



RESEARCH ARTICLE

RESPONSE OF BIOFERTILIZER IN CONJUNCTION WITH DIFFERENT LEVELS OF INORGANIC FERTILIZER IN CAULIFLOWER (*BRASSICA OLERACEA* VAR. *BOTRYTIS*) PRODUCTION AT CHITWAN, NEPAL

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ABSTRACT

The crop growth with its yield and yield-attributing character of Kathmandu local variety of cauliflower was evaluated under different levels of the recommended dose of inorganic fertilizer and bio-fertilizer inoculation at Khairahani, Chitwan during the winter season from December 2021 to February 2022. The experiment was laid out into two factorial Randomized Complete Block Design with three different levels of NPK (Viz:100% NPK-120:60:50, 75% NPK-90:45:37.5, and 50% NPK-60:30:25) and bio-fertilizer (Viz: No inoculation, Azotobacter inoculation, VAM inoculation, and Azotobacter +VAM inoculation). The treatments were replicated thrice. Azotobacter was inoculated by dipping seedlings into 10% (V/V) solution for 30 minutes whereas, VAM was inoculated at the rate of 4 Kg ha⁻¹ by soil application. The results revealed that significantly higher plant height (50.57cm), number of leaves (13.42), plant spread (55.60cm), leaf area index (2.41) at harvest, and days to 100% curding (77.62), curd weight (265.6 gm), curd diameter (26.10 cm) and marketable curd yield (8.41ton ha⁻¹) was recorded under 100% NPK fertilizer. Regarding bio-fertilizer, inoculation with Azotobacter + VAM recorded significantly higher plant height (49.15 cm), number of leaves (14.22), leaf area index (2.51), plant spread (57.52 cm) at harvest, days to 50% curding (70.22), days to 100% curding (77.6), curd diameter (25.72 cm), curd weight (249.1 gm) and marketable curd yield (8.11-ton ha⁻¹) as compared to that of the treatment with no inoculation. Interaction between the inorganic fertilizer and biofertilizer was seen as significant in plant height at 30 days after transplanting. Thus, it can be suggested that the application of a 100% recommended dose of NPK fertilizer and Azotobacter + VAM inoculation enhances the production of cauliflower.

KEYWORDS

Azotobacter, Recommended dose, VAM, Yield.

1. INTRODUCTION

Vegetables are an essential part of our diet. They are widely grown worldwide and are reflected as a protective food as they play a significant role in human nutrition. Cole crops, which include cauliflower (*Brassica oleracea* var. *botrytis*), cabbage (*B. oleracea* var. *capitate*), sprouting broccoli or broccoli (*B. oleracea* var. *italica*), Brussels sprout (*B. oleracea* var. *gemmifera*), kale (*B. oleracea* var. *acephala*). Cauliflower, which is native to the Mediterranean region, is the world's most popular commercial vegetable crop among these Cole crops. It is grown all year for its white and tender curd where the climate allows. The country's diverse agroecological conditions promote year-round cultivation of cauliflower, resulting in its market availability throughout the season leading it as one of the most popular vegetables in the Nepalese kitchen. According to MOALD 2020/21, vegetables were cultivated in Nepal in an area of 281,132 hac with a production of 3,962,383 metric tonnes in the year 2019/20, followed by 284,121 hac with a production of 3,993 metric tonnes in the year 2020/21. Furthermore, Bagmati province has cultivated vegetables on an area of 49,983 hectares, which produces 728,432 metric tonnes of vegetables, yielding 14.57 Mt/hac. Cauliflower ranked first among all vegetables in terms of area under cultivation and production in Nepal (MOALD,2020/21). Cauliflower was grown in an area of 5,934 hectares with a production of 87,600 metric tonnes and with a

productivity of 14.76mt/hac. Similarly, in the year 2020/21, Chitwan cultivated cauliflower on 450 hectares of land with a production of 5,490 Mt. and productivity of 12.20 mt/hac, which shows Chitwan is one of the major districts for contributing to the production of cauliflower in the Bagmati province. Fresh vegetables contribute 16.36% of agricultural GDP in the year 2020/21 which increased to 16.67% in the year 2021/22. According to the production domains, the area and production of cauliflower are dominated by Province no.1 with a Productivity of 17.16 Mt/hac., and province no.5 with a productivity of 15.78 Mt/hac. And Province no 3 with productivity of 17.76 Mt/hac (MOALD, 2020/21). Cauliflower is a high-value crop with high protein, carbohydrate, phosphorus, calcium, iron, and ascorbic acid levels. It has a high nutritional density while being low in fat and high in dietary fiber, folate, water, and vitamin C. Cauliflower contains phytochemicals that may benefit human health (Madhumathi et al., 2017). Cauliflower consumption also aids in the detoxification of body fats, the promotion of a healthy heart, improved digestion, and the treatment of scurvy as a blood purifier. Nitrogen is a necessary nutrient for plant growth and fruit development.

Soil is an important resource that provides crops with essential nutrients and healthy soil is essential for healthy plant growth. So, it must be well treated with manures and fertilizers to ensure increased production and productivity. Biofertilizers/inorganic fertilizers alone might not supply all

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the required nutrients for plants in sufficient amounts hence application of biofertilizer in conjunction with inorganic fertilizer is one of the best methods in supplying all the nutrients required the plants in order to maintain soil fertility, agricultural productivity, and profitability. Farmers believe that the use of excessive urea as a nitrogen fertilizer will enhance flowering, curd set, and increase curd size in cauliflower as reported by (Kodithuwakku and Kirthisinghe, 2009). Whereas, Sani *et al.* (2018) reported that excessive application of nitrogen is not only uneconomical but also induces physiological disorders and pollutes the environment and increases soil acidity, impairs soil physical condition, reduces organic matter, creates micronutrient deficiencies, increases plant susceptibility to pests and diseases, decreases soil lives, and increases soil, water, and air pollution via agricultural run-off and leaching.

Moreover, Biofertilizer reduces the requirements of inorganic fertilizer, enhances nutrient use efficiency, maintains soil quality in terms of physical, chemical, and biological properties, sustains crop production, and maintains soil health. In addition, it helps in improving disease resistance in the crop by producing antibacterial and anti-fungal compounds and also producing growth regulators (Talwar *et al.*, 2017). The application of biofertilizers improves the number of biological activities of microorganisms in soil and helps to improve plant growth, fruit yield, seed yield, and quality. Furthermore, biofertilizers are non-bulky and cheap sources of nutrients and may prove cost-effective and eco-friendly supplementation in vegetable farming and have the capacity to increase 2 to 45% yield in vegetable crops (Subedi *et al.*, 2019).

Vesicular-Arbuscular Mycorrhizae (VAM) phosphorus absorber bio-fertilizer help in the development of a stronger root system, increase root surface area, improve the growth of roots, nutrient uptake, and increased tolerance of host roots to soil-borne pathogens (Zandavalli *et al.*, 2004). Whereas, it solubilizes the unavailable phosphorus in the soil and makes it available for the plant's growth (Devi *et al.*, 2003). Azotobacter free-living bacteria colonize near the root zone and enhance the available nitrogen in the soil by N fixation. Although biofertilizer is a low-cost input that is compatible with chemical fertilizers and pesticides and is safe for both crops and users. They are environmentally friendly and pose no risk to the environment. However, their acceptance has been low, owing to farmers' lack of knowledge about the proper integration of biofertilizers with inorganic sources of nitrogen. Therefore, there is an immediate need to develop a suitable integrated nutrient management technique that will help in building soil fertility and enhancing the productivity of cauliflower. Thus, as a result, an experiment was conducted to evaluate cauliflower's response to nitrogen-fixing biofertilizer and VAM and different percentages of NPK under Chitwan conditions.

2. MATERIALS AND METHODS

The research was laid out during early winter Starting from 3rd December to 21st February 2021 in the field of Rural Reconstruction Nepal (RRN), which is part of Terai of Nepal. The research was conducted with the mid-season variety (Kathmandu Local) of cauliflower on the topic entitled "Response of Biofertilizer in conjunction with inorganic fertilizer in cauliflower production at Chitwan, Nepal". Geographically, the area is located at 27° 66" North of Latitude and 84° 58" East altitude of 149 above mean sea level.

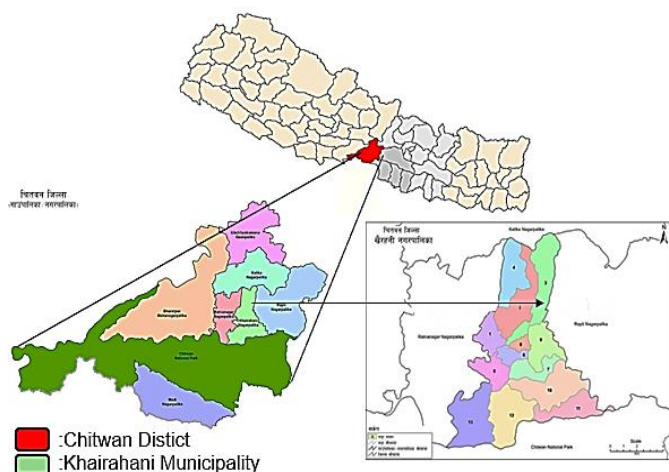


Figure 1: Map of Nepal Showing Experimental Site

Properties	Content	Category
PH	6.01	Slight acidic
Organic matter (%)	2.25%	Medium
Total Nitrogen (%)	0.108%	Low
Available Phosphorus (P ₂ O ₅ Kg ha ⁻¹)	107.101 kg/hac	High
Available Potassium (K ₂ O Kg ha ⁻¹)	215.335 kg/hac	Medium

(Source: Digital soil map of Nepal)

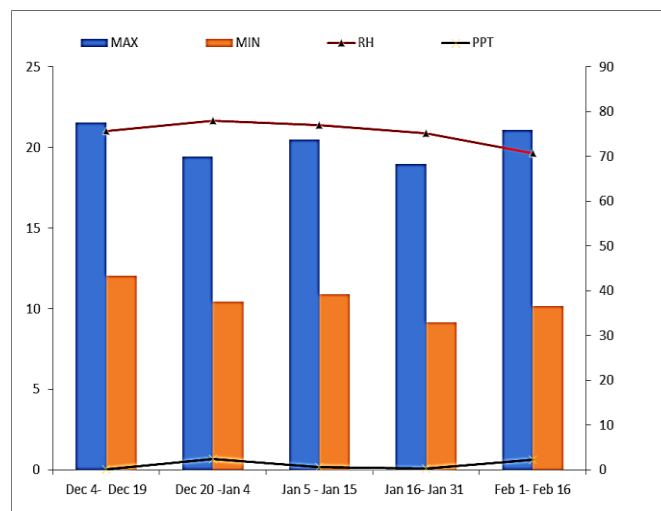


Figure 2: Weather conditions of the experimental site during the cauliflower growing season from December 2021 to February 2022. (Source: NASA power)

The research was designed into two factorial Randomized Complete Block Design with three different levels of NPK (Viz: 100% NPK-120:60:50, 75% NPK-90:45:37.5, and 50% NPK-60:30:25) and bio-fertilizer (Viz: No inoculation, Azotobacter inoculation, VAM inoculation, and Azotobacter +VAM inoculation) i.e., with 3 replication and 12 treatments and treatments were replicated thrice.

The variety of cauliflower (*Brassica oleracea* var. botrytis L.) var. Kathmandu local was used. The gross area of the plot was 1.8m x 3m (5.4m²) whereas, the net area of the plot was 1.6m². The distance between the two plots was maintained at 30 cm and each replication was separated by 0.5m space. The crop geometry was maintained at 0.45 cm x 0.60 cm with 20 seedlings per plot. The gross area of the research field was 246 m² with a selected variety- Kathmandu Local. The accurate doses of FYM i.e., 20-ton ha⁻¹ and recommended dose of NPK i.e., 120:60:50 kg NPK ha⁻¹ were applied in each plot according to its treatment.

Quantitative data were collected before harvesting the crop i.e. pre-harvest parameters are Plant height (cm), number of leaves, Leaf length (cm), Leaf Breadth(cm), Leaf Area Index, Plant spread (cm), Days to Curd initiation, Days to 50% Curd initiation, Days to 100% Curd initiation, etc. whereas, Curd diameter(cm), cued length(cm), curd weight (gm), Biomass yield (t ha⁻¹), Marketable curd yield (t ha⁻¹) were the post-harvest parameters of the plants observed after harvesting of the cauliflower. Data were analyzed by GenStat and Microsoft Excel.

2.1 Inoculum of Azotobacter and VAM

A solution of 10%(v/v) was prepared for the inoculation of seedlings. Biofertilizer - Azotobacter @ 100ml per liter of water was prepared. The required number of 25 days old seedlings were uprooted from the nursery bed and seedlings were then dipped into the solution for about 30 minutes for inoculation. VAM was used as another biofertilizer as treatment in the field which was inoculated at the rate of 4 Kg ha⁻¹ by direct soil application.

Table 2: Treatments Details

S. N	Factor A		Factor B
Fertilizer	Fertilizer Dose (120:60:50) kg NPK ha ⁻¹	Biofertilizer	
V ₁	The full Recommended dose of NPK	S ₁	No inoculation
V ₂	75% Recommended dose of NPK	S ₂	Azotobacter inoculation @ 10%(v/v)
V ₃	50% Recommended dose of NPK	S ₃	VAM inoculation @ 4kg/hac
		S ₄	Azotobacter +VAM inoculation

3. RESULT AND DISCUSSION

3.1 Plant Height

The plant height was significantly affected by the different treatments as shown in Table 2 and appendix 1. Plant height was increasing during the entire growth period. Plant at 30 DAT, 60dat and 90 DAT were highly significant with the both factors; inorganic fertilizer and bio fertilizer. At 30 DAT, maximum plant height was given by the application of full doses of 100% NPK (21.49 cm) which is at par with the 75% NPK (21.12 cm) along with maximum plant height with the inoculation of VAM (22.50 cm). However, at 60 DAT, there was significant effect of plant height (46.6 cm) in 100%NPK (46.26 cm) which was at par with application of 75% NPK (43.76 cm). In case of factor B; biofertilizer plant was maximum at inoculation of azotobacter (46.07 cm) which is at par with the treatment VAM (44.96 cm) and AZO+VAM (44.79 cm). While, lowest plant height was seen in treatment with 50% NPK and no inoculation of biofertilizer. At 90 DAT, maximum plant height was seen with 100 % NPK (50.47 cm) and with the application of AZO+VAM (49.15 cm) which is at par with the application of VAM (48.54 cm) and lowest plant height was seen in the 50 %NPK (44.64 cm) and no inoculation (42.13cm). The interaction between the biofertilizer and inorganic fertilizer shows significant differences in comparison to others. These results indicate that the importance of using biofertilizer in combination of the rational use of nitrogen source to soil increases the availability of required nutrients resulting in a positive effect on growth parameters. Nitrogen is a constituent of amino acids, nucleotides, nucleic acids, a number of coenzymes, auxins, cytokinin, and alkaloids, which induces cell elongation, cell enlargement and cell division. The significant difference in plant height must be attributed to a tandem of growth-promoting phytochemicals generated by biofertilizers and nitrogen availability stimulated by the application of nitrogen-fixing Azotobacter bacteria, which fix nitrogen from the air. The present study

confirms previous research that claimed leafy vegetables had greater plant height development (Maheswari and Kalaiyarasi, 2015). Nitrogen being an important component of chlorophyll imparts green color to the plants and improves photosynthesis which results in more production of photosynthates and ultimately increased plant height (Kaur et al., 2020b). The results of the present investigation in terms of plant height corroborate the findings (Das et al., 2014) in red cabbage on cauliflower Nath Bashyal, 2011. Similar other findings were found on (Subedi et al., 2019), (Mohapatra et al.,2013) in broccoli , (Thadani et al., 2019), (Sangeeta Shree et al.,2014) in brinjal, (Refai et al., 2018) on cauliflower.

3.2 Number of Leaves

Statistically, taking about effect of inorganic fertilizer on the bio fertilizer in a number of leaves of cauliflower is shown in Table 3 and appendix 2. The table showed that there is no significant effect of fertilizer and bio-fertilizer on the number of leaves at 30DAT. However, at 60 DAT the numbers of leaves were highly significant with both the inorganic fertilizer and biofertilizer. A higher number of the leaf was recorded in 100% NPK (12.08) and the lowest in 50 % NPK (11.17). Similarly, at 60 DAT, Biofertilizer; AZO+VAM gives the Maximum number of leaves (12.11) which is at par with the inoculation of VAM (11.67). At 90 DAT numbers of leaves were highly significant with inorganic fertilizer 100% NPK (13.42) and inoculation with AZO+VAM (14.22). The result indicates that the incorporation of biofertilizer and inorganic fertilizer in fraction help to enhance the growth and development of leaves of plant rather than the individual application of inorganic fertilizers. This is because nitrogen promotes vegetative growth and increased the number of leaves in cauliflower. A similar finding was obtained in research conducted in cabbage by (Subedi et al., 2019a; Nath Bashyal, 2011; Aravindakshan et al., 2012; Kumar et al.,2007)

Table 3: Effect of different levels of inorganic fertilizer and bio-fertilizer on growth parameters of cauliflower in Khairahani, Chitwan during 2021/22.

Treatments	PH (cm)			NOL		
	30DAT	60 DAT	90DAT	30DAT	60DAT	90DAT
Factor A: RDF (N:P: K-120:60:50)						
100	21.49 ^a	46.26 ^a	50.47 ^a	6.75	12.08 ^a	13.42 ^a
75	21.12 ^a	43.76 ^{ab}	46.33 ^b	6.75	11.33 ^b	12.58 ^b
50	19.68 ^b	41.53 ^b	44.46 ^b	6.58	11.17 ^b	12.75 ^b
SEM (±)	0.38	0.93	1.04	0.22	0.19	0.30
LSD	1.12	2.74	3.04	0.65	0.57	0.63
F-test	**	**	**	NS	**	***
Factor B: Bio-fertilizers						
No inoculation	19.31 ^c	39.58 ^b	42.13 ^b	6.22	11.11 ^b	11.67 ^c
Azotobacter	20.36 ^{bc}	46.07 ^a	48.52 ^a	6.56	11.22 ^b	12.89 ^b
VAM	22.50 ^a	44.96 ^a	48.54 ^a	7.22	11.67 ^{ab}	12.89 ^b
Azotobacter + VAM	20.87 ^b	44.79 ^a	49.15 ^a	6.78	12.11 ^a	14.22 ^a
Grand Mean	20.76	43.85	47.09	6.69	11.64	12.92
SEM (±)	0.44	1.53	1.19	0.26	0.22	0.25
LSD	1.3	3.16	3.51	0.75	0.66	0.73
F-test	***	**	**	NS	*	*
CV (%)	6.4%	7.4%	7.6%	11.5%	5.9%	13.7%
A*B	**	NS	NS	NS	NS	NS

PH - Plant height, NOL - No of leaves, * Significant at 0.05 level ** significant at 0.01 *** Significant at 0.001, CV- coefficient of variance, LSD- a least significant difference, SEM- standard error of means

3.3 Plant Spread

Plant spread as affected by biofertilizer and fertilizer is shown in table 4 and appendix 3. Plant spread at 30 DAT and 60 DAT were non-significant with the factor; of inorganic fertilizer. Whereas, it is highly significant with factor B: bio-fertilizer i.e., inoculation of VAM gives a higher plant spread (21.63 cm) in comparison with other treatments which is at par with the inoculation of AZO+VAM (20.31 cm). Similarly, at 60 DAT, higher Plant spread was obtained in the inoculation of AZO+VAM (26.17cm). At 90 DAT, plant spread was highly significant with both factors. The highest plant spread was seen at the application of 100% NPK (55.60 cm) and

inoculation of AZO+VAM (57.52 cm). These results showed that plant spread was found to be increased in 100% NPK, AZO+VAM treatment than in Sole inorganic fertilizer. Nitrogen increases cytokinin production in the roots of plants, and more cytokinin carried to the leaves results in more cell division and plant spread increases as nitrogen doses increase (Kaur et al., 2020b).

A similar finding was observed in research conducted on cauliflower by (Devi et al.,2018; M. Kumar et al., 2018; Das et al., 2014b; Subedi et al., 2019a; Nath Bashyal, 2011).

3.4 Leaf Area Index

Statistically, the Leaf area index at 30 DAT was found to be non-significant with inorganic fertilizer. But it was found to be highly significant with factor B; biofertilizer with the inoculation of VAM (0.19). At 60 DAT, LAI was found to be significant with both fertilizer biofertilizer with the highest value at 100% NPK (1.99) and inoculation of AZO+VAM (1.96) which is at par with the treatment Azotobacter (1.91) and VAM (1.87). At 90 DAT, LAI was highly significant with both factors; inorganic fertilizer and biofertilizer. The highest LAI was found at the application of 100%

NPK (2.41) which is at par with the 75%NPK (2.20). similarly, in the case of factor B; inoculation of AZO+VAM gives a higher LAI (2.51) which is at par with the inoculation of Azotobacter (2.29), and the lowest LAI was seen in the treatment 50% NPK (1.92), and inoculation of VAM (1.84). Our finding shows positive a response in leaf area on combined treatment rather than sole incorporation of inorganic fertilizers and biofertilizers. A similar result was also seen in research performed in cauliflower (Kaur et al., 2020b; Nath Bashyal, 2011; Abdulhafid Falih Hassan, 2020; Devi et al.,2008)

Table 4: Effect of different levels of inorganic fertilizer and bio-fertilizer on growth parameters of cauliflower in Khairahani, Chitwan during 2021/22.

Treatments	PH (cm)			NOL		
	30DAT	60 DAT	90DAT	30DAT	60DAT	90DAT
Factor A: RDF (N:P: K-120:60:50)						
100	18.61	21.64	55.60a	0.16	1.99a	2.41a
75	19.79	23.28	50.63b	0.16	1.79ab	2.20a
50	19.61	23.39	46.33c	0.15	1.67b	1.92b
SEM (±)	0.452	0.565	0.51	0.008	0.08	0.09
LSD	1.327	1.656	3.290	0.03	0.23	0.26
F-test	NS	NS	***	NS	*	**
Factor B: Bio-fertilizers						
No inoculation	16.94a	18.45c	47.69b	0.12c	1.526b	1.84c
Azotobacter	18.46a	21.30c	49.56b	0.16b	1.917a	2.29ab
VAM	21.63b	25.15b	49.56b	0.19a	1.872a	2.08bc
Azotobacter + VAM	20.31b	26.17a	57.52a	0.16b	1.96a	2.51a
Grand Mean	19.34	22.7	50.85	0.16	1.82	2.18
SEM (±)	0.522	0.652	0.59	0.010	0.27	0.10
LSD	1.532	1.912	3.799	0.03	0.09	0.30
F-test	***	***	***	***	*	***
CV (%)	8.1%	8.6%	7.6%	19.7%	15%	14.2%
A*B	NS	NS	NS	NS	NS	NS

PH - Plant height, NOL - No of leaves PS - Plant spread, and LAI - Leaf area index. * Significant at 0.05 level ** significant at 0.01 *** Significant at 0.001, CV- coefficient of variance, LSD- a least significant difference, SEM- standard error of means

3.5 Effect of Inorganic Fertilizer and Bio-Fertilizer Yield Attributing Parameters

3.5.1 Days to First Curd Initiation

Statistically, days of first curding were found non-significant with both factors, i.e., Inorganic fertilizer and bio fertilizer.

3.5.2 Days to 50% Curd Initiation

Days to 50% curding was found non-significant with factor A; inorganic fertilizer. Whereas, it is highly significant with factor B; treatment

3.5.3 Days 100% Curd Initiation

biofertilizer. Treatment inoculations with AZO+VAM lengthen their duration to complete its 50% curding (70.22) than the rest of the other treatments. Whereas, 50% curding was completed earlier on the treatment inoculated with VAM (56.33) which is at par with the treatment Azotobacter (68.67) and followed by the treatment with no inoculation (67.67). The days to curd initiation and 50% curding increased with increased levels of nitrogen. In addition, a higher amount of nitrogen permits the luxurious growth of the plant and delays maturity. Curd initiation and maturity delayed with an increase in N content and Biofertilizer application due to increase in the vegetative period (Nath Bashyal, 2011).

Table 5: Effect of different levels of inorganic fertilizer and bio-fertilizer inoculation on yield parameters of cauliflower in Khairahani, Chitwan during 2021/22.

Treatments	Curd initiation	50% curd initiation	100% curd initiation
Factor A: RDF (N:P:K) (120:60:50)			
100	56.33	69.08	77.62 ^a
75	55.67	68.50	76.62 ^a
50	56.5	68.00	74.63 ^b
SEM (±)	0.452	0.422	0.204
LSD	1.324	1.324	1.242
F-test	NS	NS	*
Factor B: Bio-fertilizers			
No inoculation	55.76	56.33b	74.33b
Azotobacter	56.22	68.67 ^b	75.62 ^b
VAM	56.33	67.67 ^b	77.5 ^a
Azotobacter + VAM	56.11	70.22 ^a	77.6 ^a
Grand Mean	19.34	68.53	76.29
SEM (±)	0.521	0.487	0.236
LSD	1.529	1.428	1.434
F-test	NS	**	*
CV (%)	2.80%	8.6%	0.90%
A*B	NS	NS	NS

* Significant at 0.05 level ** significant at 0.01 *** Significant at 0.001, CV- coefficient of variance, LSD- a least significant difference, SEM- standard error of the means

According to the data recorded, 100% curding was found significant with factor A; inorganic fertilizer. Longer days to complete 100% curding was found on the treatment with application 100% of inorganic fertilizer (77.62) which is at par with the treatment with application of 75% of NPK (76.62) and lowest was found on the treatment with 50% of NPK (74.63). Similarly, 100% curding was found significant with the Factor B; bio fertilizer. Longest days to complete 100% curding was found on the treatment inoculated with AZO+VAM(77.6) which is at par with the treatment with application of VAM(77.5) and earlier days to 100% curding was found on the treatment with no inoculation (74.33) which was at par with the treatment Azotobacter (75.6). The days to curd maturation increased as nitrogen levels increased. Higher nitrogen content allows the plant to grow more luxuriously and postpones maturity. Curd initiation and maturity are delayed as N content increases, and biofertilizer application is increased as N content increase in the vegetative stage (Nath Bashyal, 2011). Similar results were found on the experiment conducted the red cabbage (Shrestha et al., 2022; Subedi et al., 2019a).

3.5.4 Curd Weight

The data depicted in Table 9 and appendix 7 indicates that the average curd weight is influenced by the different treatments. Treatment with the application of 100% of inorganic fertilizer had the highest significant difference (265.3 gm) whereas; the lowest curd weight was found in the treatment with 50% NPK (161.3 gm). Similarly, curd weight was found highly significant with Factor B; Biofertilizer. Treatment inoculation with AZO+VAM gives higher curd weight (249.1 gm). And lowest curd weight among biofertilizers was found in the treatment with no inoculation.

This might be due to the synthesis of more chlorophyll and amino acid resulting in accelerated vegetative growth which might account for increased carbohydrate accumulation as a result of increased photosynthesis. A similar result was obtained from an experiment performed by (Das et al., 2014a) in red cabbage, (Thadani et al., 2019) (Subedi et al., 2019) in cauliflower, (Mohanata et al., 2018) and (Nath Bashyal, 2011) in sprouting broccoli.

3.5.5 Curd Diameter

Curd diameter was found highly significant with both factors' inorganic fertilizers and biofertilizers. The highest curd diameter was found on the treatment with the application of 100% NPK (26.10cm). The lowest curd diameter was found on the treatment 50% NPK (20.77 cm) which is at par with the treatment at 75% NPK (22.82cm). Whereas, Curd diameter was found highest significance with factor B: Biofertilizer. The highest curd diameter was found on the treatment inoculation with AZO+VAM (25.72 cm) which is at par with the treatment VAM (23.98 cm) and followed by the treatment Azotobacter (23.05 cm) and the lowest curd diameter among the factor B was found on the no inoculation (15.41 cm). Curd diameter increased due to the production of plant growth-promoting substances. These phytohormones promote plant root growth, which increases nutrient and water absorption areas. Biofertilizers saved soil microorganisms, increased nutrient mobilization from non-available to

available form, improved soil physio-chemical properties and inhibited the growth of pathogenic organisms, resulting in increased yield attributes (Nath Bashyal, 2011). Similar results were seen in red cabbage (Das et al., 2014b; Subedi et al., 2019).

3.5.6 Curd Length

Statistically, curd depth was found non-significant with both factors A; inorganic fertilizers, and Factor B; Biofertilizers. This result is attributed due to the reasons that these parameters are under strong genetic influence and did not show a significant effect (Subedi et al., 2019a).

3.5.7 Marketable Yield (t/ha⁻¹)

Statistically, Marketable curd yield was found highly significant with both the factors; Inorganic fertilizer and biofertilizer. The highest marketable yield was found on the treatment with the application of 100% NPK (8.41 ton/ha) and the lowest marketable yield was found on the treatment with 50% NPK (6.23 ton/ha) which is at par with the treatment with 75% of NPK (6.80 ton/hac). Similarly, Marketable yield was highly significant in the treatment inoculated with AZO+VAM (8.11 t ha⁻¹). Which is at par with the treatment inoculated with the VAM (7.40 ton/hac and followed by the treatment, inoculated with Azotobacter (7.04 t ha⁻¹).

As mentioned, that bacterial bio fertilizer enhances plant growth and yield through several mechanisms; synthesis of plant nutrients or phytohormone, protection from abiotic stresses and defense against plant pathogens, and reducing plant diseases (García-Fraile et al., 2015). This may be due to the synthesis of more chlorophyll and amino acid resulting in accelerated vegetative growth which might account for increased carbohydrates accumulation as a result of increased photosynthesis. They studied the effect on brinjal, tomato, and cabbage and found that inoculation of seed or roots with the bacteria Azotobacter had a high potential of increasing the yield of vegetable crops. Biofertilizer increases phytohormone production, nitrate reduction, nitrogen fixation, phosphate solubilization, and specific activities of enzymes involved in the tricarboxylic acid cycle and glycolysis pathway. Hormone-induced changes in root morphology result in increased uptake of mineral nutrients such as NO₃, NH₄, H₂PO₄, K⁺, Rb⁺, and Fe²⁺, which may increase yield. Azotobacter can fix 6.0-13.4 mg nitrogen per gram of sucrose consumed and inhibit the growth of phytopathogenic fungi, (Neupane et al., 2020). A similar result was obtained from experiments performed in sprouting broccoli and cauliflower by (Kaur et al., 2020b; Refai et al., 2018; Subedi et al., 2019a; Shrestha et al., 2022).

3.5.8 Biomass Yield (t ha⁻¹)

Statistically, biomass yield was found highly significant with factor A; Inorganic fertilizer. The highest biomass yield was found on the treatment with the application of 100% NPK (14.87 tons/hac). Whereas the lowest yield was found on the treatment with the application of 50% NPK (10.78 ton/ha) which is at par with the application of 75% NPK (11.90 ton/hac) (Talwar et al., 2017b). Similarly, the biomass yield was found non-significant with the factor biofertilizer (Subedi et al., 2019).

Table 6: Effect of different levels of inorganic fertilizer and bio-fertilizer inoculation on yield parameters of cauliflower in Khairahani, Chitwan during 2021/22.

Treatment	Curd weight(gm)	Curd diameter(cm)	Curd length (cm)	Marketable curd yield (ton ha ⁻¹)	Biomass yield (ton ha ⁻¹)
Factor A: RDF (N:P:K) (120:60:50)					
100	265.3 ^a	26.10 ^a	16.67	8.41 ^a	14.87 ^a
75	195.2 ^b	22.82 ^b	16.17	6.80 ^b	11.90 ^b
50	161.3 ^c	20.77 ^b	15.97	6.23 ^b	10.78 ^b
SEM (±)	8.27	0.76	0.50	0.31	0.71
LSD	24.24	2.22	1.47	0.89	2.08
F-test	***	***	NS	***	**
Factor B: Biofertilizers					
No inoculation	173.4 ^c	20.17 ^b	15.41	6.05 ^b	12
Azotobacter	192.1 ^{bc}	23.05 ^a	16.18	7.04 ^{ab}	12.08
VAM	214.4 ^b	23.98 ^a	16.69	7.40 ^a	12.13
Azotobacter + VAM	249.1 ^a	25.72 ^a	16.81	8.11 ^a	13.84
Grand Mean	207.2	23.23	16.27	7.15	12.51
SEM (±)	9.55	0.87	0.58	0.35	0.82
LSD	27.99	2.56	1.69	1.04	2.40
F-test	***	**	NS	**	NS
CV (%)	13.8%	11.3%	10.6%	14.9%	19.7%
A*B	NS	NS	NS	NS	NS

* Significant at 0.05 level ** significant at 0.01 *** Significant at 0.001, CV- coefficient of variance, LSD- a least significant difference, SEM- standard error of the means

4. CONCLUSIONS

The research was conducted to study the response of biofertilizer and different levels of NPK on growth and yield attributing characters of cauliflower in the terai of Nepal. The treatment factors were replicated three times in two factors Randomized Complete Block Design. The results revealed that significantly higher plant height (50.57cm), number of leaves (13.42), plant spread (55.60cm), leaf area index (2.41) at harvest, and days to 100% curding (77.62), at harvest, curd weight (265.6 gm), curd diameter (26.10 cm) and marketable curd yield (8.41ton ha⁻¹) was recorded under 100% NPK fertilizer. Regarding bio-fertilizer, inoculation with Azotobacter + VAM recorded significantly higher plant height (49.15 cm), number of leaves (14.22), leaf area index (2.51), plant spread (57.52 cm) at harvest, days to 50% curding (70.22), days to 100% curding (77.6), curd diameter (25.72 cm), curd weight (249.1 gm), and marketable curd yield (8.11-ton ha⁻¹) as compared to that of the treatment with no inoculation. Similarly, days to curd initiation and curd depth were non-significant with bio-fertilizer inoculation. The interaction effect of different levels of NPK fertilizer and bio-fertilizer application showed a significant relation between plant height at 30DAT. Thus, it can be suggested that applying of 100% recommended dose of NPK fertilizer and Azotobacter + VAM inoculation enhances the production of cauliflower.

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