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RESEARCH PAPER

Effect of integrated nutrient management on growth, yield and quality parameters of cauliflower

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Abstract

The present investigation was carried out at Experiment Farm, Udai Pratap Autonomous College, Varanasi (UP), India. Cauliflower growth, yield and quality can be boosted with the use of integrated nutrient management. Due to their complementing effects, the ideal combination of different organic and inorganic sources of nutrients may significantly boost cauliflower growth and yield. The experiment consisted of 11 treatments viz. T_1: Recommended dose of NPK (150:100:80 kg/ha), T_2: Half dose of NPK/ha + FYM @ 15 tonnes/ha, T_3: Half dose of NPK/ha + *Azospirillium* @ 5 kg/ha, T_4: Half dose of NPK/ha + FYM @ 15 tonnes/ha + *Azospirillium* @ 5 kg/ha, T_5: Half dose of NPK/ha + VAM @ 5 kg/ha, T_6: Half dose of NPK/ha + FYM @ 15 tonnes/ha + VAM @ 5 kg/ha, T_7: Half dose of NPK/ha + FYM @ 15 tonnes/ha + *Azospirillium* @ 5 kg/ha + VAM @ 5 kg/ha, T_8: Half dose of NPK/ha + Vermicompost @ 2.5 tonnes/ha, T_9: Half dose of NPK/ha + Vermicompost @ 2.5 tonnes/ha + *Azospirillium* @ 5 kg/ha, T_{10}: Half dose of NPK/ha + Vermicompost @ 2.5 tonnes/ha + VAM @ 5 kg/ha, T_{11}: Half dose of NPK/ha + Vermicompost @ 2.5 tonnes/ha + *Azospirillium* @ 5 kg/ha + VAM @ 5 kg/ha. The highest curd yield (265.65 g), curd diameter (17.99 cm), curd weight (943.55 g) and curd volume (758.62) with maximum net profit (Rs.1,57,757/ha) was obtained from T_{11} treatment. All traits had a significant positive correlation with all traits excluding TSS and Ascorbic acid, TSS showed a significant positive correlation with curd diameter whereas ascorbic acid had a significant positive correlation with plant height, plant spread, curd yield and TSS. So, economic analysis revealed that T_{11} treatment appeared to be the best for achieving the higher growth, yield and economic benefit of cauliflower.

Keywords: Cauliflower, Quality, Growth, Yield, Correlation, INM.

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Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is the most popular cole crop belongs to the family Cruciferae in the tropic and temperate regions of the world (Sharma *et al*., 2022). Cauliflower is a very tasty and much popular vegetable in India as well as all over the world. The cauliflower requires very heavy manuring as it removes large quantity of nutrients from the soil. India has been spending billions of dollar every year for the import of chemical fertilizers. But the total cauliflower production is far below the requirement. Due to its economic importance, growers are not in a position to produce good quality cauliflower having low production with high productivity due to various biotic, abiotic stresses and crop factors. To fulfill the nutritional requirement of people, total production as well as a number of vegetables should be increased. The increased use of fertilizers no doubt increases production of commodities very remarkably but it has a long-term detrimental impact on soil health. The escalating prices of chemical fertilizers and its detrimental impacts had forced farmers to adopt alternative sources of nutrients for vegetable production (Singh *et al*., 2017; Sharma, 2015). Long-term studies on crops indicated that the balanced use of NPK fertilizers could

not maintain the higher yields due to the emergence of secondary and micro-nutrient deficiencies and deterioration of soil physical properties but uses of organic manures in integrated nutrient management help in mitigating multiple nutrient deficiencies.

In recent years, the concept of integrated nutrient supply, use or management system involves efficient and judicious supply of all major components of plant nutrient sources. Chemical fertilizers in combination with animal sources, farm yard manure (FYM), vermicompost, bio-fertilizers, crop residues or recyclable waste and other locally available nutrient sources for sustaining soil fertility, health and productivity which assume significance. Vermicompost is a very good organic fertilizer and powerful growth promoter over conventional composts and a protective farm input, which increases the physical, chemical and biological properties of soil. Vermicompost promotes growth from 50 to 100% over conventional compost and 30-40% over chemical fertilizers and the production cost will be low (Verma *et al*., 2015). 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. 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. The application of *Azospiripllium* along with inorganic fertilizers proved to be beneficial and produced higher yield in cauliflower (Narayanamma *et al*., 2006). Besides, the highest plant growth parameters and yield of cauliflower were recorded with VAM and Farm Yard Manure along with inorganic fertilizers (Choudhary *et al*., 2004). The cost of synthetic fertilizers is increasing day by day so, the farmers are looking for an alternate source which may lower the cost of cultivation along with maintaining the fertility status of soil. Use of microbial inoculants to supplement a part of nitrogen requirements has attained immense importance. The purpose of this study was to investigate the effect of integrated nutrient management on growth, yield and quality of cauliflower. It would also help to find out the economic performance of different integrated nutrient management practices on cauliflower production.

Materials and Methods

Soil Sampling and Analysis

A field experiment was conducted at the experiment farm, Department of Horticulture, Udai Pratap Autonomous College, Varanasi (UP) India. Varanasi extends from 25.18N° latitude and 83.03°E longitude. Prior to the beginning of experiment, soil samples were taken in order to determine the physical and chemical properties. The texture of the soil in the experimental field was sandy loam. The soil sample from the experimental plot was obtained from a depth of up to 15 cm and examined at the Soil Testing Laboratory, UP College, Varanasi. It was air-dried, crushed, and tested for physical and chemical properties.

Field Preparation, Treatments and Observations

Cauliflower variety Snowball-16 was used in the study. FYM @ 15 tonnes/ha and vermicompost @ 2.5 tonnes/ha were incorporated in the field at the time of field preparation as per treatments. Seeds were treated with thiram @ 2.5 g/kg prior to sowing in the nursery bed and the details of treatment are presented in Table 1. The experiment was laid out in a randomized block design with eleven treatments and three replications. Each block was divided into 33 plots where 11 treatment combinations were distributed randomly in the experiment. The size of each plot was 2.40 m × 2.25 m. The distance maintained between two blocks were 1.00 m and two plots were 0.50 m. The plots were raised up to 40 cm and maintained spacing 60 cm × 45 cm, respectively. Each unit plot had 4 rows and with 5 plants. So, there were 20 plants per unit plot. Data was recorded for various traits such as plant height, no. of leaves/plant, leaf length, leaf width, leaf weight/plant, stalk length, plant spread, curd diameter, curd weight, curd volume, curd yield, total soluble solids and ascorbic acid.

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 the Microsoft excel data analysis and the mean differences were adjudged

Table 1: Details of various treatments

Code	*Treatments*
T_1	Recommended dose of NPK/ha (150 kg:100 kg:80 kg)
T_2	Half dose of NPK/ha + FYM @ 15 tonnes/ha
T_3	Half dose of NPK/ha + *Azospirillium* @ 5 kg/ha
T_4	Half dose of NPK/ha + FYM @ 15 tonnes/ha + *Azospirillium* @ 5 kg/ha
T_5	Half dose of NPK/ha + *Vesicular Arbascular Mycorrhiza*
T_6	Half dose of NPK/ha + FYM @ 15 tonnes/ha + *Vesicular* @ 5 kg/ha
T_7	Half dose of NPK/ha + FYM @ 15 tonnes/ha + *Azospirillium* @ 5 kg/ha + *Vesicular Arbascular Mycorrhiza* @ 5 kg/ha
T_8	Half dose of NPK/ha + Vermicompost @ 2.5 tonnes/ha
T_9	Half dose of NPK/ha + Vermicompost @ 2.5 tonnes/ha + *Azospirillium* @ 5 kg/ha
T_{10}	Half dose of NPK/ha + Vermicompost @ 2.5 tonnes/ha + *Vesicular Arbascular Mycorrhiza* @ 5 kg/ha
T_{11}	Half dose of NPK/ha + Vermicompost @ 2.5 tonnes/ha + *Azospirillium* @ 5 kg/ha + *Vesicular Arbascular Mycorrhiza* @ 5 kg/ha

Table 2: Effect of integrated nutrient management on various growth, yield and quality parameters of cauliflower

Treatments	*PH*	*NLP*	*LL*	*LW*	*Lwe*	*SL*	*PS*	*CD*	*CW*	*CV*	*CY*	*TSS*	*AA*
T_1	48.97	19.63	41.09	19.11	816.94	8.41	54.19	13.00	651.76	513.32	182.67	3.32	56.62
T_2	52.86	20.67	43.58	20.47	887.05	9.79	57.83	13.31	718.47	596.93	204.45	3.34	57.20
T_3	51.84	20.07	43.07	20.33	850.04	8.50	56.84	13.06	710.21	558.32	197.15	3.37	57.54
T_4	55.35	21.35	46.66	21.88	925.32	10.45	59.55	14.56	792.02	658.32	221.74	3.41	57.35
T_5	49.94	19.74	42.16	19.76	837.18	9.41	55.19	14.10	670.15	523.12	189.11	3.76	57.83
T_6	55.51	20.99	44.83	21.49	895.36	9.50	59.74	14.04	793.25	633.32	215.69	3.74	58.05
T_7	57.00	21.69	48.43	22.17	975.58	10.22	60.06	14.39	813.40	668.32	232.27	3.78	57.59
T_8	57.84	22.07	48.06	22.39	1000.39	10.13	60.50	14.97	833.45	693.13	239.03	3.42	57.82
T_9	58.79	23.22	50.34	24.16	1052.11	11.13	61.38	17.20	912.72	733.58	258.96	3.60	57.71
T_{10}	58.29	22.21	49.08	23.31	1006.81	10.31	61.06	15.13	813.46	703.45	249.13	3.53	58.50
T_{11}	59.25	23.58	50.50	24.44	1083.08	11.44	63.17	17.99	943.55	758.62	265.65	4.40	58.57
Mean	55.06	21.38	46.16	21.77	939.08	9.94	59.05	14.70	786.59	640.04	223.26	3.61	57.71
SEm±	1.10	0.40	1.02	0.53	27.17	0.29	0.83	0.48	28.04	25.06	8.52	0.09	0.17
CD at 5%	0.31	0.15	0.11	0.17	0.39	0.09	0.44	0.35	8.27	0.35	0.23	0.36	0.39
CV%	6.60	6.21	7.30	8.05	9.60	9.60	4.64	10.91	11.82	12.99	12.65	8.72	0.97

PH= Plant height, NLP= No. of leaves/plant, LL= Leaf length, LW= Leaf width, Lwe= Leaf weight/plant, SL= Stalk length, PS= Plant spread, CD= Curd diameter, CW= Curd weight, CV= Curd volume, CY= Curd yield, TSS=Total soluble soild, AA= Ascorbic acid

by a significant critical difference test (CD) as laid out by Panse & Sukhatme (1989). The correlation coefficients were calculated as suggested by Searle (1961) and Wright (1921). Standard analytical methods were used for the analysis of ascorbic acid (Harris & Ray, 1935).

Results and Discussion

Plant Growth Traits

The data revealed that the effect of integrated nutrient management of synthetic fertilizers along with organic manures affected different growth parameters like plant height, number of leaves/plant, leaf length, leaf width, leaves weight/plant, stalk length and plant spread of cauliflower as shown in Table 2. Significant difference was observed in the plant height, number of leaves/plant, leaf length, leaf width, leaves weight/plant, stalk length and plant spread due to integrated management of nutrients. Treatment T_{11} recorded the maximum plant height (59.25 cm), number of leaves/plant (23.58), leaf length (50.50 cm), leaf width (24.44 cm), leaves weight/plant (1083.08 g), stalk length (11.44 cm) and plant spread (63.17) followed by T_9 (58.79 cm), (23.22), (50.34 cm), (24.16 cm), (1052.11 g), (11.13 cm) and (61.38). The higher plant height might be attributed to the availability of greater amount of nutrients along with the efficiency of the plants of receiving proper nutrients resulting in larger leaf surface as well as prolonged greenness at both vegetative and reproductive stages (Yadav *et al*., 2007; Meena *et al*., 2018). The plant height was increased might be due to the enhancement of auxin biosynthesis and macronutrients specially nitrogen and also micronutrients from chemical fertilizers and organic manures. The application of INM was found better than only use of chemical fertilizers as it provides proper amount of nutrients for plant growth and improvement with the conservation of soil health. INM refers to the integration of organic, inorganic and biological components to increase crop productivity and maintenance of soil fertility for future use (Singh & Singh, 2005; Gruhn *et al*., 2000).

Table 3: Effect of integrated nutrient management options on economics of the crop (Rs./ha) of cauliflower

Treatment	*Yield (q/ha)*	*Gross income (Rs.)*	*Cost of cultivation (Rs.)*	*Net return (Rs.)*	*C : B ratio*
T_1	182.67	146136	42426	103710	1:3.44
T_2	204.45	163560	45363	118197	1;3.60
T_3	197.15	157720	40338	117382	1:3.87
T_4	221.74	177392	45838	131554	1:3.86
T_5	189.11	151288	40338	110950	1:3.75
T_6	215.69	172552	45838	126714	1:3.76
T_7	232.27	185816	46313	139503	1:4.01
T_8	239.03	191224	52863	138361	1:3.61
T_9	258.96	207168	53338	153830	1:3.88
T_{10}	249.13	199304	53338	143906	1;3.73
T_{11}	265.65	212520	54763	157757	1:3.90

Table 4: Correlation between growth, yield and quality factors in cauliflower

Traits	*PH*	*NLP*	*LL*	*LW*	*Lwe*	*SL*	*PS*	*CD*	*CW*	*CV*	*CY*	*TSS*	*AA*
PH	1.000												
NLP	0.952**	1.000**											
LL	0.975**	0.973**	1.000										
LW	0.964**	0.987**	0.981**	1.000									
Lwe	0.955**	0.992**	0.982**	0.980**	1.000								
SL	0.864**	0.926**	0.906**	0.911**	0.915**	1.000							
PS	0.984**	0.952**	0.952**	0.963**	0.942**	0.882**	1.000						
CD	0.790*	0.922**	0.856**	0.908**	0.905**	0.898**	0.811**	1.000					
CW	0.951**	0.983**	0.955**	0.976**	0.965**	0.902**	0.962**	0.912**	1.000				
CV	0.987**	0.983**	0.981**	0.983**	0.977**	0.912**	0.985**	0.853**	0.974**	1.000			
CY	0.973**	0.991**	0.988**	0.994**	0.993**	0.907**	0.963**	0.893**	0.971**	0.988**	1.000		
TSS	0.453	0.550	0.492	0.548	0.545	0.582	0.539	0.703*	0.596	0.491	0.528	1.000	
AA	0.687*	0.641	0.649	0.711*	0.660	0.593	0.721*	0.650	0.652	0.658	0.694*	0.684*	1.000

PH= Plant height, NLP= No. of leaves/plant, LL= Leaf length, LW= Leaf width, Lwe= Leaf weight/plant, SL= Stalk length, PS= Plant spread, CD= Curd diameter, CW= Curd weight, CV= Curd volume, CY= Curd yield, TSS=Total soluble soild, AA= Ascorbic acid
*,** significant at 0.05 and 0.01% levels, respectively

Yield Traits

The data revealed that the effectiveness of integrated nutrient management of chemical fertilizers along with organic manures affected the different reproductive stages like curd diameter, curd weight, curd volume and also the curd yield of cauliflower production as shown in Table 2. Significant differences in curd weight, curd diameter, quality and yield were recorded due to the application of chemical fertilizer along with organic manure in an integrated management method. Treatment T_{11} recorded maximum curd diameter (17.99 cm), curd weight (943.55 g), curd volume (758.62) and curd yield (265.65 g) followed by T_9 (17.20 cm), (912.72 g), (733.58) and (258.96 g), which differed significantly from each other. This difference was shown due to balanced levels of fertilizer and manure application. The treatment T_{11} was maximum in all curd diameters because of having vermicompost with *Azospirillium* and *Vesicular arbascular mycorrhiza* which contains more nutrients than vermicompost and *Azospirillium* in T_9, respectively. Vermicompost along with chemical fertilizer and biofertilizer enhance the availability of essential nutrients for the plants which increases the crop production with better quality rather than vermicompost and *Azospirillium* (Sharma & Sharma, 2010; Saha *et al*., 2015).

Qualitative Traits

The qualitative traits like maximum TSS (°Brix) and ascorbic acid content of cauliflower curd was recorded highest with the application of treatment of T_{11} (4.40°B, 58.57). It might be due to increased photosynthetic activity and other minerals resulted in improved levels of carbohydrates and other quality parameters of cauliflower curd through the way of enzymatic activity stimulated by plant growth substances produced by the application of bio-fertilizers and other nutrients (Singh, 2004; Kanaujia *et al*., 2010).

Economic Attributes

The cost of cultivation was directly associated with different inputs *viz*. cost of chemical fertilizers, FYM, vermicompost and biofertilizers. Gross income was found directly related with the yield of curd under different treatments. In term of the highest cost of cultivation, maximum gross income and maximum net profit T_{11} (Rs. 54763/ha, Rs. 212520/ha, Rs. 157757/ha) was calculated followed by the treatment T_9 (Rs. 53338/ha, Rs. 207168/ha, Rs. 153830/ha) were the least expensive (Table 3). The maximum benefit: cost ratio T_7 (1:4.01) was the most rewarding. But if the selling price of the produce increases slightly, which is volatile and keeps on changing on daily basis, the treatment T_{11} may come to be the most beneficial. From the above facts it may be inferred that the treatments T_9 and T_{11} were the most beneficial treatment may be followed in commercial cauliflower cultivation on large scale (Verma *et al*., 2015).

Interrelationship between Traits

The data presented in Table 4 explain that among growth, yield and quality factors, all traits had a significant positive correlation with all traits excluding TSS and ascorbic acid, TSS showed a significant positive correlation with curd diameter whereas ascorbic acid had a significant positive correlation with plant height, plant spread, curd yield and TSS. This indicates that the all traits in cauliflower is important, and

this trait can be omitted while selecting a nutritionally and productive for integrated nutrient management. This difference was observed due to the balanced application of fertilizers and manures and proper consumption of macro and micro nutrients along with other essential elements by the plants for their advancement in case of growth and yield. The increased total dry matter accumulation in T_{11} may be attributed to greater accumulation of photosynthates by vegetative parts in the plants having micronutrient application (Verma *et al*., 2015).

Conclusion

On the basis of the present study, it can be concluded that the application of T_{11} (half dose of NPK/ha + vermicompost @ 2.5 tonnes/ha + *Azospirillium* @ 5 kg/ha + VAM @ 5 kg/ha) treatment appeared to be the best for achieving the higher growth, yield and economic benefit of cauliflower. All traits had a significant positive correlation with all traits excluding TSS and ascorbic acid, TSS showed a significant positive correlation with curd diameter whereas ascorbic acid had a significant positive correlation with plant height, plant spread, curd yield and TSS. In this case, the application of integrated nutrient management is suitable for cauliflower production.

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सारांश

वर्तमान जांच प्रयोग फार्म, उदय प्रताप ऑटोनॉमस कॉलेज, वाराणसी (यूपी) भारत में की गई थी। एकीकृत पोषक तत्व प्रबंधन के उपयोग से फूलगोभी की वृद्धि, उपज और गुणवत्ता को बढ़ाया जा सकता है। उनके पूरक प्रभावों के कारण, पोषक तत्वों के विभिन्न कार्बनिक और अकार्बनिक स्रोतों का आदर्श संयोजन फूलगोभी की वृद्धि और उपज को काफी बढ़ा सकता है। प्रयोग में 11 उपचार शामिल थे। टी1: एनपीके की अनुशंसित खुराक (150:100:80 किग्रा/हेक्टेयर), टी2: एनपीके/हेक्टेयर की आधी खुराक + एफवाईएम @ 15 टन/हेक्टेयर, टी3: एनपीके/हेक्टेयर की आधी खुराक + एज़ोस्पिरिलियम @ 5 किग्रा/हेक्टेयर, टी4 : एनपीके/हेक्टेयर की आधी खुराक + एफवाईएम @ 15 टन/हेक्टेयर + एज़ोस्पिरिलियम @ 5 किग्रा/हेक्टेयर, टी5: एनपीके/हेक्टेयर की आधी खुराक + वीएएम @ 5 किग्रा/हेक्टेयर, टी6: एनपीके/हेक्टेयर की आधी खुराक + एफवाईएम @ 15 टन/हेक्टेयर + वीएएम @ 5 किग्रा/हेक्टेयर, टी7: एनपीके/हेक्टेयर की आधी खुराक + एफवाईएम @ 15 टन/हेक्टेयर + एज़ोस्पिरिलियम @ 5 किग्रा/हेक्टेयर + वीएएम @ 5 किग्रा/हेक्टेयर, टी8: एनपीके/हेक्टेयर की आधी खुराक + वर्मीकम्पोस्ट @ 2.5 टन/हेक्टेयर, टी9: एनपीके/हेक्टेयर की आधी खुराक + वर्मीकम्पोस्ट @ 2.5 टन/हेक्टेयर + एज़ोस्पिरिलियम @ 5 किग्रा/हेक्टेयर, टी10: एनपीके/हेक्टेयर की आधी खुराक + वर्मीकम्पोस्ट @ 2.5 टन/हेक्टेयर + वीएएम @ 5 किग्रा /हेक्टेयर, टी11: एनपीके/हेक्टेयर की आधी खुराक + वर्मीकम्पोस्ट @ 2.5 टन/हेक्टेयर + एज़ोस्पिरिलियम @ 5 किग्रा/हेक्टेयर + वीएएम @ 5 किग्रा/हेक्टेयर। टी11 उपचार से उच्चतम कर्ड उपज (265.65 ग्राम), कर्ड व्यास (17.99 सेमी), कर्ड वजन (943.55 ग्राम) और कर्ड मात्रा (758.62) अधिकतम शुद्ध लाभ (रु. 1,57,757/हेक्टेयर) के साथ प्राप्त हुई। टीएसएस और एस्कॉर्बिक एसिड को छोड़कर सभी लक्षणों के साथ सभी लक्षणों का एक महत्वपूर्ण सकारात्मक सहसंबंध था, टीएसएस ने कर्ड व्यास के साथ एक महत्वपूर्ण सकारात्मक सहसंबंध दिखाया जबकि एस्कॉर्बिक एसिड का पौधे की ऊंचाई, पौधे के प्रसार, कर्ड उपज और टीएसएस के साथ एक महत्वपूर्ण सकारात्मक सहसंबंध था। इसलिए, आर्थिक विश्लेषण से पता चला कि फूलगोभी की उच्च वृद्धि, उपज और आर्थिक लाभ प्राप्त करने के लिए टी11 उपचार सबसे अच्छा प्रतीत होता है।