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Growth and yield of cauliflower in relation to different organic and inorganic fertilizer levels in inceptisol of Northern Hills Zone of Chhattisgarh

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Abstract
A Field experiment was carried out during the *rabi* seasons of 2021-22 and 2022-23 at the Krishi Vigyan Kendra Balrampur of Indira Gandhi Krish Vishwavidyalaya, Raipur (C.G) to evaluate the effect of INM on yield and yield parameters of cauliflower in relation to different organic and inorganic fertilizer levels in inceptisol of Northern Hills Zone of Chhattisgarh. The experiment was laid down in Randomized Block Design (RBD) with eight treatments which replicated three. The treatments in the T_1 (Control), T_2 RDF (180:120: 100, $N:P_20_5:K_20$), T_3 (75% RDF), T_4 (50% RDF), T_5 (75% RDF + 2.5 t/ha vermicompost), T_6(75% RDF + 5 t/ha FYM), T_7 (50% RDF + 5 t/ha vermicompost) and T_8 (50% RDF + 10 t/ha FYM).

The application of recommended dose of fertilizer along with FYM or vermicompost found significantly superior to produced maximum growth and yield of cauliflower. The results on plant height of cauliflower measured at 20, 40 and 60 days after transplanting, indicated that the positive impact of integrated nutrient management. The highest plant height by application of recommended doses of NPK through RDF or integrated use of organic and inorganic fertilizer ie. (75% of the RDF along with vermicompost) or (75% RDF + 5 t/ha FYM) or (50% RDF + 10 t/ha FYM). The highest curd length was observed in integrated treatments (75% RDF + 2.5 t/ha Vermicompost) (12.65 cm) followed by (75% RDF + 5 t/ha FYM) (11.42 cm). The highest curd breadth was observed in the treatments, (75% RDF + 2.5 t/ha Vermicompost) (14.90 cm), (75% RDF + 5 t/ha FYM) (14.62 cm), (50% RDF + 5 t/ha Vermicompost) (13.42 cm) and (50% RDF + 10 t/ha FYM) (13.27) showed at par curd breath with RDF (180:120:100, N: $P_2O_5:K_2O$) (15.40 cm). the pooled data for curd yield revealed that treatment (75% RDF + 2.5 t/ha Vermicompost) (270.84 qt/ha) , (75% RDF + 5 t/ha FYM) (268.65 qt/ha), (50% RDF + 5 t/ha Vermicompost) (263.11 qt/ha) and (50% RDF + 10 t/ha FYM) (259.24 qt/ha) which were statistically at par with each other and also with RDF (180:120:100, $N:P_2O_5:K_2O$) (278.42 qt/ha). The lowest yield was observed in control (125.05 qt/ha).

Keywords: INM, FYM, vermicompost yield

Introduction

Cauliflower is an important cole crop and Dr. Jemson at Saharanpur first introduced it to India in 1822 during the period of East India Company (Rai and Yadav, 2005) [7] and contains 2.4 g, calcium 22 mg, vitamin A 40 IU, ascorbic acid 70 mg, thiamine 0.2 mg, riboflavin 0.1 mg and niacin 0.75mg, 100g of edible portion. It is a source of sinigrin, isothiocyanates, S-methylcysteine sulfoxide and glucobrassicin which have prominent anti-carcinogenic property.

India is the second largest producer of cauliflower in the world and occupies 452.1 (000'ha) area with a production of 8498.9 (000 MT) and productivity of 18.8 (MT ha^{-1}) (Anonymous, 2022) [1, 2]. In Chhattisgarh major cauliflower producing districts are Durg, Surguja, Balod, Surajpur, Bemetara, Korba, Kanker, Bilaspur with highest production rate in Kondagaon (Horticultural statistics at a glance, 2022). In Chhattisgarh total cultivated area is 23.95 ('000 ha), with production 453.9 (000 MT) (Anonymous, 2022) [1, 2]. Cauliflower exported from India to various countries. In India, the average per capita daily vegetable consumption is approximately 125-130 g. However, the Indian Council of Medical Research recommends a daily intake of 285-300 g of vegetables and there is a need to produce 220 million tonnes of vegetables based on current production levels.

This can be accomplished through improved high-yielding varieties, implementing effective and scientific crop nutrient management practices.

Cauliflower removes large amount of various nutrients from the soil and manuring integrated with chemical fertilizer will play an important role for maintaining sustainable crops yield and quality as well as soil health. In view of above facts, a study was planned to evaluate the cauliflower yield using nutrient management strategies, considering both quantity and quality aspects.

Materials and Methods

The experiment was conducted at krishi Vigyan Kendra Balrampur of Indira Gandhi Krish Vishwavidyalaya, Raipur (C.G) during *Rabi* 2021-22 and 2022-23. The District Balrampur is located in the Northern Hill of Chhattisgarh state, India, which has latitudes 23°08'49'to 24°06'22''N and longitudes 82°41'48''to 84°04'38''E.The experiment was laid down in Randomized Block Design (RBD) with eight treatments which replicated three. The treatments in the T_1 (Control), T_2 RDF (180:120:100, $N:P_20_5:K_20$), T_3 (75% RDF), T_4 (50% RDF), T_5 (75% RDF + 2.5 t/ha vermicompost), T_6 (75% RDF + 5 t/ha FYM), T_7 (50% RDF + 5 t/ha vermicompost) and T_8 (50% RDF + 10 t/ha FYM). The district experiences sub-tropical climate and is characterized by extreme summer and winter seasons. The mean daily maximum temperature in summer season goes up to 46 °C. The rainy season extends from the June to September with well distributed rainfall through South West monsoon. Winter season is marked by dry and cold weather with intermittent showers during the months of December and January. January is the coldest month. The mean daily maximum temperature at 30 °C and the minimum is around 10 °C. The experimental soil are sand clay loam texture.P^H was slightly acidic, organic carbon and nitrogen was low and Available Phosphorus, potassium are mediam. Available soil micronutrient Fe, Mn, Zn and B are sufficient. The Cauliflower variety Girija is a hybrid from Seminis Seeds (Monsanto), showcases a slightly open plant structure. It boasts dome-shaped and compact curds that are milky white in color, weighing an average of 1 to 1.5 kg with a moderate to good self-covering ability and mature in 60 to 70 days after transplanting.

Results and Discussion

Plant height

The plant height is one of the important characteristics, which indicate the nutrient absorption capacity as well as health of the plant. Application of RDF (recommended dose of fertilizer) alone or with combination of different organic produce significantly influenced the plant height at 20 DAT. All the treatments imposed showed significantly higher plant height compared to control but at par with RDF.

Plant height of cauliflower at 40 DAT was also significantly influenced due to varying treatments applied to cauliflower crop. The treatments T_2 (RDF (180:120:100, $N:P_2O_5:K_2O$) (41.02 cm), T_5 (75% RDF + 2.5 t/ha Vermicompost) (39.80 cm) and T_6 (75% RDF + 5 t/ha FYM) (38.79 cm), Followed by T_7 (50% RDF + 5 t/ha Vermicompost) (37.93 cm), T_8 (50% RDF + 10 t/ha FYM) (37.88 cm) and T_3 (75% RDF) (37.56 cm) were statistically at per each other. The least plant height was observed in control (29.67 cm).

Pooled data on plant height at 60 days indicated that the highest plant height was recorded in T_5 (75% RDF + 2.5 t/ha Vermicompost), (62.74 cm) T_6 (75% RDF + 5 t/ha FYM) (61.38 cm), T_3 (75% RDF) (60.55 cm), T_8 (50% RDF + 10 t/ha FYM) (60.57 cm), T_7 (50% RDF + 5 t/ha Vermicompost) (60.52 cm) which was at per each other and also with T_2 (RDF (180:120:100, $N:P_2O_5:K_2O$) (63.10 cm). While, the least plant height was observed in control (44.92 cm).

Table 1: Effect of integrated nutrient management on plant height at 20 DAT

Treatments	Plant height 20 DAT (cm)		
	2021	2022	Pooled
$T_{1:}$ Control	13.84	12.25^b	13.05^b
$T_{2:}$ RDF (180:120:100, N: $P_2O_5:K_2O$)	15.87	16.29^a	16.08^a
$T_{3:}$ 75% RDF	15.73	15.55^a	15.64^a
$T_{4:}$ 50% RDF	14.24	14.44^{ab}	14.34^{ab}
$T_{5:}$ 75% RDF + 2.5 t/ha Vermicompost	15.8	15.52^a	15.66^a
$T_{6:}$ 75% RDF + 5 t/ha FYM	15.42	15.32^a	15.37^a
$T_{7:}$ 50% RDF + 5 t/ha Vermicompost	15.39	15.22^a	15.3^a
$T_{8:}$ 50% RDF + 10 t/ha FYM	15.2	15.13^a	15.17^a
SEm (±)	0.697	0.687	0.463
CD (p = 0.05)	NS	2.083	1.403

Table 2: Effect of integrated nutrient management on plant height at 40 DAT

Treatment	Plant height 40 DAT (cm)		
	2021	2022	Pooled
$T_{1:}$ Control	29.9^c	29.44^c	29.67^c
$T_{2:}$ RDF (180:120:100, N: $P_2O_5:K_2O$)	40.23^a	41.8^a	41.02^a
$T_{3:}$ 75% RDF	37.93^{ab}	37.18^{ab}	37.56^{ab}
$T_{4:}$ 50% RDF	34.2^{bc}	34.5^{bc}	34.35^b
$T_{5:}$ 75% RDF + 2.5 t/ha Vermicompost	40.1^a	39.5^{ab}	39.8^a
$T_{6:}$ 75% RDF + 5 t/ha FYM	39.03^{ab}	38.54^{ab}	38.79^a
$T_{7:}$ 50% RDF + 5 t/ha Vermicompost	38.2^{ab}	37.65^{ab}	37.93^{ab}
$T_{8:}$ 50% RDF + 10 t/ha FYM	38.4^{ab}	37.35^{ab}	37.88^{ab}
SEm (±)	1.248	1.221	1.073
CD (p = 0.05)	3.787	3.703	3.256

Table 3: Effect of integrated nutrient management on plant height at 60 DAT

Treatments	Plant height 60 DAT (cm)		
	2021	2022	Pooled
$T_{1:}$ Control	45.7^b	44.15^c	44.92^c
$T_{2:}$ RDF (180:120:100, N: $P_2O_5:K_2O$)	63.37^a	62.83^a	63.1^a
$T_{3:}$ 75% RDF	61.17^a	59.93^{ab}	60.55^{ab}
$T_{4:}$ 50% RDF	55.93^a	54.82^b	55.38^b
$T_{5:}$ 75% RDF + 2.5 t/ha Vermicompost	62.6^a	62.88^a	62.74^a
$T_{6:}$ 75% RDF + 5 t/ha FYM	61.53^a	61.23^{ab}	61.38^{ab}
$T_{7:}$ 50% RDF + 5 t/ha Vermicompost	60.17^a	60.86^{ab}	60.52^{ab}
$T_{8:}$ 50% RDF + 10 t/ha FYM	60.47^a	60.68^{ab}	60.57^{ab}
SEm (±)	1.921	1.781	1.773
CD (p = 0.05)	5.828	5.401	5.377

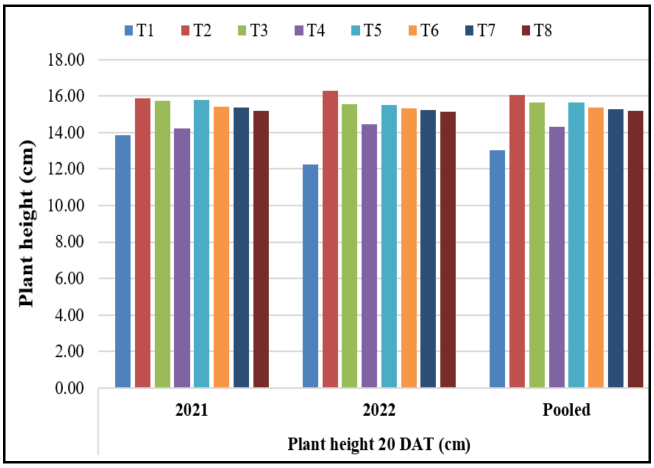

Fig 1: Effect of integrated nutrient management on plant height at 20 DAT

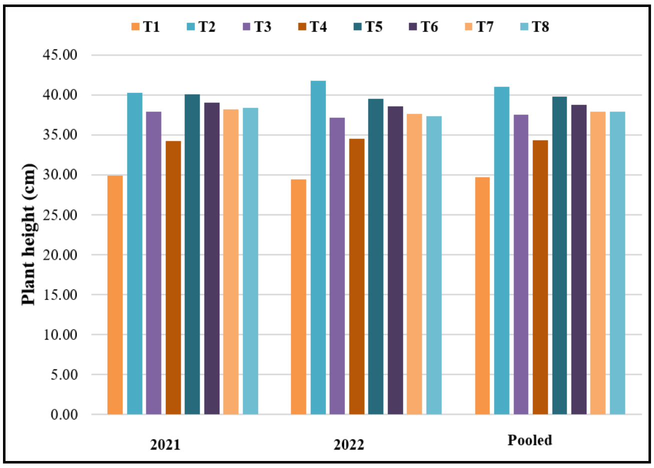

Fig 2: Effect of integrated nutrient management on plant height at 40 DAT

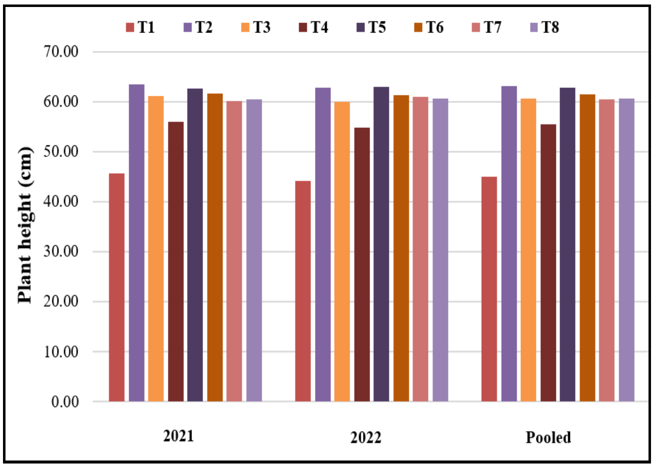

Fig 3: Effect of integrated nutrient management on plant height at 60 DAT

Curd length

The highest curd length was observed in integrated treatments T5 (75% RDF + 2.5 t/ha Vermicompost) (12.65 cm) followed by T_6 (75% RDF + 5 t/ha FYM) (11.42 cm). Treatment T_7 (50% RDF + 5 t/ha Vermicompost) (10.68 cm), T_8 (50% RDF + 10 t/ha FYM) (10.62 cm) and T_3 (75% RDF) (9.68 cm) which were statistically at par with T_2 (RDF (180:120:100, N:P_2O_5:K_2O) (12.75 cm).

Table 4: Effect of integrated nutrient management on curd length

Treatments	Curd length (cm)		
	2021	2022	Pooled
T_1: Control	5.8^{d}	5.97^{d}	5.88^{d}
T_2: RDF (180:120:100, N: P_2O_5:K_2O)	12.97^{a}	12.53^{a}	12.75^{a}
T_3: 75% RDF	9.9^{bc}	9.47^{bc}	9.68^{bc}
T_4: 50% RDF	8.27^{c}	8^{cd}	8.13^{c}
T_5: 75% RDF + 2.5 t/ha Vermicompost	12.73^{a}	12.57^{a}	12.65^{a}
T_6: 75% RDF + 5 t/ha FYM	11.57^{ab}	11.27^{ab}	11.42^{ab}
T_7: 50% RDF + 5 t/ha Vermicompost	10.9^{ab}	10.47^{b}	10.68^{b}
T_8: 50% RDF + 10 t/ha FYM	10.8^{ab}	10.43^{b}	10.62^{b}
SEm (±)	0.572	0.456	7.197
CD (p = 0.05)	1.734	1.382	1.289

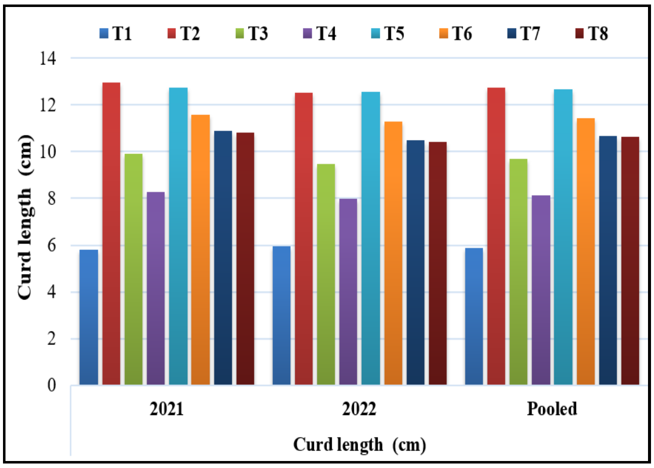

Fig 5: Effect of integrated nutrient management on curd length

Curd breadth

All the treatments imposed showed significantly higher breadth compare to control. The treatments, T_5 (75% RDF + 2.5 t/ha Vermicompost) (14.90 cm), T_6 (75% RDF + 5 t/ha FYM) (14.62 cm), T_7 (50% RDF + 5 t/ha Vermicompost) (13.42 cm) and T_8 (50% RDF + 10 t/ha FYM) (13.27) showed at par curd breath with T_2 RDF (180:120:100, N: P_2O_5:K_2O) (15.40 cm). The least curd breadth of cauliflower was observed in treatment control (8.43 cm). The higher plants height with broader curds could be due to fact that ensured adequate and balanced supply of nutrients through integrated nutrient management approaches which promoted better vegetative growth and curd development. The findings of present study were in accordance with study with of Babita *et al.* (2020) [4] and Bhowal *et al.* (2020) [6].

Table 5: Effect of integrated nutrient management on curd breadth

Treatments	Curd breadth (cm)		
	2021	2022	Pooled
T_1: Control	8.37^{c}	8.5^{c}	8.43^{c}
T_2: RDF (180:120:100, N: P_2O_5:K_2O)	15.23^{a}	15.57^{a}	15.4^{a}
T_3: 75% RDF	13.17^{ab}	13.23^{ab}	13.2^{ab}
T_4: 50% RDF	11^{b}	10.87^{bc}	10.93^{b}
T_5: 75% RDF + 2.5 t/ha Vermicompost	14.67^{a}	15.13^{a}	14.90^{a}
T_6: 75% RDF + 5 t/ha FYM	14.6^{a}	14.63^{a}	14.62^{a}
T_7: 50% RDF + 5 t/ha Vermicompost	13.6^{a}	13.23^{ab}	13.42^{a}
T_8: 50% RDF + 10 t/ha FYM	13.53^{a}	13^{ab}	13.27^{a}
SEm (±)	0.549	0.644	0.560
CD (p = 0.05)	1.665	1.954	1.697

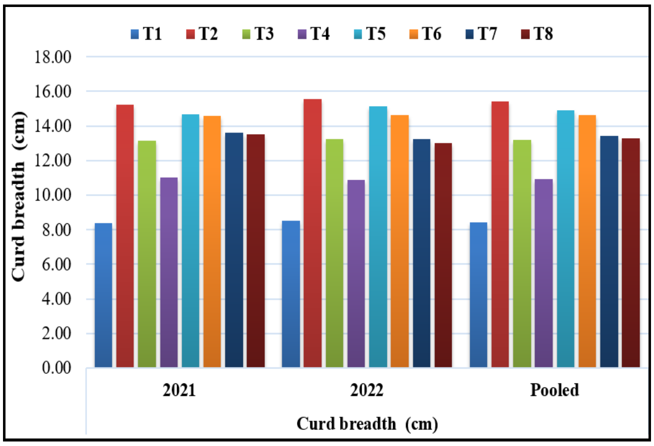

Fig 6: Effect of integrated nutrient management on curd breadth

Individual curd weight

Results on individual curd weight of cauliflower indicated that application of T_5 (75% RDF + 2.5 t/ha Vermicompost) (1.11 kg) and T_6 (75% RDF + 5 t/ha FYM) (1.07 kg) integrated treatments produced similar curd weight to treatment T_2 (RDF (180:120:100, N: P_2O_5:K_2O) (1.17 kg) which recorded the highest weight followed by and treatment T_7 50% RDF + 5 t/ha Vermicompost (1.03 kg) , T_8 50% RDF + 10 t/ha FYM (1.00 kg), T_3 (75% RDF) (0.91 kg) and T_4 50% RDF (0.79 kg), while the lowest weight of cauliflower was observed in control (0.48 kg). Similar results were reported by Islam *et al.* (2021).

Table 6: Effect of integrated nutrient management on individual curd weight

Treatments	Individual curd weight (kg)		
	2021	2022	Pooled
T_1: Control	0.46	0.50	0.48^e
T_2: RDF (180:120:100, N: P_2O_5:K_2O)	1.16	1.18	1.17^a
T_3: 75% RDF	0.92	0.9	0.91^c
T_4: 50% RDF	0.78	0.80	0.79^d
T_5: 75% RDF + 2.5 t/ha Vermicompost	1.13	1.12	1.11^{ab}
T_6: 75% RDF + 5 t/ha FYM	1.1	1.07	1.07^{ab}
T_7: 50% RDF + 5 t/ha Vermicompost	1.04	1.02	1.03^b
T_8: 50% RDF + 10 t/ha FYM	1.01	0.99	1.00^{bc}
SEm (±)	0.054	0.046	0.038
CD (p = 0.05)	0.165	0.139	0.115

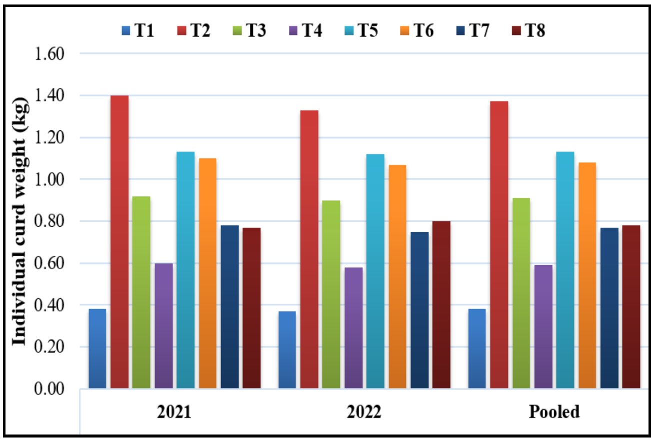

Fig 7: Effect of integrated nutrient management on individual curd weight

Curd yield

the pooled data for curd yield revealed that treatment T_5 (75% RDF + 2.5 t/ha Vermicompost) (270.84 qt/ha) , T_6 (75% RDF + 5 t/ha FYM) (268.65 qt/ha), T_7 (50% RDF + 5 t/ha Vermicompost) (263.11 qt/ha) and T_8 (50% RDF + 10 t/ha FYM) (259.24 qt/ha) which were statistically at par with each other and also with T_2 RDF (180:120:100, N:P_2O_5:K_2O) (278.42 qt/ha). The lowest yield was observed in control (125.05 qt/ha).

Table 7: Effect of integrated nutrient management on curd yield

Treatments	Curd yield (q/ha)		
	2021	2022	Pooled
T_1: Control	124^d	126.14^c	125.07^d
T_2: RDF (180:120:100, N: P_2O_5:K_2O)	276^a	280.84^a	278.42^a
T_3: 75% RDF	242.67^{bc}	248.88^{ab}	245.77^{bc}
T_4: 50% RDF	218.33^c	219.3^b	218.82^c
T_5: 75% RDF + 2.5 t/ha Vermicompost	269.33^{ab}	272.34^a	270.84^{ab}
T_6: 75% RDF + 5 t/ha FYM	266.67^{ab}	270.64^a	268.65^{ab}
T_7: 50% RDF + 5 t/ha Vermicompost	260.33^{ab}	265.88^a	263.11^{ab}
T_8: 50% RDF + 10 t/ha FYM	256.33^{ab}	262.14^a	259.24^{ab}
SEm (±)	7.554	8.034	6.936
CD (p = 0.05)	22.914	24.367	21.037

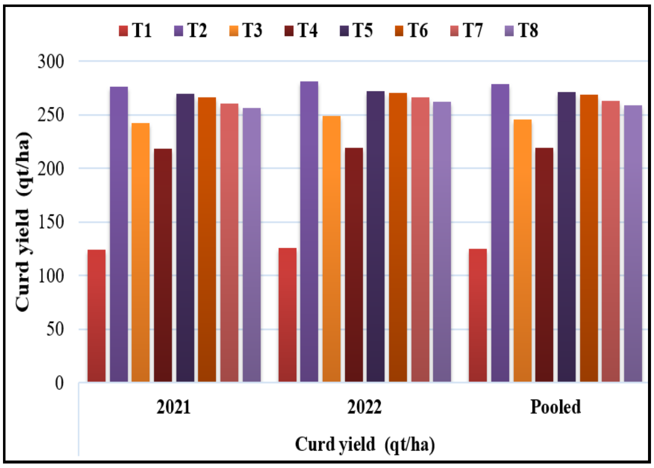

Fig 8: Effect of integrated nutrient management on curd yield

Discussion

The results on plant height of cauliflower measured at 20, 40 and 60 days after transplanting, indicated that the positive impact of integrated nutrient management. The highest plant height by application of recommended doses of NPK through RDF or integrated use of organic and inorganic fertilizer ie. (75% of the RDF along with vermicompost) or (75% RDF + 5 t/ha FYM) or (50% RDF + 10 t/ha FYM) might me due to ensure optimum supply of essential nutrients and also improved soil physical condition which enhanced more leaf area resulting in higher photo assimilates and thereby resulted in higher plant height. Similar results findings on plant height was also reported by Pawar *et al.* (2017) [10] who also observed maximum plant height was attained with balanced nutrient supply from RDF or RDF combined with different doses of vermicompost or FYM.

Curd length was all the integrated treatments of organic and inorganic combinations imposed showed similar curd length to T_2 (RDF (180:120:100, N:P_2O_5:K_2O) but significantly higher compare to control. Integrated nutrient management using chemical fertilizer (RDF) with organic manures like vermicompost and FYM was found effective in promoting cauliflower curd length similar to recommended dose of fertilizer could be due to ensure optimum nutrient levels supply through both quick and slow-release sources for fast curd initiation and enlargement. These results indicate that the significant influence of nutrient management on cauliflower curd development, with RDF alone or with integration of organic manures leading to longer curds. Similar results were also reported by Dash *et al.* (2019) and Budha *et al* (2021) [7].

The highest curd yield of cauliflower with the integrated treatments, being the final productivity parameter was may be due to its potential in meeting full nutrients demands across years. Further, by the consequent of complementary effect of INM which induced conductive physical environment leading to proper aeration, root activity and thereby increase in soil moisture holding capacity, availability and nutrient absorption would have produced higher crop growth and yield attributing characters and which also resulted in potential cauliflower yield.

It is concluded that application of 100% RDF alone or 75% RDF + 2.5 t/ha Vermicompost or 75% RDF + 5 t/ha FYM), (50% RDF + 5 t/ha Vermicompost or 50% RDF + 10 t/ha FYM produced the potential yield of cauliflower. Similar results also observed by Singh *et al.* (2019) [16].

Conclusions

The application of recommended dose of fertilizer along with FYM or vermicompost found significantly superior to produced maximum growth and yield of cauliflower.

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