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Effect of INM on nutrients uptake in relation to different organic and inorganic fertilizer levels in inceptisol of Northern hills zone of Chhattisgarh

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Abstract
A field study was carried out at Krishi Vigyan Kendra Balrampur of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G) during the *rabi* seasons of 2021-22 and 2022-23 to evaluate the effect of INM on nutrients uptake 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, $N:P_2O_5:K_2O$), 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 highest total N uptake (leaf + curd) was observed in treatment RDF (180:120:100, $N:P_2O_5:K_2O$), (75% + 2.5 t/ha vermicompost) and (75% RDF + 5 t/ha FYM). The highest total phosphorus uptake (leaf + curd) was observed in integrated treatments (75% RDF + 2.5 t/ha vermicompost), (75% RDF + 5 t/ha FYM) (50% RDF + 5 t/ha vermicompost) and also with RDF (180:120:100, $N:P_2O_5:K_2O$).The total potassium uptake was the highest by the application of integrated treatments ie. (75% RDF + 2.5 t/ha vermicompost), (75% RDF + 5 t/ha FYM), which were also comparable with (RDF (180:120:100, $N:P_2O_5:K_2O$).

Keywords: Nutrient uptake, vermicompost and FYM

Introduction
The name cauliflower has originated from the Latin words ‘Caulis’ meaning stem and ‘Florish’ meaning flower. Dr. Jemson at Saharanpur first introduced it to India in 1822 during the period of East India Company (Rai and Yadav, 2005) [9]. Cauliflower contain 92.7% water and the food value per 100 g of edible portion is as follows: energy 31 calories, protein 2.4 g, calcium 22 mg, vitamin A 40 IU, ascorbic acid 70 mg, thiamine 0.2 mg, riboflavin 0.1 mg and niacin 0.75 mg. It contains glucocinolates which in crushed leaves is broken down by myrosinase enzyme to give better taste and goitrogenic substance.
It is grown throughout the world especially in China, India, USA, Spain, Italy, Mexico and France. 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).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) [1].
Cauliflower removes large amount of various nutrients from the soil. Large scale farmer’s application of only chemical fertilizers due to alone chemical fertilizer application soils are fertilizer burn, as chemical fertilizers do not allow enough water intake for the plants. Chemical fertilizers are high in nitrogen salts, and when the nitrogen is absorbed by soil too quickly; it will dehydrate and dry up the plant.
INM practices not only enhance crop yields but also improve the nutritional quality and safety of food products. Balanced nutrient management helps in accumulation of essential nutrients and photochemical in crops, thereby enhancing their nutritional value and contributing to human health and well-being. In view of the above facts, a study was planned to evaluate the cauliflower yield, Nutrient uptake and soil fertility status of soil.

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 experimental soil are sand clay loam texture, soil P^H was slightly acidic in reaction, organic carbon and nitrogen was low and Available Phosphorus, potassium are medium. Available soil micronutrient Fe, Mn, Zn and B are sufficient. The district experiences sub-tropical climate and is characterized by extreme summer and winter seasons. The average temperature ranges from 10-46 °C during winter to summer. 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 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 Cauliflower variety Girija is a hybrid from Seminis Seeds (Monsanto), Cauliflower plot size of 5x4m^2 and spacing are 60x60 cm. FYM and vermicompost are applied in as per treatment details. Life saving irrigations was given as and when required for the crop.

Results

Nitrogen uptake by curd

Significantly higher nitrogen uptake by cauliflower curd was observed in treatments T_2 RDF (180:120:100, $N:P_2O_5:K_2O$) (106.93 kg ha^{-1}), T_5 (75% RDF + 2.5 t/ha Vermicompost) (106.31 kg ha^{-1}) and T_6 (75% RDF + 5 t/ha FYM) (105.13 kg ha^{-1}) in compared to others. The minimum nitrogen uptake by curd was observed in control (49.88 kg ha^{-1}).

Table 1: Effect of integrated nutrient management on nitrogen uptake in curd

Treatments	N uptake by curd (kg ha^{-1})		
	2021	2022	Pooled
T_1: Control	48.67^c	51.08^d	49.88^e
T_2: RDF (180:120:100, N: $P_2O_5:K_2O$)	105.47^a	108.4^a	106.93^a
T_3: 75% RDF	94.25^{ab}	97.17^{abc}	95.71^c
T_4: 50% RDF	80.85^b	85.29^c	83.07^d
T_5: 75% RDF + 2.5 t/ha Vermicompost	103.31^a	109.3^a	106.31^a
T_6: 75% RDF + 5 t/ha FYM	102.54^a	107.72^a	105.13^{ab}
T_7: 50% RDF + 5 t/ha Vermicompost	94.69^{ab}	98.95^{ab}	96.82^{bc}
T_8: 50% RDF + 10 t/ha FYM	93.44^{ab}	94.53^{bc}	93.99^c
S.Em (±)	3.32	3.08	2.04
CD (p = 0.05)	10.07	9.34	6.19

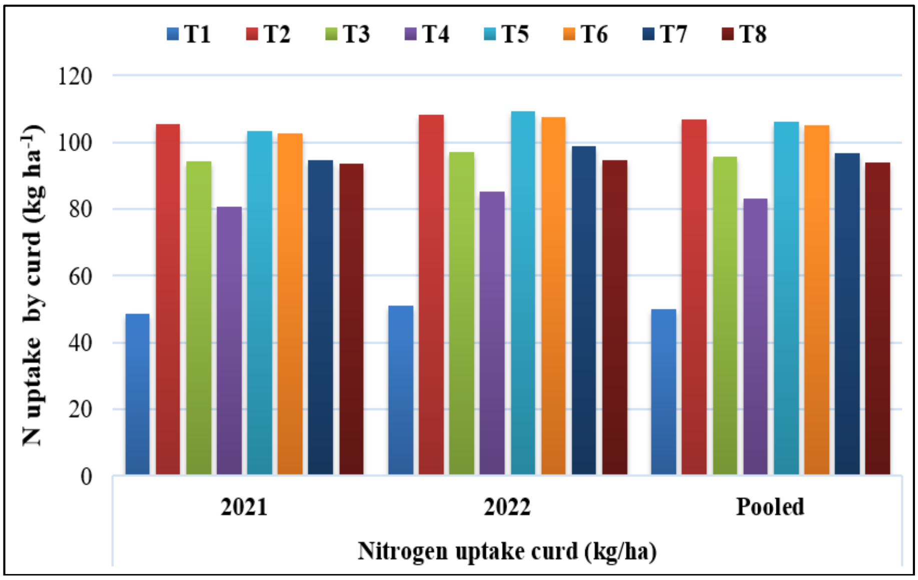

Fig 1: Effect of integrated nutrient management on nitrogen uptake in curd

Nitrogen uptake by leaf

The nitrogen uptake by leaf was observed in the application INM treatments *i e*. T_5 (75% RDF + 2.5 t/ha Vermicompost) (15.77 kg ha^{-1}) and T_6 (75% RDF + 5 t/ha FYM) (15.18 kg ha^{-1}) was at par with each other and also with T_2 (RDF (180:120:100, $N:P_2O_5:K_2O$) (16.14 kg ha^{-1}) but significantly higher over T_7 (50% RDF + 5 t/ha vermicompost) (13.86 kg ha^{-1}) T_8 (50% RDF + 10 t/ha FYM) (14.02 kg ha^{-1}), and T_3 (75% RDF) (13.83 kg ha^{-1}) treatments. The lowest (7.45 kg ha^{-1}) nitrogen uptake in leaf was observed in control.

Table 2: Effect of integrated nutrient management on nitrogen uptake in leaf

Treatments	Leaf N uptake (kg ha^{-1})		
	2021	2022	Pooled
T_1: Control	7.33^c	7.57^b	7.45^c
T_2: RDF (180:120:100, N: P_2O_5:K_2O)	16.02^a	16.26^a	16.14^a
T_3: 75% RDF	13.67^{ab}	13.99^a	13.83^b
T_4: 50% RDF	13.17^b	13.2^a	13.18^b
T_5: 75% RDF + 2.5 t/ha Vermicompost	16.06^a	15.49^a	15.77^{ab}
T_6: 75% RDF + 5 t/ha FYM	15.65^{ab}	14.71^a	15.18^{ab}
T_7: 50% RDF + 5 t/ha Vermicompost	13.2^b	14.51^a	13.86^b
T_8: 50% RDF + 10 t/ha FYM	12.98^b	15.07^a	14.02^b
SEm (±)	0.65	0.76	0.61
CD (p = 0.05)	1.98	2.30	1.86

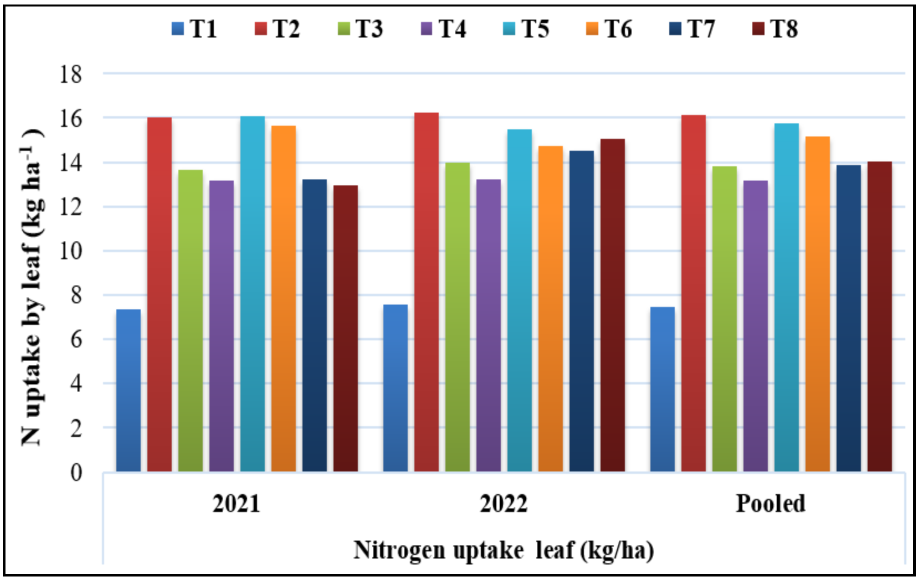

Fig 2: Effect of integrated nutrient management on nitrogen uptake in leaf

Total Nitrogen uptake

The total uptake of nitrogen by cauliflower crops was significantly influenced due to application of integrated organic and inorganic fertilizers and their combination. The pooled mean showed that the significantly highest total nitrogen uptake was observed in treatment RDF (180:120:100, N:P_2O_5:K_2O) (123.08 kg ha^{-1}) and (75% + 2.5 t/ha Vermicompost) (122.08 kg ha^{-1}) followed by (75% RDF + 5 t/ha FYM) (120.03 kg ha^{-1}). The lowest (57.32 kg ha^{-1}) total N uptake found in control.

Table 3: Effect of integrated nutrient management on total nitrogen uptake

Treatments	Total N uptake (kg ha^{-1})		
	2021	2022	Pooled
T_1: Control	56^c	58.65^d	57.32^e
T_2: RDF (180:120:100, N: P_2O_5:K_2O)	121.49^a	124.66^a	123.08^a
T_3: 75% RDF	107.92^{ab}	111.15^{abc}	109.54^c
T_4: 50% RDF	94.02^b	98.49^c	96.25^d
T_5: 75% RDF + 2.5 t/ha Vermicompost	119.37^a	124.79^a	122.08^a
T_6: 75% RDF + 5 t/ha FYM	118.18^a	122.42^{ab}	120.3^{ab}
T_7: 50% RDF + 5 t/ha Vermicompost	107.89^{ab}	113.46^{ab}	110.68^{bc}
T_8: 50% RDF + 10 t/ha FYM	106.42^{ab}	109.6^{bc}	108.01^c
SEm (±)	3.73	3.50	2.48
CD (p = 0.05)	11.32	10.63	7.52

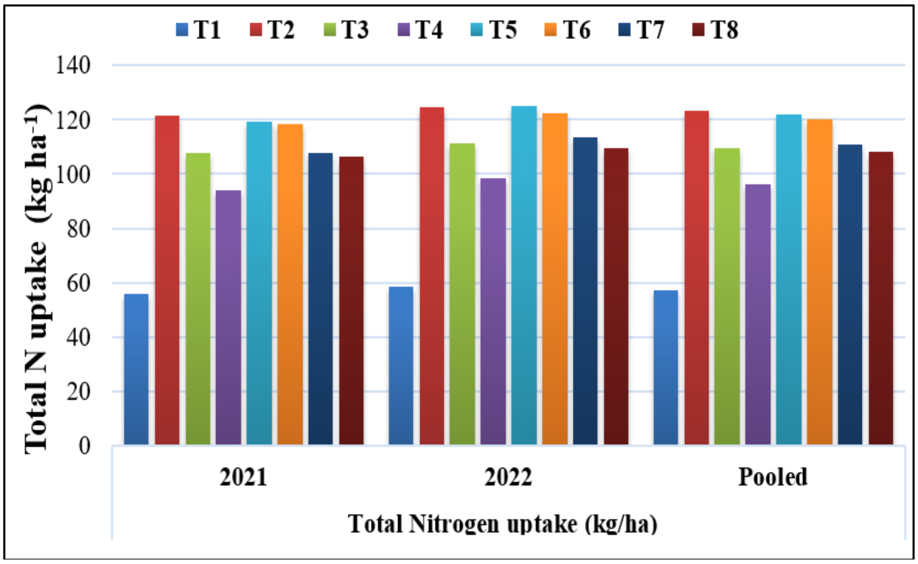

Fig 3: Effect of integrated nutrient management on total nitrogen uptake

Phosphorus uptake by curd

The treatments T_5 (75% RDF + 2.5 t/ha Vermicompost), T_6 (75% RDF + 5 t/ha FYM) and T_7 (50% RDF + 5 t/ha Vermicompost) at par with T_2 RDF but significantly higher uptake as compared to all other treatments. While, the minimum curd uptake was recorded in control.

Table 4: Effect of integrated nutrient management on phosphorus uptake in curd

Treatments	Phosphorus uptake in curd (kg ha^{-1})		
	2021	2022	Pooled
T_1: Control	9.55^c	9.26^d	9.40^d
T_2: RDF (180:120:100, N: P_2O_5:K_2O)	24.60^a	23.75^a	24.18^a
T_3: 75% RDF	22.15^a	20.38^{bc}	21.27^b
T_4: 50% RDF	18.96^b	17.97^c	18.47^c
T_5: 75% RDF + 2.5 t/ha Vermicompost	23.95^a	24.06^a	24.00^a
T_6: 75% RDF + 5 t/ha FYM	23.38^a	23.51^{ab}	23.45^{ab}
T_7: 50% RDF + 5 t/ha Vermicompost	22.84^a	22.54^{ab}	22.69^{ab}
T_8: 50% RDF + 10 t/ha FYM	22.83^a	21.68^{ab}	22.25^b
SEm (±)	0.71	0.79	0.63
CD (p = 0.05)	2.16	2.40	1.91

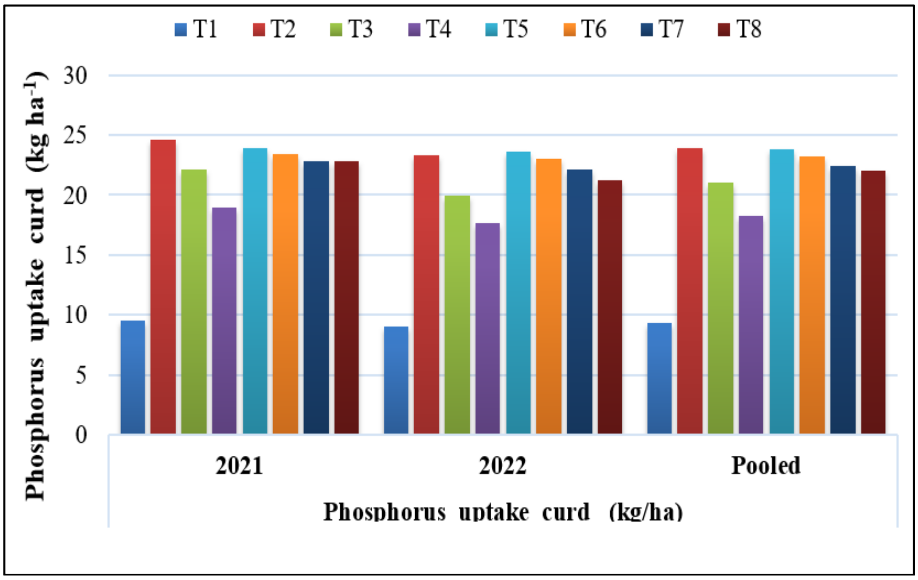

Fig 4: Effect of integrated nutrient management on phosphorus uptake in curd

Phosphorus uptake by leaf

The highest phosphorus uptake by leaf was observed in Treatment T_2 (RDF (180:120:100, N:P_2O_5:K_2O) (7.21 kg ha^{-1}), T_5 (75% RDF + 2.5 t/ha vermicompost) (6.94 kg ha^{-1}), T_6 (75% RDF + 5 t/ha FYM) (6.77 kg ha^{-1}), T_8 (50% RDF + 10 t/ha FYM) (6.77 kg ha^{-1}) and T_7 (50% RDF + 5 t/ha vermicompost) (6.62 kg ha^{-1}).These treatments are at par with each other. Minimum phosphorus uptake by leaf (2.82 kg/ha^{-1}) was observed in treatment control.

Table 5: Effect of integrated nutrient management on phosphorus uptake in leaf

Treatments	Phosphorus uptake in leaf (kg ha^{-1})		
	2021	2022	Pooled
T_1: Control	2.87^{d}	2.76^{d}	2.82^{d}
T_2: RDF (180:120:100, N: P_2O_5:K_2O)	7.19^{a}	7.23^{a}	7.21^{a}
T_3: 75% RDF	6.46^{b}	6.23^{bc}	6.35^{b}
T_4: 50% RDF	5.54^{c}	5.39^{c}	5.46^{c}
T_5: 75% RDF + 2.5 t/ha Vermicompost	7.02^{ab}	6.86^{ab}	6.94^{ab}
T_6: 75% RDF + 5 t/ha FYM	6.84^{ab}	6.71^{ab}	6.77^{ab}
T_7: 50% RDF + 5 t/ha Vermicompost	6.68^{ab}	6.56^{ab}	6.62^{ab}
T_8: 50% RDF + 10 t/ha FYM	6.67^{ab}	6.67^{ab}	6.67^{ab}
SEm (±)	0.17	0.21	0.16
CD (p = 0.05)	0.54	0.65	0.49

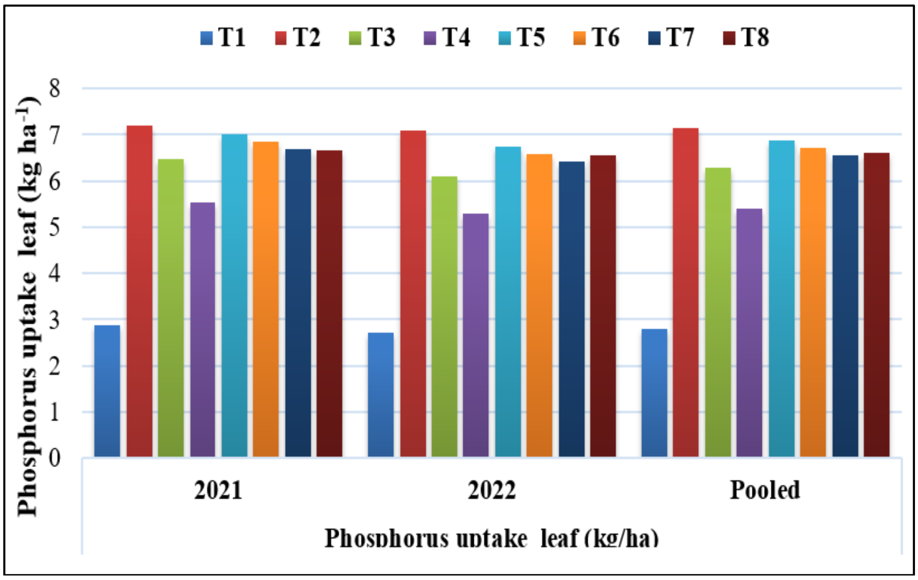

Fig 5: Effect of integrated nutrient management on phosphorus uptake in leaf

Total Phosphorus uptake

The application of treatments T_5 (75% RDF + 2.5 t/ha Vermicompost), T_6 (75% RDF + 5 t/ha FYM) and T_7 (50% RDF + 5 t/ha vermicompost) were at par with each other and also with T_2 RDF (180:120:100, N:P_2O_5:K_2O) but significant higher over others and minimum was in control.

Table 6: Effect of integrated nutrient management on total phosphorus uptake

Treatments	Total phosphorus uptake (kg ha^{-1})		
	2021	2022	Pooled
T_1: Control	12.42^{c}	12.02^{d}	12.22^{d}
T_2: RDF (180:120:100, N: P_2O_5:K_2O)	31.79^{a}	30.99^{a}	31.39^{a}
T_3: 75% RDF	28.61^{a}	26.62^{bc}	27.61^{b}
T_4: 50% RDF	24.51^{b}	23.36^{c}	23.93^{c}
T_5: 75% RDF + 2.5 t/ha Vermicompost	30.97^{a}	30.92^{a}	30.94^{a}
T_6: 75% RDF + 5 t/ha FYM	30.22^{a}	30.22^{ab}	30.22^{ab}
T_7: 50% RDF + 5 t/ha Vermicompost	29.52^{a}	29.10^{ab}	29.31^{ab}
T_8: 50% RDF + 10 t/ha FYM	29.5^{a}	28.35^{ab}	28.93^{b}
SEm (±)	0.878	0.92	0.763
CD (p = 0.05)	2.664	2.819	2.315

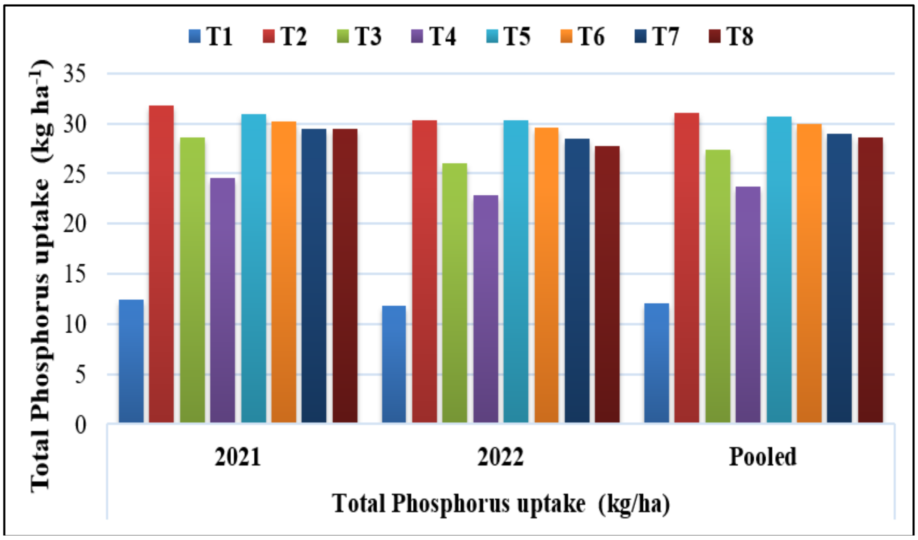

Fig 6: Effect of integrated nutrient management on total phosphorus uptake

Potassium uptake by curd

All the treatments significantly showed higher uptake as compared to control. Application of T_5 (75% RDF + 2.5 t/ha vermicompost), T_6 (75% RDF + 5 t/ha FYM) and T_7 (50% RDF + 5 t/ha vermicompost) were at par with each other and also with T_2 RDF (180:120:100, N:P_2O_5:K_2O). The highest (101.05 kg ha^{-1}) and lowest (39.29 kg ha^{-1}) uptake was observed in RDF and control, respectively.

Table 7: Effect of integrated nutrient management on potassium uptake in curd

Treatments	Potassium uptake curd (kg ha^{-1})		
	2021	2022	Pooled
T_1: Control	38.64^c	39.94^c	39.29^c
T_2: RDF (180:120:100, N: P_2O_5:K_2O)	99.50^a	100.60^a	101.05^a
T_3: 75% RDF	86.82^{ab}	91.36^{ab}	89.09^{ab}
T_4: 50% RDF	78.23^b	80.77^b	79.50^b
T_5: 75% RDF + 2.5 t/ha Vermicompost	96.97^a	100.70^a	98.83^a
T_6: 75% RDF + 5 t/ha FYM	96.28^{ab}	97.77^{ab}	97.03^a
T_7: 50% RDF + 5 t/ha Vermicompost	89.09^{ab}	92.22^{ab}	90.65^{ab}
T_8: 50% RDF + 10 t/ha FYM	87.91^{ab}	91.92^{ab}	89.91^b
SEm (±)	4.42	4.75	3.67
CD (p = 0.05)	13.40	14.43	11.13

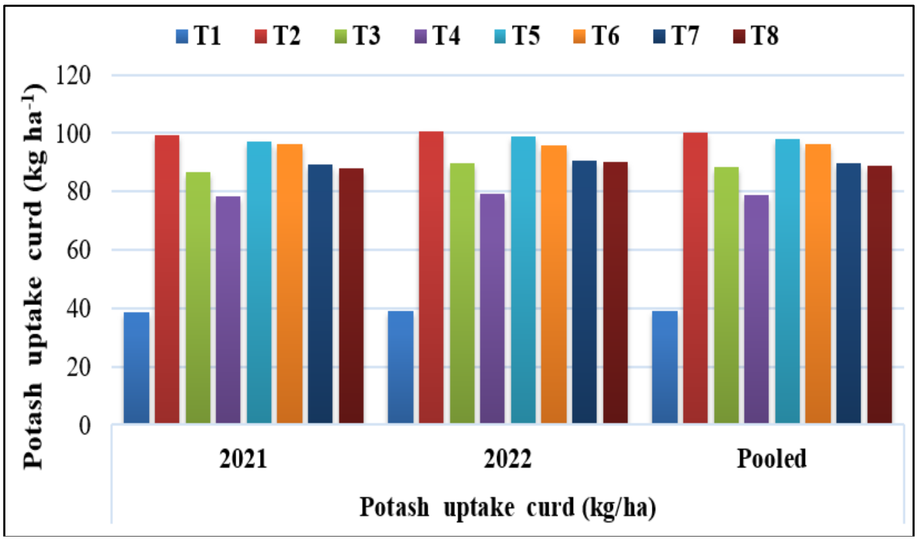

Fig 7: Effect of integrated nutrient management on potassium uptake in curd

Potassium uptake by leaf

All the treatments had significantly higher uptake compares to control. The application of 75% RDF + 2.5 t/ha vermicompost (T_5) and 75% RDF + 5 t/ha FYM (T_6) showed maximum potassium uptake by leaf and is alike to RDF (180:120:100, N:P_2O_5:K_2O) (T_2), while the minimum was observed in control.

Table 8: Effect of integrated nutrient management on potassium uptake in leaf

Treatments	Potassium uptake leaf (kg ha^{-1})		
	2021	**2022**	**Pooled**
T_1: Control	10.27^{d}	9.93^{d}	10.10^{f}
T_2: RDF (180:120:100, N: P_2O_5:K_2O)	24.74^{a}	23.95^{a}	24.35^{a}
T_3: 75% RDF	22.10^{abc}	21.86^{abc}	21.98^{bcd}
T_4: 50% RDF	19.43^{c}	19.28^{c}	19.35^{e}
T_5: 75% RDF + 2.5 t/ha Vermicompost	24.40^{a}	24.01^{a}	24.20^{ab}
T_6: 75% RDF + 5 t/ha FYM	23.47^{ab}	23.12^{ab}	23.30^{abc}
T_7: 50% RDF + 5 t/ha Vermicompost	21.43^{bc}	20.95^{abc}	21.19^{cde}
T_8: 50% RDF + 10 t/ha FYM	20.97^{bc}	20.18^{bc}	20.57^{de}
SEm (±)	0.686	0.743	0.547
CD (p = 0.05)	2.082	2.253	1.659

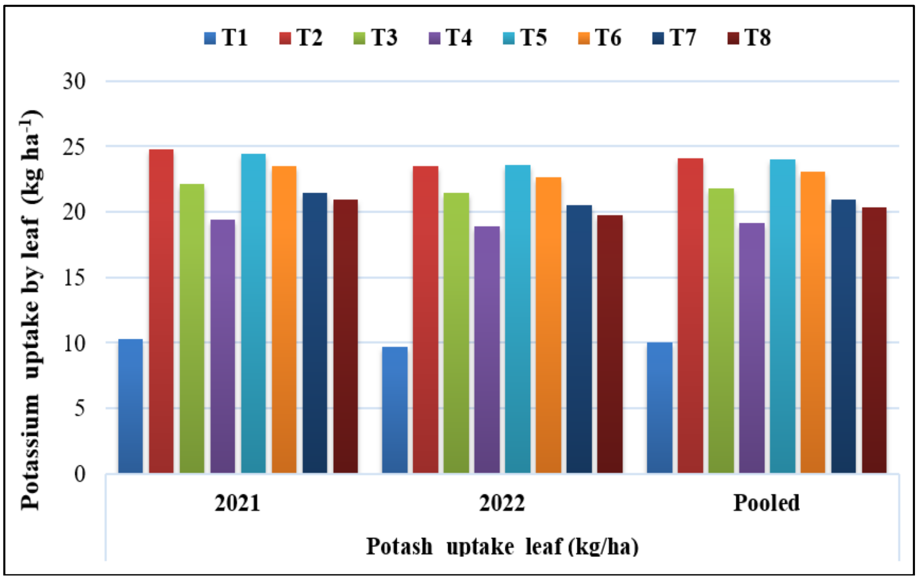

Fig 8: Effect of integrated nutrient management on potassium uptake in leaf

Total Potassium uptake

All the treatments showed significantly higher K uptake as compared to control. The total potassium uptake was the highest by the application of integrated treatments ie. T_5 (75% RDF + 2.5 t/ha Vermicompost) (123.04 kg ha^{-1}) and T_6 (75% RDF + 5 t/ha FYM) (120.32 kg ha^{-1}), which were also at par with T_2 (RDF (180:120:100, N:P_2O_5:K_2O) (125.40 kg ha^{-1}), while, the minimum was observed in control (49.39 kg ha^{-1}).

Table 9: Effect of integrated nutrient management on total potassium uptake

Treatments	Total potassium uptake (kg ha^{-1})		
	2021	**2022**	**Pooled**
T_1: Control	48.91^{c}	49.87^{c}	49.39^{c}
T_2: RDF (180:120:100, N: P_2O_5:K_2O)	124.25^{a}	126.55^{a}	125.40^{a}
T_3: 75% RDF	108.92^{ab}	113.22^{ab}	111.07^{b}
T_4: 50% RDF	97.65^{b}	100.05^{b}	98.85^{b}
T_5: 75% RDF + 2.5 t/ha Vermicompost	121.37^{a}	124.70^{a}	123.04^{a}
T_6: 75% RDF + 5 t/ha FYM	119.76^{a}	120.89^{ab}	120.32^{ab}
T_7: 50% RDF + 5 t/ha Vermicompost	110.52^{ab}	113.16^{ab}	110.84^{b}
T_8: 50% RDF + 10 t/ha FYM	108.87^{ab}	112.10^{ab}	110.49^{b}
SEm (±)	4.81	5.15	3.94
CD (p = 0.05)	14.59	15.64	11.96

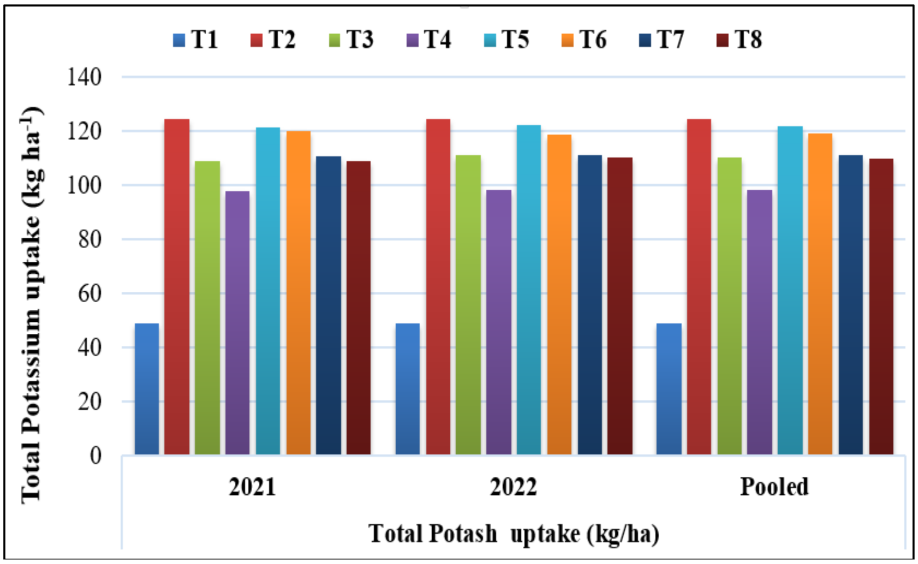

Fig 9: Effect of integrated nutrient management on total potassium uptake

Discussion

Nitrogen uptake by cauliflower

The application of chemical fertilizers along with organics treatments significant increased nitrogen uptake by cauliflower. The enhancement of nutrient uptake due to increase in specific ion fluxes at root zone biosphere in the presence of microbial decomposition of humus gradually increase that nutrient availability during crop growth which was manifested in higher nutrient uptake. Shah and Wani 2017 also observed that INM treatment increased nutrients uptake by carrot.

Addition of FYM and Vermicompost which might have increased nutrients availability which ultimately enhanced microbial activity and conversion of unavailable to available form of nutrients and by improved physical and biochemical condition of soil. (Sarangthem *et al.* 2011) [10].

Sharma *et al* 2022 [12] results was also concluded that the highest NPK uptake was recorded in treatments 150% NPK + FYM @ 250 kg/ha and 100% NPK + FYM @ 250 kg/ha which was also at par with 100% NPK (150:100:54).

Phosphorus uptake by cauliflower

The ability of a plant to take up phosphorus is largely depending on its root distribution as it is relatively immobile in the soil. Application of organic manures might have improved the soil physic-chemical environment, which encouraged proliferous root system resulting in better absorption of water and nutrients from lower layers and thus resulting in higher yield and nutrient uptake. Results of Meena *et al* (2016) [3] and Singh *et al* (2019) [14] also confirmed finding of the present study that significantly higher P uptake by maize when fertilized with manures.

Libeni *et al* (2010) [7] reported that the maximum uptake of phosphorus in ginger crop was recorded with 50% NPK + 50% FYM. Devi *et al.* (2018) [5] earlier also reported that significant and higher P uptake under 80% NPK + 20% N through FYM and VC (50:50),

Potassium uptake by cauliflower

Higher uptake under integrated treatments is because of improved physical environment, increased root proliferation to lower depth, higher mineralization of nutrients from applied organic and inorganic sources and reduced loss of nutrients through leaching,

Morya *et al* (2018) [6] also concluded that application of (50% RDF and 50% vermicompost) gave significantly highest uptake of K and was at par with (100% RDF 20-60-40 N,PK kg/ha) and (50% RDF + 25% vermicompost + Rhizobium + PSB). Sunil Kumar *et al.* (2013) [15] also concluded that integration of the fertilizer increased the N,P and K uptake in soybean.

Conclusion

The application of recommended dose of fertilizer alone or with combination of FYM or vermicompost treatments found significantly superior to maximum growth, yield and nutrient uptake in cauliflower.

The NPK uptake by cauliflower was the highest with RDF or integrated use of (75% RDF + 2.5 t/ha vermicompost) or (75% RDF + 5 t/ha FYM).

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