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Effect of Different Levels of Nitrogen and Biofertilizers on Growth and Yield of Cauliflower (*Brassica oleracea var. botrytis L.*)

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***Abstract*—** *This study explores the effect of different nitrogen levels and biofertilizer on enhancing growth and yield of cauliflower. To evaluate the results, a field experiment was carried out at Agriculture Research Farm, C B G Ag PG College, BKT during 2024-25. The experiment was laid out in a factorial randomized block design with two factors in which the first factor contains three levels of nitrogen (0, 60, and 90 kg N ha^{-1}) and the second factor consists of two levels of biofertilizer i.e., Azotobacter (0 and 2 kg ha^{-1}), applied in different combinations with three replications, resulting in six treatment combinations: T_1 - Absolute control (0 kg N ha^{-1} + no biofertilizer), T_2 - 0 kg N ha^{-1} + Azotobacter @ 2 kg ha^{-1}, T_3 - 60 kg N ha^{-1} + no biofertilizer, T_4 - 60 kg N ha^{-1} + Azotobacter @ 2 kg ha^{-1}, T_5 - 90 kg N ha^{-1} + no biofertilizer, and T_6 - 90 kg N ha^{-1} + Azotobacter @ 2 kg ha^{-1}. The interaction effect results revealed that the yield parameters increased with certain levels of nitrogen along with Azotobacter inoculation. Maximum number of curds per plot (27.78), curd diameter (26.63 cm), fresh and dry weight of curd (159.83 g and 62.90 g), yield per plot (270.74 g) and yield per hectare (21.52 Q) were found with T_6 (90 kg N ha^{-1} + Azotobacter @ 2 kg ha^{-1}), which was followed by T_5 (90 kg N ha^{-1} + no biofertilizer). However, treatment T_1 (no nitrogen and without Azotobacter) resulted in the lowest yield significantly. It was observed that the optimum dose of nitrogen with biofertilizer can reduce the need for extra nitrogen application, as nitrogen is also received through organic source (Azotobacter @ 2 kg ha^{-1}). Therefore, biofertilizer has been identified as an alternative to chemical fertilizer that increases soil fertility and crop production in sustainable farming.*

***Keywords*— Nitrogen levels, Biofertilizers, Azotobacter, Interaction effect, Cauliflower.**

I. INTRODUCTION

Cauliflower (*Brassica oleracea var. botrytis L.*) is one of the most important winter vegetable crops in the family Brassicaceae, with a chromosome number of 2n=18. It is grown throughout the country for its tender curd (aborted floral meristem), which is used for culinary purposes and processing for vegetable soup and pickling. Being a heavy feeder, cauliflower demands a constant supply of large amounts of nutrients for its luxuriant growth. Its productivity depends upon the use of balanced fertilizer; if not adequately fertilized, yield losses become apparent (Bashyal, 2013). The indiscriminate use of chemical fertilizer increases soil acidity, impairs soil physical conditions, reduces organic matter, and creates micronutrient deficiencies (Kashyap et al., 2017).

Nutritionally, cauliflower contains a good amount of vitamin B and a fair amount of protein in comparison to other vegetables, which may help protect against diseases like heart problems and cholesterol imbalances. Fresh curd of cauliflower contains 2.6 g protein, 0.4 g fat, 1 g minerals, 4 g carbohydrates, fiber, and 56 mg vitamin C per 100 g. Nitrogen is an essential plant nutrient involved in physiological processes and enzyme activities. Farmers are using urea extensively to enhance flowering, curd set, and increase curd size. Nitrogen affects crop productivity through controlling the synthesis of several key products such as nucleic acids, proteins, and phospholipids. The optimum supply of nitrogen enhances plant growth and productivity. Moreover, the excessive and overuse of nitrogen may increase the accumulation of compounds such as nitrates and non-protein compounds in edible parts (Giri et al., 2023).

The application of biofertilizers in vegetable crops has been found very effective. However, biofertilizer i.e., Azotobacter might fix nitrogen fertilizer by 10-20% as it is capable of fixing atmospheric nitrogen and also converting insoluble phosphorus into soluble phosphorus for uptake by plants (Kumar et al., 2020). Therefore, an experiment entitled "Effect of different levels of nitrogen and biofertilizers on growth and yield of cauliflower" was conducted to assess the response of different levels of nitrogen, biofertilizers, and their interaction on cauliflower growth and yield.

II. MATERIALS AND METHODS

The present investigation entitled "Effect of different levels of nitrogen and Biofertilizer on yield of cauliflower (*Brassica oleracea var. botrytis*)" was carried out at the Agricultural Research Farm, Hajipur, Chandra Bhanu Gupt Krishi Mahavidyalaya, B.K.T., Lucknow (U.P.) during the Rabi season 2024-25. An area of 11 × 21 m size was separated into 18 plots having the size of 3 × 3.5 m, arranged in three replications. The experiment was laid out in a Factorial Randomized Block Design (FRBD) under 6 treatments.

2.1 Field Preparation

Field preparation was done by mold board plough once, followed by leveling and weeding manually. The soil of the seedbed was prepared to obtain good tilth. Well-decomposed FYM was mixed equally in each plot at 20 t ha^{-1} at final land preparation. Nitrogen-fixing biofertilizer Azotobacter (1% w/w) was applied at 2 kg ha^{-1}. Biofertilizer was mixed with 10 kg FYM and left overnight. This mixture was applied in the soil in the root zone of plants. The agro-meteorological data for the crop growing period were obtained from IISR. The mean maximum and minimum temperatures (34.5°C and 14.4°C) and relative humidity (98% and 64%) were recorded per week for the crop growing season.

2.2 Seed Preparation and Transplanting

The seeds of cauliflower cultivar PSB K-1 were sown in well-prepared nursery beds of 3 m × 1 m × 0.15 m dimension, in lines, and covered with a mixture of sand, soil, and farmyard manure, then covered with a thin layer of dried grass mulch and watered with the help of a rose can. Four-week-old healthy uniform seedlings were transplanted with a spacing of 45 cm from row to row and 60 cm from plant to plant, accommodating 10 seedlings per plot.

2.3 Fertilizer Application

Phosphorus (as Single Super Phosphate) and potash (as Muriate of Potash) were applied at 75 kg per hectare during land preparation. Nitrogen fertilizer (urea) at the rate of 100 kg per hectare was applied in two split doses (20 and 40 days) after transplanting as top dressing. Half the dose of nitrogen as specified in the treatment was applied through urea at final land preparation as a basal dose.

A solution of 1:10 biofertilizer was prepared by taking a bucket of adequate quantity of water and adding 100 g of biofertilizer, mixing properly. To allow the roots to receive the inoculum, 25-day-old seedlings were plucked from the nursery bed and immersed in this solution for approximately 25-30 minutes. Application of 80-120 kg N, 60-100 kg P_2O_5, and 60-120 kg K_2O is recommended for optimum yield. Half the dose of N and the entire amount of P and K were given at the time of transplanting. The balance N was given six weeks after transplanting or at the time of earthing up. Top dressing was applied in bands, and after each application, earthing up of plants was done. Bavistin at the rate of 1% was applied to overcome the problem of damping off disease.

Yield parameters of centrally tagged plants viz., number of curds per plot, curd diameter, fresh weight of curd, dry weight of curd, yield per plot, and yield per hectare were recorded. The mean values of triplicate data of different parameters were analyzed statistically. Data were subjected to ANOVA to evaluate the significance of treatment effects.

III. RESULTS AND DISCUSSION

The effect of different levels of nitrogen and biofertilizers on growth and yield parameters is presented in Table 1.

TABLE 1
EFFECT OF DIFFERENT LEVELS OF NITROGEN AND BIOFERTILIZERS ON YIELD PARAMETERS OF CAULIFLOWER

Factor/Level	No. of curd per plot	Curd diameter (cm)	Fresh wt. of curd (g)	Dry wt. of curd (g)	Yield per plot (g)	Yield per ha (Q)
Nitrogen Levels (A)						
A_1 (0 kg N ha^{-1})	17.61	17.47	135.09	50.94	266.99	14.8
A_2 (60 kg N ha^{-1})	24.12	22.52	152.23	58	319.16	23.46
A_3 (90 kg N ha^{-1})	27.07	25.86	172.41	64.07	379.82	28.03
SEM	0.344	0.28	0.442	0.508	0.6	0.332
CD at 5% level	1.098	0.895	1.412	1.621	1.916	1.061
Biofertilizer Levels (B)						
B_1 (No Azotobacter)	21.7	20.83	146.41	56.11	303.35	15.9
B_2 (Azotobacter @ 2 kg ha^{-1})	24.28	23.06	160.07	59.23	340.62	18.7
SEM	0.281	0.229	0.361	0.414	0.49	0.271
CD at 5% level	0.896	0.731	1.153	1.323	1.565	0.866
Interaction Effects (T)						
T_1 (0 kg N, no biofertilizer)	16.25	16.11	136.11	48.83	256.31	14.42
T_2 (0 kg N + Azotobacter)	18.97	18.83	143.2	51.37	259	15.34
T_3 (60 kg N, no biofertilizer)	22.63	21.3	148.17	54.2	262.82	20.01
T_4 (60 kg N + Azotobacter)	25.6	24.73	155.84	57.4	267.61	19.58
T_5 (90 kg N, no biofertilizer)	26.22	25.08	157.06	59.43	268.11	20.05
T_6 (90 kg N + Azotobacter)	27.78	26.63	159.83	62.9	270.74	21.52
SEM	0.78	0.78	1.996	6.38	6.31	3.876
CD at 5% level	0.486	6.397	7.625	1.233	3.998	8.47

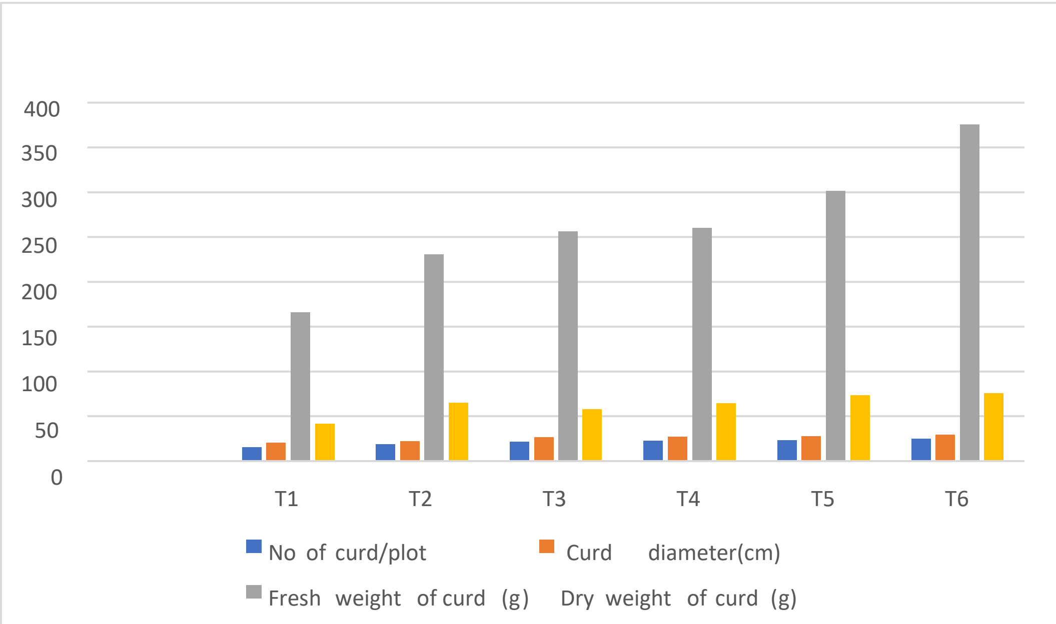

FIGURE 1: Interaction Effect of Biofertilizers and levels of Nitrogen on, No. of curd/plot Curd of diameter (cm), Fresh weight of curd (g) Dry weight of curd (g), Yield per plot and Yield per ha.

3.1 Nitrogen Effect

The main effects of nitrogen on number of curds per plot (27.07), curd diameter (25.86 cm), fresh and dry weight of curd (172.41 g and 64.07 g) were found maximum with treatment A_3 (90 kg N ha^{-1}), which was significantly higher than those recorded with A_2 (60 kg N ha^{-1}). Similar findings were reported by Kashyap et al. (2017) that fertilization with increasing levels of chemical nitrogen recorded a significant increase in yield parameters. Jat et al. (2015) reported in an experiment on cauliflower that crop fertilized with 200 kg N ha^{-1} recorded the highest plant height, diameter, and average weight of curd of cauliflower (*Brassica oleracea var. botrytis* L.). The results obtained in the present study are similar in line with Shrestha et al. (2022) on cauliflower variety Snowball-16.

3.2 Biofertilizer Effect

Application of biofertilizers on growth and yield parameters of cauliflower showed a significant increase in morphological and yield parameters as compared to control (nitrogen application without biofertilizer) treatment. However, maximum yield parameters i.e., number of curds per plot (24.28), curd diameter (23.06 cm), fresh and dry weight (160.07 g and 59.23 g), yield per plot (340.62 g), yield per hectare (18.70 Q) were produced under treatment B_2 (Azotobacter @ 2 kg ha^{-1}), which was significantly superior over treatment B_1 (without biofertilizer), where the number of curds per plot (21.70), curd diameter (20.83 cm), fresh and dry weight (146.41 g and 56.11 g), yield per plot (303.35 g) and yield per hectare (15.90 Q) were found significantly lower.

Kamdi et al. (2014) stated the significant effect of biofertilizers on growth, nodulation, and nitrogen fixation in legumes. Sharma et al. (2020) found that biofertilizer application in conjunction with nitrogen fertilizer improved net returns in cauliflower production. Singh and Singh (2005) evaluated the response of cauliflower cv. Snowball-16 to four biofertilizers (Azospirillum, Azotobacter, PSB and VAM) and two levels of nitrogen and phosphorus (75 and 100% of the recommended NPK dose of 120:60:60 kg/ha). Azospirillum + 100% of the recommended NPK recorded the highest values for growth, yield, and quality parameters. The increased supply of N and P and their higher uptake by plants might have stimulated the rate of various physiological processes in the plant and led to increased growth and yield parameters, resulting in increased pod and haulm yields in groundnut as reported by Bharathi et al. (2021). Similar results were recorded by Yamgar et al. (2001).

3.3 Interaction Effect

The interaction between different nitrogen levels and Azotobacter inoculation significantly impacted cauliflower yield. The main effects of nitrogen, biofertilizer, and their interaction were highly significant ($P < 0.01$) on curd yield (Table 1). The recommended dose of fertilizer (RDF) for cauliflower varies by region and soil but commonly ranges around 120:80:40 NPK kg ha^{-1}, particularly in regional studies.

Based on the results of Table 1, various yield parameters such as number of curds per plot, curd diameter, fresh weight of curd, dry weight of curd, yield per plot, and yield per hectare were observed statistically. The maximum number of curds per plot (27.78) was observed with treatment T_6 (90 kg N ha^{-1} + Azotobacter @ 2 kg ha^{-1}), which was significantly followed by 25.60 with treatment T_4 (60 kg N ha^{-1} + Azotobacter @ 2 kg ha^{-1}). Whereas, the minimum count of curds (16.25) was recorded with T_1 (Control). The significant difference between the treatments was found statistically.

However, treatment T_6 was found to be the best combination among all the treatments as it gave the maximum curd diameter (26.63 cm), which was followed by 25.08 cm with treatment T_5 (90 kg N ha^{-1} + no biofertilizer). The mean difference was found statistically significant among all the treatments. In the present investigation, observations showed the value 25.60 cm (T_4 - 60 kg N ha^{-1} + Azotobacter @ 2 kg ha^{-1}) was found at par with the value 24.73 cm with treatment T_3 (60 kg N ha^{-1} + no biofertilizer) significantly. This might be due to the prolonged availability of nutrients from biofertilizer-treated plots, which resulted in an increase in the diameter of the curd and ultimately the volume of the curd. The present findings are in line with those of Sanober et al. (2023) in broccoli. The minimum curd diameter (16.11 cm) was recorded with T_1 (control). Data presented on curd diameter showed a non-significant difference between treatment T_4 and T_5. The mean values are found at par with each other between T_4 and T_5.

The results revealed that yield parameters increased with an optimum dose of nitrogen along with Azotobacter inoculation. Based on the research investigation, it was found that optimum levels of nitrogen and biofertilizers had a significant effect on yield and yield-attributing characters. The observations recorded on gross curd weight clearly indicated that there was a significant difference among all the treatments on gross curd weight in cauliflower. Maximum values of fresh curd weight

(159.83 g) and dry weight of curd (62.90 g) were observed with treatment T_6 (90 kg N ha^{-1} + Azotobacter @ 2 kg ha^{-1}) significantly, which was followed by fresh weight (157.06 g) and dry weight (59.43 g) with treatment T_5 (90 kg N ha^{-1} + no biofertilizer). This might be due to the application of chemical fertilizers along with biofertilizers that increase the fresh and dry weight of plants, as reported by Srivastava and Ahlawat (1993). Kachari and Korla (2009) stated that the more gross plant weight could be attributed to optimum soil moisture in cauliflower.

In the present investigation, maximum yield per plot (270.74 g) and yield per hectare (21.52 Q ha^{-1}) was recorded with T_6 (90 kg N ha^{-1} + Azotobacter @ 2 kg ha^{-1}) significantly, which was followed by yield per plot (268.11 g) and yield per hectare (20.05 Q ha^{-1}) with treatment T_5 (90 kg N ha^{-1} + no biofertilizer). The values obtained by T4 and T5 showed all yield parameters i.e. No of curd (25.6 and 26.22).curd diameter (24.73 and 25.08 cm), Fresh weight of curd (155.84 and 157.06g) curd yield per plot (267.61 and 268.11kg) and yield per ha (20.05 and 21.52 Qha^{-1}) were found at par to each other which are found Non-significant to each other statistically. Zaki et al. (2012) concluded that in order to improve yield and reduce the use of N fertilizer, producing high yield of broccoli with high quality heads of broccoli plants of cv. Southern Star could be cultivated with a mixture of 75% organic + 25% mineral nitrogen and receiving biofertilizer containing a mixture of *Bacillus circulans*, *Bacillus megaterium*, and *Azotobacter*. Similar results were also recorded by Akanksha et al. (2023) that the yield was also found to be greatest with the treatment of Azotobacter along with the full dose of nitrogen. Hence, it was revealed that the application of biofertilizer i.e., Azotobacter with an optimum level of nitrogen fertilizer application resulted in higher yield parameters and yield, as application of biofertilizer increased the uptake and effective utilization of nutrients to enhance synthesis of carbohydrates, leading to the recombination of accumulated assimilates towards developing curds (Khedkar, 2023).

IV. CONCLUSION

On the basis of the results obtained in the present investigation, it was concluded that the yield parameters i.e., number of curds per plot (27.78), curd diameter (26.63 cm), fresh weight of curd (159.83 g), dry weight of curd (62.90 g), curd yield per plot (270.74 g), and curd yield per hectare (21.52 Q) obtained under treatment T_6 (application of 90 kg N ha^{-1} + Azotobacter @ 2 kg ha^{-1}) performed exceptionally well in all yield parameters. This was followed by treatment T_5 (90 kg N ha^{-1} + no biofertilizer). Thapa et al. (2022) reported that an adequate supply of co-limiting nutrients synergistically improves nitrogen uptake and assimilation efficiency within the plant. An integrated approach using biofertilizers to supplement a balanced nutrient value to the plant potentially reduces nitrogen application, which provides a cost-effective and environment-friendly way to achieve high yield in cauliflower.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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