Study on the effect of integrated nutrient management (INM) on yield and quality in cauliflower (*Brassica oleracea* var. *botrytis* L.)

Abstract: With the purpose to investigate the effect of integrated nutrient management (INM) on yield in Cauliflower, *Brassica oleracea* var. *botrytis* L., cv. Sabour Agrim, research was conducted using Randomized Block Design with 9 treatments replicated thrice from March 2021 to May 2021. The trial comprised of 9 different treatment combinations consisting varied sources of nutrients including in-organic, organic and bio-fertilizers. The yield parameters like gross curd weight (0.96 kg), marketable curd weight (535 g), yield per plot (13.36 kg) and yield per hectare (26.74 tonnes) were observed maximum in treatment 75%RDF+12.5%FYM+12.5%Vermicompost+Bio-fertilizer (Azotobacter+PSB) (T_6). Similar results were obtained for quality parameters like curd depth (9.09 cm), curd size (322.00 cm^2) and curd solidity (58.81 g/cm). From the studies it was inferred that the application of 75%RDF+12.5%FYM+12.5%Vermicompost+Bio-fertilizer (Azotobacter+PSB) was supposed to be the most effective treatment combination for boosted yield and quality in cauliflower.

Keywords: Integrated nutrient management (INM), Recommended Dose of Fertilizer (RDF), Treatment.

INTRODUCTION

Vegetables being an important source of nutrition are indispensable from our dietary routine. According to season, various vegetables are available. Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one among the important winter vegetable belonging to the genus *Brassica* and family Cruciferae. Cauliflower is essentially a cold weather hardy crop thought to have originated in southern Europe in the Mediterranean region and was introduced to India in 1822 from England (Sawrup and Chatterjee, 1972). Cauliflower is the fifth most important vegetable crop in India, grown in from March to November in the hills and from July to March in the plains covering an overall area of 459 thousand ha with production of about 5873.3 thousand MT/ha and productivity is 19.8 MT/ha.). Cauliflower is a profitable crop for growers because of its flexibility and various uses. Cauliflower is a major horticultural crop in India, grown primarily in states such as Bihar, Uttar Pradesh, Orissa, West Bengal, Assam, Haryana, Jharkhand and Maharashtra with an area of 4,53,000 hectares vis-à-vis with an output of 86,68,000 tonnes and a productivity of 19.13 tonnes per hectare (Anonymous, 2018). Jharkhand state is the country's 11th cauliflower producer. It produces approximately 299.64 thousand MT of curd. The area coverage under cauliflower in Jharkhand is 21.93 thousand ha. The average productivity of cauliflower in the county is 19.53 t ha-1 and in Jharkhand state it was 13.67 t ha-1 in 2018 (NHB Report, 2019). The dramatic increase in vegetable productivity and the increase in fertilizer consumption points to the crucial role of fertilizers. For obtaining higher yield, higher doses of synthetic fertilizers and pesticides are used by the farmers. The imprudent and imbalanced use of fertilizers have further deteriorated the soil. The balanced supply of nutrients through various organic sources can improve the yield and quality of cauliflower. The application of vermicompost and bio inoculants has already been proved to increase the yield and quality of cauliflower (Sharma et al., 2007). Mineral nutrition does play an important role in influencing the quality of crops. The use of INM paves the way to overcome these complications. Organized approach to nutrient management by utilizing all possibilities and combinations of varied sources of organic and inorganic fertilizers can help to maintain soil fertility and crop productivity.

Enriching the soil with beneficial microorganisms and bio-fertilizers can be the additional alternative for enhanced production of vegetables and fruits. They have the inherent ability to enrich the soil as well as to mobilize the various nutritionally important elements and micronutrients like Zn, Mo (Mishra and Dash, 2014) from non-usable to usable forms incorporating biological processes. Using biofertilizers in desired combination with inorganic fertilizers and organic manures bids a countless opportunity to intensify the production and quality as well of cauliflower. Bio-fertilizers can symbioticallyassociate with roots of the plants which readily and without harming the plant converts complex organic material into simple compounds which can be easily taken up by the plants. Micro-organisms maintains the soil fertility in long run and improves the natural habitat of soil.

It increases crops yieldby 20-30 %, replacing the chemical nitrogen and phosphorus by 25 % and arouses plant growth. Among various nitrogen fixing bacteria, *Azotobacter*, not only delivers nitrogen, but varied growth promoting hormones such as IAA and GA are synthesized.

Therefore, the present investigation was undertaken to study the effect of integrated nutrient management (INM) on growth of cauliflower.

MATERIALS AND METHODS

The existing investigation on effect of integrated nutrient management on yield and quality of cauliflower was conducted at the Ranchi Agriculture College's Experimental Farm under department of Horticulture, Birsa Agricultural University, Kanke, Ranchi from March 2021 to May 2021. The experiment was laid out in randomized block design with three replications comprising of nine treatment combinations (Table 1). The seeds of Sabour Agrim were sown in well prepared raised nursery bed.

For transplanting, twenty-five days old seedlings were used. Before transplanting in the main field seedlings were treated by dipping into solution of Azotobacter and PSB (dissolving 200 grams of each bio-fertilizer in 5 litres of water) for 30 minutes. After dipping, seedlings were immediately transplanted in the field.

Nitrogen, phosphorus and potassium were provided through urea, single super phosphate and muriate of potash, respectively. According to the treatment, the full quantity of phosphorus, potash and half of nitrogen was applied as basal dose at the time of transplanting while, remaining ½ quantity of nitrogen was applied after 30 days of transplanting. Seedlings were trans- planted in the plot size 2.25 m x 2.25 m at spacing of 45 x 45 cm. with 25 plants per plot. First light irrigation was given immediately after trans- planting. Re-sowing was carried out after 10 days of transplanting.

The observations were recorded for quality and yield attributing parameters viz. curd depth, curd size, curd solidity, gross curd weight, marketable curd weight, yield per plot and yield per hectare. The observations were recorded on five randomly selected plants in each plot for all the characters under study.

The obtained experimental data of all the parameters were subjected to statistical analysis for proper interpretation. Analysis of variance (ANOVA) was carried out on mean values separately for each character adopting standard analysis of variance technique for RBD design.

The "F" tests have been carried out for testing the significance of the findings. Approximate standard error for each factor was worked out to compare the treatment means and the critical difference (CD) was calculated at 5% level of significance using the following formula.

RESULTS AND DISCUSSION

The data pertaining to the various observations on yield and quality in cauliflower have been shown in Table 2 and 3. Parameters like curd depth, curd size, curd solidity, gross curd weight, marketable curd weight, yield per plot and yield per hectare. characterized the quality and yield of a cauliflower plant.

Quality Parameters:

Curd depth (cm)

Significant differences in curd depth, an indicator of curd size was observed in response to different treatment combinations. The maximum curd depth (9.09cm) was found in the treatment T_6 (75%RDF + 12.5% FYM + 12.5% Vermicompost + Bio-fertilizer). It was found to be statistically at par with T_3, T_4, T_5 and T_8. The result may be attributed to beneficial role of organic manures in improving soil physical, chemical and biological properties which in turn help in better nutrient absorption by plants resulting in better development of the curd. Similar findings were also reported by Neupane et al. (2020) in cauliflower. More curd depth in case of T_6 may be due to increased vegetative growth as induced by integrated nutrient management, which might have accounted for increased carbohydrates accumulation as a result of increased photosynthesis. Similar findings were also observed by Kumar et al. (2010) in cauliflower and Shree et al. (2014) in cauliflower.

Table 1. Treatment details and their symbols.

	Symbol
50%RDF + 25% FYM + 25% Vermicompost	T_1
100% FYM + 5% Jeevamrit (Soil application at fortnightly intervals)	T_2
100% Vermicompost +5% Jeevamrit (Soil application at fortnightly intervals)	T_3
75%RDF + 25% FYM + Bio-fertilizer (Azotobacter+PSB)	T_4
75%RDF + 25% Vermicompost + Bio-fertilizer (Azotobacter+PSB)	T_5
75%RDF+12.5%FYM+12.5%Vermicompost+Bio-fertilizer (Azotobacter+PSB)	T_6
Application of 5% Jeevamrit (Soil application at fortnightly intervals)	T_7
RDF of FYM & NPK (Positive Control)	T_8
Absolute control (Negative Control)	T_9

Table 2. Effect of different INM treatments on quality parameters of cauliflower plant.

	Treatments	**Curd Depth (cm)**	**Curd Size (cm^2)**	**Curd Solidity (g/cm)**
T_1	50%RDF + 25% FYM + 25% Vermicompost	7.49	150.59	42.83
T_2	*100% FYM + 5% Jeevamrit (Soil application at fortnightly intervals)*	7.09	127.79	39.99
T_3	*100% Vermicompost +5% Jeevamrit (Soil application at fortnightly intervals)*	8.49	248.79	55.43
T_4	*75%RDF + 25% FYM + Bio-fertilizer (Azotobacter+PSB)*	8.16	219.09	46.28
T_5	*75%RDF + 25% Vermicompost + Bio-fertilizer (Azotobacter+PSB)*	8.19	232.69	50.75
T_6	*75%RDF+12.5%FYM+12.5%Vermicompost+Bio-fertilizer (Azotobacter+PSB)*	9.09	322.00	58.81
T_7	*Application of 5% Jeevamrit (Soil application at fortnightly intervals)*	6.66	126.79	36.94
T_8	*RDF of FYM & NPK (Positive Control)*	8.79	318.49	54.58
T_9	*Absolute control (Negative Control)*	6.49	103.59	26.93
	Mean	0.44	11.05	3.24
	CD $_{(0.05)}$	1.31	33.13	9.72
	CV (%)	9.67	9.31	12.25

Table 3. Effect of different INM treatments on yield parameters of cauliflower plant.

	Treatments	**Gross Curd Weight (Kg)**	**Marketable curd weight (g)**	**Yield per plot (kg)**	**Yield per plot (t/ha)**
T_1	50%RDF + 25% FYM + 25% Vermicompost	0.81	326	8.15	16.29
T_2	*100% FYM + 5% Jeevamrit (Soil application at fortnightly intervals)*	0.79	285	7.12	14.25
T_3	*100% Vermicompost +5% Jeevamrit (Soil application at fortnightly intervals)*	0.92	456	11.4	22.80
T_4	*75%RDF + 25% FYM + Bio-fertilizer (Azotobacter+PSB)*	0.83	376	9.4	18.80
T_5	*75%RDF + 25% Vermicompost + Bio-fertilizer (Azotobacter+PSB)*	0.88	416	10.4	20.80
T_6	*75%RDF+12.5%FYM+12.5%Vermicompost+Bio-fertilizer (Azotobacter+PSB)*	0.96	535	13.36	26.74
T_7	*Application of 5% Jeevamrit (Soil application at fortnightly intervals)*	0.74	246	6.15	12.30
T_8	*RDF of FYM & NPK (Positive Control)*	0.93	480	12.0	24.00
T_9	*Absolute control (Negative Control)*	0.71	175	4.37	8.75
	Mean	0.04	24.56	0.59	1.23
	CD $_{(0.05)}$	0.12	73.63	1.78	3.68
	CV (%)	8.38	11.62	11.22	11.62

Curd size (cm^2)

The maximum curd size (322 cm2) was found in the treatment T_6 (75%RDF + 12.5% FYM + 12.5% Vermicompost + Bio-fertilizer) which was statistically at par with T_8. The result obtained was in conformity with the findings of Devi et al. (2018) in cauliflower and Mohanata et al. (2018) in sprouting brocolli. This might be due to increase in photosynthetic activity of plant with overall growth and increased chlorophyll content. The increased chlorophyll content produced more photosynthesis which was diverted for the growth of curd and as a such resulted in better nourishment of the curd. This might be due to integrated use of organic manure and chemical fertilizers which recorded more photosynthesis and metabolic activity which might have increased various plant metabolites responsible for cell elongation (Hatwar et al., 2003).

Curd solidity (g/cm)

The maximum curd solidity (61.14 g/cm) was observed in the treatment T_6 (75%RDF + 12.5% FYM + 12.5% Vermicompost + Bio-fertilizer) and was statistically at par withT_3, T_5 and T_8. This might be due to prolonged availability of nutrients from vermicompost treated plots which resulted in increase in compactness of curd as well as weight of the curd which ultimately increased the curd volume. The nitrogen provided by the vermicompost and FYM might have helped the plant in the synthesis of chlorophyll which resulted in increased curd diameter and ultimately volume of the curd. The present findings are in line with those of Chaudhary et al. (2012) in broccoli and Chaudhary et al. (2015) in cabbage.

YIELD PARAMETERS

Gross curd weight (kg)

Yield and productivity along with good quality of cauliflower largely depends on weight and size of the curd. Gross curd weight is an important character as there is a direct and positive correlation of gross curd weight with yield in cauliflower. The observations recorded on gross curd weight clearly indicated that there was significant difference among different treatments for gross curd weight in cauliflower. Maximum values of curd weight (0.93 kg) were recorded in T_6 (75%RDF + 12.5% FYM + 12.5% Vermicompost + Bio-fertilizer), followed by T_5 and T_6, which may be due to the application of chemical fertilizers and organics that increased the initial growth of the plant. The maximum plant height, numbers of leaves, leaf area index etc. increases photosynthetic activity and uptake of nutrients and thus, increased the fresh weight of a plant (Kachari and Korla, 2012). Idnani and Thuan (2007) stated that more gross plant weight could be attributed to optimum soil moisture and slow release of nitrogen from organic sources, bio-fertilizers and integrated effect of all the nutrients. These results were in conformity with those of Sable and Bhamare (2007) and Upadhyay et al. (2012) in cauliflower.

Marketable curd weight (g)

Productivity and quality of cauliflower largely depends on weight and size of the curd. Weight of the curd is an important character as there is a direct and positive correlation of curd weight with yield. The observations recorded on marketable curd weight indicated significant difference among different treatments in cauliflower. Maximum values of curd weight (535 g) were recorded in T_6 (75%RDF + 12.5% FYM + 12.5% Vermicompost + Bio-fertilizer), followed by T_8. The application of inorganic fertilizers, organic manure in combination with bio-fertilizers improved the soil structure as well as biological activity of the soil. This might have reduced the loss of nitrogen by increasing cation and anion exchange capacity of the soil, thereby, enhancing the curd development in cauliflower. Increased weight of curd could be due to the increase in plant height, a number of leaves, and diameter of the stem which might have increased the photosynthetic surface and thus, led to more synthesis and translocation of photosynthate towards the formation of the curd (Pawar and Barkule, 2017). The present findings are in line with those of Wani et al., (2010) in cauliflower, Chatterjee (2010) in cabbage and Chaudhary et al., (2012) in sprouting broccoli.

Yield per plot (kg) and yield per ha(t/ha)

The main objective of cultivation is to have maximum yield for better returns. Yield is responsible for commercial viability of variety and is one of the most important factors attaining highest consideration in the entire research programme. In the present study, maximum yield per plot (13.36 kg) and per hectare (26.74 t/ha) was observed in T_6 (75%RDF + 12.5% FYM + 12.5% Vermicompost + Bio-fertilizer) followed by T_8. Variable levels of yield per plot and per hectare were recorded with respect to the different combination of organic, inorganic and bio-fertilizers.

The increased curd yield with combined application of organic manures and inorganic fertilizers may be due to large uptake and effective utilization of nutrients for increased synthesis of carbohydrates, more vegetative growth and subsequently better partitioning and remobilization of accumulated assimilates towards developing curds i.e sink (Kashyap et al., 2017). According to Tekasangla et.al. (2015), integrated application of chemical fertilizers and organic manures significantly increased yield and yield attributing characters. Integrated application of organic manures and inorganic fertilizers increased the availability of N P K, improved the fertility status of soil and productivity due to which yield attributing characters might have increased. Bashyal (2011) reported that bio-fertilizers inoculation enhances phytohormone production, nitrogen fixation, phosphate solubilization and specific activities of enzymes involved in the metabolic pathway which might be the reason behind growth and yield improvement in cauliflower. The present

findings are in line with those of Sharma and Sharma (2010) and Islam et al., (2014) in cauliflower.

Conclusion

From the outcomes of present investigation, it can be inferred that treatment of 75 % RDF +12.5% FYM + 12.5% Vermicompost + Bio-fertilizer was found significantly superior in comparison with 100 % RDF for attainment of maximum yield and quality of cauliflower production. Resource deprived farmers who are unable to apply full dose of recommended fertilizer may apply 75 % of recommended dose of fertilizers along with bio-fertilizers in well-adjusted way to maximize the yeild and quality of crop.

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