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Effect of bio-fertilizers with chemical fertilizers on growth, yield, and quality of cauliflower (*Brassica oleracea var. botrytis*)

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Abstract
The present experiment entitled "Effect of bio-fertilizers with chemical fertilizers on the growth, yield, and quality of Cauliflower (*Brassica oleracea var. botrytis*)" was conducted at Horticulture Research Farm of the Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, (A Central University), Vidya- Vihar, Rae Bareli Road, Lucknow (U.P), India during Rabi season of 2015-16. The soil of the experimental field is sandy loam and slightly alkaline in nature with a soil pH of 8.2. In the trial, different nutrients are applied such as Recommended Dose of Fertilizers (RDF), FYM, Azotobacter, Azospirillum, and Vesicular Arbuscular Mycorrhizae (VAM) study the layout of the experimental field was laid down in Randomized Block Design with three replications. The observation of various character recorded revealed that the maximum height of the plant (57.793cm), number of leaves per plant (21.00), stem diameter (3.88cm), length of leaf (42.4cm), width of leaf (28..6cm), stem height (48.89cm), net curd yield (378.59g), curd with guard leaves (1349.86g), curd weight without guard leaves (929.22g), curd diameter(15.66cm), vitamin-c(93.21mg) and acidity (0.88) was found.

Keywords: RBD, cauliflower, RDF, FYM, azotobacter, Azospirillum, and VAM

Introduction
Cauliflower (*Brassica oleracea* L *var*. *botrytis*) is one of the important cool-season vegetable crops and goes by local names of Phool gobhi, fulwar, fulkabi, poogabi, gospoovu, and phulkari. The term cauliflower is derived from two Latin words, 'caulis' means cabbage and 'Floris' means flower. It is the most popular vegetable among cole crops and is diploid with 2n=2x=18 belonging to the family Brassicaceae. It is originated from a common parent, the wild cabbage or 'colewort', *Brassica oleracea var. Sylvestris* through mutation, human selection, and adaptation. There are two separate groups of cauliflower i.e. tropical and temperate. The tropical group has many varieties adapted to widely varying temperature conditions in different areas based on maturity and temperature requirement for curd initiation and development, cauliflower can be divided into four groups. Of these, three groups are typical Indian cauliflower, while the fourth is of Snowball, Erfurt, or Alpha types. Seeds of Indian cauliflower can be produced in the plains of Northern India, but Snowball types set seed only in the hilly regions of India. It is an herbaceous annual vegetable grown for its white tender 'curd' and biennial for seed production. It has a small, thick stem, bearing a whole of leaves and a branched tap root system. The main growing point develops into shortened shoot system whose apices make up the convex surface of the curd, so the curd is a floral fleshy apical meristem. The edible part, i.e. curd is generally white in color and may be enclosed by inner leaves before the exposure. The curd is the inflorescence consisting of thick, fleshy strongly ramified stalks. The inflorescence may attain a length of 1-2 m. The flowers are home in racemes on the main stem and its branches. There are 4 sepals, 4 petals, 6 stamens, and 2 carpels. The carpels form a superior ovary with a false septum and two rows of Campylotropous ovules. The androecium is tetradynamous i.e., there are two short and four long stamens. The fruit is a peculiar kind of capsule named siliqua. Each siliqua contains 10-30 seeds (Nieuwholf, 1969). It is the cross-pollinated crop and pollination is entomophilous i.e. carried out by insects, particularly honeybees. The National Research Council Committee on Diet Nutrition and Cancer, India, and the American suggested the

inclusion of vegetables belonging to the Brassicaceae family to reduce the incidence of human cancer. In ancestral times, it was used against gout, diarrhea, stomach, and coeliac troubles. Cauliflower is an excellent source of vitamin -C, folate, and a good source of potassium. Crucifer vegetables viz. cauliflower, cabbage, broccoli, and brussels sprout contain a substance called Indole-3 Carbinol that affects the metabolism of estrogen in a way that may protect against breast and other female cancers. Each 100 g edible curd contains 90.8% moisture, 4.0 g carbohydrates, 2.6 g protein, 0.4 mg thiamine, 0.10 mg riboflavin, 56 mg vitamin C, 33 mg calcium, and 1.5 mg Iron (Fageria *et al*., 2010) [2].

The bio-fertilizers denote all the nutrient inputs of biological origin for plant growth. They possess the unique ability to enhance productivity by biological nitrogen fixation are solubilization of insoluble phosphate or producing hormones vitamins or other growth factors required for plant growth. The beneficial microbes which are of great significance are biological nitrogen fixation phosphate solubilizes and mycorrhizal fungi. Azotobacter is a bacteria which have been known to fix nitrogen biologically. The use of these microbial fertilizers cut down the quantity of nitrogenous fertilizer with some improvement in the crop field. They are also reported to have an effective role in improving disease resistance in the crop by producing antibacterial and fungi compounds and produced growth regulators.

Azotobacter which was first isolated from the root rhizosphere of cereals by Beijerinckia in the early part of this country, free-livingving bacteria, fixing nitrogen equivalent to 25-30 Kg N /ha/season. It also produces hormones like Indole Acetic Acid (IAA), gibberellins, and vitamins like biotin and folic acid in field exexperiments. The application of Azotobacter increased the yield of okra, brinjal, chili, and broccoli 8.3, 8.9, 15.7, 10.3, 6.2 percent respectively. Azotobacter fixes nitrogen fertilizers by 10-20 percent. Its inoculation helps the plants in better vegetative growth due to the production of growth hormones such as auxins, gibberellins, and cytokines. Phosphatic bio-fertilizers are an important source of augmenting nutrient supplies for crop production systems. It includes phosphorus solubilizing bacteria (PSB) are heterotrophic microbes, which play a significant role in the solubilization of about 15-25 percent of insoluble phosphate. Infield experiments, the application of phosphate Solubilizing Bacteria (PSB) on brinjal and broccoli increased the field by 10.0 percent and 7.3 percent respectively. Phosphors Bacteria (PB) which is an obligate symbiotic effectively increase the absorbing root surface for nutrient and water uptake, especially important for P nutrition of plants. Phosphorus is otherwise unavailable because of limited mobility in soil. More researches on the effect of PB on plant nutrition have been concerned with phosphorus because it is a major plant nutrient and 95-99 percent of soil phosphorus Occurs in forms that are not directly available to plant. Besides phosphorus uptake of other elements also appear to be enhanced by the involvement of PB viz. N, K, Ca, Mg, S, Zn, and Fe.

Methods and Materials

The present investigation entitled "Effect of bio-fertilizers with chemical fertilizers on the growth of Cauliflower (*Brassica oleracea var. botrytis*)" was conducted at Horticulture Research Farm of the Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, (A Central University), Vidya- Vihar, Rae Bareli Road, Lucknow (U.P), India during Rabi season of 2015-16. The soil of the experimental field is sandy loam and slightly alkaline in nature with a soil pH of 8.2. The experiment was laid out in Randomized Block Design with three replications. The observation of various characters recorded revealed to be growth parameters were recorded periodically like the height of the plant, the number of leaves per plant, stem diameter, length of leaf, the width of leaf, stem height net curd yield, curd with guard leaves, curd weight without guard leaves, curd diameter, vitamin,-c and acidity. Statistical analysis of the data obtained in the different sets of the experiments was calculated as suggested by Panse and Sukhatme (1985).

Result and Discussion

The growth parameters we recorded periodically like the height of the plant, the number of leaves per plant, stem diameter, length of leaf, the width of, leaf and stem height. The recorded data revealed that there was a significant effect of bio-fertilizers with chemical fertilizers on growth parameters.

The maximum plant height (36.787 cm) was recorded at 30 DAT under treatment T_1 [RDF100%] followed (34.997cm) under treatment T_4 [Azospirillum 100%]. The minimum plant height (30.873cm) was observed under treatment T_0. (Control). At 60 DAT maximum plant height (44.67 cm) was recorded under treatment T_1 [RDF100%] followed by (43.447 cm) under treatment T_5 [VAM 100%]. The minimum plant height (40.35 cm) was observed under treatment T_0 [Control]. At 90 DAT maximum plant height (57.79 cm) was recorded under treatment T_1 [RDF 100%] followed by (55.10) under treatment T_2 [FY M 100%]. The minimum plant height (50.40 cm) was observed under treatment T_0 [Control]. Ekinci *et al*., (2014) reported that *Bacillus megaterium* TV-3D, B. megaterium TV-91C, *Pantoea agglomerans* RK-92, B. "'ubtilis TV-17C, *B. megaterium* TV-87A, *B. megaterium* KBA-10 were used in this study. The results of this study showed that different bacterial inoculations increased plant growth parameters such as fresh shoot weight, dry shoot weight, root diameter, root length, fresh root weight, dry root weight, plant height, stem diameter, leaf area, and chlorophyll contents of cauliflower transplant respectively.

Revealed the number of leaves was maximum (9.33) at the 30 DAT under treatment T_7 [RDF 50% +Azot0bacter 50%] followed by (8) T_6 [RDF50% + FYM 50%] and minimum leaves were recorded (6) under treatment T_0 [Control]. At 60 DAT the number of leaves was maximum (15) under treatment T_7 [RDF50%+Azotobacter 50%] followed by observation (12) under treatment T_8 [RDF 50%+ Azospirillum 50%]. Minimum data was found in this case was (9.33) under treatment T_0 (Control). At 90 DAT the number of leaves was maximum (21) under treatment T_7 [RDF 50%+ Azotobacter 50%]. Minimum data was found in this case was (15.6) under treatment T_0 (Control). Kumar, *et al.* (2013) Randomized Block Design with the three replication. The treatment T_{11} registered a significantly higher value plant height (62.02 cm), number of leaves/plant (25.67).

The maximum stem diameter was (1.96 cm) at 30 DAT under treatment T_8 [RDF 50%+Azospirillum 50%] followed (0.99 cm) under treatment T_{10} [FYM 50%+Azotobacter

50%]. The minimum was (0.91 cm) T_0 (Control). At 60 DAT maximum Stem diameter (2.74 cm) was recorded under treatment T_8 [RDF 50%+Azospirillum50%] followed by (2 cm) under treatment T_6 [RDF 50% FYM 50%].The minimum (1.4 cm) under treatment T_0 (Control). At 90 DAT maximum stem diameter was (3.88 cm) under treatment T_8 [RDF 50%+Azospirillum 50%] followed by (3.08cm) under treatment T_6 [RDF 50%+FYM 50%]. The minimum stem diameter (3.01 cm) under treatment T_0 (Control). These findings were supported by Dev (2012), Dragan *et al.*, (2007) [1] in cabbage, and Rahman *et al.*, (2007) in cauliflower.

The maximum length of leaves was (12.33 cm) at 30 DAT under treatment T_7 [RDF 50%+Azotobacter50%] followed (12.13 cm) under treatment T_9 [RDF50% +VAM 50%]. The minimum was (10.2 cm) T_0 (Control). At 60 DAT maximum length of the leaf (22.76 cm) was recorded under treatment T_7 [RDF 50%+Azotobacter 50%] followed by (21.93 cm) under treatment T_4 [Azospirillum 100%]. The minimum (20.22 cm) under treatment T_0 (Control). At 90 DAT maximum length of the leaf was (42.4 cm) under treatment T_7 [RDF 50%+Azotobacter 50%] followed by (41.33 cm) under treatment T_5 [VAM 100%]. The Minimum length of leaf (38.53 cm) under treatment T_1 (RDF 100%). These findings were supported by Islam *et al.*, (2014) [3] in cauliflower.

The width of leaf was maximum (7.8 cm) at the 30 DAT under treatment T_8 [RDF 50% +Azospirillum 50%] followed by (7.73 cm) T_7 [RDF 50% + Azotobacter 50%]. The observation was recorded in the case of a minimum width of leaf found (5.6cm) under the treatment T_0 (Control). After 60 DAT the width of leaf was maximum (15.6 cm) under treatment T_8 [RDF50% +Azospirillum 50%] followed by (15.2 cm) T_6 [RDF 50% + FYM 50%]. The minimum data was found in this case was (13.4cm) under treatment T_0 (Control) at 90 DAT and maximum leaf width (25.6 cm) was recorded under treatment T_8 [RDF 50% +Azospirillum 50%] followed by (24.4 cm) under treatment T_2 [FYM 100%], the minimum leaf width (21.06 cm) was observed under treatment T_0 [Control]. Lehrl and Mehrotra (1972) [5] isolated four strains of Azotobacter 100% was observed with synthetic fertilizers and up to 50% Width of leaf increase in cabbage was obtained at the lowest fertility level.

The stem height was maximum (8.83 cm) at the 30 DAT under treatment T_8 [RDF 50% +Azospirillum 50%] followed by (8.36 cm) T_3 [Azotobacter 100%]. The observation was recorded in the case of a minimum width of leaf found (6.06cm) under the treatment T_0 (Control). After 60 DAT the width of leaf was maximum (28.95 cm) under treatment T_8 [RDF 50% +Azospirillum 50%] followed by (25.86 cm) T_{10} [FYM 50% + Azotobacter 50%]. The minimum data was found in this case was (20.5 cm) under treatment T_0 (Control). 90 DAT maximum leaves width (48.89 cm) was recorded under treatment T_8 [RDF 50% +Azospirillum 50%] followed by (48.25 cm) under treatment T_2 [FYM 100%]. The minimum leaves width (45 cm) was observed under treatment T_0 [Control]. Solanki *et al.*, (2011) [9] However, no literature had been found to explain this factor. The increase in curd diameter, curd length, and stem height.

Net curd yield was obtained maximum (378.59 g) under treatment T_7 [RDF 50%+Azotobacter 50%] followed by (370.24 g) under treatment T_9 [RDF 50%+ VAM 50%]. The minimum observation (288.79g) was recorded under treatment T_0 (Control). Narayamma *et al.* (2005) application of bio-fertilizers (Azospirillum, PSB, and AM) along with inorganic produced significantly higher yield (18.6 t to 22.6 t 1130 weight of curd with leaf:

Weight of curd with guard leaves was taken after harvesting the crop and maximum (1349.86g) under treatment T_7 [RDF 50%+Azotobacter 50%] followed by (1312.90gm) under treatment T_{10}, [FYM 50% + Azotobacter 50%]. The minimum observation (860.14 g) was recorded under treatment T_2 (FYM 100%). Magd *et al.*, (2014) [6] observed that three bio-nitrogen treatments i.e. without bio-fertilization, *Azospirillum brasilense*, and *Azotobacter chroococcum* were combined with three levels of mineral nitrogen, i.e. 60, 90, and 120 kg N per Fadden (one Fadden = 0.42 ha). Plants treated with bio-nitrogen had higher vegetative growth, i.e. plant length, leaves number, fresh weight of leave stems and total plant, dry weight of leaves and heads, main head yield, and physical heads quality (weight and diameter) as well as N, P and K content of leaves and heads of broccoli than the untreated (control).

Weight of curd without guard leaf, it was obtained maximum (929 g) under treatment T_7 [RDF 50%+Azotobacter 50%] followed by (916 g) under treatment T_6 [RDF 50%+ FYM 50%]. The minimum observation (677g) was recorded under treatment T_0 (Control). Verma and Yadav (2011) [10] conducted an experiment on cauliflower cv. Pusa Snowball K-l and reported significant improvement in plant height, leaf length, leaf width, leaf weight per plant, and curd diameter with a combination of PSB + 75% P + a recommended dose of NK (120: 6O Kg/ha) through chemical fertilizers.

Curd diameter was recorded maximum (15.663 cm) under treatment T_9 [RDF 50% + VAM 50%] followed by (15.533 cm) T_{10} (FYM 50% +Azotobacter 50%). The Minimum observation (14.28 cm) was recorded in the treatment T_0 (control) Nath (2011) The highest vitamin C content of curds and the most active curd colour were recorded at 60 kg nitrogen and 2 kg bio-fertilizer ha/ 1, while the appearance and overall acceptability were recorded at 120 kg nitrogen and 2 kg bio-fertilizer ha-l. The findings demonstrated a saving of 60 kg nitrogen ha-l without significantly affecting yield.

Vitamin -C was obtained maximum (68.14mg) under treatment T_5 [VAM 100%] followed by (58.86 mg) under treatment T_7 [RDF 50%+Azotobacter 50%]. The minimum observation (35.17mg) was recorded under treatment T_0 (Control). Qureshi' *et al*. (2014) the yield obtained from a plant grown with inorganic nitrogen was generally higher than from those with FYM. The incorporation of either FYM or inorganic nitrogen increased total carotenoids during both the years. The Farm Yard Manure at high levels (45 t ha-l) increased vitamin C.

Acidity was maximum (0.88) under the treatment T_0 [control] followed by (9.86) under treatment T_{10} (FYM 50% + Azotobacter 50%). The minimum observation (0.53) was found in the treatment T_2 (FYM 100%). Kanwar *et al.* (2002) [4] reported a significant increase in curd weight, curd diameter, plant height, and acidity of cauliflower with the application of 50% NPK + organic manure.

Table 1: Effect of bio-fertilizers with chemical fertilizers on the growth of Cauliflower (*Brassica oleracea var. botrytis*)

Symbol	Treatment	Plant height (cm)			Number of leaves per plant			The stem of diameter (cm)		
		30DAT	60DAT	90DAT	30DAT	60DAT	90DAT	30DAT	60DAT	90DAT
T_0	Control	30.87	40.35	50.40	6.00	9.33	15.66	0.91	1.4	3.01
T_1	RDF (100%)	36.78	44.67	57.79	6.66	11.66	18.00	0.99	2.0	3.03
T_2	FYM (100%)	31.88	42.76	55.10	6.33	12.00	17.66	0.96	1.967	3.08
T_3	Azotobacter (100%)	30.89	41.64	54.44	7.33	12.00	18.00	0.98	1.96	3.03
T_4	Azospirillum (100%)	34.99	41.68	53.81	7.66	11.66	18.00	0.96	1.96	3.06
T_5	VAM(100%)	33.64	43.44	53.89	7.66	12.33	18.00	0.99	1.99	3.05
T_6	RDF + FYM (50%+50%)	33.24	42.36	52.54	8.00	11.33	17.33	0.983	2.0	3.063
T_7	RDF + Azotobacter (50%+50%)	32.45	41.96	54.08	9.33	15.00	21.00	0.99	1.95	3.08
T_8	RDF + Azospirillum (50%+50%)	33.89	42.83	51.69	8.00	12.00	18.00	1.96	2.74	3.88
T_9	RDF + VAM (50%+50%)	32.74	41.80	54.02	7.66	12.00	18.00	0.96	1.96	3.03
T_{10}	FYM+ Azotobacter (50%+50%)	31.20	42.80	53.51	8.00	11.33	18.00	0.997	2.0	3.02
T_{11}	FYM+ Azospirillum (50%+50%)	32.21	41.59	52.05	7.66	12.33	17.66	0.99	1.96	3.01
T_{12}	FYM+ VAM (50%+50%)	32.79	41.86	53.20	8.00	12.33	18.00	0.98	1.99	3.01
S.E±		1.506	0.835	0.612	1.325	1.513	1.630	0.06	0.301	0.145
C.D.at 5%		0.513	0.285	0.208	0.451	0.515	0.557	0.022	0.103	0.049

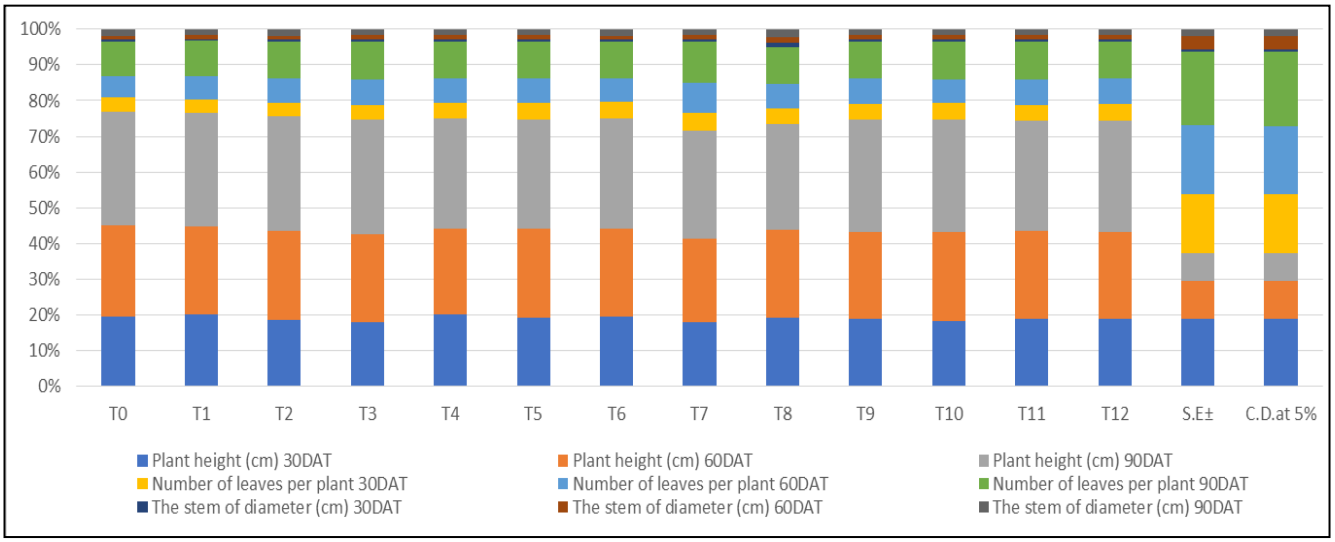

Fig 1: Effect of bio-fertilizers with chemical fertilizers on the growth of Cauliflower (*Brassica oleracea var. botrytis*)

Table 1: Effect of bio-fertilizers with chemical fertilizers on the growth of Cauliflower (*Brassica oleracea var. botrytis*)

Symbol	Treatment	Length of the leaf (cm)			Width of the leaf (cm)			Height of stem (cm)		
		30DAT	60DAT	90DAT	30DAT	60DAT	90DAT	30DAT	60DAT	90DAT
T_0	Control	10.20	20.22	38.86	5.60	13.46	21.06	6.067	16.87	45.70
T_1	RDF (100%)	11.33	21.43	38.53	6.73	13.73	23.13	7.90	20.50	47.37
T_2	FYM (100%)	11.13	21.067	38.96	7.03	14.16	24.40	7.43	21.03	48.25
T_3	Azotobacter (100%)	11.50	21.46	39.33	7.33	13.76	23.53	8.36	22.17	47.65
T_4	Azospirillum (100%)	11.83	21.93	39.30	7.43	13.73	22.73	7.90	21.82	48.21
T_5	VAM (100%)	11.76	21.86	41.13	7.46	14.36	22.33	7.86	23.61	48.07
T_6	RDF + FYM (50%+50%)	11.50	21.03	38.70	6.83	15.26	20.83	7.93	23.21	46.50
T_7	RDF + Azotobacter (50%+50%)	12.93	22.76	42.40	7.73	14.76	22.50	7.66	23.20	47.26
T_8	RDF + Azospirillum (50%+50%)	11.633	21.20	38..73	7.80	15.60	25.60	8.83	28.95	48.89
T_9	RDF + VAM (50%+50%)	12.13	21.20	38.70	6.30	14.86	21.90	7.93	25.56	47.25
T_{10}	FYM+ Azotobacter (50%+50%)	12.06	21.33	39.60	7.06	13.6	22.767	7.90	25.86	47.14
T_{11}	FYM+ Azospirillum (50%+50%)	12.03	21.20	39.23	7.23	13.833	22.533	8.00	23.65	47.217
T_{12}	FYM+ VAM (50%+50%)	12.467	21.30	38.60	7.56	14.033	22.8	7.83	24.83	47.75
S.E±		0.973	0.932	1.35	N/A	N/A	N/A	0.728	2.381	1.552
C.D.at 5%		0.331	0.317	0.46	0.422	0.619	1.068	0.248	0.811	0.529

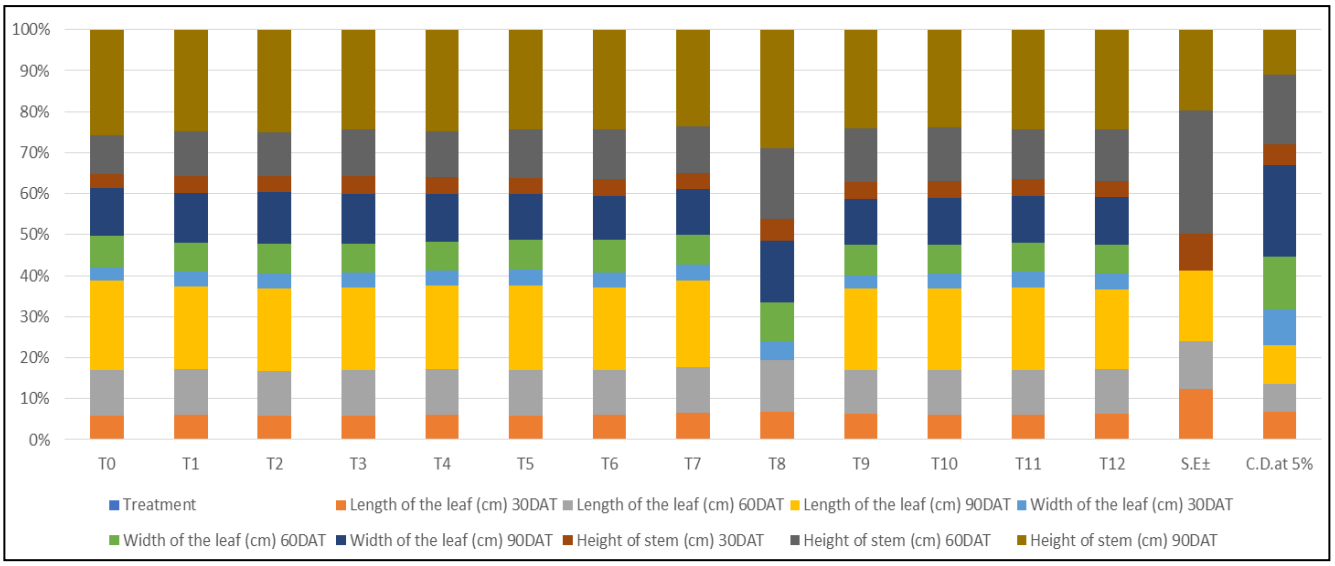

Fig 1: Effect of bio-fertilizers with chemical fertilizers on the growth of Cauliflower (*Brassica oleracea var. botrytis*)

Table 2: Effect of bio-fertilizers with chemical fertilizers on the yield, and quality of Cauliflower (*Brassica oleracea var. botrytis*)

Symbol	Treatment	Net curd yield (g)	Weight of curd with guard leaves (g)	Weight of curd without guard leaves (g)	Curd diameter (cm)	Vitamin – C (mg)	Acidity
T_0	Control	288.79	776.62	677.79	14.28	35.17	0.88
T_1	RDF (100%)	314.49	1365.52	855.521	14.36	47.99	0.78
T_2	FYM (100%)	323.51	864.143	795.74	14.45	45.14	0.537
T_3	Azotobacter (100%)	347.74	1045.73	807.15	15.22	36.81	0.783
T_4	Azospirillum (100%)	356.26	1140.21	878.313	14.95	49.27	0.59
T_5	VAM (100%)	316.61	1232.23	801.613	14.87	68.14	0.79
T_6	RDF + FYM (50%+50%)	353.45	1137.39	916.734	14.76	53.25	0.62
T_7	RDF + Azotobacter (50%+50%)	378.59	1349.86	929.22	14.84	58.86	0.817
T_8	RDF + Azospirillum (50%+50%)	350.71	1259.11	810.183	15.16	44.50	0.683
T_9	RDF + VAM (50%+50%)	370.24	1251.30	793.603	15.66	74.99	0.70
T_{10}	FYM+ Azotobacter (50%+50%)	353.79	1312.90	728.351	15.55	67.31	0.86
T_{11}	FYM+ Azospirillum (50%+50%)	341.40	1274.88	851.547	15.62	59.81	0.683
T_{12}	FYM+ VAM (50%+50%)	335.00	1262.15	755.93	15.91	71.29	0.847
S.E±		1.70	152.835	127.294	1.294	3.542	0.88
C.D.at 5%		268.71	52.052	43.354	0.415	1.206	0.78

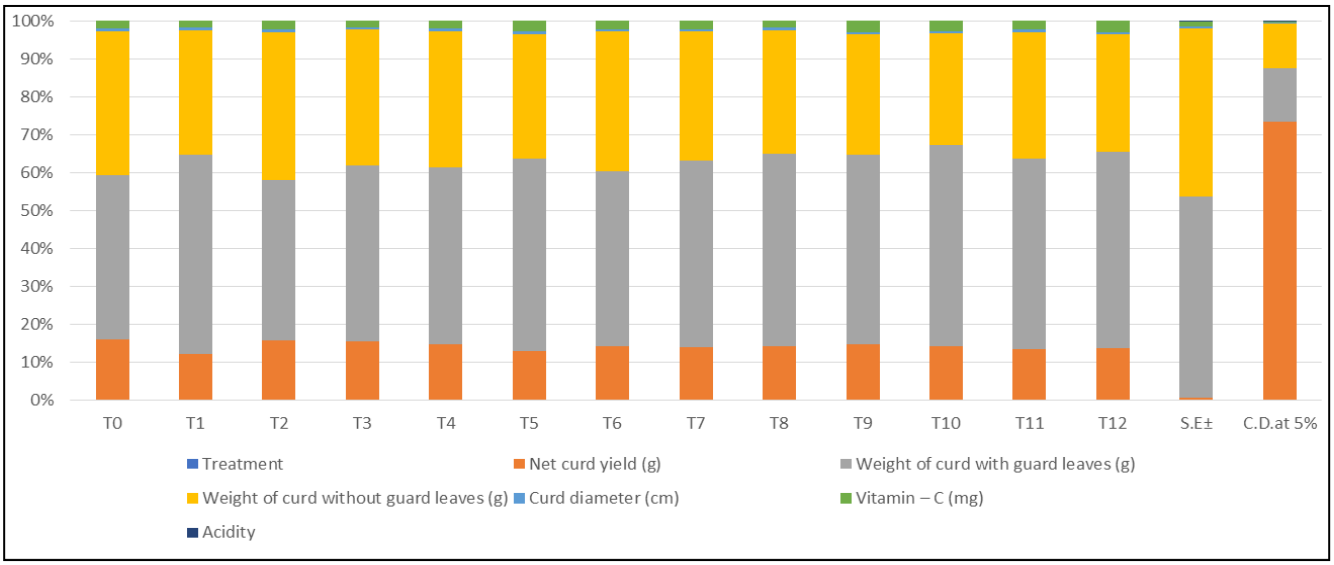

Fig 2: Effect of bio-fertilizers with chemical fertilizers on the yield, and quality of Cauliflower (*Brassica oleracea var. botrytis*)

Conclusion

It can fairly be concluded on the basis of the above fading's that the application T_8(RDF50%+Azospirillum50%) and T_7(RDF 50%+Azotobacter 50%) at the Optimum level are quite effective to promote the growth, yield, and quality of cauliflower. It increased height, leaves, length of leaf, leaves width, curd diameter, and yield per hectare, along with the better quality of curds in terms of acidity and ascorbic acid.

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