E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(6): 582-586
Received: 16-03-2024
Accepted: 19-04-2024

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

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i6h.933

Abstract
The study was carried out at the Research farm of Abhilashi University, Mandi (H.P) during the winter season 2023-24. The experiment was laid out in Randomized Block Design comprising of seven treatments with three replications. The treatments were T_1 N: P: K (100%), T_2 Farm Yard Manure (100%), T_3 Poultry Manure (100%), T_4[N: P: K (50%) + Farm Yard Manure (50%)], T_5[N: P: K (50%) + Poultry Manure (50%)], T_6[N: P: K (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)] and T_7 (Control). The results showed that treatment T_5 recorded maximum plant height (51.65 cm), leaf length (47.68 cm), leaf width (23.68 cm), days required for curd initiation (62.43 DAT), curd diameter (14.93 cm), curd weight (878.77 g), yield per plot (7.91 kg) and yield per hectare (292.95 q/ha). Similarly in terms of economics maximum gross income (₹ 5,27,304), net income (₹ 4,14,266) and (3.66) B: C ratio were recorded under treatment T_5. Therefore, T_5 appeared to be the best for achieving the higher growth, yield and economic benefit of cauliflower.

Keywords: Cauliflower, growth, yield, INM, fertilizers

Introduction
Cauliflower (*Brassica oleracea* var. *botrytis* L.) native to Mediterranean region is a temperate vegetable crop belonging to Brassicaceae family. Its basic chromosome number is 2n = 2x = 18. It is most popular for its white tender curd and extensively cultivated throughout the world. The highly suppressed pre-floral apical meristem commonly known as 'curd' is the edible part of this crop. For a good cauliflower crop, high yield, compact, white-colored and medium-sized curds, free from any disease or disorder, are desired (Varalaxmi 2009) [33]. India is the second largest producer of cauliflower followed by China. In India it is grown over an area of 473 thousand hectares with a production of 9.28 million MT (Anonymous 2021a) [1]. West Bengal, Madhya Pradesh, Bihar, Gujarat, Haryana, Orissa, Assam, Uttar Pradesh and Maharashtra are the major cauliflower growing states in India. Being an important off-season vegetable crop of mid and high hills of Himachal Pradesh, it is grown over an area of about 5.64 thousand ha with a production of 135.11 thousand MT (Anonymous2021b) [2].
Cauliflower is a rich source of vitamins A and C along with minerals such as Potassium, Sodium, Calcium, Iron, Phosphorus and Magnesium (Tekasangla *et al*. 2015) [32]. Cauliflower requires greater amount of plant nutrients as it is one of the heavy feeder plant. Constant supply of manures and fertilizer in higher doses is required to obtain good yield (Subedi *et al*.2019) [30]. The farmyard manure itself contains reasonable amounts of nutrients which become available to plants upon decomposition besides enhancing availability of native as well as applied nutrients (Chander *et al*. 2010) [8].The balanced supply of nutrients and scientific management practices has potential to increase the productivity of these vegetable crops. The crop yield and quality can be improved by combined application of inorganic and organic nutrient sources. Low and imbalanced use of chemical fertilizers is one of the major reasons for the low productivity of cauliflower (Dejene and Lemlem 2012) [10]. The integrated nutrient management approach adopts the joint application of both organic and inorganic plant nutrient sources and has the

potential to secure higher crop productivity which also enhances both human health as well as soil health (Bhattarai *et al*. 2012) [5]. Therefore, the full potential of a crop can only be achieved when the nutrient supply system includes both organic and in organic fertilizers.

Materials and Methods

The investigation was conducted during the winter season of 2023-24 at Research Farm, School of Agriculture, Abhilashi University, Mandi (H.P). Geographically the Experimental farm is located at the latitude of 31º33'32''N and longitude of 77º00'40''E and at a height of 1,432 meters above the mean sea level. The study followed Randomized Block Design (RBD) comprising of seven treatment combination and replicated three times. The plot size was 1.3m ×1.8 m and the spacing adopted was plant to plant and row to row 60cm × 45 cm. The observations were recorded on different parameters *viz.*, plant height (cm), leaf length (cm), leaf width (cm),days required for curd initiation (DAT), curd diameter (cm), curd weight (g), yield per plot (kg), yield per hectare (q),soil pH, organic carbon (%) and available NPK (kg/ha) of the soil before and after the experiment. Also on parameters like, cost of cultivation (₹/ha), gross returns (₹/ha), net returns (₹/ha) and Benefit-Cost ratio (B: C). The region experiences high rainfall from June to September's monsoon season while there is moderate to heavy rainfall from October to February along with sporadic snowfall (Figure 1).The soil had a loam texture, was moderatelyacidic in reactivity (Table 1) and the treatment details were givenin (Table 2).

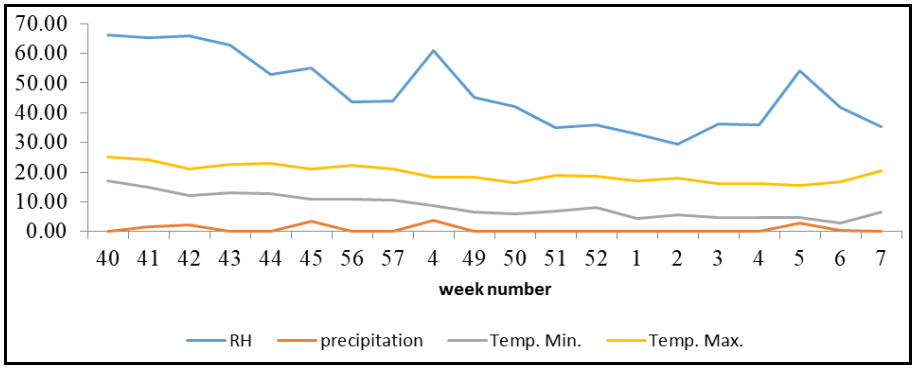

Fig 1: Mean Meteorological data of the experimental farm recorded during October to February

Table 1: Initial chemical parameters of the experimental soil

Sr. No.	Parameters	Values obtained	Methods of analysis reference
1.	Soil pH (1:2.5, soil water suspension)	5.9	Glass electrode method (Jackson, 1973)
2.	Available N (kg/ha)	233.52	Alkaline potassium permanganate (Subbiah and Asija, 1956)
3.	Available P (kg/ha)	13.84	Olsen's method of extraction with 0.5 $NaHCO_3$ at pH 8.5 (Olsen *et al*. 1954)
4.	Available K (kg/ha)	192.78	Neutral ammonium acetate extraction method (Merwin and Peech 1950)
5.	Organic carbon (%)	0.58	Rapid titration method (Walkley and Black 1934)

Table 2: Details of the treatments

Notations	Treatments
T_1	N: P: K (100%)
T_2	Farm Yard Manure (100%)
T_3	Poultry Manure (100%)
T_4	N: P: K (50%) + Farm Yard Manure (50%)
T_5	N: P: K (50%) + Poultry Manure (50%)
T_6	N: P: K (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)
T_7	Control

Result and Discussion

Growth parameter

Growth parameters *viz.* plant height (cm), leaf length (cm), leaf width (cm) and days required for curd initiationwere recorded and presented in Table 3.

Growth parameters of cauliflower were significantly influenced by different treatments. The results showed that maximum plant height (51.64 cm), leaf length (47.68 cm), leaf width (23.68 cm) and minimum days for curd initiation (62.43)were obtained under treatment T_5 [N: P: K (50%) + Poultry Manure (50%)] which was statistically at par with the treatment T_6 [(N: P: K (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)], While the minimum plant height (34.12 cm),leaf length (29.96 cm), leaf width (14.47 cm) and maximum days taken for curd initiation(70.39) were reported in treatment T_7 (Control). NPK fertilizers, with their specific ratios of nitrogen, phosphorus and potassium, promote vigorous vegetative growth, root development and overall plant health, thereby enhancing these growth parameters. Poultry manure, rich in organic matter and essential nutrients, improves soil structure and fertility, providing a balanced and slow-release nutrient supply that supports steady plant growth. When used together, NPK fertilizers and poultry manure can collectivelyoptimize nutrient availability and uptake, resulting in increased plant height, larger leaves and timely curd formation, when applied in appropriate amounts and at the right times. Similar results on effect of integrated nutrient management were reported by Pandey *et al*. (2008) [23], Kumar *et al*. (2013) [15], Jahan *et al*. (2014) [13], Shree *et al*. (2014) [27], Jasim *et al*. (2014) [14], Meena *et al*. (2017) [17], Mohanta *et al*. (2018) [19], (Shanta *et al*. 2019) [26], Basnet *et al*. (2016) [4] and Gyanwali *et al*. (2022) [11].

Yield parameter

Yield parameters *viz.* curd diameter (cm), curd weight (g), yield per plot (kg) and yield per hectare (q) were observed and presented in Table 4.

Yield parameters of cauliflower are significantly influenced by effect of integrated nutrient management practices. Among all the treatments, the maximum curd diameter (14.93 cm), curd weight (878.77 g), yield per plot (7.91 kg) and yield per hectare (292.95 q/ha) were obtained under treatmentT_5 [N: P: K (50%) + Poultry Manure (50%)] which was statistically at par with the treatment T_6 [N: P: K (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)], While the minimum curd diameter (9.38 cm), curd weight (495.67 g), yield per plot (4.46 kg) and yield per hectare (165.24 q/ha) were recorded in treatment T_7 (Control).The increase in yield parameters might be due to the combined application of different chemical fertilizers and organic manures. NPK fertilizers provide essential nutrients that enhance plant growth, leading to larger curd diameters and increased curd weight due to improved nutrient availability and uptake. Whereas poultry manure is rich in organic matter and nutrients, improves soil structure and fertility, promoting vigorous plant development and higher yields. Combined use of NPK and poultry manure enhances soil health and nutrient supply, resulting in increased yield per plot and per hectare by providing both immediate and sustained nutrient release. This integrated approach optimizes plant growth conditions, thereby maximizing overall crop productivity. Similar results were also reported by Pandey *et al*. (2007) [24], Basel *et al*. (2008) [3], Wani *et al*. (2011) [36], Kumar *et al*. (2013) [15], Meena *et al*. (2017) [17], Lodhi *et al*. (2017) [16], Mohanta *et al*. (2018) [19], Singh *et al*. (2018) [28], Rawal *et al*. (2019) [25] Neupane *et al*. (2020) [21] and Biswas *et al*. (2021) [6].

Soil parameters

Soil parameters *viz.* soil pH, organic carbon (%) and available NPK (kg/ha) were recorded after the experiment and results are presented in Table 5.

An introspection of data revealed that soil pH varied from 5.9 to 6.0. This shows that the soil of that area was found to be moderately acidic in reaction. The result revealed that different integrated nutrient management practices had no significant effect on soil pH.

Among all the treatments, maximum organic carbon (0.72%) was found in treatment T_2 [Farm Yard Manure (100%)], whereas lower content of organic carbon (0.56%) was found in treatment T_7 (control). This shows that the soil ismedium in organic carbon %. This may be due the higher amount of organic matter in the soil received through the supply of Farm Yard Manure. These results authenticated the earlier findings of Chahal *et al*. (2019) [7] and Neupane *et al*. (2020) [21].

Available NPK content shown in Table 5 revealed that highest content of available nitrogen (289.73 kg/ha), phosphorus (26.34 kg/ha) and potassium (229.79 kg/ha) was observed in treatment T_1 [N: P: K (100%)]. whereas lower content of available nitrogen (221.64 kg/ha), phosphorus (12.76 kg/ha) and potassium (185.91 kg/ha) were recorded in treatment T_7 (control).Treatment T_1 [N: P: K (100%)] Increase in available nitrogen, phosphorus and potassium content might be due to the application of full dose of NPK, which also resulted in increased soil fertility. While decreased content of NPK in soil might be due to the absence of nutrient application in controlled plots. Similar results are supported by Singh *et al*. (2018) [28], Walling *et al*. (2022) [35] and Tarafder *et al*. (2023) [31].

Economics

Economic parameters *viz.* gross returns (₹/ha), net returns (₹/ha) and Benefit-Cost ratio (B: C) were observed and presented in Table 6. The results showed that maximum gross returns₹ 5,27,304, higher net returns ₹ 4,14,266 and maximum B: C ratio 3.66 were incurred in treatment T_5 [N: P: K (50%) + Poultry Manure (50%)] followed by treatment T_6[N: P: K (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)]. Whereas lowest gross returns₹ 2,97,426, net returns ₹ 1,96,300 and B: C ratio 1.94 were observed in treatment T_7 (control). The results were supported by Singh *et al*. (2018) [28].

Table 3: Effect of integrated nutrient management practices on plant height (cm), leaf length (cm), leaf width (cm) and days required for curd initiation

Treatment code	Treatments	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Days required for Curd Initiation
T_1	N: P: K (100%)	45.24	40.87	19.87	65.42
T_2	Farm Yard Manure (100%)	38.67	32.52	16.54	68.26
T_3	Poultry Manure (100%)	41.38	37.64	18.26	66.84
T_4	N: P: K (50%) + Farm Yard Manure (50%)	43.77	38.26	19.72	66.09
T_5	N: P: K (50%) + Poultry Manure (50%)	51.64	47.68	23.69	62.43
T_6	N: P: K (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)	48.53	44.72	21.38	63.75
T_7	Control	34.12	29.96	14.47	70.39
SE(m)		1.18	0.82	0.85	0.83
$CD_{(0.05)}$		3.65	2.53	2.63	2.55

Table 4: Effect of integrated nutrient management practices on curd diameter (cm), curd weight (g), yield per plot (kg) and yield per hectare (q)

Treatment code	Treatments	Curd diameter (cm)	Curd weight (g)	Yield per plot (kg)	Yield per hectare (q)
T_1	N: P: K (100%)	13.37	784.79	7.06	261.62
T_2	Farm Yard Manure (100%)	10.92	662.64	5.96	220.90
T_3	Poultry Manure (100%)	11.39	714.38	6.43	238.15
T_4	N: P: K (50%) + Farm Yard Manure (50%)	12.63	750.83	6.76	250.30
T_5	N: P: K (50%) + Poultry Manure (50%)	14.93	878.77	7.91	292.95
T_6	N: P: K (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)	14.16	843.39	7.59	281.15
T_7	Control	9.38	495.67	4.46	165.24
SE(m)		0.38	19.72	0.18	6.57
$CD_{(0.05)}$		1.17	60.77	0.55	20.26

Table 5: Effect of integrated nutrient management practices on soil pH, organic carbon (%) and available NPK (kg/ha) of the soil after the experiment

Treatment code	Treatments	Soil pH	Organic carbon (%)	Available Nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
T_1	N: P: K (100%)	5.9	0.61	289.73	26.34	229.79
T_2	Farm Yard Manure (100%)	6.0	0.72	245.95	16.51	198.84
T_3	Poultry Manure (100%)	6.0	0.69	265.72	17.49	204.56
T_4	N: P: K (50%) + Farm Yard Manure (50%)	6.0	0.67	269.44	19.76	209.43
T_5	N: P: K (50%) + Poultry Manure (50%)	6.0	0.66	283.58	24.63	217.39
T_6	N: P: K (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)	5.9	0.64	278.19	22.17	213.62
T_7	Control	6.0	0.56	221.64	12.76	185.91
SE(m)		0.09	0.01	4.10	0.62	3.21
$CD_{(0.05)}$		NS	0.03	12.64	1.91	9.90

Table 6: Effect of integrated nutrient management practices on cost of cultivation (₹/ha), gross returns (₹/ha), net returns (₹/ha) and Benefit-Cost ratio (B: C)

Treatment code	Treatments	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B: C ratio
T_1	N: P: K (100%)	1,08,950	4,70,914	3,61,964	3.32
T_2	Farm Yard Manure (100%)	1,31,126	3,97,616	2,66,490	2.03
T_3	Poultry Manure (100%)	1,17,126	4,28,662	3,11,536	2.66
T_4	N: P: K (50%) + Farm Yard Manure (50%)	1,20,038	4,50,534	3,30,496	2.75
T_5	N: P: K (50%) + Poultry Manure (50%)	1,13,038	5,27,304	4,14,266	3.66
T_6	N: P: K (50%) + Farm Yard Manure (25%) + Poultry Manure (25%)	1,16,538	5,06,072	3,89,534	3.34
T_7	Control	1,01,126	2,97,426	1,96,300	1.94

Conclusion

From the present studies it can be concluded that among all the treatments, treatment T_5performed best for most of the growth and yield contributing traits. This treatment also resulted in maximum gross returns (₹ 5,27,304), net returns (₹ 4,14,266) with highest benefit cost ratio of (3.66). Hence, this treatment T_5 [N: P: K (50%) + Poultry Manure (50%)] may be recommended for the commercialization after verification of results by the way of conducting the field trials across the cauliflower growing areas of Himachal Pradesh.

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