Plant Archives Vol. 26, Supplement 1, 2026 pp. 1377-1383 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-1.182

INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH PARAMETERS OF CAULIFLOWER (*BRASSICA OLERACEA* VAR. BOTRYTIS L.)

Surya Pratap Patel[1], Awanish Kumar[1*], Ashish Kumar Tiwari[2], Satyavir Singh[1], Shyam Kirar[1], Jay Narayan Tiwari[3], Santosh Pandey[2] and Sankalp Singh[1]

[1]Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Bundelkhand University, Jhansi, Uttar Pradesh, India
[2]Department of Agronomy, Institute of Agricultural Sciences, Bundelkhand University, Jhansi, Uttar Pradesh, India
[5]Department of Horticulture, Institute of Agricultural Sciences, Bundelkhand University, Jhansi, Uttar Pradesh, India
*Corresponding author E-mail: awanishiasbu@gmail.com
(Date of Receiving : 13-09-2025; Date of Acceptance : 25-11-2025)

ABSTRACT

A field experiment was conducted during the Rabi season of 2024–25 at the Chemical Research Farm, Department of Soil Science and Agricultural Chemistry, Bundelkhand University, Jhansi, Uttar Pradesh, India, to evaluate the effect of integrated nutrient management (INM) on growth, morphological traits and yield of cauliflower (*Brassica oleracea* var. botrytis L.). The experiment was laid out in a Randomized Block Design (RBD) with eight treatments, each replicated three times: control (RDF), RDF + PSB, 10 t ha^{-1} FYM + 100% RDF, 10 t ha^{-1} FYM + 100% RDF + PSB, 10 t ha^{-1} vermicompost + 100% RDF, 10 t ha^{-1} vermicompost + 100% RDF + PSB, 15 t ha^{-1} FYM + 100% RDF, and 15 t ha^{-1} vermicompost + 100% RDF. Observations recorded included plant height, plant diameter, plant spread (N–S and E–W), number of leaves per plant, leaf length, fresh and dry weight at 45 DAS and at harvest, as well as maturity duration, head length, head diameter, head weight, and total yield (q/ha). Results indicated that INM treatments significantly improved all vegetative growth and yield attributes compared to the control. Maximum growth and yield parameters were recorded under T_7 (15 t ha^{-1} vermicompost + 100% RDF), with the highest plant height (30.90 cm at 45 DAS; 35.30 cm at harvest), number of leaves (20), leaf length (48.50 cm at 45 DAS; 50.00 cm at harvest), head weight (1000 g), and total yield (145 q/ha). These results suggest that the combined application of vermicompost and recommended dose of fertilizers enhances nutrient availability, vegetative vigour, and curd quality, making it a sustainable strategy for improving cauliflower productivity under semi-arid conditions.

Keywords: Cauliflower, Integrated Nutrient Management, Vermicompost, Farmyard Manure, Biofertilizers, Vegetative Growth, Yield and Plant Biomass.

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most important cole crops cultivated in India and across the world. It is a major winter vegetable valued for its high nutritional and economic importance. Cauliflower is rich in vitamins C and K, dietary fibre, folate, antioxidants and phytochemicals that contribute to human health (Patel *et al.*, 2017). Increasing consumer awareness about healthy eating has resulted in a growing demand for cauliflower in both domestic and international markets. To meet this rising demand sustainably, it is essential to adopt nutrient management practices that maintain soil fertility and protect the environment.

Modern agricultural systems have relied heavily on chemical fertilizers to increase crop productivity. Although these fertilizers provide nutrients quickly, their continuous and unbalanced use has caused several problems such as nutrient imbalance, soil degradation, reduced microbial activity, environmental pollution and increased production costs (Reddy and Reddi, 2008). This has led to a shift in focus towards eco-friendly and sustainable alternatives such as Integrated Nutrient Management (INM), which promotes the

judicious and combined use of inorganic fertilizers, organic manures and biofertilizers for sustainable crop production and soil health maintenance.

Integrated Nutrient Management aims to maintain or improve soil fertility and supply balanced nutrients to crops by integrating all possible nutrient sources. It enhances nutrient recycling, minimizes environmental hazards and supports long-term productivity. Organic manures like Farmyard Manure (FYM) and Vermicompost (VC) play an important role in improving soil structure, microbial activity, water-holding capacity and slow nutrient release, making them valuable components of INM practices (Sharma *et al*., 2020). Vermicompost, produced through the biological decomposition of organic matter by earthworms, is particularly rich in humic substances, enzymes and plant growth-promoting hormones that enhance soil fertility and plant growth (Edwards *et al*., 2004).

The inclusion of biofertilizers such as Phosphate Solubilizing Bacteria (PSB) further improves nutrient availability, especially phosphorus, by converting insoluble forms into plant-available forms (Khan *et al*., 2009). Biofertilizers not only reduce dependency on chemical fertilizers but also improve nutrient uptake, root development and overall plant vigour. Several researchers have reported positive effects of INM on the growth and yield of vegetable crops including cauliflower. Singh *et al.* (2018) observed that the integrated application of FYM and Recommended Dose of Fertilizers (RDF) significantly improved plant height, number of leaves and curd yield of cauliflower compared to the sole use of chemical fertilizers. Jat *et al.* (2016) also reported that vermicompost along with RDF enhanced vegetative growth and quality attributes of cabbage and cauliflower due to improved nutrient availability and soil conditions. Kumar *et al.* (2017) further highlighted that the interaction between organic and inorganic nutrient sources often produces synergistic effects, resulting in better nutrient uptake, photosynthetic activity and yield performance.

Despite the proven advantages of INM, its adoption in cauliflower cultivation remains limited due to a lack of region-specific studies and practical recommendations. The response of cauliflower to different nutrient combinations varies with soil type, climatic conditions, cropping history and management practices. Therefore, field-based studies are required to identify effective combinations of organic, inorganic and biological nutrient sources under local agro-ecological conditions. Keeping this in view, the present investigation was undertaken during the Rabi season of 2024–25 at Bundelkhand University, Jhansi, to evaluate the influence of Integrated Nutrient Management on the growth and development of cauliflower under Bundelkhand agro-climatic conditions. The study aimed to assess the effectiveness of different combinations of FYM, vermicompost, RDF and PSB for achieving sustainable productivity and soil health improvement in cauliflower cultivation.

Materials and Methods

Experimental Site and Climate

A field experiment was carried out during the Rabi season of 2024–25 at the Chemical Research Farm, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Bundelkhand University, Jhansi, Uttar Pradesh, India. The experimental site is located in the Bundelkhand agro-climatic zone, which experiences a semi-arid climate with hot summers and moderately cold winters. The region receives an average annual rainfall of 850–1000 mm, most of which occurs during the monsoon months (June to September). The experimental soil was sandy loam in texture, slightly alkaline in reaction (pH 7.6), low in available nitrogen, medium in available phosphorus and high in available potassium. The soil fertility status indicated moderate productivity potential suitable for vegetable cultivation.

Experimental Design and Treatments

The experiment was conducted using a Randomized Block Design (RBD) comprising eight treatments replicated three times. The treatments consisted of various combinations of Recommended Dose of Fertilizers (RDF), Farmyard Manure (FYM), Vermicompost (VC) and Phosphate Solubilizing Bacteria (PSB). The treatment structure is presented in Table 1.

Table 1 : Treatment details

Treatment Code	Treatment Description
T_0	Control (RDF)
T_1	RDF + PSB
T_2	10 t ha^{-1} FYM + 100% RDF
T_3	10 t ha^{-1} FYM + 100% RDF + PSB
T_4	10 t ha^{-1} Vermicompost + 100% RDF
T_5	10 t ha^{-1} Vermicompost + 100% RDF + PSB
T_6	15 t ha^{-1} FYM + 100% RDF
T_7	15 t ha^{-1} Vermicompost + 100% RDF

Uniform agronomic and plant protection measures were adopted across all treatments in accordance with the recommended package of practices for cauliflower cultivation. Irrigation was applied at critical growth stages based on soil moisture status. Manual weeding and hoeing were performed periodically to maintain a weed-free field and ensure proper soil aeration.

Crop Management

Healthy and uniform cauliflower seedlings were transplanted at the recommended spacing into well-prepared plots. The RDF was applied as per standard recommendations for cauliflower in the region, with nitrogen, phosphorus and potassium supplied through urea, single superphosphate and muriate of potash respectively. Organic manures (FYM and VC) were incorporated into the soil two weeks prior to transplanting, while PSB inoculation was done at the time of transplanting.

Data Recording

Observations on growth, morphological and yield attributes were recorded at 45 days after sowing (DAS) and at harvest. Parameters such as plant height, plant diameter, plant spread (north–south and east–west), number of leaves per plant, leaf length, fresh and dry weight, maturity duration, head length, head diameter, head weight and total yield (q ha^{-1}) were measured using standard agronomic procedures. Average values were computed for each treatment prior to statistical analysis.

Statistical Analysis

The experimental data were subjected to Analysis of Variance (ANOVA) following the procedure outlined by Gomez and Gomez (1984). Treatment means were compared using the Critical Difference (CD) test at a 5% probability level ($p \leq 0.05$) to determine statistical significance. Data analysis was performed using OPSTAT software and Microsoft Excel.

Results and Discussion

Vegetative Growth Parameters

The data presented in Table 1 show that integrated nutrient management (INM) significantly influenced the vegetative growth of cauliflower. The variation among treatments in plant height, plant diameter, and plant spread was evident at both 45 days after sowing (DAS) and at harvest. The Maximum plants were recorded under treatment T_7 (15 t ha^{-1} vermicompost + 100% RDF), which achieved a height of 30.90 cm at 45 DAS and 35.30 cm at harvest, while the minimum plants were observed in the control (T_0) with 25.10 cm and 30.20 cm, respectively. The increase in plant height with the combined use of vermicompost and RDF indicates better nutrient availability, improved soil structure, and enhanced microbial activity. Vermicompost supplies macro and micronutrients in readily available forms along with plant growth-promoting substances such as auxins and cytokinins, which stimulate vegetative growth (Saha *et al*., 2023). Similar findings were reported by Kumar *et al*. (2022), who noted improved plant height in cole crops under integrated nutrient management involving vermicompost and chemical fertilizers.

Plant diameter followed a similar trend, showing significant improvement under INM treatments. The maximum stem diameter was recorded in T_7 (2.75 cm at 45 DAS and 3.50 cm at harvest), followed by T_6, while the minimum was found in T_0. The increase in plant diameter under organic and inorganic nutrient combinations can be attributed to enhanced nutrient uptake and balanced supply of essential elements that promote cell division and expansion. The incorporation of FYM and vermicompost improved soil organic matter and microbial population, which in turn supported better stem growth. A significant increase in plant spread was also noted under INM practices. The highest spread was observed in T_7 (45.0 cm in both N–S and E–W directions), while the lowest was in T_0 (41.0 cm N–S and 41.2 cm E–W). The greater spread under T_7 reflects enhanced vegetative vigour and canopy development due to efficient nutrient utilization. These results are consistent with those of Singh *et al*. (2021), who reported that INM practices improve foliage development and chlorophyll synthesis in cole crops through balanced nutrient supply.

The enhancement in vegetative parameters under treatments involving FYM + RDF + PSB can be linked to improved nitrogen availability and phosphorus solubilization by PSB, both of which are vital for leaf growth and elongation (Bhat *et al*., 2022). PSB inoculation increases the bioavailability of phosphorus from insoluble sources, promoting metabolic activity and overall plant vigour. The superior fresh and dry biomass observed in T_7 highlights the beneficial role of vermicompost in improving soil physical properties such as aeration and water-holding capacity. Vermicompost also contributes to nutrient mineralization and microbial enrichment, leading to enhanced root development and nutrient uptake (Gupta *et al*., 2023). The higher dry matter accumulation under this treatment suggests better assimilation and partitioning of nutrients into plant tissues, resulting in robust plant growth and improved yield potential. Vermicompost's positive effects on microbial biomass and enzymatic activities have also been reported by Yadav *et al*. (2023), supporting its role in enhancing organic matter decomposition and nutrient cycling.

Table 1 : Effect of Integrated Nutrient Management on Vegetative Growth Parameters of Cauliflower.

Treatment	Plant Height 45day(cm)	Plant Height at harvest	Plant Diameter (cm)	Plant Diameter at harvest	Plant Spread (N–S) (cm)	Plant spread (E-W)
T_0	25.10	30.20	1.60	2.20	41.00	41.20
T_1	26.20	31.10	1.80	2.45	41.50	41.70
T_2	26.60	31.50	1.95	2.60	42.00	42.10
T_3	27.80	32.40	2.10	2.85	42.30	42.50
T_4	28.00	32.80	2.20	3.00	42.80	42.90
T_5	28.60	33.20	2.35	3.10	43.10	43.40
T_6	29.30	34.00	2.50	3.25	44.00	44.10
T_7	30.90	35.30	2.75	3.50	45.00	45.00
SEm±	**0.34**	**0.40**	**0.03**	**0.77**	**0.82**	**0.76**
C.D. (p=0.05)	**1.05**	**1.35**	**0.09**	**0.02**	**1.96**	**2.32**

The data presented in Table 2 indicate that integrated nutrient management (INM) significantly influenced the number of leaves per plant, leaf length, and both fresh and dry biomass of cauliflower. All growth attributes showed a progressive improvement with the combined application of organic, inorganic, and biofertilizer inputs compared to the control. The maximum number of leaves per plant (20.0) was recorded in T_7 (15 t ha^{-1} vermicompost + 100% RDF), while the minimum (14.0) was observed in the control (T_0). The increase in leaf number under integrated treatments can be attributed to a steady and balanced nutrient supply throughout the growth period. Organic manures such as vermicompost and FYM improve soil physical properties, enhance microbial activity, and promote nutrient mineralization, which together stimulate leaf initiation and expansion (Bambal *et al*., 2018; Bahadur *et al*., 2017). Similar findings were also reported by Bhusan *et al*. (2015), who observed that INM significantly improved leaf development in knol-khol under subtropical conditions.

Leaf length also increased markedly under integrated nutrient applications. Treatment T_7 recorded the longest leaves (48.50 cm at 45 DAS and 50.00 cm at harvest), followed by T_6, whereas T_0 produced the shortest leaves (40.00 cm and 41.50 cm, respectively). The increase in leaf size under T_7 may be due to the availability of nitrogen, phosphorus, and potassium in balanced proportions, along with micronutrients and growth-promoting substances released from vermicompost. These nutrients are vital for cell division, elongation, and chlorophyll formation, which ultimately result in longer and broader leaves (Ceronio *et al*., 2012; Asghar *et al*., 2016). Adeleye *et al*. (2010) also noted similar results, reporting that the application of organic manures enhanced leaf nutrient content and photosynthetic surface area in yam.

Table 2 : Effect of Integrated Nutrient Management on Vegetative Growth Parameters of Cauliflower.

Treatment	Number of Leaves/Plant	Leaf Length (cm) 45 day	Leaf Length at harvest	Plant Fresh Weight (g)	Plant Dry Weight (g)
T_0	14.0	40.00	41.50	250.0	90.0
T_1	15.2	41.20	42.60	400.0	105.0
T_2	15.8	42.30	43.80	480.0	112.0
T_3	16.5	43.10	45.00	580.0	120.0
T_4	17.1	44.00	46.20	660.0	128.0
T_5	17.8	45.30	47.00	740.0	135.0
T_6	18.5	46.80	48.20	850.0	145.0
T_7	20.0	48.50	50.00	1000.0	160.0
SEm±	**0.27**	**0.62**	**0.54**	**9.85**	**2.31**
C.D. (p=0.05)	**0.83**	**1.91**	**1.67**	**30.09**	**7.09**

The fresh and dry weight of plants followed a similar trend, increasing significantly with the integration of vermicompost, FYM, and RDF. The highest fresh weight (1000 g) and dry weight (160 g) were obtained under T_7, while the lowest values (250 g and 90 g) were recorded in T_0. The improvement in plant biomass under T_7 reflects efficient nutrient assimilation and enhanced photosynthetic activity

resulting from improved soil structure and microbial population. Organic manures not only improve nutrient availability but also enhance soil aeration and water retention capacity, leading to vigorous plant growth (Abouel Magd *et al*., 2019; Chander and Verma, 2015). These findings are in agreement with Bhardwaj *et al*. (2017) and Basyal (2016), who reported increased vegetative growth and biomass in cauliflower under integrated use of biofertilizers and chemical fertilizers.

The synergistic interaction between organic and inorganic nutrient sources plays a critical role in improving nutrient uptake efficiency. Vermicompost contains humic substances and plant growth regulators that enhance root development and nutrient translocation, while chemical fertilizers ensure an immediate nutrient supply (Castro *et al*., 2016; Chan *et al*., 2008). As a result, plants under T_7 maintained higher metabolic activity and assimilate accumulation throughout the growth period. The enhanced dry matter accumulation under integrated treatments indicates better nutrient partitioning into structural and storage tissues. According to Bhardwaj *et al*. (2018), the substitution of part of the inorganic fertilizers with organic sources improves crop growth and yield while maintaining soil fertility. Similarly, Agarwal *et al*. (2010) reported that balanced nitrogen nutrition and proper plant spacing significantly influence the growth and marketable yield of cauliflower in cold arid regions.

Table 3 : Effect of Integrated Nutrient Management on Yield and Head Attributes of Cauliflower.

Treatment	Maturity Duration (days)	Head Length (cm)	Head Diameter (cm)	Head Weight (g)	Yield (q/ha)
T_0	75	11.00	12.00	500.00	100.00
T_1	77	12.50	13.20	610.00	112.00
T_2	78	13.20	14.00	680.00	118.00
T_3	79	14.00	15.00	740.00	125.00
T_4	80	15.20	16.00	810.00	130.00
T_5	82	16.00	16.50	870.00	136.00
T_6	83	16.50	17.00	920.00	140.00
T_7	85	18.00	18.00	1000.00	145.00
SEm±	**1.09**	**0.16**	**0.23**	**13.20**	**1.67**
C.D. (p=0.05)	**3.30**	**0.52**	**0.73**	**40.45**	**5.12**

The influence of integrated nutrient management (INM) on the yield and head characteristics of cauliflower is presented in Table 3.3. The data indicate a significant variation among treatments in terms of maturity duration, head length, diameter, weight, and total yield per hectare. Maturity duration was extended progressively with higher nutrient inputs. The earliest maturity (75 days) was observed in the control (T_0), while the latest maturity (85 days) occurred in T_7 (15 t ha^{-1} vermicompost + 100% RDF). The increased growth duration under INM is likely due to improved nutrient availability, particularly nitrogen, phosphorus and potassium, which promote sustained vegetative and curd development (Abouel Magd *et al*., 2019; Agarwal *et al*., 2010). Organic manures and biofertilizers provide a slow and steady nutrient release, supporting prolonged growth and physiological maturity (Bahadur *et al*., 2017; Basyal, 2016).

Head length and diameter were markedly enhanced under integrated treatments. T_7 produced the largest heads (18.0 cm length and 18.0 cm diameter), whereas the control exhibited the smallest heads (11.0 cm length and 12.0 cm diameter). The increase in head size under T_7 can be attributed to improved nutrient uptake facilitated by the combined action of vermicompost, FYM, and chemical fertilizers. Vermicompost contributes humic substances and plant growth hormones that enhance cell division, enlargement and photosynthate translocation, thereby improving head formation (Ceronio *et al*., 2012; Chan *et al*., 2008). Adequate nitrogen and phosphorus supply from RDF and PSB further support curd development by promoting meristematic activity and energy availability for rapid head growth (Bhardwaj *et al*., 2017; Bhardwaj *et al*., 2018).

Head weight showed a similar trend, with T_7 producing the maximum weight (1000 g per head) compared to 500 g in the control. The increase in head weight under integrated treatments reflects the cumulative effect of better vegetative growth, leaf area expansion, and efficient translocation of assimilates from source to sink. Improved soil physical and biological properties under organic amendments enhance water retention, aeration, and nutrient mineralization, which collectively contribute to higher biomass accumulation and curd development (Gupta *et al*., 2023; Yadav *et al*., 2023; Bhusan *et al*., 2015).

The total yield per hectare was significantly influenced by INM. T_7 recorded the highest yield (145 q/ha), followed by T_6 (140 q/ha), whereas the lowest yield (100 q/ha) was observed in the control. The enhanced yield under vermicompost-based INM is a result of synergistic effects between organic and inorganic nutrient sources, which improve nutrient-use efficiency, plant vigour, and photosynthetic efficiency (Singh *et al*., 2021; Abouel Magd *et al*., 2019). Biofertilizers such as PSB enhance phosphorus availability, supporting curd formation and metabolic processes essential for high yield (Bhat *et al*., 2022). Moreover, the combined application of organic and inorganic nutrients maintains a favourable microclimate in the root zone, stimulating microbial activity and nutrient cycling, which ultimately supports higher head weight and total yield (Adeleye *et al*., 2010; Asghar *et al*., 2016).

Overall, the results demonstrate that the integration of vermicompost, FYM, PSB, and RDF not only improves vegetative growth and leaf development but also enhances head characteristics and productivity of cauliflower. Among all treatments, T_7 (15 t ha^{-1} vermicompost + 100% RDF) consistently outperformed other treatments, highlighting the importance of INM as a sustainable and effective strategy for achieving higher yield and superior quality in cauliflower under semi-arid Indian conditions. These findings are in agreement with previous studies emphasizing the role of organic amendments, biofertilizers, and balanced chemical fertilization in improving both yield and nutrient-use efficiency in cole crops (Anonymous, 2018; Bhardwaj *et al*., 2018; Bahadur *et al*., 2017).

Conclusion

Integrated nutrient management significantly improved the growth, biomass, and yield of cauliflower. The best performance was observed in T_7 (15 t ha^{-1} vermicompost + 100% RDF), indicating that combining organic manures, biofertilizers, and chemical fertilizers enhances nutrient availability, plant vigour, and curd quality. These results highlight INM as a sustainable and effective strategy for increasing productivity while maintaining soil fertility.

References

Abouel Magd, M.M., Abd E.T. Fattah, A.A. and Selim, E.M. (2019). Influence of mineral and organic fertilization methods on growth, yield and nutrients uptake by Cauliflower crop. *World J. Agric, Sci*., **5**(5): 582-589.

Adeleye, E.O., Ayeni, L.S. and Ojeniyi, S.O. (2010). Effect of poultry manure on soil physico-chemical properties, leaf nutrient contents and yield of Yam (*Dioscorea rotundata*) on alfisol in South western Nigeria. *Journal of American Science,* **6**(10):871-878.

Agarwal, A., Gupta, S. and Ahmed Z. (2010). Nitrogen nutrition and plant density influencing marketable head yield of Cauliflower in cold arid desert of Ladakh. *Acta Horticulturae,* **756**: 321-323.

Anonymous (2018). Horticultural Statistics at a Glance. Government of India Ministry of Agriculture & Farmers' Welfare Department of Agriculture, Cooperation & Farmers' Welfare, New Delhi.

Asghar, H. N., Ishaq, M., Zahir, Z. A., Khalid, M. and Arshad, M. (2016). Response of radish to integrated use of nitrogen fertilizer and recycled organic waste. *Pakistan Journal of Botany*, **38**(3): 691-700.

Bahadur A., Singh J., Singh K.P., Upadhyay, A. K. and Rai, M. (2017). Effect of organic amendments and bio fertilizers on growth, yield and quality attributes of Chinese cabbage. *Research Journal of Agriculture and Biological Sciences*, **3**(6): 858- 885.

Bambal, A.S., Verma, R.M., Panchbhai, D.M., Maharkar, V. K. and Khankhane, R. N. (2018). Effect of bio fertilizers and nitrogen levels on growth and yield of cauliflower (*Brassica oleracea* var. *botrytis*. L). *Orissa Journal of Horticulture*, **26**:14-17.

Basyal, L.N. (2016). Response of cauliflower to nitrogen fixing biofertilizer and graded levels of nitrogen. *Journal of Agriculture and Environment*, **12**: 41-50.

Bhardwaj A.K., Kumar P. and Singh R.K. (2017). Response of nitrogen and pre-planting treatment of seedlings with the azotobacter on growth and productivity of Cauliflower (*Brassica oleracea* Var. *italica*). *The Asian Journal of Horticulture,* **2**(1): 15-17.

Bhardwaj, M.L., Raj Harender and B.L. Koul (2018). Yield response and economics of organic sources of nutrients as substitute to inorganic sources in tomato (*Lycopersicon esculentum*), Okra (*Hibiscus esculentus*), cabbage (*Brassica oleracea var*. cpitata) and cauliflower (*Brassica oleracea var. botrytis). Indian Journal of Agricultural Sciences,* **70**(10): 653- 656.

Bhat, M. A., Sharma, A. & Gupta, M. (2022). Effect of integrated nutrient management on yield and nutrient uptake in cauliflower. *Journal of Plant Nutrition*, **45**(3), 356–367.

Bhusan, A., Sharma, A.K. and Sharma, J.P. (2015). Integrated nutrient management in knol-khol under Jammu and Kashmir condition. *J. Res., SKUAST-J,* **9**(2): 240-243.

Ceronio, G.M., Engelbrecht, G.M. and Mbatha, A.N. (2012). Organic fertilizer use and the potential influence on cabbage (*Brassica oleracea* L. var. *capitata*) plant and soil nutrient composition. *Acta Horticulturae.* **1**(938): 265-272.

Chan, K.Y., Dorahy, C., Wells, T., Fahey, D., Donovan, N., Saleh, F. and Barchia, I. (2008). Use of garden organic compost in vegetable production under contrasting soil P status. *Australian Journal of Agricultural Research* **59**(4): 374-382.

Edwards, C.A., Arancon, N.Q., and Sherman, R.L. (2004). *Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management*. CRC Press.

Gupta, A., Verma, R., & Singh, R. (2023). Role of vermicompost and biofertilizers in enhancing productivity of cole crops under organic farming. *Indian Journal of Horticulture*, **80**(2), 310–316.

Jat, J. R., Yadav, B. L., & Meena, R. H. (2016). Response of cabbage to integrated nutrient management under semi-arid conditions. *Haryana Journal of Horticultural Sciences*, **45**(2), 177–180.

Khan, M. S., Zaidi, A., & Wani, P. A. (2009). Role of phosphate-solubilizing microorganisms in sustainable agriculture - A review. *Agronomy for Sustainable Development*, **29**(1), 43–54.

Kumar, A., Kumar, S., & Singh, B. (2017). Effect of integrated nutrient management on growth and yield of cauliflower under mid-hill conditions. *Indian Journal of Horticulture*, **74**(1), 84–88.

Kumar, V., Mishra, S., & Singh, J. (2022). Comparative response of organic and inorganic fertilizers on growth and quality of broccoli. *Vegetable Science*, **49**(1), 89–94.

Patel, J. R., Patel, N. B., & Bhalu, V. B. (2017). Effect of INM on yield and economics of cauliflower (*Brassica oleracea* var. botrytis L.). *International Journal of Current Microbiology and Applied Sciences*, **6**(5), 1101–1107.

Reddy, S. R., & Reddi, R. (2008). Principles of Agronomy. Kalyani Publishers, Ludhiana.

Saha, S., Roy, D., & Paul, T. (2023). Vermicompost and nutrient dynamics: a review of biological properties and yield impact in vegetable crops. *International Journal of Agriculture and Biology*, **25**(4), 565–574.

Sharma, R. K., Meena, R. K., & Singh, M. (2020). Influence of organic manures and inorganic fertilizers on growth and yield attributes of cabbage. *Journal of Krishi Vigyan*, **8**(2), 17–21.

Singh, P., Yadav, M., & Meena, M. (2021). Effect of INM on vegetative growth and yield of cauliflower (*Brassica oleracea* var. *botrytis* L.). *Journal of Agriculture and Ecology*, **11**(1), 20–26.

Singh, V., Yadav, R. K., & Choudhary, S. (2018). Effect of integrated nutrient management on growth, yield and quality of cauliflower. *International Journal of Chemical Studies*, **6**(2), 291–294.

Yadav, R., Sharma, V., & Rana, S. (2023). Soil microbial activity and plant performance under integrated nutrient management in vegetable cropping systems. *Agricultural Reviews*, **44**(3), 415–422.