Synergistic Effects of Organic Manures and Biofertilizers on the Growth Performance of Cauliflower (*Brassica oleracea* L. var. botrytis) cv. Pusa Snowball-1

ABSTRACT

The experiment was carried out during *Rabi* 2023-24at the Experimental, Organic Research farm Kargunwa ji, Jhansi, Department of Horticultural Sciences, Institute of Agricultural Sciences, Bundelkhand University Jhansi (Uttar Pradesh). The present experiment was carried out using Randomized block design with three replicationsto study the effect of organic manures, i.e. (farmyard manure (FYM), vermicompost and poultry manure) and biofertilizers individually or in combination on the growth performance of cauliflower.The obtained results can be summarized as follows:

The plant height was found to move significantly due to various treatments at every observation stage of plants. Among treatments, T_6 (50% Biofertilizer + 50% Vermicompost) treatment resulted in significantly higher plant height at every stage as compared to the remaining treatments.

Application of50% Biofertilizer + 50% FYM treatment(T_5) was found the second-best treatment. Accordingly, at 60 days stage the maximum height up to 33.56 cm was recorded in the case of T_1(100% FYM) treatment, followed by 32.31 cm in the case of T_1(100% FYM) treatment. Economically,the results confirmed the fact that organic and bio-fertilizer treatments were effective but less profitable compared to traditional fertilizers, where treatment T0 (($N_{100}P_{60}K_{80}$) recorded the highest B:C ratio (2.53) and followed by T_6(50% Biofertilizer + 50% Vermicompost) treatment with 1.78 B:C ratio.

Key words:Cauliflower, biofertilizers, Manure andOrganic

1. INTRODUCTION

Cauliflower, scientifically known as (*Brassica oleracea* L. var. *botrytis*) is 2n = 18**,** belongs to the family Brassicaceae,commonly referred to as the mustard or cauliflower family known for its edible, white curd that is botanically classified as an inflorescence, (Yamaguchi, 1983 and Grout, 1988)). The plant is native to the Mediterranean region but is now grown worldwide due to its adaptability to various climates and soil conditions(Horne, 1952). It is a cool-season crop, requiring temperate climates with moderate rainfall or irrigation (Crozier, 1891).The cauliflower head, commonly referred to as the “curd,” is rich in nutrients, including vitamins C, K, and B6, folate, fiber, and antioxidants, making it an essential part of a balanced diet(Swarup and Brahmi 2005).Cauliflower is a cruciferous vegetable, and Pusa Snowball-1 is a specific cultivar known for its high yield and quality. The variety is typically chosen for its uniformity and market acceptance.Organic manures refer to natural fertilizers like compost, farmyard manure (FYM), or Vermicompost, which provide essential nutrients and improve soil structure and microbial activity (Shankar et al.,2019).

Organic manures are considered environmentally friendly and sustainable for agriculture, offering slow-releasing nutrients that enhance long-term soil healthSastry et al.(2019).Biofertilizers are microbial products that enhance plant growth by promoting nutrient availability or fixing nitrogen Sastry *et al.*,(2019).

One of the critical issues in cauliflower farming is its high nutrient demand, particularly for nitrogen, phosphorus, and potassium. The conventional use of chemical fertilizers has been the standard practice to meet these nutrient needs (Maggoni et al.,2010). However, excessive reliance on chemical fertilizers can lead to environmental degradation, soil nutrient imbalances, and reduced soil health. These challenges highlight the importance of exploring sustainable alternatives, such as organic manures and biofertilizers, which may offer solutions to improve soil fertility, enhance plant growth, and increase yields in a more environmentally friendly manner (Lim, 2013).

Farmyard manure (FYM)consists of Nitrogen (N): 0.5%, Phosphorus (P): 0.2% and Potassium (K): 0.5%. FYM is an excellent soil amendment for cauliflower, contributing to higher yields, better plant health, and enhanced soil sustainability. FYM is generally applied in larger quantities compared to chemical fertilizers. It offers a more balanced and slow-release nutrient supply**,** supporting sustainable soil health"The reference should be added here to emphasize better the topic" (Turhan and Ozmen, 2021; Bopcha and Agarwal,2024). Vermicompost typically contains a balanced amount of NPK (Nitrogen, Phosphorus, Potassium) and various micronutrients. Vermicompost content is N: 1–2%, P: 1–1.5% and K: 1–2%.Buyukarslanand Demir (2024). Poultry manure generally contains high amounts of nutrients, especially nitrogen, and its NPK composition can be around:N: 2–4%, P: 1.5–3% and K: 1–2%(Singh et al.,2023).Azotobacter is a free-living nitrogen-fixing bacterium that can fix atmospheric nitrogen into a form usable by plants. VAM (*Vesicular Arbuscular Mycorrhiza*) VAM refers to a group of beneficial fungi that form a symbiotic relationship with plant roots(Zbar*et al.*,2021). These fungi are crucial for nutrient and water uptake. These amendments can work synergistically to promote healthy crop growth, particularly for nutrient-hungry crops like Cauliflower.Vermicompost and Poultry Manure provide organic matter and essential nutrients for the crop. Azotobacter ensures a steady nitrogen supply through biological nitrogen fixation(Naorem et al.,2024). VAM enhances nutrient and water uptake, promoting strong root development and better resilience.By using a combination of these organic and biological amendments, farmers can improve soil health, reduce chemical fertilizer dependency, and promote sustainable farming practices.

Such research maycompare the impact of organic manures and biofertilizers individually or in combination with conventional chemical fertilizers.

Methodology:

Experimental Site

The experiment was conducted at the organic research farm of the Department of Horticulture, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.). Jhansi is situated at latitude 25^{0}'27 N, longitude 78^{0}35 E, and 271 meters above the mean sea level during the *Rabi* season of 2023-24. The site was chosen for its conducive environment for crop growth and the availability of necessary facilities for the research.

Climate and Weather Conditions

Jhansi experiences a Mediterranean hot summer climate (Csa) characterized by hot summers and mild winters. The city is located at an elevation of 0 meters above sea level, and its average annual temperature is 30.03°C (86.05°F), which is 4.06% higher than the national average. The mean yearly temperature in Jhansi is recorded at 25.8°C (78.4°F), and the total annual precipitation is approximately 871 mm (34.3 inches), which supports the farming activities in the region.

Methods

The present experiment was design and optimized under Randomized block design with three replications with plot size- (2.4×1.8) m with total number of plots 24. The number of rows per plant rows per plant accommodating spacing (60×60) cm. Gross experimental area - 370 m^2. The Net experimental area - 214 $m^2$with treatments 7, including the check/control plot. The distance between rows - 60 cm between plants - 45 cm. The Organic manure and biofertilizers were procured from the University campus.

Economic studies :

Cost of cultivation

The cost of cultivation was calculated based on the expenses incurred in cultivating a given area of cauliflower where it was cultivated.The cost of cultivation was worked out input-wise and operation-wise, together with their percentage of the total.

Gross income (Rs/ha)

Gross income was worked out based on aggregate of all direct costs applied in cauliflower cultivation.

Net income (Rs/ha)

The overall income was worked out based on aggregate of all direct costs applied in brinjal cultivation.

Statistical analysis

Analysis of variance (Anova) The total variations amongst the treatment for different attributes were tested for significance by 'F' test using analysis of variance technique. The degrees of freedom, mean sum of squares and 'F' values were calculated as follows:

Table 1: Descriptive Satatistics

Sources of variation	**df**	**S.S**	**M.S.S**	**F**
Replication	(r-1)	Sr	**Msr**	**MSr / MSe**
Treatments	(t-1)	St	**Mst**	**MSt / MSe**
Error	(r-1)(t-1)	**Se**	**Mse**	
Total	rt-1	**St**		

Where r = number of replication

t = number of treatments.

Each sum of squares (S.S) was divided by the corresponding degrees of freedom to get the MSS. To find out the 'F' values from the table (**Fisher and Yates, 1953**) the mean square values were tested against the error mean squares. The standard error of difference between any two genotype means is expressed by the formula –

$$\textbf{S.E (m)} = \sqrt{\frac{2MSe}{r}}$$

Where MSe= Error means square

r = Number of replications.

The test of significance of difference between means of two genotypes for a character was done by ëtí test and critical difference (CD) was calculated as follows: C.D. = S.E (m) × 't' Where 'is the table value at 5% level of significance for the error degree of freedom.

Table 2: Physical and Chemical composition of the soil sample of the experimental site

Particulars	Value obtained	Method
Physical character		
Fine sand %	42 %	By international pipette method (*Pipper*, 1950)
Silt %	38 %	
Clay%	20 %	
Texture	Sandy-loam	
Chemical composition		
Soil pH	7.5	Method no. 4 USDA handbook no. 60 (*Richard* 1954)
Electrical conductivity(dsm)	0.45	EC meter
Available nitrogen (kg N/hac)	214.0	Alkaline KMno4 (*Subbiah &Asija*, 1956)
Available potash (kg K_2O_5/ha)	203.20	Flame-photometer method (*Metson*, 1956)
Available phosphoros (Kg P_2O_5/ha)	18.10	Olsen extraction method(*Olsen et al.* 1954)

RESULTS AND DISCUSSION

Morphological Parameters

1. **Plant height (cm)**

The data for plant height at 30, 45, and 60 days of transplanting are shown in Table 3. The increase in plant height, in general, was observed with the advancement of plant growth up to the 45-day stage. It was, in general, enhanced steadily between 30 to 45 and 45 to 60 days period in all the treatments; at 30 days stage, the plant height in various treatments ranged from lowest 21.69 cm to highest 23.86 cm, whereas at 60 days stage, it ranged from 31.75 cm to 33.56 cm.

The plant height was found to move significantly due to various treatments at every stage of observation of plants. Among treatments, T_6 having 50% Biofertilizer + 50% Vermicompost resulted in significantly higher plant height at every stage than the remaining treatments. 50% Biofertilizer + 50% FYM (T_5) was found the second-best treatment. Accordingly, at the 60-day stage, the maximum height of up to 33.56 cm was recorded in the case of T_1, followed by 32.31 cm in the case of T_1. In contrast, the significantly lowest height only 30.83 to 30.85 cm was recorded in the case of T_4 and treatments having lower doses of fertilizers. The influence of PSB biofertilizer was also found in the lowest order next to control treatment.The best treatments T_6 and T_5 proved significantly superior to $T_{1,}$ having 100% NPK. FYM (T_1) proved significantly superior to vermicompost (T_2). Similar results due to effect of organic and bio-fertilizers were recorded by Peralta-Antonioet al. (2019); Kayeshet al. (2019); Shankar et al. (2019).

2. **Numberofleaves/plants**

The number of leaves per plant were also counted at different growth intervals under each treatment. The mean values so obtained were subjected to statistical computation. The mean data are presented in Table 4 and exhibited through them.Thenumberof leaves, ingeneral, wasfound toenhance withthe enhancement of plant growth up to 60 days of observation. The leaves were formed almost at an equal rate from the beginning period of plant growth up to 60 days of transplanting. At 30 days stage, the leaves ranged from lowest 6.22/plant to highest 7.61/plant in various treatments, whereas at 60 days stage, the leaves ranged from lowest 15.70 to highest 19.95/plant.

The different treatments exerted significant impact upon this parameter at every stageof observation. Out of the various treatments, T4 having all four inputs, brought about a significantly higher number of leaves per plant at every stage of observation as compared to the rest of the treatments.T_1 treatment having 20 t FYM/ha was found the second best in raising this parameter. According to the maximum number of leaves (19.95/plant) were noted at the 60-day stage from T_5 treatment. This was followed by T_1 treatment (18.78) leaves/plant. On the other hand, the equally lowest number of leaves formation (15.70 to 15.85plants) was observed in the case of T_6 and T_7 treatments.

The general observation was that half a dose of FYM or Vermicompost when applied with biofertilizer resulted in significantly lower leaf formation than the other treatments. T_1 having 20t FYM/ha proved significantly superior to Vermicompost5t/ha (T_2). Similarly, T_5 was found significantly superior to T_6 having 100 % NPK. This trend of treatment effect was observed at every stage of observation.Similar results due to effect of organic and bio-fertilizers were recorded by Jha et al. (2017); Kayeshet al. (2019); Shankar et al . (2019).

3. NetprofitandB:Cratio

The net profit and B:C ratio were estimated under each treatment based on the existing market rates of inputs and outputs. The mean data so obtained are presented in Table 5.Amongthefertilizer treatments100%recommendeddoseoffertilizer($N_{100}P_{60}K_{80}$) resulted in the highest net profit, up toRs.47048/hawith the highest 2.51B:C ratio.However, this was followed by T_6(50% Biofertilizer + 50% Vermicompost) with Rs. 35,254/ha net income and 1.78 B:C ratio. The treatment $T_1$and gave almost equal net profit ranging from Rs 35121 to Rs 32569/ha, the B:C ratio ranged from1.75 to 1.62. On the other hand, the lowest net profit (Rs. 17189/ha) and B:C ratio (1.66) were recorded in the case of T_6treatment. The net profit of this T_6treatment was much low than that obtained from the other treatments. Among these applied organic sources of nutrients, the netprofitranged from the lowest (Rs 27,189) in the case of Vermicompost to the highest (Rs 35,389/ha)in the case of FYM. Thus, Vermicompost and FYMwere found almost in thewide rage in giving profit/ha. Treatments like T_3 and T_7further lowered down the net profit in comparison the other combinations with otherorganic sources of nutrients. There were larger differences in the netprofit obtained from the different treatments. The netprofit from 100% NPK (T_2) was higher by Rs 35,254/ha compared to the best treatment, T_5, where all fournutrient inputs were applied together. Cost economics for all the treatments was worked out based on the incurred input cost and market price of the produce at the time of experimentation. Similar findings have also been reported by (Bhusanet al.,2010; Choudhary et al., 2017; Jhaet al., 2017), (Akhther et al.,2018; Patidaret al.,2018) and Rana et al., 2020).

CONCLUSION

The study observed significant effects of various treatments on plant height, number of leaves, and net profit. Plant height increased steadily from 30 to 60 days across treatments, with the highest growth recorded in T_6 (50% Biofertilizer + 50% Vermicompost), followed by T5 (50% Biofertilizer + 50% FYM). Treatment T_6 also showed the lowest number of leaves, while T_4, combining all four inputs, resulted in the highest leaf count at every growth stage. Regarding cost-benefit analysis, T_1 (100% NPK) generated the highest net profit (Rs. 47,048/ha) and B:C ratio (2.51), while treatments involving organic amendments like FYM and Vermicompost resulted in moderate net profits, with T6 showing the lowest. Organic and bio-fertilizer treatments were effective but less profitable compared to traditional fertilizers.

FUTURE SCOPE

Optimizing the combination and application rates of biofertilizers, organic amendments, and chemical fertilizers to improve plant growth and yield further while reducing environmental impact. Exploring the long-term effects of integrated nutrient management (INM) practices on soil health, sustainability, and cost-effectiveness is essential. Additionally, studies could investigate the economic viability of such treatments across different crop types and regions, considering factors like climate, soil characteristics, and market prices. Further experimentation could also include the evaluation of other organic amendments, such as compost or green manures, and their synergistic effects with biofertilizers. Lastly, exploring innovative methods to enhance nutrient use efficiency and reduce input costs could lead to more sustainable farming practices.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Table 3: Plant height of cauliflower at different growth stages as influenced by different treatments

Tr.No.	Treatments	Plant height(cm)DAT		
		30	45	60
T0	Control	22.12	28.81	32.02
T1	100%FYM	23.28	28.02	32.31
T2	100%Vermicompost	22.01	27.16	31.95
T3	100%PoultryManure	21.69	26.78	31.75
T4	100%Biofertilizer (*Azotobacter*+VAM)	23.02	28.31	32.47
T5	50%Biofertilizer+50%FYM	23.47	30.17	32.23
T6	50%Biofertilizer+50%Vermicompost	23.86	31.42	33.56
T7	50%Biofertilizer+50%PoultryManure	22.51	28.69	32.14
	Sem±	0.192	0.042	0.085
	C.D.(5%)	0.571	0.142	0.214

Table 4: Number of leaves/ plant of cauliflower at different growth stages as influenced by different fertility treatments

Tr.No.	Treatments	Number of leaves/plants		
		30	45	60
T0	Control	7.45	10.78	18.01
T1	100%FYM	7.58	11.41	17.00

T2	100%Vermicompost	7.16	11.32	17.85
T3	100%PoultryManure	6.78	10.85	16.85
T4	100%Biofertilizer(*Azotobacter*+VAM)	7.12	11.32	18.98
T5	50%Biofertilizer+50%FYM	7.29	10.21	17.52
T6	50%Biofertilizer+50%Vermicompost	7.76	11.88	19.45
T7	50%Biofertilizer+50%PoultryManure	6.85	10.45	16.54
	Sem±	0.008	0.016	0.052
	C.D.(5%)	0.027	0.053	0.140

Table5: Net profit and B:C ratio from cauliflower as influenced by different fertility treatments

Tr.No.	Treatments	Netincome (Rs./ha)	B:CRatio
T0	Control	47,048	2.53
T1	100%FYM	35,121	1.75
T2	100%Vermicompost	27,196	1.51
T3	100%PoultryManure	28,175	1.54
T4	100%Biofertilizer(*Azotobacter*+VAM)	25,327	1.48
T5	50%Biofertilizer+50%FYM	26,785	1.49
T6	50%Biofertilizer+50%Vermicompost	35,254	1.78
T7	50%Biofertilizer+50%PoultryManure	32,569	1.62
	Sem±	1.23	0.11
	C.D.(5%)	3.45	1.14