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Impact of bio fertilizers based nutrient management on growth and yield of cauliflower cv. Pusa Snowball KT 25

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Abstract
An experiment was laid out in Randomized Block Design (RBD) at Vegetable Research Farm, RHRS, ACHF, NAU, Navsari, Gujarat during *Rabi* season, 2019-2020 to study the different bio-fertilizers *Azospirillium*, PSB and KMB with different fertility levels of NPK on growth and yield of cauliflower. The experiment consist of 10 treatments *viz.*, T_1: 75% RDN + *Azospirillium* (5 l ha^{-1}), T_2: 100% RDN + *Azospirillium* (5 l ha^{-1}), T_3: 75% RDP + PSB (5 l ha^{-1}), T_4: 100% RDP + PSB (5 l ha^{-1}), T_5: 75% RDK + KMB (5 l ha^{-1}), T_6: 100% RDK + KMB (5 l ha^{-1}), T_7: 75% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}), T_8: 100% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}), T_9: 100% RDF (200:75:37.5) NPK kg ha^{-1} and T_{10}: *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}). Among different treatments, application of 100% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}) recorded maximum plant height (58.40 cm), stalk length (12.20 cm), number of leaves $plant^{-1}$ (19.60), N-S plant spread (63.07 cm), E-W plant spread (66.80 cm), curd diameter (21.77 cm), gross weight of curd (2.19 kg $plant^{-1}$), net weight of curd (866.00 g $plant^{-1}$), yield $plot^{-1}$ (17.32 kg) and total yield (32.07 t ha^{-1}) as well as minimum days to curd initiation (47.40) and days to marketable curd maturity (63.53).

Keywords: Cauliflower, bio-fertilizers, nitrogen, phosphorus, potassium, PSB, *Azospirillum*, recommended dose

Introduction
Cauliflower (*Brassica oleraceae* var. *botrytis* L.) is one of the most important winter vegetable crop in the family Brassicaceae having chromosome number 2n = 18. The name cauliflower consists of two *Latin* words namely '*caulis*' means cabbage and '*floris*' means flower. The crop is a native of southern Europe in the Mediterranean region and introduced in India in 1822 A. D., from England. It is grown throughout the country for its tender curds (aborted floral meristems) which are cooked as vegetable, use as vegetable soup and pickling. Hence, the use of chemical fertilizers should be reduced to the minimum and may be substituted with integrated use of bio-fertilizers. The approach of integrated plant nutrient system aims at sustaining productivity with minimum deleterious effects of chemicals on soil health and environment. The application of bio-fertilizers in vegetable crops has been found very effective. Bio-fertilizers offer an economically attractive and ecologically sound means of reducing external inputs and improving quality as well as quantity of internal sources. (Thamburaj and Singh, 2001) [1]. Bio-fertilizers can symbiotically associate with plant roots and microorganisms can readily and safely convert the complex organic material into simple compounds, and easily taken up by the plants. It increases crops yield by 20 to 30%, replaces chemical nitrogen and 25% phosphorus as well as stimulates plant growth (Gupta *et al*., 2015) [2].

Material and Methods
The experiment was conducted at Vegetable Research Farm, Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat during *Rabi* season, 2019-2020. The experiment was laid out in Randomized Block Design (RBD) with three replications, which included 10 treatments *viz.*, T_1: 75% RDN + *Azospirillium* (5 l ha^{-1}), T_2: 100% RDN + *Azospirillium* (5 l ha^{-1}), T_3: 75% RDP + PSB (5 l ha^{-1}), T_4: 100% RDP + PSB (5 l ha^{-1}), T_5: 75% RDK + KMB (5 l ha^{-1}), T_6: 100% RDK + KMB (5 l ha^{-1}), T_7: 75% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}), T_8: 100% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}), T_9: 100% RDF (200:75:37.5) NPK kg ha^{-1} and T_{10}: *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}).

Single seedling of cv. Pusa Snowball KT 25 was dibbled at each hill at 45 cm x 45 cm spacing. Full dose of FYM (20 t ha^{-1}) was applied at the time of land preparation. The inorganic fertilizers were supplied to crop through neem coated urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O). Entire P, K and 50% N was applied as a basal dose and remaining 50% N as top dressing in two split doses 30 days after transplanting and at 45 days after transplanting as per the treatments to the respective plots. Bio-fertilizers such as *Azospirillium* (5 l ha^{-1}), PSB (5 l ha^{-1}) and KMB (5 l ha^{-1}) were applied in soil after 15 days of first and second dose of chemical fertilizers application. The observations on growth and yield parameters were recorded at the time of harvesting and subjected to statistical analysis of variance technique as described by Panse and Sukhatme (1985) [3].

Results

Effect of bio-fertilizers based nutrient management on growth attributes

Data on various growth attributes depicted in table 1 and it revealed that soil application of 100% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}) recorded the maximum plant height (58.40 cm), stalk length (12.20 cm), number of leaves $plant^{-1}$ (19.60), N-S plant spread (63.07 cm) and E-W plant spread (66.80 cm) which was statistically at par with 75% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}) where, minimum plant height (39.60 cm), stalk length (8.40 cm), number of leaves $plant^{-1}$ (13.60), N-S plant spread (52.27 cm) and E-W plant spread (51.67 cm) was observed in control. Minimum days to curd initiation (47.40 days) was recorded with soil application of 100% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}) and it was at par with treatments 100% RDN + *Azospirillium* (5 l ha^{-1}), 100% RDK + KMB (5 l ha^{-1}) and 75% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}). The maximum days to curd initiation was taken by control (65.20 days). The treatment 100% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}) took minimal days to marketable curd maturity (63.53 days) and it was on same bar with treatments 100% RDN + *Azospirillium* (5 l ha^{-1}), 100% RDP + PSB (5 l ha^{-1}), 100% RDK + KMB (5 l ha^{-1}) and 75% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}). The maximal days to marketable curd maturity was noted in control (81.13 days). These findings are coincides with work done by Kumar *et al*. (2017) [4] and Gupta *et al.* (2018) [5] in cabbage and they reported maximum plant height, stalk length and number of leaves $plant^{-1}$ with combine application of bio-fertilizers and inorganic fertilizers. Pawar and Barkule (2018) [6] who found the earliness in curd initiation of plant with combine application of bio-fertilizers and inorganic fertilizers. Tekasangla *et al.* (2015) [7], Singh *et al.* (2018) [8] and Subedi *et al.* (2019) in cauliflower and they reported increased in plant spread with inoculation of combine application of bio-fertilizers and inorganic fertilizers.

Effect of bio-fertilizers based nutrient management on yield attributes

Data on various yield parameters highlighted in table 2 and it revealed that soil application of 100% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}) increasing the curd diameter (21.77 cm), gross weight of curd (2.19 kg $plant^{-1}$), net weight of curd (866.00 g $plant^{-1}$) and yield of curd (17.32 kg $plot^{-1}$ and 32.07 t ha^{-1}) which was statistically significant over all other treatments except treatments 75% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}) which was at par. Minimum curd diameter (16.17 cm), gross weight of curd (1.20 kg $plant^{-1}$), net weight of curd (628.67 g $plant^{-1}$) and yield of curd (12.33 kg $plot^{-1}$ and 22.66 t ha^{-1}) was observed in control. These findings are in line with Singh and Singh (2019) [10] in cauliflower and they reported that combined application of *Azospirillium*, PSB and KMB along with inorganic fertilizers resulted in curd diameter, gross weight of curd, net weight of curd, yield per plot and yield per ha.

Discussion

Effect of bio-fertilizers based nutrient management on growth attributes

The raise in the plant height in treatment T_8 (100% RDF + *Azospirillium* 5 l ha^{-1} + PSB 5 l ha^{-1} + KMB 5 l ha^{-1}) is due to combined effect of inorganic fertilizers with bio-fertilizers which lead to the decomposition of organic matter by microbial inoculants and thus releasing the available nutrients to the plants from the soil and additionally, the application of inorganic fertilizers resulted ultimate increase in height of plant. It may also due to the cell elongation by the presence of nitrogenous compounds. Nitrogen being a constituent of amino acids, nucleotides, nucleic acids, a number of co-enzymes, auxins, cytokinins and alkaloids which induces cell elongation, cell enlargement as well as cell division (Renuka and Shankar, 2001) [11]. The augment in stalk length in treatment (T_8) 100% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}) might be due to increase uptake of nutrients and metabolic activities through the beneficial effect of bio-fertilizers and inorganic fertilizers as they accelerated the vegetative growth (Singh *et al.*, 2018) [8]. The increase in number of leaves in treatment T_8 might be due to combined effect of bio-fertilizers and application of inorganic fertilizers resulted in higher absorption of nutrients enhanced cell division, cell elongation and thus associated increase in metabolic activity (Torrey, 1950) [12]. The treatment T_8 was performed better in minimum number of days taken to curd initiation and marketable curd maturity may be due to application of bio-fertilizers with inorganic fertilizers might be resulted in better inorganic nitrogen utilization and enhanced biological N-fixation. Better synthesis of plant growth hormones and ability of the phosphate solubilizers to solubilize and increase the availability of inorganic phosphorus from insoluble form and ultimately leads to early curd formation (Singh *et al*., 2010) [13]. The accelerated plant spread (N-S and E-W) in treatment T_8 *i.e*., 100% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}) may be due to combined effect of bio-fertilizers which made the unavailable form of nutrients to available form at critical stages of plant growth, resulted for luxuriant growth of the plant. The integration of bio-fertilizers might have supplemented the cause with their ability to increase the photosynthetic capacity and secretion of beneficial growth promoting substances like IAA, GA, kinetin, riboflavin and thiamine, which can result in better plant spread (Malik *et al*., 2005) [14].

Effect of bio-fertilizers based nutrient management on yield attributes

The augment curd diameter in treatment 100% RDF +

Azospirillium 5 l ha^{-1} + PSB 5 l ha^{-1} + KMB 5 l ha^{-1} (T_8) might be due to early release of available phosphorus and nitrogen through bio-fertilizers along with inorganic fertilizers, their availability in sufficient quantities at time of curd development also improved the fertility status of soil thus improving productivity due to which yield attributing characters like curd diameter might have increased (Kumari *et al.*, 2017) [4]. The expanded in gross weight and net weight of curd may be bio-fertilizers owing to better root proliferation, rhizosphere development and uptake of nutrients as well as water, higher leaf area development ultimately higher rate of photosynthesis activity thus resulting ultimately in the increased gross weight of curd per plant (Singh and Singh, 2019) [10]. Curd yield per plot and yield per ha might have augmented due to enhancement of phytohormone production, nitrate reduction, nitrogen fixation, phosphate solubilization, specific activities of enzymes involved in the tricarboxylic acid cycle and the glycolysis pathway might be the reason behind yield increase. Hormone induced modification in root morphology leads to enhanced uptake of mineral nutrients might help increasing yield, it can be attributed by increase in uptake of nutrients resulting in faster synthesis and translocation of photosynthates from source (leaves) to sink (curd). On other hand bio-fertilizers have capacity to inhibit the growth of phytopathogenic fungi species such as *Alternaria*, *Venturia*, *Sclerotinia*, *Rhizoctonia*, and *Pythium* and thus, enable the plants to grow well without disease, which may help in increasing cauliflower yield there by increased the productivity of cauliflower (Pawar and Barkule, 2018) [6].

Table 1: Effect of bio-fertilizer based nutrient management on growth attributes in cauliflower cv. Pusa Snowball KT 25

Treatments	Plant height (cm)	Stalk length (cm)	Number of leaf plant^{-1}	Days to curd initiation	N-S (cm)	E-W (cm)	Days to marketable curd maturity
T_1: 75% RDN + *Azospirillium* (5 l ha^{-1})	45.20	09.40	15.60	59.80	55.13	55.93	74.20
T_2: 100% RDN + *Azospirillium* (5 l ha^{-1})	47.40	10.20	16.20	55.40	55.40	57.40	70.13
T_3: 75% RDP + PSB (5 l ha^{-1})	45.40	09.80	14.60	59.60	55.27	57.53	74.53
T_4: 100% RDP + PSB (5 l ha^{-1})	46.80	10.00	15.00	56.20	55.73	57.87	69.40
T_5: 75% RDK + KMB (5 l ha^{-1})	45.20	09.40	15.40	59.20	54.40	51.53	74.07
T_6: 100% RDK + KMB (5 l ha^{-1})	49.20	10.40	15.60	55.20	55.77	54.07	69.93
T_7: 75% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1})	58.20	11.20	18.00	54.40	62.20	63.93	69.20
T_8: 100% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1})	58.40	12.20	19.60	47.40	63.07	66.80	63.53
T_9: 100% RDF (200:75:37.5) NPK kg ha^{-1}	41.13	09.40	15.60	60.40	52.27	51.67	74.93
T_{10}: *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1})	39.60	08.40	13.60	65.20	50.53	49.47	81.13
S.Em.±	2.02	0.46	0.78	2.79	2.35	2.30	3.00
C.D. at 5%	5.99	1.38	2.33	8.30	6.99	6.85	8.94
C.V.%	7.33	8.00	8.52	8.45	7.28	7.05	7.23

Table 2: Effect of bio-fertilizer based nutrient management on yield parameters in cauliflower cv. Pusa Snowball KT 25

Treatments	Curd diameter (cm)	Gross weight of curd (kg plant^{-1})	Net weight of curd (g plant^{-1})	Yield (kg plot^{-1})	Yield (t ha^{-1})
T_1: 75% RDN + *Azospirillium* (5 l ha^{-1})	17.67	1.86	706.67	14.11	26.14
T_2: 100% RDN + *Azospirillium* (5 l ha^{-1})	18.13	1.88	749.33	14.35	26.58
T_3: 75% RDP + PSB (5 l ha^{-1})	18.37	1.84	668.67	13.26	24.55
T_4: 100% RDP + PSB (5 l ha^{-1})	18.87	1.86	686.67	13.73	25.43
T_5: 75% RDK + KMB (5 l ha^{-1})	18.57	1.89	736.00	14.10	26.11
T_6: 100% RDK + KMB (5 l ha^{-1})	18.83	1.90	746.00	14.83	27.46
T_7: 75% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1})	20.17	2.15	855.33	17.00	31.49
T_8: 100% RDF + *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1})	21.77	2.19	866.00	17.32	32.07
T_9: 100% RDF (200:75:37.5) NPK kg ha^{-1}	17.07	1.78	687.33	12.94	23.96
T_{10}: *Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1})	16.17	1.20	628.67	12.23	22.66
S.Em.±	0.76	0.08	30.67	0.82	1.52
C.D. at 5%	2.26	0.24	91.12	2.43	4.50
C.V.%	7.09	7.61	7.25	9.86	9.85

Conclusions

From the results of investigation, it was inferred that the effect of bio-fertilizer based nutrient management on growth parameters *viz.*, plant height (58.40 cm), stalk length (12.20 cm) number of leaves plant^{-1} (19.60), days to curd initiation (47.40), N–S plant spread (63.07 cm), E–W plant spread (66.80 cm) and days (63.53) to marketable curd maturity (63.53) found significant in analysis. Under all this growth parameters, T_8 (100% RDF + *Azospirillium* 5 l ha^{-1} + PSB 5 l ha^{-1} + KMB 5 l ha^{-1}) found as a best treatment. Maximum curd diameter (21.77 cm), gross weight of curd (2.19 kg plant^{-1}), net weight of curd (866.00 g plant^{-1}), yield (17.32 kg plot^{-1}) and total yield (32.07 t ha^{-1}) was noted in soil application of 100% RDF + *Azospirillium* 5 l ha^{-1} + PSB 5 l ha^{-1} + KMB 5 l ha^{-1} (T_8) and minimum gross weight of curd (1.20 kg), net curd weight (628.67 g), yield plot^{-1} (12.23 kg) and total yield (22.65 t ha^{-1}) was recorded in T_{10} (*Azospirillium* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}).

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