in the station farm to evaluate the response of cauliflower to organic nutrition under integrated farming in homesteads. The soil belonged to the ultisol laterite group with initial pH of 4.1, available N, P and K, 128.5, 12.82 and 212.16 kg $ha^{-1}$, respectively. The treatments included were $T_1$: 100% POP recommendation as chemical fertilizers, $T_2$: 50% NPK as chemicals + 50% substitution with vermicompost + poultry manure, $T_3$: 50% NPK as chemicals + 50% substitution with vermicompost + goat manure and $T_4$: 100% NPK as organic manures (vermicompost + goat manure + poultry manure). Seedlings of cauliflower, hybrid variety NS 60 N, were trans planted at 20 days in furrows at a spacing of 45 cm × 45 cm. FYM @ 25 t $ha^{-1}$ was uniformly applied in all plots initially and the nutrient sources as per treatments in three splits, one week after transplanting, 20

DAP and 30 DAP. Chemical fertilizers were applied in two splits, after transplanting and 30 DAP. The other management practices were done as per the KAU recommendations for the crop. Observations on growth parameters were recorded at periodic intervals and yields at harvest. The performances of cauliflower crop under varying sources of organic manures available in an integrated farming system. The different sources tried were goat manure, poultry manure, vermicompost at 50% level substitution of nitrogen, 100% organic nutrition and 100% chemical fertilizers. Analysis of the results revealed curd yields to be better for the organically grown plants and the curds raised with organic and integrated sources were found to retain the quality longer than chemical fertilizer application. Low temperature storage proved better than open storage. The economic analysis proved that organic nutrition with the biowastes available within the farming system was more economic and sustainable compared to the use of purchased chemical inputs.

Mutalib *et al.* (2013) conducted an experiment on the effects of vermicomposts and composts on the nutrient status, growth and yield of cauliflower to assess the potential of these organic fertilizers in replacing the chemical fertilizer for cauliflower production under protected structure. They observed that the yield and curd production were significantly higher in vegetable waste vermicomposting than the chemical fertilizers using and the curd formation were 7 days earlier than the chemically fertilized plants. The growth and yield of cauliflower remarkably influenced by organic and inorganic fertilizer management, for which an integrated approach for maintaining yield sustainability and soil fertility (Noor *et al.*, 2007).

Bashyal (2011) carried out a field experiment at Rampur, Chitwan, Nepal during September, 2007 to February, 2008 to assess the response of cauliflower (*Brassica oleracea* L. var. *botrytis* cv. Kathmandu Local) to biofertilizer containing free living nitrogen fixing bacteria *Azospirillum* and *Azotobacter* and different levels of nitrogen. The experiment was laid out in factorial Randomized Complete Block Design consisting of 10 treatments (nitrogen 0, 30, 60, 90 and 120 kg ha$^{-1}$ alone and in combinations of 2 kg of the nitrogen fixing biofertilizer) arranged in 5 × 2 complete factorial with 3 replications. Application of nitrogen along with the biofertilizer significantly increased morphological, yield and quality characters as compared to application of nitrogen without biofertilizer. The maximum stem height, stem diameter, highest curd height, curd diameter, fresh curd weight and curd yield were recorded at 120 kg nitrogen and 2 kg biofertilizer $ha^{-1}$. Cauliflower curd yield obtained at 120 kg nitrogen $ha^{-1}$ did not significantly differ with the curd yield recorded at 60 kg nitrogen and 2 kg biofertilizer $ha^{-1}$. The earliest days to curd initiation and maturity were recorded at 30 kg nitrogen and 2 kg biofertilizer $ha^{-1}$. The highest vitamin C content of curds and the most attractive curd color were recorded at 60 kg nitrogen and 2 kg biofertilizer $ha^{-1}$, while the appearance and over all acceptability were recorded at 120 kg nitrogen and 2 kg biofertilizer $ha^{-1}$. The finding demonstrated a saving of 60 kg nitrogen $ha^{-1}$ without significantly affecting yield.

Sharma and Sharma (2010) reported significant improvement in plant height, number of leaves per plant, curd diameter, curd depth, gross weight/plant and marketable curd yield when cauliflower was treated with inorganic fertilizers in presence of bio-fertilizers. Cowdung contains a number of nutrients that can improve physical, chemical and biological properties of soil (Suparman and Supiati, 2004). The use of cowdung can improve the growth and yield some crops such as maize, soybean, cucumber, cauliflower and some vegetable crops (Mucheru-Muna *et al.*, 2007; Ghorbani *et al.*, 2008; Mahmoud *et al.*, 2009; Jahan *et al.*, 2014).

Wani *et al.* (2010) conducted an experiment during rabi of 2004-2005 to find out the optimum dose and best combination of organic and inorganic sources of nutrients for maximizing yield and improving quality of cauliflower cv Snowball-16. Combined application of 50% recommended dose of NPK and poultry manure at 3 t/ha recorded significantly higher curd yield (325.1 q/ha), followed by combined application of 50% recommended dose of NPK and mixture of FYM, poultry manure, sheep manure and pea straw. Highest net returns (Rs. 178,096/ha) and benefit cost ratio (3.59) were also recorded for the treatment including combined use of 50% recommended dose of NPK and poultry manure at 3 t/ha. Application of 50% recommended dose of NPK + mixture of half dose of FYM, poultry manure, sheep manure and pea straw remained second in order.

Ara *et al.* (2009) reported that all the vegetative development parameters like plant height, number of leaves per plant, entire plant weight, weight of marketable curd per plant and yield t/ha were impacted altogether by the utilization of various organic manures alongside mineral fertilizers.

Kachari and Korla (2009) carried out an experiment laid out with three levels of inorganic fertilizers, NPK (100, 75 and 50% of recommended dose of NPK 125: 75: 65 kg/ha), inoculation of four bio-fertilizers (*viz. Azotobacter*, *Azospirillum*, vesicular arbuscular mycorrhizae, PSB1), recommended dose of FYM, i.e. @ 25 t/ha and their combinations. Observations were recorded on the different aspects of the plant like growth and development characters (plant height, leaf length, leaf width, leaf area, number of leaves, leaf weight, stalk length, root biomass, days to curd formation), yield attributing characters (curd size, curd height, gross curd weight, net curd weight and yield per hectare). Though the treatments performed differently during both the years of the studies, nitrogen and potassium gave consistent results during both the years with respect to growth and yield attributing characters.

According to Khan *et al.* (2008), organic and inorganic fertilizers have a positive impact on cabbage and broccoli production. A field experiment at Bangladesh

Agricultural Research Institute (BARI) found that using poultry manure (5-10 t $ha^{-1}$) in accordance with the 50-75 recommended doses of chemical fertilizers resulted in significantly higher yields of cabbage and broccoli. The use of a moderate dose of poultry manure in combination with chemical fertilizer appeared to be cost-effective, resulting in a higher economic return.

# CHAPTER III

# MATERIALS AND METHODS

# CHAPTER III

# MATERIALS AND METHODS

This chapter describes the materials and methods which were used in the field to conduct the experiment entitled “Effect of integrated nutrient management on the growth and yield of cauliflower” during the period from October 2020 to February 2021. The materials and methods that were used for conducting the experiment have been presented in this chapter. It comprises a short description of experimental site, soil and climate, variety, growing of the crops, experimental design and treatments and collection of data presented under the following headings:

## 3.1 Description of the experimental site

The research work was conducted at Horticulture Farm, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period 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 (Anon, 1987) and presented in Appendix I.

## 3.2 Soil characteristics

The texture of the soil in the experimental field was silty loam. The soil in the experimental area is part of the Modhupur Tract (UNDP, 1988) and belongs to AEZ No. 28. Before conducting the experiment, a 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 which is shown in Appendix II.

## 3.3 Climate and weather

The climate of 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 (Edris *et al.*, 1979). The Bangladesh Meteorological Department, Agargoan, Dhaka, provided details of the meteorological data collected during the experiment, which are presented in Appendix III.

### 3.4 Crop/planting material

The seed of variety BARI Fulkopi-1 (Rupa) was collected from Bangladesh Agricultural Research Institute (BARI), Joydepur, Gazipur, Bangladesh.

### 3.5 Experimental treatments

The experiment consisted of 13 treatments:

$T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control)
$T_2$= $T_1$+ Cowdung (5 t/ha)
$T_3$= $T_1$+ Vermicompost (4 t/ha)
$T_4$= $T_1$+ Mushroom spent compost (4 t/ha)
$T_5$= $T_2$ + $B_{0.6}Mo_{0.54}$ kg/ha
$T_6$= $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha
$T_7$= $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha
$T_8$= $T_2$ + Bio-fertilizer (5 kg/ha)
$T_9$= $T_3$ + Bio-fertilizer (5 kg/ha)
$T_{10}$= $T_4$ + Bio-fertilizer (5kg/ha)
$T_{11}$= $T_5$ + Bio-fertilizer (5 kg/ha)
$T_{12}$= $T_6$+ Bio-fertilizer (5 kg/ha) and
$T_{13}$= $T_7$ + Bio- fertilizer (5 kg/ha)

### 3.6 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) having single factor with three replications. The total area of the experimental plot was divided into three equal blocks. Each block was divided into 13 plots where 13 treatments combination were distributed randomly. There were 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 and two plots were 1.00 m and 0.50 m, respectively. The plots were raised up to 10 cm and maintaining spacing 60 cm × 40 cm, respectively.

### 3.7 Seedbed preparation

Seedbed was prepared on 1$^{st}$ week of October 2020 for raising seedlings of cauliflower and the size of the seedbed was 3 m × 1 m. For making seedbed, the soil was well ploughed to loosen friable and dried masses to obtained good tilth. Weeds, stubbles and dead roots were removed from the seedbed. Cowdung was applied to prepared seedbed. The soil was treated by Sevin 50WP @ 5kg ha$^{-1}$ to protect the young plants from the attack of mole crickets, ants and cutworm.

### 3.8 Seed treatment

Seeds were treated by Provax 200WP @ 3g $kg^{-1}$ to protect some seed borne diseases.

### 3.9 Seed sowing

Seeds were sown on 10 October 2020 in the seedbed. Sowing was done thinly in lines spaced at 5 cm distance. Seeds were sown at a depth of 2 cm and covered with a fine layer of soil before being lightly watered with a water can. Following that, the beds were covered with dry straw to keep the required temperature and moisture levels. The dry straw cover was removed as soon as the seed sprout emerged. When the seeds germinated, white polythene was used to provide shade to protect the young seedlings from the scorching sun and rain.

### 3.10 Raising of seedlings

Light watering and weeding were done several times. No chemical fertilizers were applied for raising of seedlings. Seedlings were not attacked by any kind of insect or disease. 25 days old healthy seedlings were transplanted into the experimental field on 5 November 2020.

### 3.11 Land preparation

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. Weeds and stubbles were removed and a desirable tilth of soil was obtained for seedling transplanting. Drainage channels were built around the land to prevent water logging caused by rainfall during the study period. When the plot was finally ploughed, the soil was treated with Furadan 5G @ 15 kg $ha^{-1}$ to protect the young seedlings from cut worm attack.

### 3.12 Application of manures and fertilizers

Manures and fertilizers were applied as per the treatment. Organic manure and inorganic fertilizer was used as the source of nitrogen, phosphorus and potassium. Total amount of organic manure was applied during final land preparation as per treatment. The following doses of fertilizers and manures were used in this experiment:

| Fertilizers | Doses of fertilizers (kg/ha) | Doses of nutrients (kg/ha) |
|---|---|---|
| Urea | 260.87 | N - 120 |
| TSP | 300 | P - 60 |
| MoP | 200 | K - 100 |
| Gypsum | 111.11 | S - 20 |
| Borax | 3.53 | B - 0.6 |
| Ammonium molybdate | 1 | MO - 0.54 |

| Organic Manures | Doses of manues (ton/ha) | Nutrients concentrations (%) | | |
|---|---|---|---|---|
| | | N | P | K |
| Cowdung | 5 | 1-1.1 | 0.3-0.33 | 0.46-0.51 |
| Vermicompost | 4 | 1.7-2.7 | 1.25-2.25 | 1.2-1.6 |
| Mushroom spent compost | 5 | 1.5 | 0.5 | 1.09 |

| Bio-fertilizer | Dose (kg/ha) | Components |
|---|---|---|
| Azospirillum | 5 | Bio compost, tricho card, phosphorus, vermicompost. |

### 3.13 Transplanting of seedlings

Seedbeds were watered before uprooting the seedlings to minimize the damage of roots 25 days old healthy seedlings were transplanted at the spacing of 60 cm × 40 cm in the experimental plots on 5 November 2020 as per treatment. Planting was done in the afternoon. For better establishment, light irrigation was applied immediately after transplanting around each seedling. Watering was done for up to five days until they could establish their own root system.

## 3.14 Intercultural operations

### 3.14.1 Gap filling

Very few seedlings were damaged after transplanting and new seedlings from the same stock were replaced these.

### 3.14.2 Weeding

The plants were kept under careful observation. Weeding was done at four to five times. First weeding was done two weeks after transplanting. Another weeding was done after 12-15 days interval as per necessity.

### 3.14.3 Irrigation

For better establishment, light irrigation was applied immediately after transplanting around each seedling. Watering was done for up to five days until they could establish their own root system. Irrigation was given based on the moisture content of the soil. During the crop period, irrigation was performed four times.

### 3.14.4 Pest control

The crop was attacked by cutworms, mole cricket and field cricket during the early stage of growth of seedlings in the month of December. This insect was controlled by spraying Dursban 20 EC @ 0.1%.

### 3.14.5 General observation

The field was frequently observed to notice any changes in plants, pest and disease attack and necessary action was taken for normal plant growth.

## 3.15 Harvesting

Curds were harvested at different dates according to maturity indices. Harvesting was started on 1 February 2021 and was completed on 28 February 2021. The curds were harvested with 10 cm of stem attached with the sprouts. Randomly selected 5 plants were harvested from each unit plot for recording growth, yield and quality parameter and together with rest of entire plot per plot for estimating yield. Harvesting was done very carefully. Different yield contributing data have been recorded from the mean of 5 randomly harvested plants of every harvesting stage.

### 3.16 Collection of data

The data pertaining to following characters were recorded from five plants randomly selected from each plot except yield of curd which was recorded plot wise. The following parameters were studied for the present experiment.

#### 3.16.1 Plant height (cm)

Plant height was recorded at 15, 30, 45 and 60 days after transplanting (DAT) by using meter scale. Height was measured from ground level to the tip of the longest leaf of an individual plant. Thus mean value of the five selected plants per plot was considered as the height of the plant and was expressed in centimeter.

#### 3.16.2 Number of leaves per plant

Number of leaves per plant was counted at 15, 30, 45 and 60 days after transplanting (DAT) from five randomly selected plants. Fallen leaves were counted on the basis of scar marks on the stem introduced by the petiole of the leaves.

#### 3.16.3 Largest leaf Length (cm)

Length of largest leaf was measured at harvest from the base of the petiole to the tip of leaf with a meter scale and was recorded in centimeter.

#### 3.16.4 Largest leaf breadth (cm)

Breadth of largest leaf was measured at harvest from the widest part of the lamina by a meter scale and was expressed in centimeter.

#### 3.16.5 Spread of plant canopy per plant (cm)

Crown spread was measured in centimeter at harvest by taking the mean diameter of the canopy of an individual plant in several directions.

#### 3.16.6 Root length (cm)

A distance between the bases to the tip of the root was measured in cm at 60 DAT with the help of scale for determining the length of root.

#### 3.16.7 Stem length (cm)

A distance between the bases to the tip of the stem was measured in cm at harvest with the help of' scale for determining the length of stem.

### 3.16.8 Stem diameter (cm)

Stem diameter was measured at 60 DAT with a measuring scale placing it vertically at the widest point of the stem. It was expressed in centimeter.

### 3.16.9 Diameter of curd per plant (cm)

Selected five curds were sectioned in the middle vertically with a sharp knife. The diameter of the curd was measured in cm with a scale as the horizontal distance from one side to another side of the sectioned curd.

### 3.16.10 Total weight of curd per plant (g)

Fresh weight of the edible part per plant was recorded and expressed in gram.

### 3.16.11 Dry matter percentage of leaves per plant

At first 100 g fresh leaf from selected plants was collected, cut into pieces and dried under sunshine for a few days and then dried in oven at 70℃ for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter percentage of the leaf was computed by the simple calculation from the weight recorded by the following formula:

$$\text{Dry matter percentage of leaves (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

### 3.16.12 Dry matter percentage of curd per plant

At first 100 g fresh curd from selected plants was collected, cut into pieces and dried under sunshine for a few days and then dried in oven at 70℃ for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken.

The dry matter percentage of the curd was computed by the simple calculation from the weight recorded by the following formula:

$$\text{Dry matter percentage of curd (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

#### 3.16.13 Yield per plot (kg)

Yield per unit plot was calculated by adding the yields of all plants of each unit plot and expressed in kilogram (kg).

#### 3.16.14 Gross yield per hectare (t)

Gross yield of a cauliflower was measured as the whole plant weight including the leaves of all the plant of a plot and gross yield per hectare was calculated by converting the weight of the cauliflower plant of plot into hectare and expressed in t $ha^{-1}$.

### 3.17 Economic analysis

Cost of production was analyzed in order to find out the most economic return under different integrated nutrient management practices. All input costs, including the cost for lease of land and interest on running capital were considered for computing the cost of production. The interests were calculated @ 15% per year for 6 months. The cost and return analyses were done in details according to the procedure followed by Alam *et al.* (1989). The Benefit Cost Ratio (BCR) was calculated as follows:

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

### 3.18 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 computer package program MSTAT-C (software) and the mean differences were adjudged by least significant difference test (LSD) as laid out by Gomez and Gomez (1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

# CHAPTER IV

# RESULTS AND DISCUSSION

The experiment was conducted to observe the effect of integrated nutrient management on growth and yield of cauliflower under the soil and agro climatic condition of Sher-e-Bangla Agricultural University (SAU), Dhaka. Data on different growth and yield parameters were recorded. The analysis of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendix (V-X). This chapter comprises of the presentation and discussion of the results obtained from the present study. The results have been presented, discussed and possible interpretations were given in tabular and graphical forms. The results obtained from the experiment have been presented under separate headings and sub-headings as follows:

## 4.1 Plant height

Statistically significant variation was observed on plant height due to different nutrient management at 15, 30, 45 and 60 DAT under the present experiment (Table 1 and Appendix V). At 60 DAT, the tallest plant (50.20 cm) was observed from $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment. Chemical fertilizers having macro and micro nutrients could not provide the proper nutrients, so in treatment $T_{12}$ applying vermicompost with these increased the plants growth almost 50%-100% rather than other conventional compost and also containted higher amount of nutrients. Then adding bio-fertilizers that had fixed nitrogen which was the main requirement for cauliflower production, because cauliflower is heavy feeder of nitrogen. However, the shortest plant (35.90 cm) was revealed from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment because of the emergence of secondary nutrients and micronutrients for the physical enhancement of the plants. Meena *et al.* (2018) reported that the interaction effect due toapplication of bio-fertilizer and growth regulator had significant increased growth (plant height, leaves plant$^{-1}$) and yield over the control. Bashyal (2011) reported that application of nitrogen along with the biofertilizer significantly increased morphological (plant height), yield and quality characters as compared application of nitrogen without biofertilizer.

**Table 1. Effect of different integrated nutrient management on plant height (cm) at different days after transplanting of cauliflower**

| Treatments | Plant height (cm) at | | | |
|---|---|---|---|---|
| | 15 DAT | 30 DAT | 45 DAT | 60DAT |
| $T_1$ | 4.80 f | 11.60 g | 17.60 h | 35.90 i |
| $T_2$ | 6.50 e | 13.70 f | 21.60 g | 37.90 h |
| $T_3$ | 7.30 cde | 14.70 e | 22.30 g | 39.20 g |
| $T_4$ | 7.00 de | 14.50 ef | 22.00 g | 37.60 h |
| $T_5$ | 7.70 bcd | 16.00 cd | 26.40 de | 45.30 d |
| $T_6$ | 8.20 bc | 16.70 bc | 27.90 bc | 47.90 b |
| $T_7$ | 7.90 bcd | 16.50 bc | 27.10 cd | 46.20 cd |
| $T_8$ | 7.10 de | 15.00 e | 24.60 f | 40.90 f |
| $T_9$ | 7.70 bcd | 16.10 cd | 25.40 ef | 43.90 e |
| $T_{10}$ | 7.60 cd | 15.40 de | 25.30 ef | 41.80 f |
| $T_{11}$ | 7.80 bcd | 16.80 bc | 28.50 b | 47.10 bc |
| $T_{12}$ | 9.37 a | 18.40 a | 30.20 a | 50.20 a |
| $T_{13}$ | 8.70 ab | 17.20 b | 28.60 b | 48.30 b |
| $LSD_{(0.05)}$ | 1.04 | 0.9774 | 1.1058 | 1.2458 |
| CV% | 8.25 | 3.72 | 2.60 | 3.71 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Here, $T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control), $T_2$ = $T_1$ + Cowdung (5 t/ha), $T_3$ = $T_1$ + Vermicompost (4 t/ha), $T_4$ =$T_1$ + Mushroom spent compost (4 t/ha), $T_5$ = $T_2$ +$B_{0.6}Mo_{0.54}$ kg/ha, $T_6$ = $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_7$ = $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_8$ = $T_2$ + Bio-fertilizer (5 kg/ha), $T_9$ = $T_3$ + Bio-fertilizer (5 kg/ha), $T_{10}$ = $T_4$ + Bio-fertilizer (5 kg/ha), $T_{11}$ = $T_5$ + Bio-fertilizer (5 kg/ha), $T_{12}$ = $T_6$ + Bio-fertilizer (5 kg/ha) and $T_{13}$ = $T_7$ + Bio-fertilizer (5 kg/ha)

### 4.2 Number of leaves per plant

Significant variation was noticed on number of leaves per plant of cauliflower due to different integrated nutrient management at 15, 30, 50, 45 and 60 DAT under the experiment (Fig. 1 and Appendix VI). At 60 DAT, the maximum number of leaves per plant (23.73) was obtained from $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment because in $T_{12}$ vermicompost improved water holding capacity which was highly needed for vegetative growth of cauliflower. Then biofertilizer along with these had ameliorated soil fertility, where the minimum number of leaves per plant (13.60) was revealed from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment because of nutrient deficiency. The results of the experiment were coincided with the findings of Ali *et al.* (2018). They reported that organic manure addition with chemical fertilizers performed better in number of leaves per plant compared to only inorganic fertilizers. Mishra *et al.* (2018) reported that application of NPK/ha with vermicompost in sprouting broccoli was found to be the best for obtaining maximum leaves per plant. Bio-fertilizers are perceived as growth regulators besides biological nitrogen fixation collectively leading to much higher response on number of leaves of cauliflower (Yeptho *et al.*, 2012).

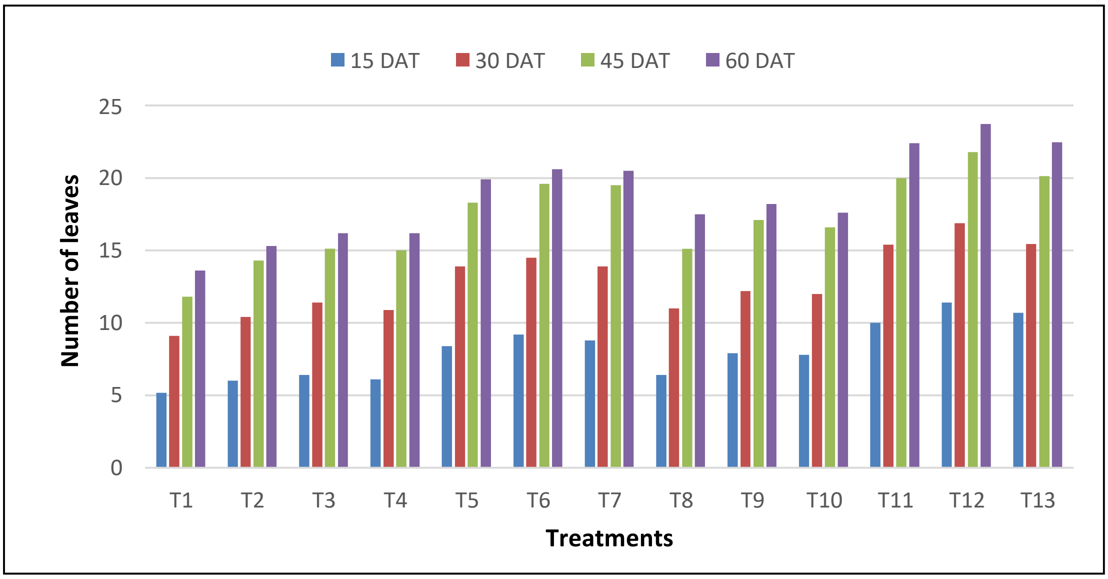



**Fig. 1. Effect of integrated nutrient management on number of leaves at different days after transplanting of cauliflower**

Here, $T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control), $T_2$= $T_1$ + Cowdung (5 t/ha), $T_3$= $T_1$+ Vermicompost (4 t/ha), $T_4$=$T_1$ + Mushroom spent compost (4 t/ha), $T_5$= $T_2$ +$B_{0.6}Mo_{0.54}$ kg/ha, $T_6$= $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_7$ = $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_8$= $T_2$ + Bio-fertilizer (5 kg/ha), $T_9$= $T_3$ + Bio-fertilizer (5 kg/ha), $T_{10}$= $T_4$ + Bio-fertilizer (5 kg/ha), $T_{11}$= $T_5$ + Bio-fertilizer (5 kg/ha), $T_{12}$= $T_6$ + Bio-fertilizer (5 kg/ha) and $T_{13}$= $T_7$ + Bio-fertilizer (5 kg/ha)

### 4.3 Largest leaf length

Length of largest leaf of cauliflower showed significant variation at harvest due to different integrated nutrient management under the experiment (Table 2 and Appendix VII). At harvest, the maximum length of largest leaf per plant (43.30 cm) was obtained from $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment which was statistically similar with $T_{11}$ (42.40 cm) and $T_{13}$ (42.49 cm) treatment, respectively. On the other hand the minimum length of largest leaf per plant (30.30 cm) was revealed from the $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment. It was revealed that the length of leaves per plant increased with the increase in days after transplanting (DAT) and at harvest. It also revealed that the length of largest leaf per plant increased with different integrated nutrient management. Sharma and Sharma (2010) reported that leaf length increased with integrated nutrient management on cauliflower than control. Bashyal (2011) reported that application of nitrogen along with the biofertilizer significantly increased morphological, yield and quality characters as compared to application of nitrogen without biofertilizer. The maximum leaf length, leaf breadth, stem height, stem diameter, highest curd height, curd diameter, fresh curd weight and curd yield were recorded at nitrogen with biofertilizer treatment.

### 4.4 Largest leaf breadth

Significant variation was observed on leaf breadth of cauliflower due to different integrated nutrient management (Table 2 and Appendix VII). At harvest, the maximum leaf breadth (19.20 cm) was obtained from $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment which was statistically similar with $T_{11}$ (18.80 cm) and $T_{13}$ (18.90 cm) treatment, respectively. On the other hand the minimum leaf breadth (11.90 cm) was revealed from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment. It was revealed that the breadth of leaves per plant increased with the increase in days after transplanting (DAT) i.e., 15, 30, 45 DAT and at harvest. Salwa and Kashem (2019) observed the similar result. Kachari and Korla (2009) reported that different aspects of the plant like growth and development characters (plant height, leaf length, leaf width, leaf area, number of leaves, leaf weight were performed better in addition of bio-fertilizer with recommended dose of NPK.

### 4.5 Spread of canopy per plant

Significant variation on spread of canopy per plant of cauliflower was observed at harvest due to different integrated nutrient management (Table 2 and Appendix VII). At harvest, the maximum spread of canopy per plant (55.47 cm) was obtained from $T_{12}$ ($T_6$ + Biofertilizer (5 kg/ha) treatment. The minimum spread of canopy per plant (39.63 cm) was revealed from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment. The result of the experiment was in coincided with the findings of Ali *et al.* (2018). They reported that organic manure with in addition of recommended dose of chemical fertilizer performed better compared to only inorganic fertilizers. Bashyal (2011) reported that application of nitrogen along with the biofertilizer significantly increased morphological, yield and quality characters as compared to application of nitrogen without biofertilizer.

### 4.6 Root length

Length of root of cauliflower showed significant variation due to different integrated nutrient management under the experiment (Table 3 and Appendix VIII). At harvest, the maximum length of root per plant (38.70 cm) was obtained from $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment because in $T_{12}$ vermicompost had increased soil porosity that was helpful for the plants for better root growth and bio-fertilizer had enhanced microbial growth for the development of plants. Besides, $T_{12}$ treatment was statistically similar to $T_{13}$ (37.80 cm) treatment where cowdung was used instead of vermicompost, which had less nutrients availability. The minimum length of root per plant (29.30 cm) was revealed from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment because of only using chemical fertilizers. The result of the experiment was in coincided with the findings of Neupane *et al.* (2020) who reported that the root length, root diameter and root density were better in integrated nutrient treatments as compared to control. Mahmoud *et al.* (2009) and Jahan *et al.* (2014) reported that the use of cowdung can improve the growth and yield some crops such as maize, soybean, cucumber, cauliflower and some vegetable crops.

**Table 2. Effect of integrated nutrient management on largest leaf length, largest leaf breadth and spread of canopy of cauliflower**

| Treatments | Largest leaf length (cm) | Largest leaf breadth (cm) | Spread of canopy (cm) |
|---|---|---|---|
| $T_1$ | 30.30 i | 11.90 i | 39.63 j |
| $T_2$ | 37.50 h | 13.80 h | 42.03 i |
| $T_3$ | 38.60 fgh | 14.80 fg | 44.50 h |
| $T_4$ | 37.90 h | 14.20 gh | 42.93 i |
| $T_5$ | 40.30 de | 17.80 c | 49.73 ef |
| $T_6$ | 41.80 bc | 18.15 bc | 51.37 cd |
| $T_7$ | 41.10 cd | 18.10 bc | 50.40 de |
| $T_8$ | 38.00 gh | 15.40 ef | 45.63 gh |
| $T_9$ | 39.60 ef | 16.40 d | 48.27 f |
| $T_{10}$ | 39.10 fg | 15.90 de | 46.50 g |
| $T_{11}$ | 42.40 ab | 18.80 ab | 52.33 bc |
| $T_{12}$ | 43.30 a | 19.20 a | 55.47 a |
| $T_{13}$ | 42.49 ab | 18.90 ab | 53.17 b |
| $LSD_{(0.05)}$ | 1.1311 | 0.8869 | 1.4982 |
| CV% | 4.2 | 3.21 | 4.78 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Here, $T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control), $T_2$= $T_1$ + Cowdung (5 t/ha), $T_3$= $T_1$+ Vermicompost (4 t/ha), $T_4$=$T_1$ + Mushroom spent compost (4 t/ha), $T_5$= $T_2$ +$B_{0.6}Mo_{0.54}$ kg/ha, $T_6$= $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_7$ = $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_8$= $T_2$ + Bio-fertlizer (5 kg/ha), $T_9$= $T_3$ + Bio-fertlizer (5 kg/ha), $T_{10}$= $T_4$ + Bio-fertilizer (5 kg/ha), $T_{11}$= $T_5$ + Bio-fertilizer (5 kg/ha), $T_{12}$= $T_6$ + Bio-fertilizer (5 kg/ha) and $T_{13}$= $T_7$ + Bio-fertilizer (5 kg/ha)

### 4.7 Stem length

Significant variation on length of stem of cauliflower plants was observed due to different integrated nutrient management practices (Table 3 and Appendix VIII). At harvest, the maximum length of stem per plant (14.60 cm) was obtained from $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment because vermicompost is rich in NPK, micronutrients and plant growth hormone and enzymes. Bio-fertilizer worked as growth promoter having richness of beneficial microbes. $T_{12}$ treatment, which was statistically similar to $T_{11}$ (13.90 cm) having cowdung as organic manure and $T_{13}$ (14.07 cm) treatment having mushroom spent compost, which had upgraded the growth of plants but could not enhanc soil fertility. In contrast, the minimum length of stem per plant (8.30 cm) was revealed from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment. The results of the experiment was also coincide with the findings of Bashyal (2011) who reported that application of nitrogen along with the biofertilizer significantly increased morphological, yield and quality characters as compared to application of nitrogen without biofertilizer. The maximum stem height, stem diameter, highest curd height, curd diameter, fresh curd weight and curd yield were recorded at 120 kg nitrogen and 2 kg biofertilizer $ha^{-1}$. Ghorbani *et al.* (2008), Mahmoud *et al.* (2009) and Jahan *et al.* (2014) reported that the use of cowdung can improve the growth and yield some crops such as maize, soybean, cucumber, cauliflower and some vegetable crops.

### 4.8 Stem diameter

Significant variation on stem diameter of cauliflower plants was observed due to different integrated nutrient management practices (Table 3 and Appendix VIII). At harvest, the maximum stem diameter per plant (3.33 cm) was obtained from $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment because vermicompost and bio-fertilizer along with chemical fertilizers had provided balanced nutrients to cauliflower to make stems more succulent and healthy, where the minimum length of stem diameter (1.90 cm) was revealed from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment. Meena *et al.* (2018) reported that application of biofertilizer significantly increased stem diameter of cauliflower.

**Table 3. Effect of integrated nutrient management on root length, stem length and stem diameter of cauliflower**

| Treatments | Root length (cm) | Stem length (cm) | Stem diameter (cm) |
|---|---|---|---|
| $T_1$ | 29.30 i | 8.30 g | 1.90 j |
| $T_2$ | 31.20 h | 9.60 f | 2.23 i |
| $T_3$ | 32.60 fg | 10.20 ef | 2.43 h |
| $T_4$ | 32.10 gh | 9.80 f | 2.33 hi |
| $T_5$ | 34.80 cd | 12.20 c | 2.73 ef |
| $T_6$ | 35.80 c | 13.60 b | 2.93 cd |
| $T_7$ | 35.30 c | 12.40 c | 2.83 de |
| $T_8$ | 33.10 efg | 10.20 ef | 2.60 g |
| $T_9$ | 34.00 de | 11.10 d | 2.66 fg |
| $T_{10}$ | 33.60 ef | 10.67 de | 2.56 g |
| $T_{11}$ | 37.00 b | 13.90 ab | 3.03 bc |
| $T_{12}$ | 38.70 a | 14.60 a | 3.33 a |
| $T_{13}$ | 37.80 ab | 14.07 ab | 3.13 b |
| $LSD_{(0.05)}$ | 1.1502 | 0.7598 | 0.1061 |
| CV% | 4.99 | 5.89 | 2.36 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Here, $T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control), $T_2$= $T_1$ + Cowdung (5 t/ha), $T_3$= $T_1$+ Vermicompost (4 t/ha), $T_4$=$T_1$ + Mushroom spent compost (4 t/ha), $T_5$= $T_2$ +$B_{0.6}Mo_{0.54}$ kg/ha, $T_6$= $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_7$ = $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_8$= $T_2$ + Bio-fertilizer (5 kg/ha), $T_9$= $T_3$ + Bio-fertilizer (5 kg/ha), $T_{10}$= $T_4$ + Bio-fertilizer (5 kg/ha), $T_{11}$= $T_5$ + Bio-fertilizer (5 kg/ha), $T_{12}$= $T_6$ + Bio-fertilizer (5 kg/ha) and $T_{13}$= $T_7$ + Bio-fertilizer (5 kg/ha)

### 4.9 Curd diameter

Statistically significant difference was noticed on curd diameter of cauliflower plants due to integrated nutrient management practices during the experimentation (Fig. 2 and Appendix VIII). The results of the experiment revealed that at harvest the maximum curd diameter per plant (17.43 cm) was obtained from $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment because vermicompost had created nutrient cycle on soil that fulfill the shortage of nutrients, which developed not only the vegetative growth but also the yield. Bio-fertilizer was considered as a feasible and sustainable attractive biotechnological alternative to increase crop yield and restore soil fertility. On the other hand the minimum curd diameter per plant (13.73 cm) was revealed from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment. Similar result was observed by Sharma and Sharma (2010). They reported that significant improvement in curddiameter, curd depth, gross weight/plant and marketable curd yield when cauliflower was treated with inorganic fertilizers in presence of bio-fertilizers. Bashyal (2011) reported that application of 120 kg nitrogen along with the 2 kg biofertilizer per hectare significantly increased morphological, yield and quality characters as compared to application of nitrogen without biofertilizer. The maximum stem height, stem diameter, highest curd height, curd diameter, fresh curd weight and curd yield were recorded at 120 kg nitrogen and 2 kg biofertilizer $ha^{-1}$.

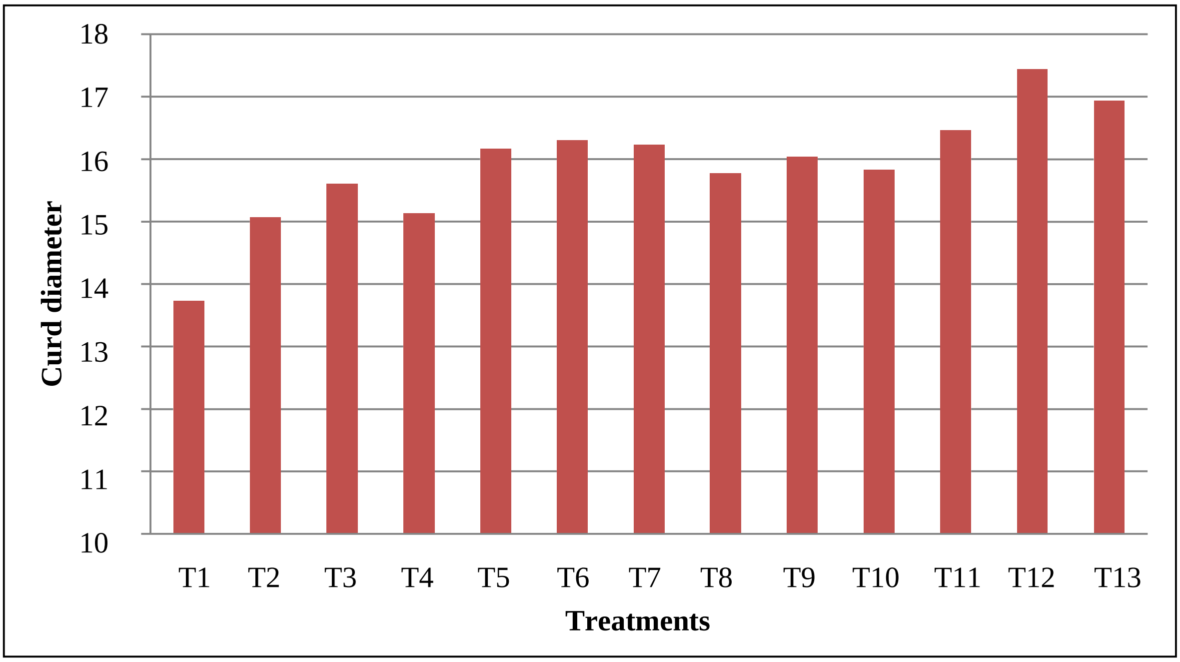



**Fig. 2. Effect of integrated nutrient management on curd diameter (cm) of cauliflower**

Here, $T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control), $T_2$= $T_1$ + Cowdung (5 t/ha), $T_3$= $T_1$+ Vermicompost (4 t/ha), $T_4$=$T_1$ + Mushroom spent compost (4 t/ha), $T_5$= $T_2$ +$B_{0.6}Mo_{0.54}$ kg/ha, $T_6$= $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_7$ = $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_8$= $T_2$ + Bio-fertilizer (5 kg/ha), $T_9$= $T_3$ + Bio-fertilizer (5 kg/ha), $T_{10}$= $T_4$ + Bio-fertilizer (5 kg/ha), $T_{11}$= $T_5$ + Bio-fertilizer (5 kg/ha), $T_{12}$= $T_6$ + Biofertilizer (5 kg/ha) and $T_{13}$= $T_7$ + Bio-fertilizer (5 kg/ha)

### 4.10 Curd weight per plant

Integrated nutrient management practices exhibited a statistically significant influence on curd weight per plant of cauliflower under the study (Fig. 3 and Appendix IX). The maximum weight of curd per plant (956.33 g) was obtained from $T_{12}$ ($T_6$+ Bio-fertilizer (5 kg/ha) treatment because in $T_6$ vermicompost was used with bio-fertilizer. On the other hand the minimum weight of curd per plant (517.20 g) was achieved from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment. The result of the experiment was in coincided with the findings of Sharma and Sharma *et al.* (2010). They reported that integrated nutrient management increase the curd weight and yield of curd of cauliflower than the control treatment. The use of cowdung can improve the growth and yield some crops such as maize, soybean, cucumber, cauliflower and some vegetable crops (Mahmoud *et al.*, 2009). Bashyal (2011) reported that 120 kg nitrogen and 2 kg biofertilizer $ha^{-1}$ produced the maximum weight of curd of cauliflower. Noor *et al.* (2007) also revealed that the growth and yield of cauliflower remarkably influenced by organic and inorganic fertilizer management.

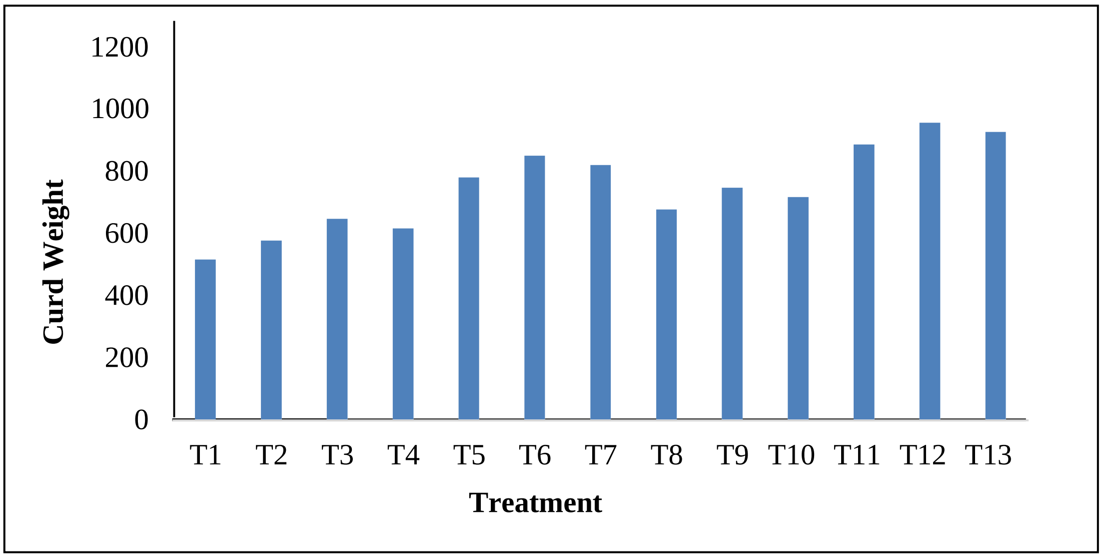



**Fig. 3. Effect of integrated nutrient management on curd weight (g) of cauliflower**

Here, $T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control), $T_2$= $T_1$ + Cowdung (5 t/ha), $T_3$= $T_1$+ Vermicompost (4 t/ha), $T_4$=$T_1$ + Mushroom spent compost (4 t/ha), $T_5$= $T_2$ +$B_{0.6}Mo_{0.54}$ kg/ha, $T_6$= $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_7$ = $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_8$= $T_2$ + Bio-fertilizer (5 kg/ha), $T_9$= $T_3$ + Bio-fertilizer (5 kg/ha), $T_{10}$= $T_4$ + Bio-fertilizer (5 kg/ha), $T_{11}$= $T_5$ + Bio-fertilizer (5 kg/ha), $T_{12}$= $T_6$ + Bio-fertilizer (5 kg/ha) and $T_{13}$= $T_7$ + Bio-fertilizer (5 kg/ha)

### 4.11 Dry matter (%) of leaves

Integrated nutrient management practices exhibited a statistically significant influence on dry matter percentage of leaves per plant of cauliflower under the study (Table 4 and Appendix IX). The maximum dry matter of leaves per plant (8.31%) was obtained from $T_{13}$ ($T_7$ + Bio-fertilizer (5 kg/ha) treatment which was statistically similar to $T_{12}$ (8.23%) treatment. On the other hand the minimum dry matter of leaves per plant (5.10%) was achieved from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment. The results of the experiment was in coincided with the findings of Sharma and Sharma (2010) who reported that dry matter percentage ofleaves of cauliflower increased with 50% of inorganic fertilizer with 50% of organic manure and biofertilizers. Bashyal (2011) reported that application of 120 kg nitrogen along with the 2 kg biofertilizer per hectare significantly increased morphological, yield and quality characters as compared to application of nitrogen without biofertilizer. Mushroom spent compost promotes the quality of soil that improves the crop growth and yield (Ashrafi *et al.*, 2014).

### 4.12 Dry matter (%) of curd

Integrated nutrient management practices exhibited a statistically significant influence on dry matter percentage of curd per plant of cauliflower under the study (Table 4 and Appendix IX). The maximum dry matter of curd per plant (13.50%) was obtained from $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment which was statistically similar to $T_{13}$ (12.77%) treatment. On the other hand the minimum dry matter of leaves per plant (7.80%) was achieved from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment. Verma *et al.* (2015) reported that recommended dose of chemical fertilizers along with vermicompost and *Azotobacter* improves the crop growth and yield contributing characters of cabbage.

**Table 4. Effect of integrated nutrient management on dry matter (%) of leaves and dry matter (%) of curd of cauliflower**

| Treatments | Dry matter (%) of leaves | Dry matter (%) of curd |
|---|---|---|
| **$T_1$** | 5.10 h | 7.80 j |
| **$T_2$** | 6.00 g | 9.03 i |
| **$T_3$** | 6.50 efg | 9.70 ghi |
| **$T_4$** | 6.30 fg | 9.37 hi |
| **$T_5$** | 7.13 cde | 10.73 ef |
| **$T_6$** | 7.50 c | 11.70 cd |
| **$T_7$** | 7.33 cd | 11.20 de |
| **$T_8$** | 6.70 defg | 10.07 fgh |
| **$T_9$** | 7.03 cde | 10.43 efg |
| **$T_{10}$** | 6.90 cdef | 10.13 fgh |
| **$T_{11}$** | 7.55 bc | 12.10 bc |
| **$T_{12}$** | 8.23 ab | 13.50 a |
| **$T_{13}$** | 8.31 a | 12.77 ab |
| **$LSD_{(0.05)}$** | 0.703 | 0.8165 |
| **CV%** | 5.87 | 5.89 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Here, $T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control), $T_2$= $T_1$ + Cowdung (5 t/ha), $T_3$= $T_1$+ Vermicompost (4 t/ha), $T_4$=$T_1$ + Mushroom spent compost (4 t/ha), $T_5$= $T_2$ +$B_{0.6}Mo_{0.54}$ kg/ha, $T_6$= $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_7$ = $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_8$= $T_2$ + Bio-fertilizer (5 kg/ha), $T_9$= $T_3$ + Bio-fertilizer (5 kg/ha), $T_{10}$= $T_4$ + Bio-fertilizer (5 kg/ha), $T_{11}$= $T_5$ + Bio-fertilizer (5 kg/ha), $T_{12}$= $T_6$ + Bio-fertilizer (5 kg/ha) and $T_{13}$= $T_7$ + Bio-fertilizer (5 kg/ha)

### 4.13 Yield per plot

Significant variation on yield per plot was observed due to different integrated nutrient management practices (Table 5 and Appendix X). From the results of the experiment showed that the highest yield per plot (10.50 kg) was observed from $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment. On the other hand the lowest yield per plot (3.88 kg) was revealed from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment which was statistically similar to $T_2$ and $T_4$ treatments . Rabindra *et al.* (2021) also observed the similar trends. They reported that NPK with vermicompost and bio fertilizer increase the growth and yield of cauliflower. Sharma and Sharma (2010) reported significant improvement in curd yield per plot and marketable curd yield per hectare when cauliflower was treated with inorganic fertilizers in presence of bio- fertilizers. Mahmoud *et al.* (2009) and Jahan *et al.* (2014) also reported that the use ofcowdung can improve the growth and curd yield cauliflower and some vegetable crops. Bashyal (2011) reported that application of nitrogen along with the biofertilizer significantly increased morphological, yield and quality characters as compared to application of nitrogen without biofertilizer. The maximum stem height, stem diameter, highest curd height, curd diameter, fresh curd weight and curd yield were recorded at 120 kg nitrogen and 2 kg biofertilizer $ha^{-1}$.

### 4.14 Yield per hectare

Significant variation on yield per hectare was observed due to different integrated nutrient management practices (Table 5 and Appendix X). From the results of the experiment showed that the highest yield per hectare (36.34 t) was observed from the treatment $T_{12}$ ($T_6$ + Biofertilizer (5 kg/ha) treatment. Because in $T_{12}$ vermicompost was used. On the other hand the lowest yield per hectare (13.50 t) was achieved from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment which was similar to $T_2$ treatment. The result of the experiment also coincided with the findings of Simarmata *et al.* (2016) who reported that chemical fertilizer with cowdung increase the curd yield of cauliflower. Application of nitrogen along with the biofertilizer significantly increased morphological, yield and quality characters as compared to application of nitrogen without biofertilizer. The maximum stem height, stem diameter, highest curd height, curd diameter, fresh curd weight and curd yield were recorded at 120 kg nitrogen and 2 kg biofertilizer $ha^{-1}$. Isaac and Manu (2013) also reported that the curd yields to be better for the organically grown plants and the curds raised with organic and integrated sources were found to retain the quality longer than chemical fertilizer application.

**Table 5. Effect of integrated nutrient management on yield per plot and yield perhectare of cauliflower**

| Treatments | Yield per plot (kg) | Yield per hectare (t) |
|---|---|---|
| **$T_1$** | 3.88 j | 13.50 j |
| **$T_2$** | 4.89 ij | 17.00 ij |
| **$T_3$** | 6.17 fgh | 21.44 g |
| **$T_4$** | 5.33 hij | 18.50 hi |
| **$T_5$** | 7.11 def | 24.44 ef |
| **$T_6$** | 8.52 bc | 29.60 bc |
| **$T_7$** | 7.67 cd | 26.60 de |
| **$T_8$** | 5.78 ghi | 20.40 gh |
| **$T_9$** | 7.34 de | 25.50 de |
| **$T_{10}$** | 6.50 efg | 22.60 fg |
| **$T_{11}$** | 8.09 bcd | 28.10 cd |
| **$T_{12}$** | 10.50 a | 36.34 a |
| **$T_{13}$** | 9.12 b | 31.68 b |
| **$LSD_{(0.05)}$** | 1.1631 | 2.7051 |
| **CV%** | 9.84 | 6.59 |

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Here, $T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control), $T_2$= $T_1$ + Cowdung (5 t/ha), $T_3$= $T_1$+ Vermicompost (4 t/ha), $T_4$=$T_1$ + Mushroom spent compost (4 t/ha), $T_5$= $T_2$ +$B_{0.6}Mo_{0.54}$ kg/ha, $T_6$= $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_7$ = $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_8$= $T_2$ + Bio--fertilizer (5 kg/ha), $T_9$= $T_3$ + Bio-fertilizer (5 kg/ha), $T_{10}$= $T_4$ + Bio-fertilizer (5 kg/ha), $T_{11}$= $T_5$ + Bio-fertilizer (5 kg/ha), $T_{12}$= $T_6$ + Bio-fertilizer (5 kg/ha) and $T_{13}$= $T_7$ + Bio-fertilizer (5 kg/ha)

### 4.15 Economic Analysis

Input costs for land preparation, fertilizer, manures, irrigation and manpower required for all the operations from seed sowing to harvesting of cauliflower were recorded as per experimental plot and converted into cost per hectare. Price of cauliflower was considered as per market rate (20,000 Tk. per ton).

The economic analysis presented under the following headings-

### 4.15.1 Gross Return

Different integrated nutrient management showed different value in terms of gross return under the study (Table 6). The highest gross return (Tk. 726800) was obtained from $T_{12}$ ($T_6$ + Biofertilizer (5 kg/ha) treatment and the second highest gross return (Tk. 633600) was found in $T_{13}$ ($N_{120}P_{60}K_{100}S_{20}B_{0.6}Mo_{0.54}$ kg/ha + Mushroom Spent Compost (4 t/ha) + Biofertilizer (5 kg/ha) treatment. The lowest gross return (Tk. 270000) was obtained from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment (Table 6).

### 4.15.2 Net Return

Different value of net return was found from different integrated nutrient management practices. The highest net return Tk. 524202 was obtained from $T_{12}$($T_6$ + Biofertilizer (5 kg/ha) treatment because bio-fertilizer has reduced production cost. Though vermicompost sold at higher price, the yield was much more than other compost and second highest Tk. 453502 was obtained from $T_{13}$ ($T_7$ + Biofertilizer (5 kg/ha) treatment. On the other hand, lowest net return Tk. 137869 was obtained from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment (Table 6).

### 4.15.3 Benefit cost ratio

Application of different integrated nutrient management exerted the highest benefit cost ratio (3.59) was recorded from $T_{12}$ ($T_6$ + Biofertilizer (5 kg/ha) treatment and the second highest benefit cost ratio (3.52) was estimated from $T_{13}$ ($T_7$ + Biofertilizer (5 kg/ha) treatment and the lowest benefit cost ratio (2.04) was obtained from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment (Table 6). From economic point of view, it is apparent from the above results that $T_{12}$ ($T_6$ + Biofertilizer (5 kg/ha) treatment was more profitable treatments than rest of the treatments (Table 6). Benefit Cost Ratio was calculated by the following-

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

**Table 6. Cost and return of cauliflower using different integrated nutrient management**

| Treatments | Yield (t/ha) | Gross return (Tk./ha) | Total cost of production (Tk./ha) | Net return (Tk./ha) | Benefit cost ratio (BCR) |
|---|---|---|---|---|---|
| **$T_1$** | 13.5 | 270000 | 132131 | 137869 | 2.04 |
| **$T_2$** | 17 | 340000 | 160256 | 179744 | 2.12 |
| **$T_3$** | 21.44 | 428800 | 199631 | 229169 | 2.15 |
| **$T_4$** | 18.5 | 370000 | 177131 | 192869 | 2.09 |
| **$T_5$** | 24.44 | 488800 | 161816 | 326984 | 3.02 |
| **$T_6$** | 29.6 | 592000 | 201191 | 390809 | 2.94 |
| **$T_7$** | 26.6 | 532000 | 178691 | 353309 | 2.98 |
| **$T_8$** | 20.4 | 408000 | 161662 | 246338 | 2.52 |
| **$T_9$** | 25.5 | 510000 | 201037 | 308963 | 2.54 |
| **$T_{10}$** | 22.6 | 452000 | 178537 | 273463 | 2.53 |
| **$T_{11}$** | 28.1 | 562000 | 163223 | 398777 | 3.44 |
| **$T_{12}$** | 36.34 | 726800 | 202598 | 524202 | 3.59 |
| **$T_{13}$** | 31.68 | 633600 | 180098 | 453502 | 3.52 |

Price of cauliflower: 20,000 Tk. per ton

Here, $T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control), $T_2$= $T_1$ + Cowdung (5 t/ha), $T_3$= $T_1$+ Vermicompost (4 t/ha), $T_4$=$T_1$ + Mushroom spent compost (4 t/ha), $T_5$= $T_2$ +$B_{0.6}Mo_{0.54}$ kg/ha, $T_6$= $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_7$ = $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_8$= $T_2$ + Bio-fertilizer (5 kg/ha), $T_9$= $T_3$ + Bio-fertilizer (5 kg/ha), $T_{10}$= $T_4$ + Bio-fertilizer (5 kg/ha), $T_{11}$= $T_5$ + Bio-fertilizer (5 kg/ha), $T_{12}$= $T_6$ + Bio-fertilizer (5 kg/ha) and $T_{13}$= $T_7$ + Bio-fertilizer (5 kg/ha)

# CHAPTER IV

# SUMMARY AND CONCLUSION

# CHAPTER V

## SUMMARY AND CONCLUSION

The experiment was carried out at the "Horticulture Farm" of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during November 2020 to March 2021 to study the effect of integrated nutrient management practices on growth and yield of cauliflower. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Deep Red Brown Terrace Soils under Tejgaon soil series. The experiment consisted of 13 treatments *viz.* $T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control), $T_2$= $T_1$ + Cowdung (5 t/ha), $T_3$= $T_1$+ Vermicompost (4 t/ha), $T_4$=$T_1$ + Mushroom spent compost (4 t/h$T_5$= $T_2$ +$B_{0.6}Mo_{0.54}$ kg/ha, $T_6$= $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_7$ = $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_8$= $T_2$ + Bio-fertilizer (5 kg/ha), $T_9$= $T_3$ + Bio-fertilizer (5 kg/ha), $T_{10}$= $T_4$ + Bio-fertilizer (5 kg/ha), $T_{11}$= $T_5$ + Bio-fertilizer (5 kg/ha), $T_{12}$= $T_6$ + Bio-fertilizer (5 kg/ha) and $T_{13}$= $T_7$ + Bio-fertilizer (5 kg/ha).The total numbers of unit plots were 39. The size of unit plot was 2.88 $m^2$ (1.8 m × 1.6 m). Data on different yield contributing characters and yield were recorded to find out the best integrated nutrient management practices for the potential yield of cauliflower. Data on different growth, yield contributing characters and yield were recorded. Significant variation was observed from most of the growth and yield parameters. Data revealed that in case of different integrated nutrient management, at harvest, the tallest plant height (50.20 cm), maximum number of leaves per plant (23.73), largest leaf length per plant (43.30 cm) and largest leaf breadth per plant (19.20 cm) was obtained from $T_{12}$ ($T_6$ + Bio- fertilizer (5 kg/ha) treatment where shortest plant height (35.90 cm), minimum number of leaves per plant (13.60), largest leaf length per plant (30.30 cm) and largest leaf breadth per plant (11.90 cm) was obtained from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment. Maximum spread of canopy per plant (55.47 cm) was obtained from $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment. The minimum spread of canopy per plant (39.63 cm) was revealed from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment. The maximum length of root per plant (38.70 cm) was obtained from $T_{12}$ ($T_6$ + Bio- fertilizer (5 kg/ha) treatment where the minimum length of root per plant (29.30 cm) was revealed from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment. At harvest, the maximum length of stem per plant (14.60 cm), stem diameter per plant (3.33 cm), curd diameter per plant (17.43 cm), weight of curd per plant (956.33 g), dry matter of curd per plant (13.50 %), yield per plot (10.50 kg) and yield per hectare (36.34 t) was obtained from $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment and dry matter of leaves per plant (8.31%) was maximum in $T_{13}$ ($T_7$ + Bio-fertilizer (5 kg/ha). On the other hand the minimum length of stem per plant (8.30 cm), stem diameter per meter

(1.90 cm), curd diameter per plant (13.73 cm), weight of curd per plant (517.20 g), dry matter of leaves per plant (5.10%), dry matter of curd per plant (7.80%), yield per plot (3.88 kg) and yield per hectare (13.50 t) was achieved from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment.

The highest gross return (Tk. 726800) was obtained from $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment and the second highest gross return (Tk. 633600) was found in $T_{13}$ ($T_7$ + Bio-fertilizer (5 kg/ha) treatment. The highest net return (Tk. 524202) was obtained from $T_{12}$ ($T_6$ + Bio-fertilizer (5 kg/ha) treatment and second highest (Tk. 453502) was obtained from $T_{13}$ ($T_7$ + Bio-fertilizer(5 kg/ha) treatment. On the other hand lowest net return (Tk. 137869) was obtained from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment. The highest benefit cost ratio (3.59) was noted from $T_{12}$ ($T_6$ + Bio- fertilizer (5 kg/ha) treatment and the second highest benefit cost ratio (3.52) was estimated from $T_{13}$ ($T_7$ + Biofertilizer (5 kg/ha) treatment and the lowest benefit cost ratio (2.04) was obtained from $T_1$ ($N_{120}P_{60}K_{100}S_{20}$ kg/ha) treatment.

# CONCLUSION

- This study revealed that different integrated nutrient management practices have a positive effect on growth and yield of cauliflower.
- In case of yield of cauliflower, the integrated nutrient management practices $T_{12}$ ($T_6$ + Biofertilizer (5 kg/ha) treatment was given the best performance of all the yield contributing parameters and yield of cauliflower than the other treatments.
- In the economic point of view, the $T_{12}$ ($T_6$ + Biofertilizer (5 kg/ha) treatment was more suitable than the other treatments, beneficial and played a vital role for circular economy. So, it can be repeated in different agro ecological zones of Bangladesh for better yield and consideration value for money concept.

# REFERENCES

## REFERENCES


Alam, M. S., Iqbal, T. M. T., Amin, M. and Gaffar, M. A. (1989). Krishitattic Fasaler Utpadan O Unnayan (in Bengali). T. M. Jubair Bin Iqbal, Sirajgonj. p. 231-239.

Ali, S., Kashem, M. A. and Sarker, M. M. H. (2018). Effect of vermicompost on the growth and yield of cauliflower in acid soil of Bangladesh. *J. Sylhet Agril. Univ.*, **5**(1): 37-43.

Anonymous. (1987). Annual Report, Bangladesh Agricultural Research Institute, Joydebpur, Dhaka, p. 7.

Ara, N., Kaisar, M.O., Khalequzzaman, K.M., Kohinoor, H., Ahamed, K.U. (2009). Effect of different dates of planting and lines on the growth, yield and yield contributing characteristics of cauliflower. *J. Soil Nat.*, **3**(1): 16-19.

Ashrafi, R., Rahman, M., Jahiruddin, M. and Mian, M.H. (2014). Quality assessment of compost prepared from spent mushroom substrate. *Prog. Agric.*,**25**: 1-8.

Bashyal, L.N. (2011). Response of cauliflower to nitrogen fixing biofertilizer and graded levels of nitrogen. *J. Agric. Env.,* **12**: 41-50.

BBS. (Bangladesh Bureau of Statistics), (2021). Year Book of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, GOB. Dhaka, Bangladesh, p. 79.

Bhadra, R., Mehedi, M.N.H, Akter, S., Rouf, M.A. and Mohosina, F. (2019). Effect of cowdung and boron on growth and yield of broccoli (*Brassica oleracea). J. Biosci. Agric. Res.,* **22**(2): 1845-1851.

Changkija, M., Kanaujia, S.P., Jha, A., Sema, A. and Maiti, C.S. (2017). Effect of integrated nutrient management on growth, yield and quality of broccoli (*Brassica oleraceae* var. *italica* L.) cv. Calabrese under foothill condition of Nagaland. *Veg. Sci.,* **44**(1): 47-53

Chaudhary, M.M., Bhanvadia A.S. and Parmar, P.N. (2015). Effect of integrated nutrient management on growth, yield attributes and yield of cabbage (*Brassica oleracea var. capitata* L.) under Middle Gujrat conditions. *Trends Biosci.,* **8**(8): 2164-2168.

Chumyani, Kanaujia, S.P., Singh, V.B. and Singh, A.K. (2012). Effect of integrated nutrient management on growth, yield and quality of tomato (*Lycopersicum esculentum* Mill.). *J. Soil Crops.,* **22**(1): 65-71.

Devi, M., Spehia, R.S., Menon, S., Mogta, A. and Verma, A. (2018). Influence of integrated nutrient management on growth and yield of cauliflower (*Brassica oleraceae)* var. *botrytis*) and soil nutrient status. *Intl. J. Chem. Stud.,* **6**(2): 2988-2991.

Edris, K. M., Islam, A. T. M., Chowdhury, M. S. and Haque, A. K. M. (1979). Detailed Soil Survey of Bangladesh. Department Soil Survey, Govt. of the People""s Republic of Bangladesh. p. 118.

FAO (Statistics Division). (2018). Statistical Database. Food and Agricultural Organization of the United Nations, Rome, Italy. pp. 80.

Farahzety, A.M. and Aishah, H.S. (2013). Effects of organic fertilizers on performance of cauliflower (*Brassica oleracea* var. *botrytis*) grown under protected structure. *J. Trop. Agric. Fd. Sci.*, **41**(1): 15-25.

Ghorbani, R., Koocheki, A. Jahan, M. and Asadi, G.A. (2008). Impact of organic amendements and compost extracts on tomato production and storability in agroecological system. *Agron. Sustain. Dev.,* **8**: 307-311.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research (Second Edn.). John Wiley and Sons, New York. pp. 139-240.

Gruhn, P., Francesco, G. and Montague, Y. (2000). Integrated nutrient management, soil fertility and sustainable agriculture: Current issues and challenges. Vision discussion paper 32, IFPRI Washington DC.

Isaac, S. R. and Manu, M. (2013). Response of cauliflower to organic nutrition under integrated farming in homesteads. *Intl. J. Res. Agric. Sci.,* **1**(3): 186-188.

Islam, M., Hoque, T.S., Khan, R.N.A., Farzana, S., Ahmed, M., and Khodabakhshloo, N. (2021). Influence of different integrated nutrient management strategies on growth, yield and nutritional qualities of cauliflower. *Agric. Res*., **10**(4): 656-664.

Jahan, F.N., Shahjalal, A.T.M., Paul, A.K., Mehraj, H. and Jamaluddin, A.F.M. (2014). Efficacy of vermicompost and conventional compost on growth and yield of cauliflower. *Bangladesh J. Res. Pub.,* **10**(1): 33-38.

Kachari, M. and Korla, B.N. (2009). Effect of biofertilizers on growth and yield of cauliflower cv. PSB K-1. *Indian J. Hort.,* **66**(4): 496-501.

Khan, M.S., Shil, N.C. and Noor, S. (2008). Integrated nutrient management for sustainable yield of major vegetable crops in Bangladesh. *Bangladesh J. Agric. Environ.,* **4**: 81-94.

Latha, P. M., Sirisha, K. and Lakshmi, B. K. M. (2017). Effect of integrated nutrient management on yield and economics of broccoli. *J. Res. ANGRAU.,* **45**(4): 71-75.

Mahmoud, E., EL-Kader, N.A., Robin, P.N., Akkal-Corfini, and El-Rahman, L.A. (2009). Effects of different organic and inorganic fertilizers on cucumber yield and some soil properties. *World J. Agric. Sci.,* **5**(4): 408-414.

Meena, M.K., Aravindakshan, K., Dhayal, M., Singh, J. and Meena, S.L. (2018). Effect of biofertilizers and growth regulators on growth attributes of cauliflower (*Brassica oleracea* var. *botrytis* L.) cv. Pusa Paushja. *Intl. J. Curr. Microbiol. App. Sci.,* **7**: 885-890.

Mishra, S. P., Mohanta, R., Nandi, A. K., Pattnaik, A., Hossain, M. M. and Padhiary, A. K. (2018). Effects of integrated nutrient management on growth, yield, quality and economics of sprouting broccoli (*Brassica oleracea* var. *italica*) cv. Shayali. *J. Pharmacog. Phytochem.,* **7**(1): 2229-2232.

Mondal, T., Ghanti, P., Mahato, B., Mondal, A. R. and Thapa, U. 2003. Effect of spacing and biofertilizer on yield and yield attributes of direct sown chilli (*Capsicum annuum* L. cv. Bona Lanka). *Env. Eco.,* **21**: 712-715.

Mucheru-Muna, M., Mugendi, D., Kungu, J., Mugwe, J. and Bationo, A. (2007). Effects of organic and mineral fertilizer inputs on maize yield and soil chemical properties in a maize cropping system in Meru South Distrit, Kenya. *Agroforest Sys.,* **69**: 189-197.

Mutalib, A., Farahzety, and Aishah, H.S. (2013). Effects of organic fertilizers on performance of cauliflower (*Brassica oleracea* var. *botrytis*) grown under protected structure. *J. Tropical Agric. Sci.,* **41**: 15-25.

Neupane, B., Aryal, K., Chhetri, L.B. and Regmi, S. (2020). Effects of integrated nutrient management in early season cauliflower production and its residual effects on soil properties. *J. Agric. Nat. Res.,* **3**(2): 353-365.

Noor, S., Farid, A.T.M., Shil, N.C. and Hossain, A.K.M. (2007). INM for Cauliflower „In: *10 years Soil Science Research Activity and Future Strategies,* Soil Science Division, BARI, Joydebpur, Gazipur, Bangladesh. Pp. 8.

Prabhakar, M., Hebbar, S.S., Nair, A.K., Shivashankara, K.S., Chinnu J.K. and Geetha, G.A. (2015). Effect of different organic nutrient levels on growth, yield and quality in cauliflower. *Indian J. Hort.,* **72**(2): 293-296.

Purkayastha, T.J., Singh, C.S. and Chhonkar, P.K. (1998). Growth and iron nutrient of broccoli grown in a typic ustochrept as influenced by VAM fungi in presence of pyrite and farmyard manure. *Biol. Fert. Soil.,* **27**(1): 45-48.

Rabindra, B., Yadav, D A., Singh D. G. K. and Shekhar, D. C. (2021). Effects of integrated nutrient management on growth and yield attribute of cauliflower (*Brassica oleracea* var. *botrytis* L.). *Pharma Innov. J.,* **10**(9): 1231-1234.

Rahman, A., Nabi, N.A.K.M., Amin, S.A.M., Abu, S.M., Rahman, S., Hossain, P.R., Rahman, M.H., Hossaine, S.M.M. and Mirza, M. (2014). Building Urban Resilience: Assessing Urban and Peri-urban Agriculture in Dhaka, Bangladesh. United Nations Environment Programme (UNEP), Nairobi, Kenya.

Rashid, M.M. (1999). Sabji Bigan.Text Book Division, Bangla Academy, Dhaka, Bangladesh. 217.

Saha, P., Kalia, P. and Joshi, S. (2015). Genetic analysis of yield components and curd color of midseason heat tolerant Indian cauliflower (*Brassica oleracea* var. *botrytis* L.). *SABRAO J. Breeding Gen.,* **47**(2): 124-132.

Salwa, M. and Kashem, M.A. (2019). Effect of nutrient management on growth and yield of cauliflower hybrids in haor area. *Bangladesh Agron. J.* **22**(1): 95-104.

Sangeeta S., Singh, V.K. and Kumar, R. (2014). Effect of integrated nutrient management on yield and quality of cauliflower (*Brassica olerecea var. botrytis* L.). *Bioscan*., **9**(3): 1053-1058.

Sharma, K.C. and Sharma, L.K. (2010). Effect of biofertilizers and NPK levels on growth and yield of mid-maturity group of cauliflower under mid hill sub-humid conditions of Himachal Pradesh. *J. Hill Agric.*, **1**: 19-22.

Siddique, M.A.H. (2004). Effect of zinc, boron and molybdenum on seed production of cauliflower. An unpublished Thesis of Master of Science. Department of Horticulture, Bangladesh Agril. Univ., Mymensingh. pp. 1-3.

Simarmata, M. Susanti, L. and Setyowati, N. (2016). Utilization of manure and green organic composts as alternative fertilizers for cauliflower production. *J. Agril. Tech.,* **12**(2): 311-319.

Sinha, A., Kumar, R., Srivastava, S. and Srivastava, M. (2010). Production of organic manure from kitchen waste: ensuring livelihood of resource poor women.

Solaiman, M.A.H, Farzana, L. and Amin, M.R. (2016). Potentiality of producing summer cauliflower as influenced by organic manures and spacing. *Asian J. Med. Biol. Res.,* **2**(2): 304-317.

Suparman, M. and Supiati, (2004). Chemical analysis on cows‟ feces using probotic technique. Proceedings of the Conference of National Technician of Agriculture (Indonesian). South Sulawesi. pp. 43-49.

Tekasangla, S. P. and Singh, P. K. (2015). Integrated nutrient management for quality production of cauliflower in acid alfisol of Nagaland**.** *Karnataka J. Agric. Sci.,* **28**(2): 244-247.

UNDP. (1988). Land Resources Appraisal of Bangladesh for Agricultural Development. Report No. 2. Agro-ecological Regions of Bangladesh.

Verma, V. K., Singh, B. M. and Singh, T. (2015). Response of integrated nutrient management modules on growth, yield and quality attributes in cabbage (*Brassica oleracea* var. *capitata* L.) and their economics. *Veg. Sci.,* **42**(2): 8-14.

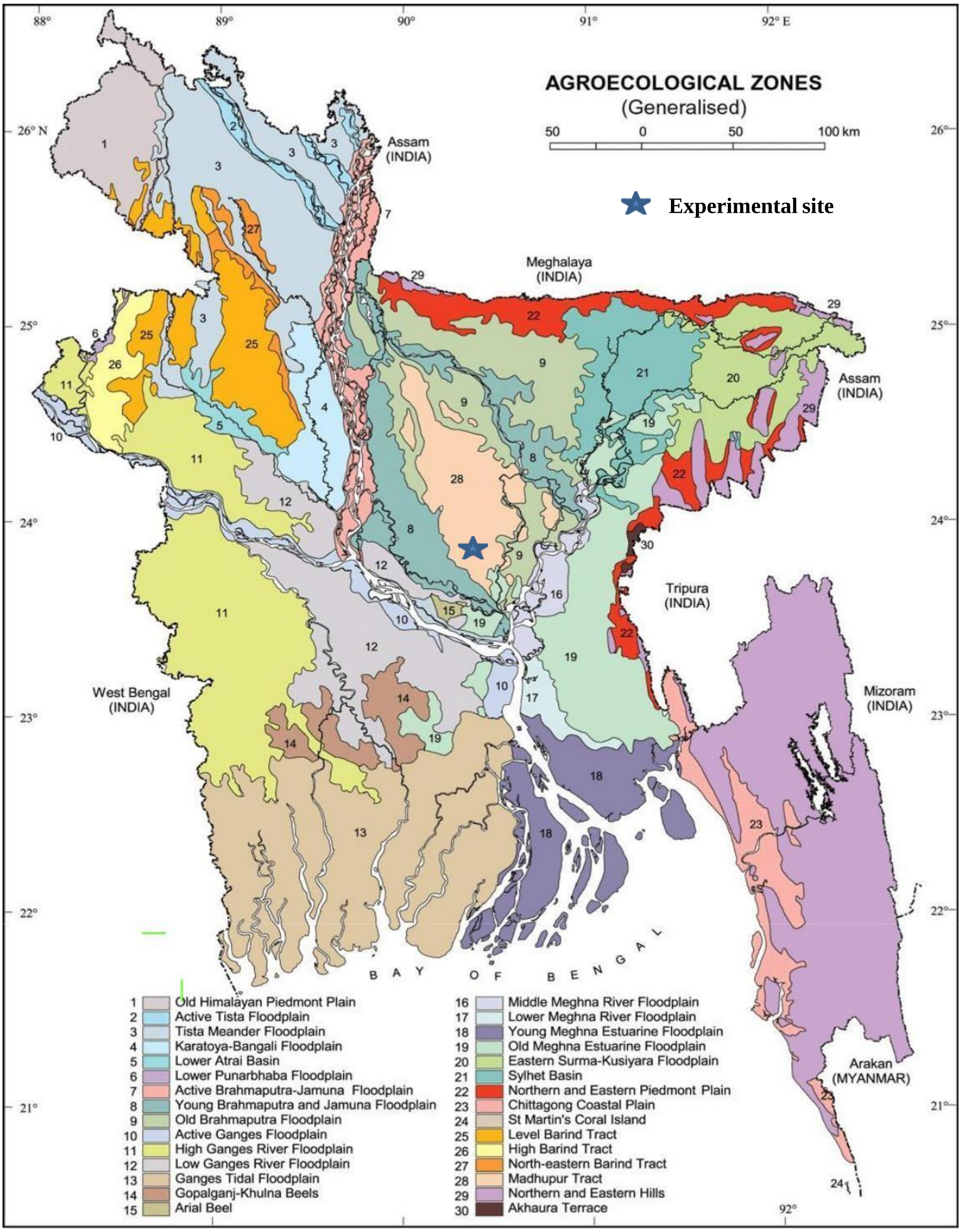
Wani, A.J., Mubarak, T. and Rather, G.H. (2010). Effect of organic and inorganic nutrient sources on growth and curd yield of cauliflower. *Env. Ecol.,* **28**(3): 1660-1662.

Yeptho, A.V., Singh, A.K., Kanaujia, S.P. and Singh, V.B. (2012). Quality production of kharif onion (*Allium cepa*) in response to biofertilizers inoculated organic manures. *Indian J. Agric. Sci.*, **82**(3): 236-240.

# APPENDICES

## APPENDICES

### Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location



**Appendix II. Monthly records of air temperature, relative humidity (RH) and rainfall during the period from November 2020 to March 2021**

| Month and year | RH (%) | Air temperature (°C) | | | Rainfall (mm) |
|---|---|---|---|---|---|
| | | *Max.* | *Min.* | *Mean* | |
| November, 2020 | 56.25 | 28.70 | 8.62 | 18.66 | 14.5 |
| December, 2020 | 51.75 | 26.50 | 9.25 | 17.87 | 12.0 |
| January, 2021 | 46.20 | 23.70 | 11.55 | 17.62 | 0.0 |
| February, 2021 | 37.95 | 22.85 | 14.15 | 18.50 | 0.0 |
| March, 2021 | 35.75 | 21.55 | 15.25 | 18.40 | 0.0 |

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

**Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka**

A. Morphological characteristics of the experimental field

| **Morphological features** | **Characteristics** |
|---|---|
| Location | Sher-e-Bangla Agricultural University, Dhaka |
| *AEZ* | Modhupur Tract (28) |
| General Soil Type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |
| Flood level | Above flood level |
| Drainage | Well drained |
| Cropping pattern | Not Applicable |

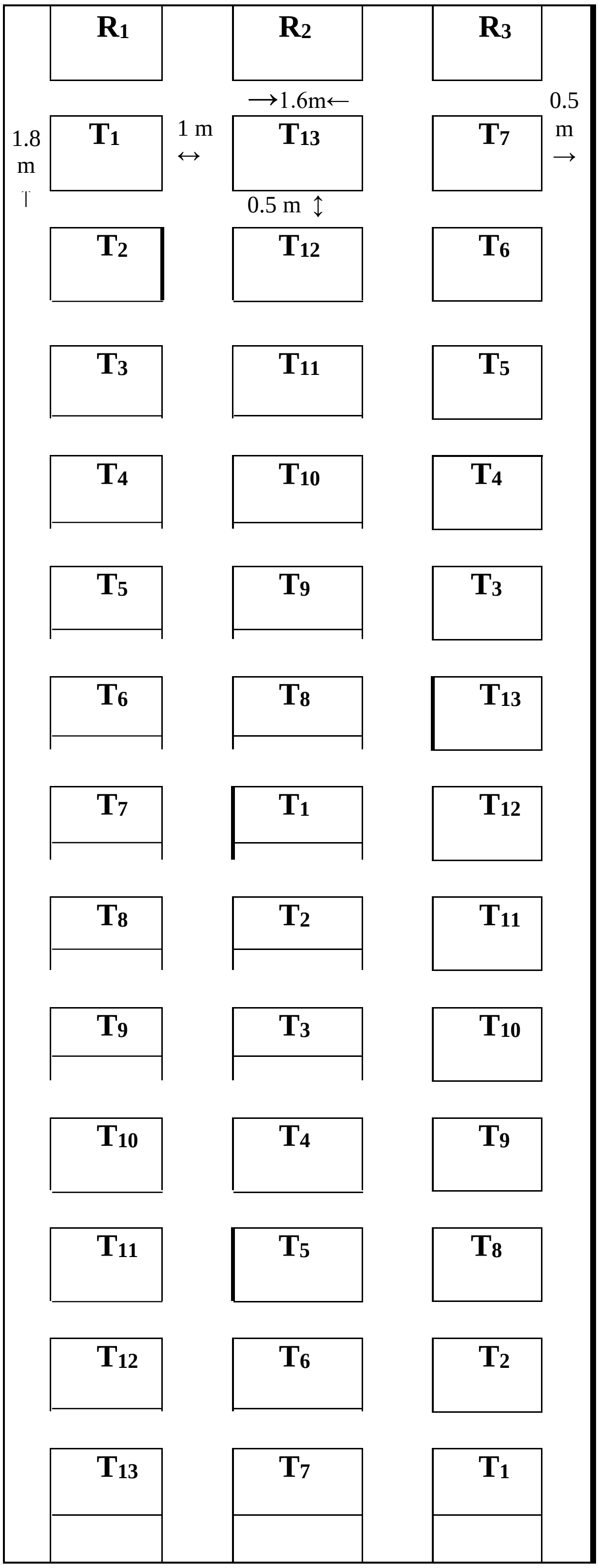
Source: Soil Resource Development Institute (SRDI)

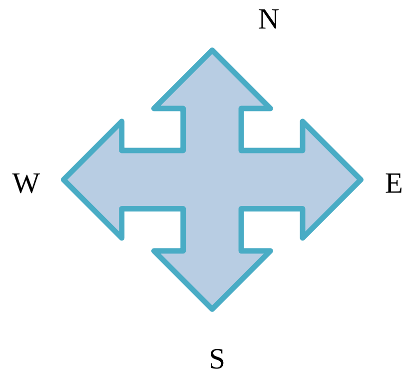
B. Physical and chemical properties of the initial soil

| **Characteristics** | **Value** |
|---|---|
| Partical size analysis % Sand | 27 |
| %Silt | 43 |
| % Clay | 30 |
| Textural class | Silty Clay Loam |
| pH | 6.2 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| Total N (%) | 0.03 |
| Available P (ppm) | 20 |
| Exchangeable K ( me/100 g soil) | 0.1 |
| Available S (ppm) | 45 |

Source: Soil Resource Development Institute (SRDI)

**Appendix IV. Layout of the experimental field**




Plot size: 1.8 m × 1.6 m

**Treatments: Integrated nutrient Management (13)**

$T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control)

$T_2$= $T_1$+ Cowdung (5 t/ha)

$T_3$= $T_1$+ Vermicompost (4 t/ha)

$T_4$= $T_1$+ Mushroom spent compost (4 t/ha)

$T_5$= $T_2$ + $B_{0.6}Mo_{0.54}$ kg/ha

$T_6$= $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha

$T_7$= $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha

$T_8$= $T_2$ + Bio-fertilizer (5 kg/ha)

$T_9$= $T_3$ + Bio-fertilizer (5 kg/ha)

$T_{10}$= $T_4$ + Bio-fertilizer (5kg/ha)

$T_{11}$= $T_5$ + Bio-fertilizer (5 kg/ha)

$T_{12}$= $T_6$+ Bio-fertilizer (5 kg/ha) and

$T_{13}$= $T_7$ + Bio- fertilizer (5 kg/ha)

**Appendix V. Mean square values of plant height at different days after transplanting of cauliflower**

| Sources of variation | Degrees of freedom | Mean square values of plant height at | | | |
|---|---|---|---|---|---|
| | | 15 DAT | 30 DAT | 45 DAT | 60 DAT |
| Replication | 2 | 0.41718 | 1.17308 | 0.3331 | 0.5315 |
| Integrated Nutrient Management | 12 | 3.62308** | 9.07423** | 37.3923** | 65.5431** |
| Error | 24 | 0.38385 | 0.33641 | 0.4306 | 0.5465 |

** significant at 1% level of significance

**Appendix VI. Mean square values of number of leaves plant$^{-1}$ at different days after transplanting of cauliflower**

| Sources of variation | Degrees of freedom | Mean square values of number of leaves per plant at | | | |
|---|---|---|---|---|---|
| | | 15 DAT | 30 DAT | 45 DAT | 60 DAT |
| Replication | 2 | 0.2172 | 0.5177 | 0.8592 | 0.9295 |
| Integrated Nutrient Management | 12 | 11.4731** | 16.1936** | 25.2803** | 28.5783** |
| Error | 24 | 0.2605 | 0.3782 | 0.5448 | 0.3893 |

** significant at 1% level of significance

**Appendix VII. Mean square values of largest leaf length plant$^{-1}$, largest leaf breadth plant$^{-1}$ and spread of canopy per plant of cauliflower**

| Sources of variation | Degrees of freedom | Mean square values of | | |
|---|---|---|---|---|
| | | Largest leaf length | Largest leaf breadth | Spread of canopy per plant |
| Replication | 2 | 0.0993 | 0.0505 | 0.6987 |
| Integrated Nutrient Management | 12 | 33.6538** | 15.8523** | 68.1124** |
| Error | 24 | 0.4505 | 0.2770 | 0.7904 |

** significant at 1% level of significance

**Appendix VIII. Mean square values of root length, stem length, stem diameter and curd diameter of cauliflower**

| Sources of variation | Degrees of freedom | Mean square values of | | | |
|---|---|---|---|---|---|
| | | Root length | Stem length | Stem diameter | Curd diameter |
| Replication | 2 | 0.0100 | 0.0772 | 0.00644 | 0.44767 |
| Integrated Nutrient Management | 12 | 21.6831** | 12.1359** | 0.46270** | 9.00817** |
| Error | 24 | 0.4658 | 0.2033 | 0.00397 | 0.45717 |

** significant at 1% level of significance

**Appendix IX. Mean square values of curd weight per plant, dry matter (%) of leaves and dry matter (%) of curd per plant of cauliflower**

| Sources of variation | Degree of freedom | Mean square values of | | |
|---|---|---|---|---|
| | | Curd weight per plant | Dry matter (%) of leaves | Dry matter (%) of curd |
| Replication | 2 | 51.7 | 0.28113 | 0.15462 |
| Integrated Nutrient Management | 12 | 53848.1** | 2.52102** | 1.18192** |
| Error | 24 | 90.3 | 0.08654 | 0.03628 |

** significant at 1% level of significance

**Appendix X. Mean square values of yield per plot and yield per hectare of cauliflower**

| Sources of variation | Degrees of freedom | Mean square values of | |
|---|---|---|---|
| | | Yield per plot | Yield per hectare |
| Replication | 2 | 1.61318 | 0.657 |
| Integrated Nutrient Management | 12 | 9.60928** | 115.120** |
| Error | 24 | 0.47634 | 2.577 |

** significant at 1% level of significance

## Appendix XI: Production cost of cauliflower per hectare

### A): Material cost (Tk.)

| Treat-ments | Seed (250 g/ha) | Fertilizers and manures | | | | | | Sub Total |
|---|---|---|---|---|---|---|---|---|
| | | Urea + TSP + MoP + Gypsum | B + Mo | Cowdung | Vermi-compost | Mushroom spent compost | Bio-fertilizer | 1 (A) |
| $T_1$ | 9000 | 19784 | - | - | - | - | - | 28784 |
| $T_2$ | 9000 | 19784 | - | 25000 | - | - | - | 53784 |
| $T_3$ | 9000 | 19784 | - | - | 60000 | - | - | 88784 |
| $T_4$ | 9000 | 19784 | - | - | - | 40000 | - | 68784 |
| $T_5$ | 9000 | 19784 | 1387 | 25000 | - | - | - | 55171 |
| $T_6$ | 9000 | 19784 | 1387 | - | 60000 | - | - | 90171 |
| $T_7$ | 9000 | 19784 | 1387 | - | - | 40000 | - | 70171 |
| $T_8$ | 9000 | 19784 | - | 25000 | - | - | 1250 | 55034 |
| $T_9$ | 9000 | 19784 | - | - | 60000 | - | 1250 | 90034 |
| $T_{10}$ | 9000 | 19784 | - | - | - | 40000 | 1250 | 70034 |
| $T_{11}$ | 9000 | 19784 | 1387 | 25000 | - | - | 1250 | 56421 |
| $T_{12}$ | 9000 | 19784 | 1387 | | 60000 | - | 1250 | 91421 |
| $T_{13}$ | 9000 | 19784 | 1387 | - | - | 40000 | 1250 | 71421 |

Cauliflower seed @ Tk. 9000
Vermicompost @ Tk. 15000 $t^{-1}$
Mushroom spent compost @ Tk. 10000 $t^{-1}$
Cowdung @ Tk. 5000 $t^{-1}$
Bio fertilizer @ Tk. 250 per kg

Urea @ Tk. 22 per kg
TSP @ Tk. 22 per kg
MoP @ Tk. 15 per kg
Gypsum @ Tk. 40 per kg
Borax @ Tk. 240 per kg Ammonium molybdate @ Tk. 1000 per kg

Here, $T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control), $T_2$= $T_1$ + Cowdung (5 t/ha), $T_3$= $T_1$+ Vermicompost (4 t/ha), $T_4$=$T_1$ + Mushroom spent compost (4 t/ha), $T_5$= $T_2$ +$B_{0.6}Mo_{0.54}$ kg/ha, $T_6$= $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_7$ = $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_8$= $T_2$ + Bio-fertilizer (5 kg/ha), $T_9$= $T_3$ + Bio-fertilizer (5 kg/ha), $T_{10}$= $T_4$ + Bio-fertilizer (5 kg/ha), $T_{11}$= $T_5$ + Bio-fertilizer (5 kg/ha), $T_{12}$= $T_6$ + Bio-fertilizer (5 kg/ha) and $T_{13}$= $T_7$ + Bio-fertilizer (5 kg/ha)

**B) Non-material cost (Tk. /ha)**

| Treatments | Land preparation | Seed sowing and transplanting | Intercultural operation | Harvesting | Sub total | Total input cost 1 (A) + 1 (B) |
|---|---|---|---|---|---|---|
| $T_1$ | 18000 | 9000 | 12000 | 15000 | 54000 | 82784 |
| $T_2$ | 18000 | 9000 | 12000 | 15000 | 54000 | 107784 |
| $T_3$ | 18000 | 9000 | 12000 | 15000 | 54000 | 142784 |
| $T_4$ | 18000 | 9000 | 12000 | 15000 | 54000 | 122784 |
| $T_5$ | 18000 | 9000 | 12000 | 15000 | 54000 | 109171 |
| $T_6$ | 18000 | 9000 | 12000 | 15000 | 54000 | 144171 |
| $T_7$ | 18000 | 9000 | 12000 | 15000 | 54000 | 124171 |
| $T_8$ | 18000 | 9000 | 12000 | 15000 | 54000 | 109034 |
| $T_9$ | 18000 | 9000 | 12000 | 15000 | 54000 | 144034 |
| $T_{10}$ | 18000 | 9000 | 12000 | 15000 | 54000 | 124034 |
| $T_{11}$ | 18000 | 9000 | 12000 | 15000 | 54000 | 110421 |
| $T_{12}$ | 18000 | 9000 | 12000 | 15000 | 54000 | 145421 |
| $T_{13}$ | 18000 | 9000 | 12000 | 15000 | 54000 | 125421 |

Labor cost @ 300 Tk. per Person

Here, $T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control), $T_2$= $T_1$ + Cowdung (5 t/ha), $T_3$= $T_1$+ Vermicompost (4 t/ha), $T_4$=$T_1$ + Mushroom spent compost (4 t/ha), $T_5$= $T_2$ +$B_{0.6}Mo_{0.54}$ kg/ha, $T_6$= $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_7$ = $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_8$= $T_2$ + Bio-fertilizer (5 kg/ha), $T_9$= $T_3$ + Bio-fertilizer (5 kg/ha), $T_{10}$= $T_4$ + Bio-fertilizer (5 kg/ha), $T_{11}$= $T_5$ + Bio-fertilizer (5 kg/ha), $T_{12}$= $T_6$ + Bio-fertilizer (5 kg/ha) and $T_{13}$= $T_7$ + Bio-fertilizer (5 kg/ha)

### C) Overhead cost and total cost of production (Tk.)

| Treatments | Cost of lease of land (Tk.) | Miscellaneous cost (5% of input cost) (Tk.) | Interest on running capitalfor 6 months (15% of the total input cost)(Tk.) | Total (Tk.) | Total cost of production (input cost + interest on running capital, Tk./ha) |
|---|---|---|---|---|---|
| $T_1$ | 39000 | 4139 | 6208 | 49347 | 132131 |
| $T_2$ | 39000 | 5389 | 8083 | 52472 | 160256 |
| $T_3$ | 39000 | 7139 | 10708 | 56847 | 199631 |
| $T_4$ | 39000 | 6139 | 9208 | 54347 | 177131 |
| $T_5$ | 39000 | 5458 | 8187 | 52645 | 161816 |
| $T_6$ | 39000 | 7208 | 10812 | 57020 | 201191 |
| $T_7$ | 39000 | 6208 | 9312 | 54520 | 178691 |
| $T_8$ | 39000 | 5451 | 8177 | 52628 | 161662 |
| $T_9$ | 39000 | 7201 | 10802 | 57003 | 201037 |
| $T_{10}$ | 39000 | 6201 | 9302 | 54503 | 178537 |
| $T_{11}$ | 39000 | 5521 | 8281 | 52802 | 163223 |
| $T_{12}$ | 39000 | 7271 | 10906 | 57177 | 202598 |
| $T_{13}$ | 39000 | 6271 | 9406 | 54677 | 180098 |

Here, $T_1$= $N_{120}P_{60}K_{100}S_{20}$ kg/ha (control), $T_2$= $T_1$ + Cowdung (5 t/ha), $T_3$= $T_1$+ Vermicompost (4 t/ha), $T_4$=$T_1$ + Mushroom spent compost (4 t/ha), $T_5$= $T_2$ +$B_{0.6}Mo_{0.54}$ kg/ha, $T_6$= $T_3$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_7$ = $T_4$ + $B_{0.6}Mo_{0.54}$ kg/ha, $T_8$= $T_2$ + Bio-fertilizer (5 kg/ha), $T_9$= $T_3$ + Bio-fertilizer (5 kg/ha), $T_{10}$= $T_4$ + Bio-fertilizer (5 kg/ha), $T_{11}$= $T_5$ + Bio-fertilizer (5 kg/ha), $T_{12}$= $T_6$ + Bio-fertilizer (5 kg/ha) and $T_{13}$= $T_7$ + Bio-fertilizer (5 kg/ha)

## SOME PICTORIAL VIEW DURING EXPERIMENTATION

**Plate 1. Photograph of seedbed**

**Plate 2. Photograph of transplanting of seedlings in the main field**

**Plate 3. Photograph of fertilization on the plot**

**Plate 4. Photograph of vegetative stage of cauliflower**


**Plate 5. Photograph of general view of the experimental plot**

**Plate 6. Photograph of curd of cauliflower**

**Plate 7. Photograph of harvested curds of cauliflower**