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Studies on influence of bio-fertilizers on quality and economics of cauliflower cv. PSB K-1 production

Manisha Kachari[*] and B.N. Korla
Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan 173 230

ABSTRACT

A field experiment was carried out on cauliflower (*Brassica oleracea* L. var. *botrytis* cv. Pusa Snowball K-1) during 2006 and 2007 with objectives to know the influence of bio-fertilizers (*Azotobacter*, *Azospirillum*, AMF, PSB-1) and inorganic fertilizers (RD of NPK kg/ha) on quality and economics of cauliflower. The experiment was laid out in randomised block design consisting of 21 treatments. The results indicated that bio-fertilizers in combinations with inorganic fertilizers performed better as compared to control (FYM), recommended dose of NPK and bio-fertilizers alone. The application of PSB 1 + 50 or 75 or 100 per cent of phosphorus+ recommended dose of nitrogen and potassium performed significantly better overall other treatments including control for quality characters followed by AMF + 50 or 75 or 100 per cent of phosphorus + recommended dose of nitrogen and potassium. The inoculation of PSB 1 + 100 per cent phosphorus+ recommended dose of nitrogen and potassium recorded highest yield (33.94 t/ha) with cost benefit ratio of 1:2.58 over uninoculated control (FYM).

Key words: Cauliflower, *Azotobacter*, *Azospirillum*, AMF, phosphate solubilizing bacteria, quality.

INTRODUCTION

Cauliflower (*Brassica oleracea* L. var. *botrytis*) is an important vegetable grown in Himachal Pradesh and is one of the highly preferred vegetable. Being a heavy feeder cauliflower demands constant supply of large amount of nutrients and water for its luxuriant growth. The global energy crisis has increased the cost of the chemical fertilizers and this trend is expected to continue. Inspite of the unlimited reservoir of nitrogen in the air manufacturing of 1 kg fertilizer of nitrogen require six times more energy than that needed to produce either phosphorus or potassium fertilizers. The cost of chemical fertilizers will reach beyond the reach of marginal farmers in near future. The industrial nitrogen fixation not only depletes our finite reserves of fossils, fuels but also generates large quantities of principal greenhouse gas, nitrous oxide, which is 300 times more toxic than carbon dioxide. The indiscriminate use of chemical fertilizers increase soil acidity, impairs soil physical condition, reduces organic matter, creates micronutrients deficiencies, increases plant susceptibility to pest and diseases, decreases soil lives, increases, soil, water, air pollution via agricultural run off and leaching (Bashyal, 4). This necessitated supplying of biofertilizers artificially. Biofertilizers is low cost inputs compatible with chemical fertilizers and pesticides safe to crop and users both, ecofriendly and pose no danger to the environment. Application of *Azotobacter* and *Azospirillum* apart from ability to fix atmospheric nitrogen, they are also known for synthesis biologically active growth promoting substances (Asokan *et al.*, 1). Phoshate solubilizing bacteria (PSB) and AMF are effective in solubilization of inorganic phosphorus due to the production of organic acid which lead to release of phosphate into solution which is absorbed by plants. Their acceptability has been rather low, chiefly because farmers are unaware of the appropriate integration of biofertilizers with chemical fertilizers. Therefore an experiment was carried out to assess the response of late cauliflower to biofertilizers under Himachal Pradesh conditions.

MATERIALS AND METHODS

The present study was undertaken during 2006 and 2007 in the Experimental Farm of Department of Vegetable Crops, Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan to see the response of cauliflower to organic and synthetic fertilizers in soils of Himachal Pradesh. The experiment was laid out in RBD with three replication and 21 treatments, *viz.* T_1 (FYM), T_2 (Recommended dose of NPK + FYM), T_3 (FYM + *Azospirillum* + PSB 1), T_4 (FYM + *Azotobacter* + PSB 1), T_5 (FYM + arbuscular mycorrhiza + *Azospirillum*), T_6 (FYM + arbuscular mycorrhiza + *Azotobacter*), T_7 (*Azospirillum* + 50% N + recommended dose of P and K), T_8 (*Azospirillum* + 75% N + recommended dose of P and K), T_9 (*Azospirillum* + 100% N + recommended dose of P and K), T_{10} (*Azotobacter* + 50% N + recommended

*Corresponding author's present address: Krishi Vigyan Kendra, Dibrugarh, Assam; E-mail: manisha_kachari@yahoo.co.in

dose of P and K), T_{11} (*Azotobacter* + 75% N + recommended dose of P and K), T_{12} (*Azotobacter* + 100% N + recommended dose of P and K), T_{13} (PSB1 + 50% N + recommended dose of P and K), T_{14} (PSB1 + 75% N + recommended dose of P and K), T_{15} (PSB1 + 100% N + recommended dose of P and K), T_{16} (PSB1 + 50% P + recommended dose of N and K), T_{17} (PSB1 + 75% P + recommended dose of N and K), T_{18} (PSB1 + 100% P + recommended dose of N and K), T_{19} (AMF + 50% P + recommended dose of N and K),T_{20} (AMF + 75% P + recommended dose of N and K), T_{21} (PSB1 + 100% P + recommended dose of N and K). In each treatment plants were transplanted in a plot size of 2.4 m × 2 m and a spacing of 60 cm × 45 cm. Bio-fertilizers were applied as seed treatment, seedling dip treatment and soil application. The observations on quality attributes were recorded. The test of homogeneity was worked out by comparing the error mean sum of square of both the year as such pooled analysis was done.

RESULTS AND DISCUSSION

Mean data (Table 1) indicated that bio-fertilization and its effect on quality attributes of cauliflower. Curd

Table 1. Effect of INM treatments on quality attributing characters in cauliflower.

Treatment	Curd compactness		Mean	Ascorbic acid (mg/100 g)		Mean	β-carotene (μg/100 g)		Mean	TSS (°B)		Mean
	1st y	2nd y		1st y	2nd y		1st y	2nd y		1st y	2nd y	
T_1	0.012	0.016	0.014	46.23	46.76	46.50	12.61	13.66	13.14	4.2	4.4	4.3
T_2	0.017	0.024	0.020	52.54	55.16	53.85	13.77	15.05	14.41	4.5	4.7	4.6
T_3	0.013	0.017	0.015	51.49	54.64	53.07	12.81	14.29	13.55	5.2	5.5	5.3
T_4	0.014	0.018	0.016	49.38	51.49	50.44	12.89	14.54	13.72	5.2	5.4	5.3
T_5	0.015	0.023	0.019	50.44	53.59	52.02	13.89	15.44	14.67	4.7	4.9	4.8
T_6	0.016	0.022	0.019	50.96	54.11	52.54	15.92	17.33	16.63	5.2	5.1	5.2
T_7	0.021	0.026	0.024	63.34	63.89	63.62	16.09	17.84	16.97	5.5	5.7	5.6
T_8	0.028	0.028	0.028	64.10	60.10	62.1	16.28	17.39	16.84	6.7	6.6	6.6
T_9	0.026	0.031	0.029	68.30	68.82	68.56	19.24	22.82	21.03	6.7	7.2	6.9
T_{10}	0.031	0.033	0.032	64.73	65.67	65.20	18.93	20.02	19.48	6.3	6.6	6.4
T_{11}	0.025	0.028	0.027	63.05	64.73	63.89	16.01	17.61	16.81	7.5	7.3	7.4
T_{12}	0.035	0.035	0.035	61.99	61.74	61.87	15.97	17.49	16.73	6.5	7.0	6.7
T_{13}	0.024	0.030	0.027	57.07	58.79	57.96	17.94	19.17	18.56	7.7	7.7	7.7
T_{14}	0.018	0.027	0.23	69.35	69.87	69.61	23.11	24.16	23.64	8.0	8.1	8.0
T_{15}	0.034	0.034	0.034	57.79	58.84	58.32	33.65	35.72	34.69	6.2	6.5	6.3
T_{16}	0.022	0.025	0.024	71.45	72.23	71.84	39.93	40.98	40.46	8.2	8.4	8.3
T_{17}	0.032	0.029	0.031	72.50	73.97	73.24	21.25	20.99	21.12	8.0	7.8	7.9
T_{18}	0.036	0.036	0.036	67.25	67.25	67.25	16.81	19.01	17.91	8.5	8.9	8.7
T_{19}	0.031	0.042	0.037	59.89	61.26	60.58	16.02	17.65	16.84	5.7	6.0	5.8
T_{20}	0.042	0.047	0.045	54.64	57.68	56.16	17.89	17.86	17.88	6.2	6.5	6.3
T_{21}	0.043	0.044	0.044	55.48	55.69	55.59	19.08	20.50	19.79	6.7	6.8	6.7
CD at 5%	0.0008	0.0007	0.0005	4.77	4.54	3.24	0.67	0.54	0.42	1.19	0.48	-
Test of homogeneity		NS			NS			NS			S	
CD (5%) Year		0.0001			1.00			0.13		-	-	-
Treatment		0.0005			3.24			0.42		-	-	
Treatment × year		0.0007			4.59			0.59		-		

1st y = First year; 2nd y = Second year

compactness was found to be significantly influenced by treatment, year and treatment × year interaction. All the AMF treatments gave more compact curds being maximum in PSB1 + 100% P + recommended dose of N and K and AMF + 75% P + recommended dose of N and K. This increase in compactness may be due to more leaf width which covered the curd resulting less exposure to the sunlight or due to production of plant growth promoting substance by biofertilizers and this giving compactness. Ascorbic acid content was comparatively more in PSB 1followed by *Azospirillum* or *Azotobacter.* PSB1 + 50% P + recommended dose of N and K and PSB1 + 75% P + recommended dose of N and K recorded maximum values and it may be due to biosynthesis of auxin and gibberellins by phosphobacteria (Sattar *et al*., 13). Barea *et al*. (3) was also of the opinion that gibberellins could either augment the biosynthesis of ascorbic acid or block oxidation of synthesized ascorbic acid by ascorbic acid oxidase which ultimately resulted in increase the ascorbic acid content. β-carotene was showed maximum in PSB1 + 50% P + recommended dose of N and K and PSB1 + 100% N + recommended dose of P and K and this might be due to accumulation of phosphate solubilizing isolates in the rhizosphere (Baya *et al*., 5) and were readily available to the plant for quality curd production. Phosphate solubilizing bacteria found to influence total soluble solids of cauliflower as most value of both the years showed maximum in PSB1 + 100% P + recommended dose of N and K followed by PSB1 + 50% P + recommended dose of N and K and PSB1 + 75% N + recommended dose of P and K and minimum in control. Improvement in TSS with the application of bio-fertilizers over control could be attributed to better nutrient uptake and translocation of photosynthetes from leaves besides physiological and biochemical activities (Thilakavathy and Ramaswamy, 14; Umar *et al*., 15). Among bio-fertilizers the nitrogen uptake (Table 2) was the maximum with PSB1 + phosphorus followed by *Azotobacter* + nitrogen and AMF + phosphorus, both being almost same. It may inferred that when organics are applied along with inorganic fertilizers to soil, complex nitrogenous compounds slowly breaks down and make steady nitrogen supply throughout the growth period of the crop (Kondapanaidu, 9). More acquisition or uptake of nitrogen may be or due to expanded root growth and root hair development (Gilroy and Jones, 7). The phosphorus uptake was significantly maximum in PSB1 + 50% P + recommended dose of N and K than all other treatments showing that the growth of bacteria around plant rhizosphere dramatically increased the surface area of roots for exploration of nutrients particularly phosphorus. Besides numerous genes encoding NO_3 - and PO_4 - transporters have been encoding and characterized in this regards (Ragothama, 12; Gilroy and Jones, 7). High expression of these genes is frequently seen at the tip and in young root hairs and their expression is responsive to the nutrient uptake (Ragothama, 12). Potassium uptake showed maximum in PSB1 + 100% P + recommended dose of N and K and minimum in control. Reason may be due to positive correlation between total bacterial count and potassium uptake (Milosevic *et al*., 11) or perhaps due to combined application of organic and inorganic fertilizers which not only increases the yield of the crops but also enhanced the nutrient availability of soil and their uptake by crops (Kondapanaidu, 9). NPK content in soil after harvest (Table 3) found to be significant. Available nitrogen after harvest was maximum in AMF + 50% P + recommended dose of N and K and minimum in control. The maximum available N in soil may be due to synergistic effect with the nitrogen fixing bacteria (Asokan *et al.*, 1) or might be attributed to the greater multiplication of soil microbes along with organics. These organics during mineralization convert organically bound nitrogen to inorganic form resulting in higher available nitrogen in soil (Balyan, 2). The available phosphorus was maximum in AMF followed by *Azotobacter* + inorganic fertilizers. Availability of more phosphorus may be due to presence of mycorrhizal fungi which might be possessing phosphorus solubilizing activity (Lapeyne *et al*., 10). They are capable of utilizing phosphorus from inositol phosphorus and possess phosphatase activity which further affected there release of phosphorus from soil organic matter (Koide and Schreiner, 8) or due to the release of organic acid during microbial decomposition of organic matter that have helped in solubility of native phosphorus (Kondapanaidu, 9) and hence increase available phosphorus in soil. Maximum availability of potassium after harvest recorded in PSB1 + 100% P + recommended dose of N and K followed by AMF + 75% P + recommended dose of N and K and PSB1 + 75% P + recommended dose of N and K. Increase in available K may be due to the interaction of organic matter with clay soil besides addition of potassium to the available potassium pool of the soil (Bharadwaj and Omanwar, 6). Data showed (Table 4) propounded that the inoculation of PSB 1 + 100 % P + recommended dose of N and K was beneficial in boosting the curd yield and fetching maximum net return (Rs. 1,22,322) per hectare and cost benefit ratio of 1:2.58 for cauliflower curd production as compared to minimum return per hectare (Rs. 27,030) and cost benefit ratio of 1: 0.53 in control (FYM).

Table 2. Effect of INM strategies on NPK uptake by cauliflower plants.

Treatment	N uptake (kg/ha)		Mean	P uptake (kg/ha)		Mean	K uptake (kg/ha)		Mean
	1st y	2nd y		1st y	2nd y		1st y	2nd y	
T_1	215.97	237.00	226.48	15.57	16.61	16.09	117.73	112.75	115.24
T_2	322.75	412.53	372.64	22.61	21.32	21.96	169.23	146.79	158.01
T_3	263.41	352.33	307.87	20.51	19.70	20.10	150.44	145.44	147.94
T_4	285.84	362.38	324.11	23.71	21.67	22.69	164.35	144.19	154.27
T_5	230.00	367.41	298.70	21.96	23.96	22.96	160.33	159.66	159.99
T_6	217.31	264.15	240.73	20.74	24.00	22.37	156.09	142.70	149.39
T_7	362.49	422.75	392.62	22.93	25.97	24.45	173.81	190.62	182.21
T_8	342.14	431.50	386.82	26.90	29.29	28.09	186.74	165.53	176.13
T_9	344.41	452.62	398.51	24.47	31.11	27.79	190.61	234.88	212.74
T_{10}	547.20	537.77	542.48	28.85	38.15	33.5	232.93	297.72	265.32
T_{11}	460.72	422.00	441.36	22.89	25.33	24.11	230.76	231.47	231.11
T_{12}	465.28	466.24	465.76	28.12	30.97	29.54	233.44	262.36	247.90
T_{13}	427.04	436.71	431.87	29.18	29.25	29.22	218.41	218.51	218.46
T_{14}	421.58	452.08	436.83	23.23	26.61	24.92	193.43	214.54	203.98
T_{15}	427.33	522.13	474.73	30.11	38.37	34.24	219.52	231.07	225.29
T_{16}	550.00	549.28	549.64	39.24	41.10	40.17	246.42	304.76	275.59
T_{17}	551.31	540.00	545.65	28.68	32.02	30.35	237.83	224.16	230.99
T_{18}	510.32	552.00	531.15	31.35	38.54	34.94	310.2	322.23	316.21
T_{19}	525.73	530.32	528.02	32.63	34.28	33.46	227.08	224.42	225.75
T_{20}	389.00	490.34	439.67	30.37	32.72	31.54	187.61	169.23	178.42
T_{21}	507.25	454.07	480.66	31.79	41.33	36.56	258.61	319.19	288.90
CD at 5%	0.04	0.14	-	0.44	0.56	0.36	0.22	0.38	-
Test of homogeneity		S			NS			S	
CD (5%) Year		-			0.11			-	
Treatment		-			0.36			-	
Treatment × year		-			0.50			-	

1st y = First year; 2nd y = Second year

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Table 3. Effect of INM on soil 'NPK' content after harvest in cauliflower.

Treatment	'N' content (kg/ha)		Mean	'P' content (kg/ha)		Mean	'K' content (kg/ha)		Mean
	1st y	2nd y		1st y	2nd y		1st y	2nd y	
T_1	224.65	226.65	225.65	18.77	20.87	19.82	98.83	99.56	99.20
T_2	254.79	271.18	262.98	23.03	21.66	22.35	106.60	104.50	105.55
T_3	306.19	305.70	305.94	21.91	24.02	22.97	102.14	107.09	104.62
T_4	309.48	311.71	310.59	19.56	25.13	22.35	103.77	103.56	103.67
T_5	269.18	268.37	268.77	24.44	26.54	25.49	106.28	109.20	107.74
T_6	302.22	308.71	305.46	23.49	25.59	24.54	100.49	106.15	103.32
T_7	313.71	313.71	313.71	24.91	28.42	26.67	116.24	119.32	117.78
T_8	400.73	402.78	401.75	36.20	39.09	37.65	112.49	114.16	113.33
T_9	386.59	400.44	393.51	36.98	40.49	38.74	107.77	111.80	109.79
T_{10}	311.36	318.04	314.70	36.04	38.14	37.09	109.34	118.62	113.98
T_{11}	335.22	337.78	336.50	35.56	37.84	36.70	113.19	115.09	114.14
T_{12}	348.36	356.04	352.20	38.39	38.31	38.35	109.90	114.62	112.26
T_{13}	350.60	362.54	356.57	28.50	35.93	32.22	108.72	112.48	110.6
T_{14}	310.37	315.71	313.04	30.09	32.19	31.14	114.61	121.21	117.91
T_{15}	332.05	360.24	346.14	26.32	27.01	26.67	109.19	116.74	112.97
T_{16}	337.68	338.78	338.23	37.15	41.61	39.38	108.48	111.80	110.14
T_{17}	447.31	447.64	447.47	27.09	29.19	28.14	122.60	123.80	123.20
T_{18}	358.24	358.24	358.24	35.73	37.67	36.70	126.06	128.74	127.40
T_{19}	447.31	449.31	448.31	33.83	30.60	32.22	110.83	116.04	113.44
T_{20}	402.78	404.78	403.78	39.51	39.25	39.38	124.73	127.10	125.92
T_{21}	443.27	445.51	444.39	41.82	43.92	42.87	114.84	120.05	117.45
CD at 5%	0.43	2.01	-	0.63	0.98	-	1.31	0.61	-
Test of homogeneity		S			S			S	
CD (5%) Year		-			-			-	
Treatment		-			-			-	
Treatment × year		-			-			-	

1st y = First year; 2nd y = Second year

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Table 4. Economics of various inorganic and bio-fertilizer treatments on cauliflower production.

Sl. No.	Curd yield (t/ha)	Gross income (Rs./ha)	Cost of cultivation (Rs./ha)	Net return (Rs./ha)	C:B ratio
T_1	15.62	78,100	51,070	27,030	1:0.53
T_2	25.58	1,27,900	57,007	70,892	1:1.24
T_3	23.72	1,18,600	51,810	66,790	1:1.28
T_4	25.42	1,27,100	51,810	75,290	1:1.45
T_5	22.38	1,11,900	51,810	60,090	1:1.15
T_6	22.81	1,14,050	51,810	62,240	1:1.20
T_7	29.80	1,49,000	45,437	103,562	1:2.28
T_8	30.37	1,51,850	46,407	105,442	1:2.27
T_9	32.02	1,60,100	47,377	112,722	1:2.37
T_{10}	30.74	1,53,700	45,437	108,262	1:2.38
T_{11}	27.34	1,36,700	46,407	90,292	1:1.95
T_{12}	29.90	1,49,500	47,377	102,122	1:2.16
T_{13}	28.67	1,43,350	45,437	97,912	1:2.15
T_{14}	27.25	1,36,250	46,407	89,842	1:1.94
T_{15}	33.49	1,67,450	47,377	120,,072	1:2.53
T_{16}	29.40	1,47,000	46,589	100,410	1:2.16
T_{17}	30.26	1,51,300	46,983	104,316	1:2.22
T_{18}	33.94	1,69,700	47,377	122,322	1:2.58
T_{19}	29.05	1,45,250	46,589	98,660	1:2.12
T_{20}	28.52	1,42,600	46,983	95,616	1:2.04
T_{21}	29.24	1,,46,200	47,377	98,822	1:2.09

Sale rate of curd = Rs. 5,000/t (rate as approved by University)

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