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Improvement in Plant Growth and Yield of Cauliflower after Application of Biofertilizers and Inorganic Nutrient Sources

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ABSTRACT

Cauliflower is a highly nutritious and delicious vegetable, rich in vitamin A, C and minerals like calcium, iron and iodine. The experiment was laid out in randomized block design with 13 treatments consisting of different combinations of inorganic fertilizer and bio-fertilizer. On the basis of present investigation, T_{12} [N : P : K (200 : 100 : 100 kg/ha)+PSB (4.5 g/plot)] followed by T_{11} [N : P : K (200 : 100 : 100 kg/ha)+ *Azotobacter* (4.5 g/plot)] with row to row distance 40 cm and plant to plant distance 45 cm were the best combinations for cauliflower cultivation. Application of bio-fertilizers of nutrients and higher dose of NPK in T_{12} [N : P : K (200 : 100 : 100 kg/ha)+PSB (4.5 g/plot)] ensured greater plant height (42.52 cm), number of leaves/plant (30.74), plant spread (65.79 cm), weight of untrimmed curd (2.85 kg), weight of trimmed curd (998.86 g), curd yield/plot (15.98 kg), curd yield/ha (394.61 q) and diameter of curd (23.82 cm) of cauliflower. The maximum value of benefit : cost ratio (3.22) was also obtained in this treatment. This confirmed the application of PSB or *Azotobacter* as supplementary dose with RDF for highly remunerative cauliflower cultivation.

Key words: *Azotobacter*, bio-fertilizers, cauliflower, phosphate solubilizing bacteria (PSB), plant growth, yield

INTRODUCTION

Vegetables are considered as protection food as they are rich in all the essential nutrients, mainly vitamins, minerals and antioxidants. Cauliflower (*Brassica oleracea* var. *botrytis* L.) is a leading cole crop belonging to family Cruciferae or Brassicaceae. Among the various cole crops, cauliflower is grown throughout the world as a winter season vegetable crop (Giri, 2020). The cauliflower produces seed biennial and produces vegetable annually. Curd is edible portion of cauliflowers that is white in colour and consist of a closed aggregated flower with a developed bunchy style inflorescence. Nutritional value/100 g fresh edible portion of cauliflower contains 91% moisture, 4.5% sugar, 2.5% protein, 1.8% crude fibre and 0.3% low fat (Uher *et al.*, 2017). The calcium of cauliflower is 150 mg and potassium is 325 mg/100 g among vitamins, it contains carotene and vitamin C (100 g/100 g) and calorific value is 245 kj/100 g. This vegetable is being grown throughout the year for whitish-tender curd. In India, it is widely cultivated in every state of the country. The cauliflower is grown round the world for its nutritional importance, high productivity as well as due to wider adaptability under various ecological conditions.

Among various essential nutrients of plants, nitrogen is an important which has direct impact on growth, development and reproduction. The increased level of nitrogen application improves protein content and minimizes the bolting problem (Xue *et al.*, 2016). This element promotes vegetative growth, improves size and compactness of curd, also the nutrient content of curds and reduces the buttoning per cent (Gocher *et al.*, 2017). Phosphorus plays significant role as structural and functional unit in various molecules and cellular processes. It is chief constituent of nucleic acids (DNA and RNA)

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phytic and energy units (ATP, GTP, etc.) in the cell. The early-stage plant life is dominated by growth which needs sufficient amount of nitrogen to promote protein synthesis, building block of cell and cell division. In later phase, it becomes important for development of reproductive primordia to bring transition between vegetative to reproductive phases in cauliflower. It regulates various synthetic processes as it is essential constituents of enzymes. Thus, it is very important for transformation of energy into carbohydrate and fat metabolism (Gocher *et al.*, 2017). Potassium plays significant role in balanced growth of plants and imparting disease resistance. This is an important mineral to maintain osmotic balance in plants, thereby, improving the transportation of nutrients photosynthates and hormones in plants. Thus, it regulates the balanced utilization of water and mineral nutrition and helps in synthetic process of macromolecules including protein and chlorophyll (Sardans and Peñuelas, 2021). Biofertilizers are product of microbial origin which has ability to transform the free atmospheric nitrogen to the soil for utilization by plants. Further, it brings the conversion of nutrients like phosphorus, potassium or micronutrients from unavailable to available farm (Dasgupta *et al.,* 2021). The excess use of chemical fertilizers has brought a drastic degradation in soil texture, structure and chemistry where biofertilizers can act as soil savers. The biofertilizers along with crop residues like leaves or organic mulches are important for conservation of soil moisture and improvement of soil physical, chemical and biological properties (Ginni *et al.*, 2020). Hence, keeping the sustainability of soil in mind, the current investigation was carried out to know the effect of bio-fertilizer (PSB and *Azotobacter*) and inorganic fertilizer on growth and yield of cauliflower with high cultivation economics.

MATERIALS AND METHODS

The experiment was conducted at Research Farm of School of Agriculture, ITM University, Gwalior (M. P.). The location can be characterized as sub-tropical climate with hot and dry summer with maximum temperature exceeding 45°C in May-June. The winters were cold with the temperatures reaching as low as 2°C in December and January. The climatic condition is suitable to grow cauliflower in this region at commercial level. The experiment was laid on randomized block design with 13 treatments and three replications. The treatment details were : T_0–Control, T_1–N : P : K (140 : 40 : 40 kg/ha), T_2–N : P : K (140 : 40 : 40 kg/ha)+*Azotobacter* (4.5 g/plot), T_3–N : P : K (140 : 40 : 40 kg/ha)+PSB (4.5 g/plot), T_4–N : P : K (160 : 60 : 60 kg/ha), T_5–N : P : K (160 : 60 : 60 kg/ha)+*Azotobacter* (4.5 g/plot)], T_6–N : P : K (160 : 60 : 60 kg/ha)+PSB (4.5 g/plot), T_7–N : P : K (180 : 80 : 80 kg/ha), T_8–N : P : K (180 : 80 : 80 kg/ha)+*Azotobacter* (4.5 g/plot), T_9–N : P : K (180 : 80 : 80 kg/ha)+PSB (4.5 g/plot), T_{10}–N : P : K (200 : 100 : 100 kg/ha), T_{11}–N : P : K (200 : 100 : 100 kg/ha)+*Azotobacter* (4.5 g/plot) and T_{12}–N : P : K (200 : 100 : 100 kg/ha)+PSB (4.5 g/plot)]. The observations were recorded on plant height, leaf count, plant spread, weight of untrimmed and trimmed curd, curd yield, curd size, gross returns, net returns and benefit : cost ratio.

RESULTS AND DISCUSSION

The plant height, leaf count and plant spread influenced by bio-fertilizers and inorganic fertilizer at 15, 30 and 45 DAT were found to be significant (Table 1). The maximum plant height (42.52 cm), leaf count (30.74) and plant spread (65.79 cm) were observed in T_{12}–N : P : K (200 : 100 : 100 kg/ha)+PSB (4.5 g/plot) followed by T_{11}–N : P : K (200 : 100 : 100 kg/ha)+*Azotobacter* (4.5 g/plot)] and T_{10}–N : P : K (200 : 100 : 100 kg/ha), while the lowest growth parameters were recorded in T_0–Control. It is obvious from the observation that higher dose of NPK (200 : 100 : 100/ha) as inorganic source resulted in better plant growth due to availability of greater amount of primary nutrients. The similar finding was reported by Kumar *et al.* (2018). Further, the treatments supplemented with biofertilizers in combination with higher dose of N : P : K as in T_{12} and T_{11} resulted in higher plant growth in comparison to only inorganic source. This might be associated with ability of biofertilizers to synthesize phytohormones ensuring better cell division and cellular metabolism as discussed by Kumar *et al.* (2021). Emergence of leaves is function of the plant growth and cellular metabolism and accounts for greater photosynthetic activity in plants. The greater leaf count/plant in the treatments with higher

Table 1. Plant growth parameters of cauliflower after application of bio-fertilizer and inorganic fertilizers

Treatment	Plant height (cm)			Leaf counts/ plant			Plant spread (cm)		
	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT	15 DAT	30 DAT	45 DAT
T_0	7.58	16.27	30.21	3.91	7.51	12.45	13.59	29.38	47.70
T_1	9.07	19.52	33.10	5.35	8.96	20.75	16.32	35.87	52.37
T_2	9.03	12.18	32.35	4.58	9.00	15.50	15.27	32.34	51.67
T_3	8.48	20.32	36.74	5.33	10.92	19.17	17.03	34.55	58.66
T_4	8.03	21.86	37.10	4.83	9.50	16.50	16.23	37.73	55.01
T_5	8.02	21.66	37.28	4.75	9.00	15.50	17.37	33.85	49.92
T_6	9.34	16.84	35.62	6.29	10.72	19.58	15.29	36.79	56.54
T_7	8.85	18.18	32.27	5.42	11.58	19.17	18.47	31.74	59.18
T_8	8.15	17.54	35.84	5.79	11.35	16.67	16.65	37.75	55.08
T_9	7.91	18.71	33.31	5.83	9.42	15.83	15.72	36.92	54.44
T_{10}	16.62	23.29	40.94	7.49	13.37	27.08	17.38	34.70	60.92
T_{11}	17.35	24.75	41.26	8.00	14.59	28.46	20.06	37.16	63.20
T_{12}	18.58	26.57	42.52	8.86	16.48	30.74	20.92	38.07	65.79
C. D. (P=0.05)	0.934	2.095	2.676	1.639	1.097	1.167	3.641	3.096	2.421
S. Em±	0.320	0.718	0.917	0.561	0.376	0.400	1.248	1.061	0.830
C. V.	5.257	6.112	4.405	16.538	5.946	3.499	12.752	5.227	2.557

dose of nutrients in form of inorganic fertilizers with or without supplementary dose of biofertilizers as PSB or *Azotobacter* may be related to greater availability of N, P and K which was required by plant for synthesis of protein, cell metabolism or synthesis of energy unit by plant. Further, presence of PSB might be responsible for mobilization of phosphorus to the plants from soil, while presence of *Azotobacter* could be able to add phytohormones (Wasai and Minamisawa, 2018). These all components might be responsible for better growth and development in plants as described by Santoyo *et al.* (2021). Plant spread is result of vegetative growth in terms of height, number of leaves and curd size. As per the discussion, the plant height and number of leaves were greater after application of higher doses of inorganic fertilizers with or without supplementary dose of PSB or *Azotobacter*.

Yield and the related attributes were significantly influenced by different combinations of biofertilizer and inorganic fertilizer (Table 2). The maximum diameter of curd (23.82 cm), weight of untrimmed curd (2.85 kg), weight of trimmed curd (998.86 g) and curd yield (15.98 kg/plot and 394.61 q/ha) were estimated in T_{12}–N : P : K (200 : 100 : 100 kg/ha)+PSB (4.5 g/plot) followed by T_{11}–N : P : K (200 : 100 : 100 kg/hectare)+*Azotobacter* (4.5 g/plot) and T_{10}–N : P : K (200 : 100 : 100 kg/ha), while the lowest growth parameters were

Table 2. Yield and related attributes of cauliflower after application of bio-fertilizer and inorganic fertilizers

Treatment	Weight of untrimmed curd (kg)	Weight of trimmed curd (g)	Curd yield/ plot (kg)	Curd yield (q/ha)	Diameter of curd (cm)
T_0	1.24	461.67	7.39	182.39	13.20
T_1	2.41	793.33	12.69	313.42	18.00
T_2	2.20	864.00	13.82	341.33	15.25
T_3	2.13	795.33	12.73	314.21	16.25
T_4	1.89	730.00	11.68	288.40	15.86
T_5	1.15	622.39	9.96	245.88	15.15
T_6	2.23	855.67	13.69	338.04	17.45
T_7	2.14	810.67	12.97	320.26	16.40
T_8	2.03	733.00	11.73	289.58	15.88
T_9	2.11	707.67	11.32	279.57	15.78
T_{10}	2.66	923.04	14.77	364.66	21.38
T_{11}	2.73	954.54	15.27	377.10	22.19
T_{12}	2.85	998.86	15.98	394.61	23.82
C. D. (P=0.05)	0.150	6.329	0.101	2.501	0.911
S. Em±	0.051	2.168	0.035	0.857	0.312
C. V.	4.157	0.476	0.476	0.478	3.101

recorded in T_0–Control. The observations recorded on yield and related attributes like diameter of curd and weight of curd had reflected significant effect of application of PSB or *Azotobacter* in comparison to only inorganic sources. Further, the inorganic fertilizers in higher doses had also resulted in greater size and weight of curd resulting in higher yield. The greater yield due to application of higher fertilizer doses might be associated with better plant growth, greater number of leaves and so greater yield of curd. This can be conformed from the findings of Singh *et al.* (2018) and Eimon *et al.* (2019). Further, the significant influence of PSB or *Azotobacter* application might be associated with greater nutrient availability due to microbial activities resulting in greater photosynthetic activities which can be confirmed by findings of Chand *et al.* (2017).

The cost of cultivation is function of all input costs used during production of cauliflower. It is sum of fixed and variable costs. The greater cost of cultivation in T_{11}, T_{10} and T_8 might be associated with higher cost of inorganic fertilizers and *Azotobacter* in comparison to PSB (Table 3). Gross returns are the total money value of marketable produce which was reported to be greater in T_{12}, T_{11} and T_{10} which might be associated with greater yield of curd. Similarly, the net returns were also highest in T_{12}, followed by T_{11}, T_{12}, T_2 and T_6 due to low input cost and high yield of curd in these treatments. Further B : C. ratio was reported to be highest in T_{12} (3.22) followed by T_{11} (2.90), T_{10} (2.81), T_2 (2.74) and T_6 (2.68). The greater B : C ratio in these treatments might be the result of greater net returns and lower cost of cultivation as observational from the table. This conformed the application of PSB or *Azotobacter* as supplementary dose with RDF as highly remunerative for cauliflower cultivation. The present finding is in conformity with the findings of Ray *et al.* (2018) and Jaiswal *et al.* (2020).

The correlation studies on various yield contributing traits (Table 4) confirmed the maximum correlation (r = 0.662) for curd yield and weight of trimmed curd in relation to plant height at 45 days after planting followed by

Table 3. Economics of cauliflower cultivation after application of bio-fertilizer and inorganic fertilizers

Treatment	Gross returns (Rs./ha)	Cost of cultivation (Rs./ha)	Net returns (Rs./ha)	Benefit : cost ratio
T_0	145912.00	58775.00	87137.00	1.49
T_1	250736.00	66365.60	184370.40	2.77
T_2	273064.00	68965.60	204098.40	2.95
T_3	251368.00	69365.60	182002.40	2.62
T_4	230720.00	68878.30	161841.70	2.34
T_5	196704.00	71478.30	125225.70	1.75
T_6	270432.00	71878.30	198553.70	2.76
T_7	256208.00	71521.30	184686.20	2.58
T_8	231664.00	74121.30	157542.70	2.12
T_9	223656.00	74521.30	149134.70	2.00
T_{10}	291728.00	74174.50	217553.50	2.93
T_{11}	301680.00	76774.50	224905.50	2.92
T_{12}	315688.00	77174.50	238513.50	3.09

Table 4. Correlation studies between yield contributing attributes

Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1	1							
X_2	0.828**	1						
X_3	0.773**	0.895**	1					
X_4	0.839**	0.992**	0.872**	1				
X_5	0.563*	0.847**	0.829**	0.849**	1			
X_6	0.662*	0.845**	0.845**	0.843**	0.929**	1		
X_7	0.662*	0.845**	0.845**	0.843**	0.929**	1.000**	1	
X_8	0.500^{NS}	0.755**	0.72**	0.741**	0.898**	0.953**	0.953**	1

*,**Significant at P=0.05 and P=0.01 levels, respectively. X_1: Plant height at 45 DAT (cm), X_2: Leaf counts/plant at 45 DAT, X_3: Plant spread at 45 DAT (cm), X_4: Diameter of curd (cm), X_5: Weight of untrimmed curd (kg), X_6: Weight of trimmed curd (g), X_7: Curd yield (q/ha) and X_8: Benefit : cost ratio.

weight of untrimmed curd (r=0.563) at 0.05% level of significance. However, at 0.01 level of significance, the highest correlation (r=1.00) was reported between curd yield and weight of trimmed curd followed by curd yield and weight of trimmed as well as with the weight of untrimmed curd (r=0.929).

CONCLUSION

It was observed that application of biofertilizers of nutrients and higher dose of NPK in T_{12}–N : P : K (200 : 100 : 100 kg/ha)+PSB (4.5 g/plot) ensured greater plant height (42.52 cm), number of leaves/plant (30.74), plant spread (65.79 cm), weight of untrimmed curd (2.85 kg), weight of trimmed curd (998.86 g), curd yield/ plot (15.98 kg), curd yield/ha (394.61 q) and diameter of curd (23.82 cm) in cauliflower [*Brassica oleracea* (L.) var. *botrytis*]. The economics of cultivation of cauliflower under different treatments conformed that the T_{12}–N : P : K (200 : 100 : 100 kg/ha)+PSB (4.5 g/ plot) was the best treatment due to highest net returns (Rs. 238513.50/ha) and B : C ratio (3.09) on net income basis.

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