



Study on effect of integrated nutrient management on growth and yield of cauliflower (*Brassica oleracea* var. *botrytis* L.)

Rohit Pawar* and Santosh Barkule

84/B, Baba Sadan, Jotirling Colony, Golibar Maidan, Godoli, Satara-415001 (Maharashtra), INDIA

*Corresponding author. E-mail: rohitpawar0099@gmail.com

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Abstract: In order to investigate the effect of integrated nutrient management on growth and yield components in Cauliflower, *Brassica oleracea* var. *botrytis* L., cv. Pusa snowball- 16, an experiment was conducted using Randomized Block Design with two replications. The experiment comprised of 14 different treatment combinations comprising of different sources of nutrients including organic, inorganic and bio-fertilizers. The growth parameters like height of plant (12.10, 23.50 cm), number of leaves per plant (9.10, 14.40) and diameter of stem (1.20, 2.10 cm) at 40 and 60 DAT respectively, the days required for curd initiation (62.00 days), days required for curd maturity (85.70 days) and staying period of curd (9.50 days) were observed maximum in treatment combination 75 % RDF + FYM + *Azotobacter* + *Azospirillum* (T₆). The yield parameters like weight of curd per plot (17.50 kg/plot) and yield per hectare (180.04 q/ha) which was increased 44.10 per cent over RDF. From the studies it can be inferred that the application of 75 % RDF + FYM along with *Azospirillum* and *Azotobacter* was found to be the most effective treatment combination for getting enhanced growth and yield in cauliflower.

Keywords: Cauliflower, Fertilizers, Growth, Yield

INTRODUCTION

Vegetable plays an important role in human nutrition. These are indispensable group of food, providing vitamins, minerals, protein, carbohydrates and fibers in the diet, besides having medicinal value and provide nutritional security. Among different vegetables, cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most important winter vegetable among the cole crops which belongs to the genus *Brassica* of the family Cruciferae. Cauliflower is essentially a cold weather hardy crop and thrives best in cool and moist climate. Cauliflower is the fifth most important vegetable crop in India, primarily grown in the winter season. In India cauliflower grown over an area 433.9 thousand ha with production of about 5873.3 thousand MT/ha and productivity is 19.8 MT/ha. The dramatic increase in vegetable productivity and the increase in fertilizer consumption point to the crucial role of fertilizers. In 2014, the highest area and production of cauliflower is in West Bengal ie.73.6 thousand ha, 1879.0 thousand MT/ha respectively (Anonymous, 2014).Cauliflower is being grown round the year for its white and tender curd. It is widely cultivated all over India and abroad for its special nutritive values, high productivity and wider adaptability under different ecological conditions. Like other vegetable crops of the family cauliflower are a heavy feeder of mineral elements, it removes large amount of macronutrients from the soil. Heavy manuring has been recommended for getting

good yield of cauliflower by different workers in India (Roy, 1981, Randhawa and Khurana, 1983). Mineral nutrition does play an important role in influencing the quality of crops and it is fact that the soil health deteriorates due to continuous use of chemical fertilizers, (Savci, 2012). The integrated nutrient management paves the way to overcome these problems, which involves conjunctive use of chemical fertilizers and organic manures to sustain crop production as well as maintenance of soil health (Nanjappa *et al.*, 2001). Systematic approach to nutrient management by tapping all possible sources of organic and inorganic in a judicious manner to maintain soil fertility and crop productivity is the essence of integrated nutrient management (INM).

In addition, utilization of bio-fertilizers, which have a ability to enrich the soil with beneficial microorganisms as well as to mobilize the nutritionally important elements like P, K and micronutrients like Zn, Mo (Mishra and Dash, 2014) from non-usable to usable forms through biological processes resulting in enhanced production of fruits and vegetables offer an alternative. The use of biofertilizers in combination with chemical fertilizers and organic manures offers a great opportunity to increase the production as well as quality of cauliflower. Bio-fertilizers can symbiotically associate with plant roots. Involved microorganisms could readily and safely convert complex organic material into simple compounds, so that they are easily

taken up by the plants. Microorganism function is in long duration, causing the soil fertility. It maintains the natural habitat of the soil. It increases crops yield by 20-30 %, replaces chemical nitrogen and phosphorus by 25 % and stimulates plant growth. It can also provide protection against drought and some soil-borne diseases (Purkayastha *et al.*, 1998). Among the nitrogen fixing bacteria, *Azotobacter*, not only provides nitrogen, but also synthesizes growth promoting hormones such as IAA and GA. *Azospirillum* also helps in plant growth and increases the yield of crops by improving root development, mineral uptake etc. The positive role of these bio-fertilizers has been recorded in many vegetables and spice crops by different scientists. To maintain long term soil health and productivity there is a need for integrated nutrient management through manures and bio-fertilizers apart from costly chemical fertilizers for better yield of the crop (Mondal *et al.*, 2003).

Therefore, the present investigations were undertaken to study the effect of inorganic fertilizers alone and in combination with different bio-fertilizers on growth and yield of cauliflower.

MATERIALS AND METHODS

The present investigation on effect of integrated nutrient management on growth and yield of cauliflower was carried out at vegetable Research Farm of Department of Horticulture, College of Agriculture, Latur, under Vasantrao Naik Marathawada krishi vidyapeeth Parbhani in Maharashtra. The experiment was laid out in randomized block design with two replications comprising of fourteen treatment combinations (Table 1). The seeds were sown in raised nursery beds. After sowing, seeds were covered with a thin film of soil mixed with Farm Yard Manure. Thereafter, paddy straws mulching was incorporated to reduce moisture loss. The beds were irrigated twice a day with the help of water can to maintain optimum moisture in soil.

Twenty five days old seedlings were used for transplanting in the main field. The required quantity of bio-fertilizers such as *Azotobacter* and *Azospirillum* (10

kg/ha) was mixed in soil and given to the respective plots. The FYM (10 t/ha) and NPK (120:80:40 kg/ha) was applied as per the decided treatments in which half dose of nitrogen through urea along with the full dose of phosphorous through single super phosphate and potassium through murate of potash was applied. The half dose of nitrogen was given as per treatments after 30 days of transplanting. Healthy uniform seedlings of four weeks age were selected for transplanting and they were treated with bavistin @ 2 g /lit and transplanted in the plot size 3.6 m x 2.7 m at spacing of 60 x 45 cm. Thus, the numbers of plants per plot were 36. Light irrigation was given immediately after transplanting.

The observations were recorded for growth and yield attributing characters viz. plant height (cm), stem diameter (cm), number of leaves per plant, leaf area per plant (cm²), number of days taken to curd initiation, number of days taken to curd maturity, staying period of curd, yield per plot (kg), yield per hectare (q/ha). Five plants in each treatment combination and in each replication were randomly selected and tagged properly for recording various observations.

The experimental data of all the parameters was subjected to statistical analysis for proper interpretation. The statistical analysis of data in respect of the growth and yield components was done according to the standard procedure given for randomized block design by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

The data pertaining to the various observations on growth and yield parameters in cauliflower have been shown in Table 2a, 2b, 3 and 4. Vegetative growth of a cauliflower plant was characterized by plant height, number of leaves, diameter of stem etc., which influenced the total yield of crop.

Growth characters: Marked effect in height of the plant was obtained when supplied with inorganic fertilizers in combination with organic manure and bio-fertilizers than sole application of inorganic fertilizers. The data revealed that the height of plant was significantly influenced due to different treatments of INM at different growth stages. At 20 Days after Transplanting (DAT), the maximum plant height (7.20 cm) was recorded in the treatment of 100 % RDF + *Azotobacter* + *Azospirillum* (T₃), and it was at par with treatments T₄, T₂, T₁, T₆, T₅, T₇ and T₈. Whereas, the minimum plant height (4.25 cm) was recorded in the treatment T₁₀. At 40 DAT, the treatment of 75 % RDF + FYM + *Azotobacter* + *Azospirillum* (T₆) has recorded maximum plant height (12.10 cm) while, rest of the treatments were at par except T₁₀ and T₁₄. The minimum plant height (8.60 cm) was recorded in treatment control (T₁₄). At 60 DAT, the treatment of 75 % RDF + FYM + *Azotobacter* + *Azospirillum* (T₆) was recorded maxi-

Table 1. Treatment details and their symbols.

Treatments details	Symbol
100 % RDF (120:80:40 kg/ha.)	T ₁
100 % RDF+ FYM+ <i>Azotobacter</i> + <i>Azospirillum</i>	T ₂
100 % RDF + <i>Azotobacter</i> + <i>Azospirillum</i>	T ₃
100 % RDF + FYM + <i>Azotobacter</i>	T ₄
100 % RDF+ FYM + <i>Azospirillum</i>	T ₅
75 % RDF + FYM + <i>Azotobacter</i> + <i>Azospirillum</i>	T ₆
75 % RDF + <i>Azotobacter</i> + <i>Azospirillum</i>	T ₇
75 % RDF+ FYM + <i>Azotobacter</i>	T ₈
75 % RDF+ FYM + <i>Azospirillum</i>	T ₉
50 % RDF+ FYM + <i>Azotobacter</i> + <i>Azospirillum</i>	T ₁₀
50 % RDF+ FYM + <i>Azotobacter</i>	T ₁₁
50 % RDF + FYM + <i>Azospirillum</i>	T ₁₂
50 % RDF + <i>Azotobacter</i> + <i>Azospirillum</i>	T ₁₃
Control.	T ₁₄

Table 2 a. Effect of different INM treatments on growth parameters of cauliflower plant at different growth stages.

Tr. No.	Treatments	Plant Height (cm)			Number of leaves per plant		
		20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
T ₁	100 % RDF (120:80:40 kg/ha.)	5.90	11.30	17.80	6.00	7.50	12.50
T ₂	100 % RDF+ FYM+ <i>Azotobacter</i> + <i>Azospirillum</i>	5.95	12.00	21.40	5.10	8.40	11.70
T ₃	100 % RDF + <i>Azotobacter</i> + <i>Azospirillum</i>	7.20	11.60	20.00	6.20	8.20	12.00
T ₄	100 % RDF+ FYM + <i>Azotobacter</i>	6.30	11.60	21.30	5.40	7.20	12.60
T ₅	100 % RDF+ FYM + <i>Azospirillum</i>	5.60	10.60	18.50	5.60	7.70	11.80
T ₆	75 % RDF + FYM + <i>Azotobacter</i> + <i>Azospirillum</i>	5.85	12.10	23.50	5.55	9.10	14.40
T ₇	75 % RDF + <i>Azotobacter</i> + <i>Azospirillum</i>	5.55	10.80	17.50	5.30	7.70	12.80
T ₈	75 % RDF+ FYM + <i>Azotobacter</i>	5.30	10.60	18.40	4.40	8.20	13.10
T ₉	75 % RDF+ FYM + <i>Azospirillum</i>	5.10	9.60	17.50	4.70	7.00	11.40
T ₁₀	50 % RDF+ FYM + <i>Azotobacter</i> + <i>Azospirillum</i>	4.25	8.70	16.30	4.50	6.90	11.90
T ₁₁	50 % RDF+ FYM + <i>Azotobacter</i>	4.40	9.40	15.30	4.90	7.60	12.70
T ₁₂	50 % RDF + FYM + <i>Azospirillum</i>	5.25	9.70	16.60	5.00	7.20	12.20
T ₁₃	50 % RDF + <i>Azotobacter</i> + <i>Azospirillum</i>	4.55	9.40	16.30	3.90	6.80	11.80
T ₁₄	Control	4.50	8.60	14.90	4.50	6.20	11.20
	S.E. ±	0.63	0.88	1.05	0.34	0.39	0.48
	C.D. at 5%	1.92	2.70	3.22	1.06	1.19	1.49

imum plant height (23.50 cm) and treatments T₂ and T₄ were found statistically at par and recorded plant height of 21.40 cm and 21.30 cm respectively. The least plant height (14.90 cm) was recorded in treatment control (T₁₄).

The maximum increase in plant height in the treatment T₆ could be due to nitrogen being a constituent of amino acids, nucleotides, nucleic acids, a number of co-enzymes, auxins, cytokinins and alkaloids, induces cell elongation, cell enlargement and cell division. The increase in plant height could be because of certain growth promoting substances secreted by the *Azospirillum*, which in turn, might have led to better root development, better transportation of water, uptake and deposition of nutrients. Thus, sufficient nutrient availability required for better growth of plants which in turns leads to increase in height of plants. The similar trend of result was also reported by Sable and Bhamare (2007), who reported that, the combined application of *Azotobacter* and *Azospirillum* increase the plant height. These results are also in agreement with the finding of

Shree *et al.* (2014).

Maximum numbers of leaves At 20 DAT, the average numbers of leaves were maximum (6.20) in treatment of 100 % RDF + *Azotobacter* + *Azospirillum* (T₃) while, the treatments T₁, T₅, T₆, T₄ and T₇ were statistically at par. The treatment T₁₃ was recorded the least (3.90) number of leaves. At 40 DAT, the average numbers of leaves were maximum (9.10) in treatment of 75 % RDF + FYM + *Azotobacter* + *Azospirillum* (T₆) while, the treatments T₂, T₃ and T₈ were statistically at par. The treatment control (T₁₄) has recorded the least (6.20) number of leaves. At 60 DAT, the treatment of 75 % RDF + FYM + *Azotobacter* + *Azospirillum* (T₆) recorded maximum leaves per plant (14.40) and it was at par with the treatment T₈. The minimum numbers of leaves (11.20) were recorded in the treatment control (T₁₄).

The maximum number of leaves in treatment T₆ could be attributed to timely supply of nutrients particularly nitrogen which is required for vegetative growth of plant in this treatment. The FYM as a source of organ-

Table 2 b. Effect of different INM treatments on growth parameters of cauliflower plant at different growth stages.

Tr. No.	Treatments	Diameter of stem (cm)			Leaf area per plant (cm ²)		
		20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
T ₁	100 % RDF (120:80:40 kg/ha.)	0.65	1.10	1.70	121.95	3372.50	12298
T ₂	100 % RDF+ FYM + <i>Azotobacter</i> + <i>Azospirillum</i>	0.60	0.90	1.70	134.20	3777.10	13678
T ₃	100 % RDF + <i>Azotobacter</i> + <i>Azospirillum</i>	0.65	1.00	1.75	129.20	3291.25	12457
T ₄	100 % RDF + FYM + <i>Azotobacter</i>	0.50	0.90	1.55	103.10	3542.70	12108
T ₅	100 % RDF+ FYM + <i>Azospirillum</i>	0.55	1.00	1.80	118.90	3265.00	11867
T ₆	75 % RDF + FYM + <i>Azotobacter</i> + <i>Azospirillum</i>	0.55	1.20	2.10	114.80	3483.70	13033
T ₇	75 % RDF + <i>Azotobacter</i> + <i>Azospirillum</i>	0.50	1.00	1.75	104.00	3318.00	12229
T ₈	75 % RDF+ FYM + <i>Azotobacter</i>	0.50	1.20	1.85	96.10	3253.10	11991
T ₉	75 % RDF+ FYM + <i>Azospirillum</i>	0.50	0.90	1.60	91.47	2594.90	10434
T ₁₀	50 % RDF+ FYM + <i>Azotobacter</i> + <i>Azospirillum</i>	0.55	0.90	1.65	105.85	2643.00	11480
T ₁₁	50 % RDF+ FYM + <i>Azotobacter</i>	0.60	0.90	1.65	106.80	2739.70	12549
T ₁₂	50 % RDF + FYM + <i>Azospirillum</i>	0.45	0.90	1.80	96.75	2781.70	11393
T ₁₃	50 % RDF + <i>Azotobacter</i> + <i>Azospirillum</i>	0.45	0.90	1.75	84.55	2306.70	12784
T ₁₄	Control	0.45	0.80	1.40	83.60	2132.40	10182
	S.E. ±	0.04	0.08	0.12	8.46	829.21	1832
	C.D. at 5%	0.13	0.24	0.37	25.80	N.S.	N.S.

Table 3. Effect of different INM treatments on curd initiation, curd maturity and staying period of cauliflowerer.

Tr. No.	Treatments	Days required for curd initiation	Days required for curd maturity	Staying period of curd (Days)
T ₁	100 % RDF (120:80:40 kg/ha.)	70.50	90.70	7.75
T ₂	100 % RDF+ FYM + Ab. + Ap.	69.80	87.10	6.25
T ₃	100 % RDF + Ab. + Ap.	66.50	89.40	6.75
T ₄	100 % RDF + FYM + Ab.	67.50	89.50	6.95
T ₅	100 % RDF+ FYM + Ap.	69.50	89.70	7.25
T ₆	75 % RDF + FYM + Ab. + Ap.	62.00	85.70	9.25
T ₇	75 % RDF + Ab. + Ap.	68.20	86.80	7.00
T ₈	75 % RDF+ FYM + Ab.	66.30	89.20	8.25
T ₉	75 % RDF+ FYM + Ap.	66.40	89.50	6.75
T ₁₀	50 % RDF+ FYM + Ab. + Ap.	67.30	88.80	7.75
T ₁₁	50 % RDF+ FYM + Ab.	71.80	94.90	6.75
T ₁₂	50 % RDF + FYM + Ap.	75.50	93.80	5.75
T ₁₃	50 % RDF + Ab. + Ap.	75.20	96.30	6.75
T ₁₄	Control.	76.20	97.20	5.75
	S.E. ±	2.43	2.21	0.52
	C.D. at 5%	7.48	6.76	1.60

ic manure might have helped in development of the physical properties of soil like porosity, aeration and water holding capacity. The soil application of bio-fertilizers might have helped to increase the biological nitrogen fixation and availability of phosphorus required for strong vegetative growth. Thus, it ultimately leads to production of more number of leaves in this treatment. The minimum number of leaves in control treatment is obvious, might be due to lack of proper amount of nutrient needed for production of more number of leaves. Similar result has been reported by Peerzada *et al.* (2009) in cabbage. The results are in accordance with the findings of Gurav (2002) who reported that the application of *Azotobacter* and *Azospirillum* with inorganic fertilizers significantly increase the 14.12 number of leaves in cabbage.

The different INM treatments produced significant effect on stem diameter. The maximum diameter of stem At 20 DAT, the maximum stem diameter (0.65 cm) was recorded in T₁ and T₃, while, treatments T₂, T₁₁, T₅, T₆ and T₁₀ which was found at par. Minimum stem diameter (0.45 cm) was recorded in treatments T₁₂, T₁₃ and T₁₄. At 40 DAT, the maximum stem diameter (1.20 cm) was observed in T₆ and T₈ and it was at par with treatments T₁, T₃, T₅ and T₇. The minimum stem diameter (0.80 cm) was recorded in treatment control (T₁₄). At 60 DAT, the maximum stem diameter (2.10 cm) was observed in treatment of 75 % RDF + FYM + *Azotobacter* + *Azospirillum* (T₆) while, the treatments T₈, T₅, T₃ and T₇ were found to be at par with each other. The minimum stem diameter (1.40 cm) was recorded in treatment control (T₁₄). The reason behind this maximum diameter of stem may be due to the more succulence in stem and balanced C: N ratio and sufficient supply of available nutrient from the soil. This might be due to less retention in the roots and more translocation to aerial parts for synthesis of protoplasmic protein and other metabolites enabling the expansion of photosynthetic area due to which the di-

ameter of stem increased. Similar trend of result was also observed in the experimentation of Sable and Bhamare (2007) who reported that the application of inorganic fertilizers plus bio-fertilizers created a favorable condition and supply sufficient nutrients for proper growth of plant.

The result of present investigation indicated that At 20 DAT, the maximum leaf area per plant (134.20 cm²) was recorded in treatment of 100 % RDF + FYM + *Azotobacter* + *Azospirillum* (T₂) while, treatments T₃, T₁, T₅ and T₆ were at par. The minimum leaf area (83.60 cm²) was observed in treatment control (T₁₄). The leaf area per plant was not significantly influenced due to different treatments of INM at 40 and 60 DAT. However, maximum leaf area (3777.10 cm²) at 40 DAT and (13678 cm²) at 60 DAT was recorded in treatment of 100 % RDF + FYM + *Azotobacter* + *Azospirillum* (T₂) while, the minimum leaf area per plant (2132.40 cm²) at 40 DAT and (10182 cm²) at 60 DAT was recorded in treatment control (T₁₄). It indicated that the treatment of application of 100 % RDF have produced the larger leaf area at early stages. This could be attributed to the availability of required quantity of nutrients in general and nitrogen in particular for plants in these treatments. The minimum leaf area (83.60 cm²) in control treatment may be due to lack of required quantity of nitrogen required for production and development of leaves. The non-significant differences in leaf area in advanced stages of crop growth could be due to maximum utilization of absorbed nutrients for completion of vegetative growth of the plant. The scanning of available literature does not show any supporting evidence with the findings of present investigation.

Yield and yield contributing characters: Days required for curd initiation data clearly showed significant variation in days required for curd initiation along with treatments. The minimum days required for curd initiation (62.00 days) were recorded in the treatment

Table 4. Effect of different INM treatments on curd yield parameters of cauliflower.

Tr. No.	Treatments	Weight of curd (g)	Yield per plot (kg).	Yield per hectare (q).	Per cent increase/decrease in yield over RDF
T ₁	100 % RDF (120:80:40 kg/ha.)	688.55	12.14	124.94	---
T ₂	100 % RDF+ FYM + <i>Ab.</i> + <i>Ap.</i>	908.60	17.10	175.92	40.80
T ₃	100 % RDF + <i>Ab.</i> + <i>Ap.</i>	888.60	16.54	162.13	29.77
T ₄	100 % RDF + FYM + <i>Ab.</i>	904.15	15.50	159.48	27.65
T ₅	100 % RDF+ FYM + <i>Ap.</i>	637.55	15.82	160.80	28.70
T ₆	75 % RDF + FYM + <i>Ab.</i> + <i>Ap.</i>	933.30	17.50	180.04	44.10
T ₇	75 % RDF + <i>Ab.</i> + <i>Ap.</i>	800.90	13.51	138.99	11.25
T ₈	75 % RDF+ FYM + <i>Ab.</i>	877.65	16.65	171.32	37.12
T ₉	75 % RDF+ FYM + <i>Ap.</i>	879.75	14.15	145.52	16.47
T ₁₀	50 % RDF+ FYM + <i>Ab.</i> + <i>Ap.</i>	642.00	12.08	124.23	-0.57
T ₁₁	50 % RDF+ FYM + <i>Ab.</i>	480.70	9.87	101.51	-15.55
T ₁₂	50 % RDF + FYM + <i>Ap.</i>	569.25	10.44	107.43	-14.01
T ₁₃	50 % RDF + <i>Ab.</i> + <i>Ap.</i>	528.60	9.57	98.41	-21.23
T ₁₄	Control.	372.70	6.22	64.07	-48.72
	S.E. ±	58.70	1.37	5.31	---
	C.D. at 5%	176.30	4.11	15.93	---

of 75 % RDF + FYM + *Azotobacter* + *Azospirillum* (T₆) while, rest of the treatments were at par except T₁₁, T₁₂, T₁₃ and T₁₄. The maximum days required (76.20 days) was in the treatment control (T₁₄). Days required for curd maturity result showed that, the minimum days required for curd maturity (85.70 days) were in the treatment of 75 % RDF + FYM + *Azotobacter* + *Azospirillum* (T₆) and it was at par with the treatments T₇, T₂, T₁₀, T₈, T₃, T₄, T₅ and T₁. The maximum period required for curd maturity (97.20 days) was recorded in the treatment control (T₁₄). The minimum days required for curd initiation and curd maturity was recorded in treatment of 75 % RDF + FYM + *Azotobacter* + *Azospirillum*, (T₆). However, the maximum days required for curd initiation and curd maturity was recorded in treatment control (T₁₄). The probable reason for early curd initiation and curd maturity might be due to higher dose of N which was not effective as excess of N resulted in lodging by including an undue lengthening of stem internodes which delays the maturation of curds and also affects the curd quality. On the other hand, P nutrient could not be exerting significant effect on days taken for curd formation. Bio-fertilizers secreted hormones which enhances early curd initiation and curd maturity. Similar results have been reported by Sharma *et al.* (2002) in sprouting broccoli and Sable and Bhamare (2007) in cauliflower. These results are in accordance with the findings of Chatterjee *et al.* (2012) who reported that the application of inorganic fertilizers with organic manure and bio-fertilizers has significant effect on curd initiation and curd maturity.

The treatment of 75 % RDF + FYM + *Azotobacter* + *Azospirillum* (T₆) recorded significant results with more staying capacity (9.25 days) and it was at par with treatments T₈, T₁₀ and T₁. The least staying period of curd (5.75 days) was observed in treatment control (T₁₄). This might be due to organic manure and *Azotobacter* and *Azospirillum* apart from nitrogen fixing

potential produced plant growth hormones. These bacteria increased the activity of plant growth substances like Gibberellic acid, Indole acetic acid. While, by *Azospirillum* soil application plant might have responsible for increased vegetative growth which resulted in increasing staying period of curd. The similar trends of result was also reported by Gurav (2002) in cabbage and Sable and Bhamare (2007) in cauliflower who reported that the combination of inorganic fertilizers, organic manure and bio-fertilizers significantly increase the staying period of curd.

The data on the yield parameter indicated the significant differences. Curd yield per plot and yield per hectare observed significant variation in response to the levels of application of inorganic fertilizers with organic manure and bio-fertilizers. The treatment of 75 per cent RDF + FYM + *Azotobacter* + *Azospirillum* (T₆) recorded maximum yield in both yield per plot as well as yield per hectare (17.50 kg/plot, 180.04 q/ha) and it was at par with the treatment T₂ (17.10 kg/plot, 175.92 q/ha) and T₈ (16.65 kg/plot, 171.32 q/ha). Lowest yield per plot as well as yield per hectare was recorded in treatment control (T₁₄) i.e. 6.33 kg per plot, 64.07 q per ha. The per cent increase in yield over RDF was recorded maximum (44.10 per cent) in the treatment of 75 % RDF+ FYM + *Azotobacter* + *Azospirillum* (T₆) while, followed by (40.80 per cent) in treatment of 100 % RDF+ FYM + *Azotobacter* + *Azospirillum* (T₂). The decrease in yield comparison with RDF (-48.72 per cent) was recorded in treatment Control (T₁₄). The contribution of 75 % RDF with FYM and bio-fertilizers to increase in yield can be attributed to the balanced C: N ratio and enhanced availability of essential plant nutrient hence, increased rate and efficiency of metabolic activities resulting in higher assimilation of proteins and carbohydrates. The beneficial role of added FYM and bio-fertilizers in improving soil physical, chemical and biological properties was well known, which in turn helped in better

nutrient absorption by the plant resulted in better yield. Increased in yield can also be attributed to sustained availability of nutrient throughout the growing season also efficacy of inorganic fertilizers is much pronounced when they were combined with organic manure and bio-fertilizers. Such beneficial effects of bio-fertilizers and inorganic fertilizers have been recorded by Chatterjee *et al.* (2012) in cabbage and Sable and Bhamare (2007) in cauliflower. The results of the present investigation revealed that the treatment receiving inorganic sources of nutrient with combination of bio-fertilizers was found to be best in all growth and yield parameters except leaf area per plant in cauliflower.

Conclusion

From the result of present investigation, it can be concluded that treatment of 75 % RDF + FYM + *Azotobacter* + *Azospirillum* was found significantly superior in comparison with 100 % RDF for getting maximum growth and yield of cauliflower production. The treatment of 75 % RDF + FYM @ 10t/ha + *Azotobacter* @ 10 kg/ha + *Azospirillum* @ 10 kg/ha was proved to be the optimum combination of inorganic and bio-fertilizer for improving the yield in cauliflower. Resource poor farmers who are unable to apply full dose of recommended fertilizer may apply 75 % of recommended dose of fertilizers along with bio-fertilizers in balanced way to maximize yield of crop and almost save the 25 per cent of the cost of fertilizers.

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