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VM Chaudhari
Ph.D. Scholar, Department of Vegetable Science ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat, India

NK Patel
Assistant Professor, Department of Vegetable Science ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat, India

DC Barot
Ph.D. Scholar, Department of Vegetable Science ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat, India

Nisha Nadoda
Ph.D. Scholar, College of Horticulture, Jagudan, SDAU, Gujarat, India

Corresponding Author:
VM Chaudhari
Ph.D. Scholar, Department of Vegetable Science ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat, India

Economics of cauliflower production effected by biofertilizer-based nutrient management

VM Chaudhari, NK Patel, DC Barot and Nisha Nadoda

Abstract
Cauliflower is economically important vegetable crops for farmer during Rabi season. Nutrient management with biofertilizers help to increase yield of Cauliflower which ultimately help to increase farmers' incomes. 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 *Azospirillum*, 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 + *Azospirillum* (5 l ha^{-1}), T_2: 100% RDN + *Azospirillum* (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 + *Azospirillum* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}), T_8: 100% RDF + *Azospirillum* (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}: *Azospirillum* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}). Among different treatments, application of 100% RDF + *Azospirillum* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}) recorded maximum net returns (₹ 319877.17 ha^{-1}) and BCR (1.98).

Keywords: Treatments, application, net returns

1. Introduction
First of all India is an agricultural country and agricultural sector play important role in country's economics. Agricultural sector share 18.3% GDP in national income of 2022-23. In India seventy percent rural people are directly or indirectly connected with agriculture. Horticulture is the one of the major part of the agriculture and day by day area and production of horticultural crops are increased. Vegetable crops contributions are remain large among other horticulture crops over the last five years (59-61%). Production of vegetable crops increased from 101.2 million tonnes to 184.40 million tonnes during 2004-05 to 2017-18. It covered area of 10,259 '000 hectare with 1, 84, 394 '000 metric tonnes and 17.97 tonne per hectare production and productivity, respectively (Anon., 2020) [1].

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most important winter hardy vegetable crop belong to the family Brassicaceae which having chromosome number of 2n = 18 (Singh, 2012) [11]. The name cauliflower derived from two *Latin* words namely '*caulis*' means cabbage and '*floris*' means flower (Reddy and Kumar, 2022) [14]. The crop is originated from southern Europe in the Mediterranean region and introduced in India in 1822 A. D., from England. It is grown all over the country for its tender curds (aborted floral meristems) which use for cooked as vegetable, use as vegetable soup and pickling (Chadha, 2019) [2].

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) [13]. 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) [3]. Economics play vital role for vegetable growers. Selection of crops and economics is an fundamental part of success full production of vegetable crops.

Economic feasibility of the fertilizer practices is an essential element to improve crop productivity (Shahid *et al*., 2015) [10]. By considering above facts, the experiment was laid out to study the effect of bio-fertilizer based nutrient management on economics of cauliflower production.

2. Materials and methods

2.1 Experimental site and weather Data

The present investigation was carried out during *Rabi* 2019-20 at Vegetable Research Farm, Regional Horticultural Research Station, Navsari Agricultural University, Navsari, in block-E, plot-6. According to agro-climatic conditions of Gujarat state, Navsari falls under ‘South Gujarat Heavy Rainfall Zone, AES-III’. The climate of this zone is typically tropical and monsoonic. An average rainfall of the zone is about 1500 millimeters (mm) and is generally distributed between second fortnight of June to September end. Winter starts from November and end by middle of February. December and January are cold months with minimum 8.4 ºC to maximum 31.5 °C temperature. From middle of February gradual rise in temperature is generally seen. Pusa Snowball KT 25 is well response for late *Rabi* in south Gujarat region. The transplanting was done at 60 cm × 45 cm spacing in *Rabi* season.

2.2 Treatment Details

In present investigation include 10 treatments *viz.*, T_1: 75% RDN + *Azospirillum* (5 l ha^{-1}), T_2: 100% RDN + *Azospirillum* (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 + *Azospirillum* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}), T_8: 100% RDF + *Azospirillum* (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}: *Azospirillum* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}) with 3 replications in Randomized Block Design.

2.3 Methodology of Applications

Nitrogenous fertilizer was applied in 3 split doses [(50% as basal, 25% top dressed 30 DATP (1st Dose) and 25% 45 DATP (2nd Dose)]. Phosphorus and potash was applied as basal dose along with 20 t FYM. *Azospirillum*, PSB and KMB @ 5 litres ha^{-1} was applied in soil after 15 days of first and second dose of chemical fertilizer application. Each biofertilizers was individually mixed with 50 kg FYM and kept overnight then applied in plot as per treatment.

2.4 Calculation of Cost for Cultivation

Calculation of cost of cultivation include Cost A, Cost B, Cost C, Gross return, Net return and Benefit Cost Ration. Cost of cultivation was calculated by the formula which given below (Raju and Rao). Detail of cost of fixed cost, Variable cost and economics of cauliflower productions as affected by the biofertilizer based nutrient management was given in table 1,2 and 3, respectively.

Cost A: It is sum of fixed cost and variable cost

Cost B: It obtained by Gross return divided by 16

Cost C: The sum of Cost A and Cost B is called as Cost C

Gross return: Total curd yield multiplied by price of 1kg curd (here, price of 1kg curd is Rs. 15)

Net return: Gross return – Cost C

BCR= (Net income)/(Cost C)

3. Results and Discussion

Economics of cauliflower production had influence by the biofertilizers based nutrient management which was showed in Table 3, net income and BCR which affected by various treatment is noted in Fig. 1 and 2, respectivly. The treatment T_8 (100% RDF + *Azospirillum* 5 l ha^{-1} + PSB 5 l ha^{-1} + KMB 5 l ha^{-1}) had maximum net income (₹ 319877.17) along with higher BCR (1.98) per hectare. While, treatment T_7 (75% RDF + *Azospirillum* 5 l ha^{-1} + PSB 5 l ha^{-1} + KMB 5 l ha^{-1}) had second higher net income (₹ 313279.89) and BCR (1.97) per hectare. Where, lower net income (₹ 195967.62) and BCR (1.36) per hectare were recorded under treatment T_{10} *i.e.*, *Azospirillum* (5 l ha^{-1}) + PSB (5 l ha^{-1}) + KMB (5 l ha^{-1}).

Result regarding economics was might be due to T_{10} had the lowest variable cost due to the absent of inorganic fertilizers application. But on other hand, the yield in T_{10} is lowest as compare to other treatment which leads to low net income and BCR as compare to the other treatments. Where in treatment T_8 variable cost is maximum among the other treatments due to application of full dose of inorganic fertilizers but yield of curd is maximum as compare to the other treatments which ultimately increase the net income as well as BCR. Although, plant treated with chemical fertilizers (NPK) with biofertilizers (*Azospirillum*, PSB and KMB) gave the higher yield as compare to the treatment which have only one chemical fertilizers and biofertilizers among three or solo of chemical fertilizers and biofertilizers. The results might be due to the reason that, yield was found higher under the plant treated with T_8 because biofertilizers 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 thereby increased the productivity and ultimately increase the net income as wall as BCR of cauliflower production (Pawar and Barkule, 2018) [6]. These findings are in line with, Sangeeta *et al.* (2014) [9], Islam *et al.* (2014) [4], Kumari *et al.* (2017) [5] and Subedi *et al.* (2019) [12].

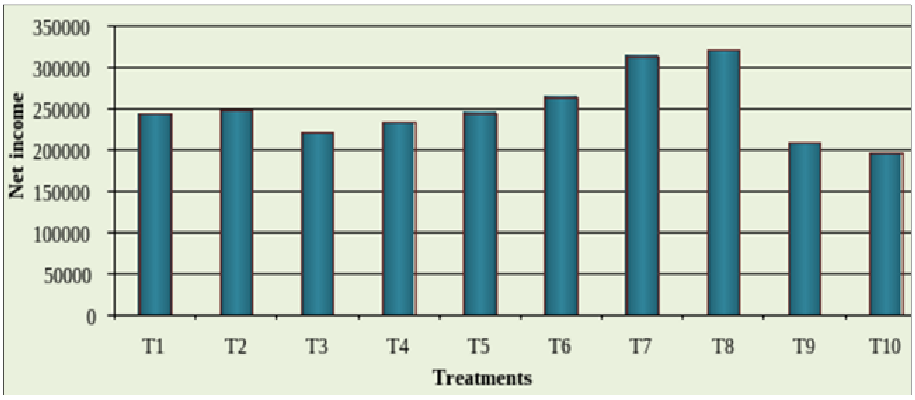

Fig 1: Effect of biofertilizer based nutrient management on Net income of cauliflower production

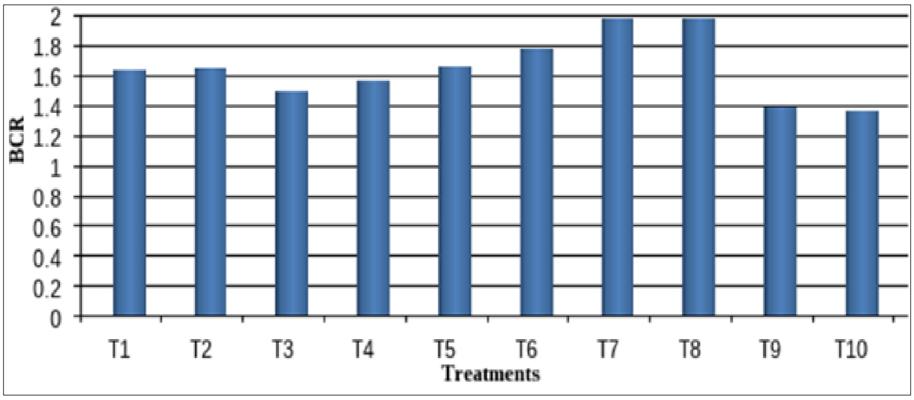

Fig 2: Effect of biofertilizer-based nutrient management on BCR of cauliflower production

Table 1: Details of fixed cost

Description	Rate	Cost (₹)
1. Preparatory tillage		
i) Ploughing by tractor with M. B. plough (8 hr.)	@ ₹ 400/hr.	3,200
ii) Ploughing by tractor with cultivator (8 hr.)	@ ₹ 300/ hr.	2,400
iii) Ploughing by tractor with M. B. plough (8 hr.)	@ ₹ 650/ hr.	5,200
Total		10,800
2. Manures		
i) FYM @ 20 ton/ha	@ ₹ 750/ton	11,400
ii) Expenditure on manure application	@ ₹ 200/ton of FYM	4,000
Total		15,400
3. Layout and Transplanting		
i) Layout, preparation of channel, beds, making furrows and earthing up (6 labours for two days)	@ ₹ 250/labour/day	3,000
ii) Seedlings requires (40,000 nos.)	@ ₹ 0.4/seeding	16,000
iii) Transplanting (35 labours for one day)	@ ₹ 250/labour/day	8,750
iv) Gap filling (5 labours for one day)	@ ₹ 250/labour/day	1,250
Total		26,000
4. Intercultural operations		
i) Weeding (28 labours for one day) 2 times	@ ₹ 250/labour/day	14,000
ii) Interculturing (34 labours for one day)	@ ₹ 250/labour/day	8,500
iii) Blanching (4 labours for six days)	@ ₹ 250/labour/day	6,000
Total		28,500
5. Irrigation application		
i) Irrigation-8 (@20 hours for one ha.)	@ ₹ 30/hour	4,800
ii) Labour charge (two men for one irrigation)	@ ₹ 250/labour/day	4,000
Total		8,800
6. Plant protection		
i) Labour for spraying (2 men for spray)	@ ₹ 250/labour/day	4,000
ii) Chlorpyrifos (@ 2 lit/ha) 1 spray	@ ₹ 475/lit	950
iii) Thiamethoxam (@ 400 ml/ha) 3 spray	@ ₹ 895/lit	1,074
iv) Imidacloprid (@ 300 ml/ha) 2 spray	@ ₹ 1340/lit	804
v) Profenofos (@ 1 lit/ha) 2 spray	@ ₹ 460/lit	920
Total		7,748
7. Harvesting and Marketing		
i) Harvesting (20 labours for one day) 3 times	@ ₹ 250/labour/day	15,000
ii) Transporation (25000 kg/ha)	@ ₹ 10/100 kg	2,500
iii) Uprooting the plants (20 labours for one day)	@ ₹ 250/labour/day	5,000
Total		22,500
Grand total		1,19,748

Table 2: Details of variable cost

Treatments	Require quantity of bio-fertilizers	Cost of bio-fertilizers	Require quantity of chemical fertilizers	Cost of chemical fertilizers	Number of applications with 2 labour	Application cost	Treatment cost
T_1: 75% RDN + *Azospirillum* (5 l ha^{-1})	5 l ha^{-1}	600	326.1 kg urea ha^{-1}	1764.20	5	2500.00	4864.20
T_2: 100% RDN + *Azospirillum* (5 l ha^{-1})	5 l ha^{-1}	600	434.8 kg urea ha^{-1}	2352.20	5	2500.00	5452.20
T_3: 75% RDP + PSB (5 l ha^{-1})	5 l ha^{-1}	600	352.5 kg SSP ha^{-1}	1628.50	3	1500.00	3728.50
T_4: 100% RDP + PSB (5 l ha^{-1})	5 l ha^{-1}	600	434.8 kg SSP ha^{-1}	2008.70	3	1500.00	4108.70
T_5: 75% RDK + KMB (5 l ha^{-1})	5 l ha^{-1}	600	46.87 kg MOP ha^{-1}	201.50	3	1500.00	2301.70
T_6: 100% RDK + KMB (5 l ha^{-1})	5 l ha^{-1}	600	62.5 kg MOP ha^{-1}	268.70	3	1500.00	2368.70
T_7: 75% RDF + *Azospirillum* + PSB + KMB (5 l ha^{-1})	15 l ha^{-1}	1800	326.1 kg urea ha^{-1} 352.5 kg SSP ha^{-1} 46.87 kg MOP ha^{-1}	1764.20 1628.50 201.50	5	2500.00	7894.20
T_8: 100% RDF + *Azospirillum* + PSB + KMB (5 l ha^{-1})	15 l ha^{-1}	1800	434.8 kg urea ha^{-1} 434.8 kg SSP ha^{-1} 62.5 kg MOP ha^{-1}	2352.20 2008.70 268.70	5	2500.00	8929.60
T_9: 100% RDF kg ha^{-1} (200:75:37.5)	NA	NA	434.8 kg urea ha^{-1} 434.8 kg SSP ha^{-1} 62.5 kg MOP ha^{-1}	2352.20 2008.70 268.70	3	1500.00	7129.60
T_{10}: *Azospirillum* + PSB + KMB (5 l ha^{-1})	15 l ha^{-1}	1800	NA	NA	2	1000.00	2800.00
Total							49577.40

Table 3: Effect of biofertilizer based nutrient management on Net income and BCR of cauliflower production

Treatments	Yield (kg ha^{-1})	Fixed cost	Variable cost	Cost A	Cost B	Cost C	Gross return	Net return	BCR
1	2	3	4	5	6	7	8	9	10
				3 + 4	8/16	5 + 6	2 x ₹ 15	8 - 7	9/7
T_1	26140.00	119748.00	5030.51	124778.51	24506.25	149284.76	392100.00	242815.24	1.63
T_2	26580.00	119748.00	5674.01	125422.01	24918.75	150340.76	398700.00	248359.24	1.65
T_3	24550.00	119748.00	4849.50	124597.50	23015.63	147613.13	368250.00	220636.87	1.49
T_4	25430.00	119748.00	5491.44	125239.44	23840.63	149080.07	381450.00	232369.93	1.56
T_5	26110.00	119748.00	2920.22	122668.22	24478.13	147146.35	391650.00	244503.65	1.66
T_6	27460.00	119748.00	3193.75	122941.75	25743.75	148685.50	411900.00	263214.50	1.77
T_7	31490.00	119748.00	9800.23	129548.23	29521.88	159070.11	472350.00	313279.89	1.97
T_8	32070.00	119748.00	11359.20	131107.20	30065.63	161172.83	481050.00	319877.17	1.98
T_9	23960.00	119748.00	8559.20	128307.20	22462.50	150769.70	359400.00	208630.30	1.38
T_{10}	22660.00	119748.00	2800.00	122548.00	21243.75	143791.75	339900.00	196108.25	1.36

Note: Average selling price of cauliflower: ₹ 15 per kg

Treatment detail

T_1	75% RDN + *Azospirillum* (5 l ha^{-1})
T_2	100% RDN + *Azospirillum* (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 + *Azospirillum* (5 l ha^{-1}) + PSB(5 l ha^{-1}) + KMB (5 l ha^{-1})
T_8	100% RDF + *Azospirillum* (5 l ha^{-1}) + PSB(5 l ha^{-1}) + KMB (5 l ha^{-1})
T_9	100% RDF kg ha^{-1} (200:75:37.5)
T_{10}	*Azospirillum* (5 l ha^{-1}) + PSB(5 l ha^{-1}) + KMB (5 l ha^{-1})

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