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Growth, Yield and Quality of Cauliflower (*Brassica oleracea* var. *botrytis*) as Affected by Integrated Nutrient Management under Low Hill Region of Himachal Pradesh

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ABSTRACT: The challenge for agriculture over the coming decades will be to meet the world's increasing demand for food in a sustainable way. This is usually accomplished by use of chemical fertilizers and the production of new high yielding varieties. Both components are much expensive and consequently leads to an increase in the total cost production. Overuse of chemical fertilizers not only diminishes agricultural net profit, but also has a negative effect on soil health and crop yield, posing health and environmental risks. Thus, using a minimum effective dose of sufficient and balance quantities of organic and inorganic fertilizers to replace the portion of chemical fertilizers with organic manure is becoming a very promising practice not only for maintaining higher productivity but also for greater crop production stability. Therefore, a field experiment was conducted at the experimental farm of Department of Vegetable Science, College of Horticulture and Forestry Neri, Hamirpur (H.P.) during the Rabi season of 2020-2021 with the objective to study the effect of integrated nutrient management on growth, yield and quality of cauliflower cv. PSBK-1.The experiment was comprising of nine treatments in the plots having dimensions of 2.0 × 1.4 m at a spacing of 60 × 45 cm and randomized complete block design with three replications. The best results for growth and quality parameters *viz.* days to marketable curd maturity (113.33), plant height (74.76 cm), stalk length (8.04 cm), number of leaves per plant (20.83), leaf length (48.75 cm) and dry matter content (10.98 %) were observed in plots fertilized with treatment T_8 i.e. (50% recommended dose of FYM(125q/ha) + 50% sheep manure(96q/ha) + 50% RDF of NPK + fortnight application of jeevamrit @ (5%) followed by treatment T_5 (Recommended dose of sheep manure (192q/ha) as basal dose at the time of field preparation + 75% RDF of NPK + jeevamrit @ 5% (fortnight Application). The yield and its contributing traits *viz.* curd depth (9.03 cm), curd diameter (13.19 cm), marketable curd weight (962.83 g), gross plant weight (2.18 kg) and yield per plot (9.18 kg) also registered maximum in T_8 module. Hence, module T_8 can be recommended for better crop growth, quality and higher yield.

Keywords: INM, cauliflower, jeevamrit, panchgavya, yield, quality.

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis*) is one of the most important vegetable crops in the mustard family (Brassicaceae). This crop is rich in minerals such as potassium, sodium, iron, phosphorus, calcium and magnesium. In India, cauliflower is a major vegetable crop grown mainly in states like Bihar, Uttar Pradesh, Orissa, West Bengal, Assam, Maharashtra, Haryana and Himachal Pradesh having area 4,58,000 hectare with production of 88,40,000 MT and 19.13 tonnes/hectare productivity (Anonymous, 2019). In Himachal Pradesh, cauliflower is cultivated in 5,917 hectares of land with a total production of 1,29.577 MT (Anonymous, 2019). It is important to provide sufficient amounts of nutrients to the soil in a timely and effective manner for good crop cultivation. This is usually achieved by production of new high yielding varieties and use of chemical fertilizers. Both of these components are much expensive and consequently results in increasing the total cost of production which ultimately affects the economy of small and marginal farmers. Also, the overuse of chemical fertilizers to increase the crop production has long run impact on ecology, soil health and other natural resources which ultimately affect living organisms including beneficial soil microorganisms and human beings (Merentola *et al.* 2012). Thus, using a balanced quantity of organic and inorganic fertilizers to replace the portion of chemical fertilizers with organic manures is becoming a very promising practice for maintaining higher productivity and also for greater crop production stability.

In modern intensive agriculture, no single dose of plant nutrients applied through chemical fertilizers, organic

manures, crop residues or bio- fertilizers can meet the entire nutrient need of a crop. Rather, these needs to be used in an integrated manner following a management technology which is practicable, economically viable, socially acceptable and ecologically sound. Integrated nutrient management (INM) is the process of improving and maintaining soil fertility for long-term crop productivity by integrating all available organic, inorganic, and biotic resources in a way that is appropriate for each cropping system and farming situation, considering the environmental, social, and economic implications. INM (integrated nutrient management) is an old-age system but due to subsistence farming as nutrient removal by the crops was very low, its importance was not realized earlier. But at present, because of intensive farming being practiced INM system has a great significance (Mahajan and Sharma, 2005).

Organic fertilizers are ecologically friendly as they encourage the growth of beneficial microbes and enhance soil health (Omotoso *et al.*, 2018). Utilization of the locally produced manure (plant and animal waste) for vegetable production may increase crop yield with reduced use of chemical based fertilizers. The organic manures contain lesser quantities of plant nutrients as compare to chemical fertilizers but the presence of growth promoting enzymes and hormones besides plant nutrients make them vital for improvement of soil fertility and crop production (Bhuma 2001). Farm Yard Manure (FYM) is an important the most valuable organic fertilizer for crop production. FYM is a bulky organic manure for crop production which releases the soil compaction and improves the aeration in addition to supply of plant nutrients (Kale and Bano, 1986).

The Jeevamrit and Panchagavya are low- cost organic preparations and eco- friendly. These organic liquid products enrich the soil with microorganism's mineralization of soil besides enhancing the growth, yield and quality (Sreenivasa *et al*., 2010). The organic liquid formulations contain essential macro and micro nutrients, essential amino acids and growth promoting factors like indole acetic acid (IAA) and gibberellic acid (GA) along with beneficial microorganisms and thus assist in improving the growth, yield and quality of vegetable crops (Gore and Sreenivasa, 2011).

Hence, the study was carried out to check the performance of different doses of organic and inorganic fertilizers on growth, yield and quality of cauliflower.

MATERIAL AND METHODS

The study was undertaken at experimental farm of Department of Vegetable Science, College of Horticulture and Forestry, Neri, Hamirpur. 'Pusa Snowball K-1' recommended variety of cauliflower was selected to check the performance of integrated nutrients. The experiment was comprising of nine treatments having randomized block design and three replications (Table 1). Field was prepared and levelled thoroughly. Calculated quantities of FYM, jeevamrit, panchagavya, sheep manure and other inorganic fertilizers like SSP and MOP were applied in individual plots before sowing of seed. However, urea was applied in split doses; first half at the time of sowing and the other half again in two equal splits, first after one month of sowing and remaining after one month of first application in plots wherever applicable as per treatments. Organic formulations like Jeevamrit and Panchagavya were applied at fortnight interval.

Seedlings were uprooted and transplanted in field at a spacing of 60 × 45 cm after one month of sowing of seed in the nursery. To raise the crop successfully, all the package of practices were followed. Five randomly plants were selected to record the observations in each plot for all the characters under study viz. days to curd maturity, plant height (cm), stalk length (cm), number of leaves per plant, leaf length (cm), curd depth (cm), curd diameter (cm), curd compactness, gross plant weight (Kg), marketable curd weight (g), yield per plot (Kg), total soluble solids (TSS) and dry matter content (%). For proper interpretation, the experimental data of all parameters was subjected to statistical analysis. Standard procedure given for randomized block design by Panse and Sukhatme (1967) were followed for the statistical analysis of data with respect to growth, yield and quality parameters.

Table 1: Details of the treatments.

Treatment	Treatment Details
T_1	Recommended dose of FYM (250q/ha) and NPK (120 kg N, 80 kg P and 75 kg K/ha) at the time of field preparation (**control**).
T_2	Recommended dose of FYM (250q/ha) at the time of field preparation as basal dose + 75% RDF of NPK + jeevamrit @ 5% (fortnight application)
T_3	Recommended dose of FYM (250 q/ha) + 75% RDF of NPK + panchagavya @ 3% (fortnight application)
T_4	75% recommended dose of FYM (187q/ha) at the time of field preparation as basal dose + 50% RDF of NPK + jeevamrit @ 5% (fortnight application) + panchagavya @ 3% (fortnight application)
T_5	Recommended dose of sheep manure (192q/ha) at the time of field preparation as basal dose + 75% RDF of NPK + jeevamrit @ 5% (fortnight Application)
T_6	Recommended dose of sheep manure (192q/ha) at the time of field preparation as basal dose + 75% RDF of NPK + panchagavya @ 3% (fortnight application
T_7	75% recommended dose of sheep manure (144q/ha) at the time of field preparation as basal dose + 50% RDF of NPK + jeevamrit @ 5% (fortnight application) + panchagavya @ 3% (fortnight application)
T_8	50% recommended dose of FYM (125q/ha) + 50% recommended dose of sheep manure (96q/ha) at the time of field preparation as basal dose + 50% RDF of NPK + jeevamrit @ 5% (fortnight application)
T_9	50% recommended dose of FYM (125q/ha) + 50% recommended dose of sheep manure (96q/ha) at the time of field preparation as basal dose + 50% RDF of NPK + panchagavya @ 3% (fortnight application)

RESULTS AND DISCUSSION

A. Growth and Quality

Growth and quality traits were significantly influenced by application of different treatments. Application of 50% recommended dose of FYM (125q/ha) + 50% recommended dose of sheep manure (96q/ha) at the time of field preparation as a basal dose + 50% RDF of NPK + jeevamrit @ 5% (fortnight application) (T_8) observed significantly better results for plant height (74.76 cm), number of leaves per plant (20.83), leaf length (48.75), stalk length (8.04 cm), days to curd maturity (113.33), TSS (6.51°B), and dry matter content (10.98%). Maximum curd compactness (99.67 g/cm) was noticed with the application of Recommended dose of sheep manure (192q/ha) at the time of field preparation as a basal dose + 75% RDF of NPK + jeevamrit @ 5% (fortnight Application) i.e. in T_5 treatment.

Plant height is a pivotal yield component trait associated with plant morphological architecture and other yield related traits. Plant height is generally a genetically controlled character but it is influenced by environmental factors as well. The highest plant height observed with the treatment T_8 in the present studies might be attributed to increased growth and development of crop due to combined application of optimum level of inorganic and organic fertilizers which might have improved the physico-chemical and biological characteristic of the growth medium (Lodhi *et al*., 2017). Singh *et al*. (2015) also noted maximum plant height with the application of integrated use of N, P, K and organic manures in broccoli. According to them, this might be due to the synthesis of proteins from nitrogen which formed the carbohydrates in crop plants which in turn favoured plant height and number of leaves.

According to Shree *et al.* (2014), the significant effect on yield parameters such as plant height, number of leaves, curd weight, yield, curd size index and leaf size index as a consequence of application of N, P and K along with organics might be due to the availability of more nitrogenous compounds to the plant from organic and inorganic sources together which increased the foliage of the plant and thereby increased photosynthesis. The adequate supply of three major nutrients N, P and K expected to regulate the plant physiological functions and morphological responses favourably. These findings are in close conformity with the findings of Simarmata *et al*. (2016).

In present studies, maximum stalk length (8.04 cm) was found with the application of treatment T_8 (50% RDF of FYM + 50% RDF of sheep manure as basal dose at the time of field preparation + 50% RDF of NPK + fortnight application of jeevamrit @ 5%) which was closely followed by T_5 (7.94 cm) and T_2 (7.88 cm). These findings are in close conformity with those of Chahal *et al.* (2019), who observed increase in stalk length by integrated application of different organic and inorganic fertilizers in cauliflower. Increase in stalk length in treatment T_8 might be attributed to less retention in the roots and more translocation of nutrients to aerial parts for synthesis of protoplasmic protein and other metabolites (Rather *et al*. 2018).

Harvesting horticultural produce at the appropriate maturity stage is crucial for optimum yield and to maintain its intrinsic quality for maximum earnings. cauliflower is harvested as soon as the curd attains desirable size, shape and colour. Number of days to harvest is an important trait for cauliflower as it indicates the time period of crop maturity. Harvesting too early or too late reduces productivity and quality of produce. In the present studies, it was found that T_8 took minimum days to attain marketable curd maturity. Chemical fertilization and organic manures may have a significant impact since they increased soil nutritional quality, resulting in a faster rate of crop growth and development. Plants with higher fertility levels had more vegetative growth and early head formation, whereas those with lower fertility had slower growth and development. (Chaubey *et al.*, 2006).

Analysis of data showed significant difference among various treatment combinations for total soluble solids. Maximum total soluble solids (6.51°B) was recorded with treatment T_5 (50% RDF of FYM + 50% RDF of sheep manure as basal dose at the time of field preparation + 50% RDF of NPK + fortnight application of jeevamrit @ 5%) which was statistically at par with treatment T_8 (6.41°B). High TSS in treatment T_8 might be due to increased photosynthetic activity and other mineral resulted improved levels of carbohydrates of cauliflower curd through the way of enzymatic activity that stimulated by plant growth substances produced by application of jeevamrit and other nutrients (Singh *et al.*, 2018).

Curd compactness is the important character in cauliflower which indicates the quality of curd. Curd compactness is inversely correlated with curd depth and the market acceptability of the curds depends upon curd solidity (Singh and Nath, 2012). In the present study, curd compactness was more in T_5 (99.67g/cm) which was statistically at par with T_8 (99.23g/cm), T_2 (98.17 g/cm), T_1 (97.12 g/cm) and T_7 (96.82 g/cm). Quality of cauliflower is usually evaluated by curd solidity or curd compactness. More curd solidity or curd compactness in T_5 might be due to prolonged availability of nutrients which resulted in increase in compactness of curd as well as weight of the curd which ultimately increased the curd volume.

Significant differences among various treatment combinations for dry matter content were also observed. Highest dry matter content (10.98%) was recorded in treatment T_8 (50% RDF of FYM + 50% RDF of sheep manure as basal dose at the time of field preparation + 50% RDF of NPK + fortnight application of jeevamrit @ 5%). Lowest dry matter content (8.91%) was recorded in treatment T_3 (Recommended dose of FYM (250q/ha) as basal dose at the time of field preparation + 75% RDF of NPK + fortnight application of panchagavya @ 3%). Increased dry matter content in curd might be due to the fact that nitrogen is the major constituent of plant protein, amino acids and carbohydrates. So as a result of increased uptake of nitrogen by combined application of organic manures and inorganic fertilizers, dry matter content is also increased (Kumar *et al.* 2012).

Table 2: Effect of INM on growth and quality parameters of cauliflower.

Treatments	Plant height (cm)	Number of leaves	Leaf length (cm)	Stalk length (cm)	Days to maturity	TSS (°B)	Curd compactness (g/cm)	Dry matter content (%)
T_1	66.33	19.00	46.50	7.66	114.66	6.23	97.12	10.00
T_2	68.83	19.16	48.16	7.88	115.00	6.33	98.17	10.17
T_3	63.50	17.50	41.50	7.34	119.66	6.15	93.76	8.91
T_4	68.51	18.16	46.00	7.69	117.00	6.21	95.89	9.06
T_5	72.50	19.66	48.50	7.94	114.33	6.41	99.67	10.27
T_6	65.60	17.94	41.58	7.27	119.00	6.13	94.99	9.16
T_7	69.53	18.38	45.00	7.52	118.33	6.27	96.82	10.01
T_8	74.76	20.83	48.75	8.04	113.33	6.51	99.23	10.98
T_9	65.33	18.16	43.66	7.51	118.00	6.25	96.78	9.49
MEAN	**68.32**	**18.75**	**45.51**	**7.65**	**116.59**	**6.28**	**96.93**	**9.78**
$CD_{0.05}$	**6.71**	**1.72**	**4.00**	**NS**	**NS**	**0.16**	**2.87**	**0.70**
SE(m)	**2.23**	**0.57**	**1.33**	**0.16**	**1.97**	**0.05**	**0.95**	**0.05**
C.V.	**5.28**	**5.47**	**6.15**	**3.47**	**0.58**	**1.97**	**1.97**	**6.94**

B. Yield and yield related traits

Yield and yield related traits were also significantly affected by various combinations of organic and inorganic fertilizers., Gross plant weight (2.18 kg), marketable curd weight (962.83 g), maximum yield per plot (9.18 kg) curd diameter (13.19 cm) and curd depth (9.02 cm) were recorded with the treatment T_8 (Application of 50% recommended dose of FYM (125q/ha) + 50% recommended dose of sheep manure (96q/ha) at the time of field preparation as a basal dose + 50% RDF of NPK + fortnight application of jeevamrit @ 5%) followed by treatment T_5 (i.e.Recommended dose of sheep manure (192q/ha) at the time of field preparation as a basal dose+ 75% RDF of NPK + jeevamrit @ 5% (fortnight Application).

Yield and productivity along with good quality of cauliflower largely depends on weight and size of the curd. Gross plant weight is an important character as there is a direct and positive correlation of gross plant weight with yield in cauliflower. Analysis of data indicated that there was significant difference among different treatments for gross plant weight in cauliflower. Maximum values of gross plant weight (2.18 kg) were recorded in T_8 (50% RDF of FYM + 50% RDF of sheep manure as basal dose at the time of field preparation + 50% RDF of NPK + fortnight application of jeevamrit @ 5%). Treatment T_8 was statistically at par with T_5 (2.03 kg), T_2 (1.97 kg), T_7 (1.94 kg) and T_4 (1.88 kg). The maximum gross weight of plant in treatment T_8 may be due to increased vegetative growth of the plant as induced by integration of various nutrients which might account for increased carbohydrates accumulation as a result of increased photosynthesis

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. Analysis of data showed significant effect of different INM treatments on curd weight. Maximum curd weight (962.83 g) was observed in T_8 (50% RDF of FYM + 50% RDF of sheep manure as basal dose at the time of field preparation + 50% RDF of NPK + fortnight application of jeevamrit @ 5%) which was statistically at par with treatment T_5 (930.83 g) and T_1 (886.23 g). The increase in curd weight might be due to more photosynthesis from a larger area of the leaves and the translocation of photosynthates to the sink which is ultimately the curd (Shree *et al.*, 2014).

Table 3: Effect of INM on yield and yield related attributes of cauliflower.

Treatments	Gross plant weight (kg)	Marketable curd weight (g)	Yield per plot (kg)	Curd diameter (cm)	Curd depth (cm)
T_1	1.61	886.23	8.02	12.29	8.54
T_2	1.97	866.00	8.25	12.79	8.64
T_3	1.49	759.16	6.26	10.90	7.99
T_4	1.88	801.18	7.07	11.74	8.32
T_5	2.03	930.83	8.51	13.02	9.03
T_6	1.76	768.92	6.74	11.44	7.88
T_7	1.94	833.00	7.78	12.08	8.04
T_8	2.18	962.83	9.18	13.19	9.02
T_9	1.65	810.50	6.93	12.17	8.14
MEAN	**1.84**	**846.51**	**7.64**	**12.18**	**8.40**
$CD_{0.05}$	**0.35**	**96.32**	**1.17**	**0.74**	**0.75**
SE(m)	**0.11**	**32.13**	**0.39**	**0.24**	**0.25**
C.V.	**12.14**	**8.33**	**12.42**	**6.16**	**5.15**

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. Analysis of data indicated the significant difference among treatments for yield per plot. In the present study, maximum yield per plot (9.18 kg) was obtained with treatment T_8 (50% RDF of FYM + 50% RDF of sheep manure as basal dose at the time of field preparation + 50% RDF of NPK + fortnight application of jeevamrit @ 5%). Treatment T_8 was statistically at par with treatment T_5 (8.51 kg), T_2 (8.25) and T_1 (8.02 kg), respectively.

With combined application of organic manures and inorganic fertilizers there is increase curd yield and yield related traits and it might 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 (Kashyap *et al*. 2017). With integrated use of various chemical fertilizers and organic manures there is significant increase in curd diameter and curd depth which might be attributed to increase in photosynthetic activity of plant and increased chlorophyll content. Due to increased chlorophyll content the plant produced more photosynthesis which was diverted for the growth and better nourishment of the curd. These results were also in line found by Singh *et al*. (2018) and Neupane *et al*. (2020).

CONCLUSION

In the present study, best results were produced by treatment T_8 (50% recommended dose of FYM + 50% recommended dose of sheep manure + 50% RDF of NPK + fortnight application of jeevamrit @ 5%) in terms of growth, yield and quality characters as well as B: C ratio followed by treatment T_5 (Recommended dose of sheep manure + 75% RDF of NPK + fortnight application of jeevamrit @ 5%).

So, it can be concluded that, integrated application of different chemical fertilizers and organic manures enhances the growth, yield and quality of cauliflower which ultimately results in maximum net returns. Hence, for getting higher yield on sustainable basis, module T_8 (50% recommended dose of FYM + 50% recommended dose of sheep manure + 50% RDF of NPK + fortnight application of jeevamrit @ 5%) can be suggested as a best combination for low hill region of Himachal Pradesh.

Conflict of Interest. None.

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