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Effect of integrated nutrient management on growth, yield and quality of cucumber (*Cucumis sativus* L.)

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Abstract
A field experiment was conducted during the Kharif 2024-25 at the Horticultural Research Farm, School of Agriculture, Suresh Gyan Vihar University, Jaipur. The study was aimed at evaluating the effect of integrated nutrient management practices on cucumber (*Curcumis sativus* L.) under the semi-arid conditions of Rajasthan. The experiment was laid out in a randomized block design. Treatments consist ofT_1 - Control, T_2 - 100% recommended dose of fertilizer (RDF 100:60:60 NPK/ha), T_3 - 100% farmyard manure (FYM 25 t/ha), T_4 - 100% Vermicompost (VC 10 t/ha), T_5 - 75% RDF + 25% FYM, T_6 - 75% RDF + 25% Vermicompost, T_7 - 50% RDF + 50% FYM, T_8 - 50% RDF + 50% Vermicompost, T_9 - 75% RDF + 12.5% FYM + 12.5% Vermicompost, and T_{10} - 50% RDF + 25% FYM + 25% Vermicompost. The results indicate that among the different treatments T_9 (75% RDF + 12.5% FYM + 12.5% Vermicompost) recorded the best performance among all treatments. This treatment significantly enhanced plant growth, fruit yield, and quality parameters compared to both control and sole fertilizer applications. The highest total fruit yield (253.38 q/ha), maximum total soluble solids (3.84° Brix), and longest shelf life (7.86 days) were recorded in T_9. It also resulted in the highest net return (₹1,52,076/ha) and benefit-cost ratio (4.00), thus proving its economic superiority. So, in was concluded that the treatment combination T_9- 75% RDF + 12.5% FYM + 12.5% VC are best for cucumber cultivation.

Keywords: Cucurbits, economics, quality, balanced, ecosystem, vermicompost, yield

Introduction
Cucumber (*Cucumis sativus* L.) belongs to the family Cucurbitaceae, which comprises around 118 genera and over 825 species. It is a warm-season, annual, monoecious vine, cultivated for its tender fruits consumed as vegetables. It gained popularity across the globe due to its refreshing taste, nutritional properties and multipurpose culinary uses. As per the National Horticulture Board (NHB, 2023) [13], cucumber is cultivated over 81,000 hectares in India, with an annual production of 1.25 million tonnes and an average productivity of 15.4 t/ha. Major cucumber-growing states include Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh and Bihar. In Rajasthan, cucumber is grown mostly in Jaipur, Ajmer, Tonk and Dausa districts, under both open-field and protected conditions Cucumber is an excellent source of vitamins A, C, K, and B6, potassium, pantothenic acid, magnesium, phosphorus, copper and manganese (Vimala *et al.* 1999) [25]. The ascorbic acid and caffeic acid present in the cucumber helps to reduce the skin irritation (Okonmah, 2011) [14]. According to the USDA Nutrient Database (2022) [24], 100 g of cucumber provides 15 kcal energy, 3.6 g carbohydrates, 0.7 g protein, 0.1 g fat, and 0.5 g fiber. It is rich in potassium (147 mg), magnesium (13 mg), Vitamin C (2.8 mg) and Vitamin K (16.4 mcg). Cucumber also contains antioxidants like cucurbitacins, lignans, flavonoids and other polyphenols that contribute to its detoxifying, anti-inflammatory and hydrating properties (USDA, 2022; Nargis *et al.*, 2021) [12, 24]. Cucumber is used for fresh consumption and for preservation. Immature fruits are mainly used as salad, pickling and also used with curd for the preparation of "Rayata" (Singh *et al.* 2020) [20]. Cucumber thrives in well-drained, loamy to sandy loam soils, rich in organic matter. It grows well in soils with a pH between 6.0 and 7.5. Poorly drained, heavy clay soils should be avoided due to the crop's shallow root system and sensitivity to waterlogging (Thamburaj and Singh, 2001) [23]. In the

semi-arid regions, low soil fertility and organic matter content are common issues, hence integrating organic sources is essential for soil improvement and better crop performance (Kayesh *et al*., 2023) [9]. It is highly sensitive to temperature and photoperiod. It performs best in a temperature range of 25 °C to 30 °C, with adequate humidity during flowering and fruiting stages. It is sensitive to frost and low temperatures, which affect germination and fruit set. The crop requires abundant sunlight and grows optimally under long-day conditions (Sirohi *et al*., 2019) [21]. The semi-arid Eastern Plain Zone of Rajasthan (Zone IIIa), which includes Jaipur, is characterized by hot summers, low and erratic rainfall (500-700 mm annually) and sandy loam soils, making moisture and nutrient management critical for successful cultivation (RARI, Durgapura, 2022).

Integrated nutrient management (INM) is an ecologically sound and economically viable approach that combines chemical fertilizers, organic manures, and bioinoculantsto maintain soil fertility and achieve optimum crop yield. INM enhances nutrient use efficiency, improves soil structure and promotes beneficial microbial activity. In cucumber cultivation, INM has proven effective in increasing fruit number, size, weight and quality while also improving soil health and reducing environmental hazards associated with indiscriminate chemical fertilizer use. Combining 50-75%% recommended dose of fertilizer (RDF) with farmyard manure (FYM) or vermicompost has shown significant improvements in vegetative growth, fruit yield and shelf life (Solankey *et al*. 2018) [22]. FYMis age-old, slow-releasing organic manure composed of decomposed animal waste, straw and bedding materials. It contains essential plant nutrients and contributes to the improvement of soil texture, water retention, and aeration. FYM also supports soil microbial activity and provides a continuous supply of nutrients throughout the crop growth period. Application of FYM @ 25 t/ha in cucumber has been reported to increase fruit yield by 18-22% over the control (Choudhary *et al*., 2024) [4]. Its long-term use enhances the organic carbon pool and suppresses soil-borne pathogens, contributing to better plant health and productivity. In this regard the present experiment was conducted to assess the effect of different organic manures partially substituted by chemical fertilizers on the growth, yield and quality of cucumber.

Materials and Methods

The experiment was conducted during summer season of 2024-25 at Horticultural Research Farm, School of Agriculture Suresh Gyan Vihar University Jaipur. Geographically, the study area is located at 75º51'44" E longitude and 26º48'35" N latitude. The half dose of nitrogen, full dose of phosphorus and potassium were applied in the experimental plots at the time of seed sowing. The remaining half dose of nitrogen was applied in two equal doses at vining stage and flower initiation stage. Similarly, plant protection measures were also done with spraying preventive sprays of neem oil (3%) and Bordeaux mixture (1%) to manage fungal and sucking pests. Imidacloprid (0.3 ml/L) was used for controlling aphid and whitefly as needed. Carbendazim (0.1%) was applied in early stages to prevent damping off and powdery mildew. The experiment was laid out in randomized block design (RBD) and replicated thrice. Total ten treatments were tried namely T_1 - Control, T_2 - 100% RDF (100:60:60 NPK/ha), T_3 - 100% FYM (25 t/ha), T_4 - 100% Vermicompost (10 t/ha), T_5 - 75% RDF + 25% FYM, T_6 - 75% RDF + 25% Vermicompost, T_7 - 50% RDF + 50% FYM, T_8 - 50% RDF + 50% Vermicompost, T_9 - 75% RDF + 12.5% FYM + 12.5% Vermicompost, and T_{10} - 50% RDF + 25% FYM + 25% Vermicompost. The cucumber variety Pusa Uday was taken for study purpose. Variety Pusa Uday was developed and released in 2004 by the Indian Agricultural Research Institute, New Delhi. It is a high-yielding and early-maturing variety recommended for cultivation during the spring-summer and rainy seasons, particularly well suited to the North Indian plains and areas around Delhi NCR. The seeds were sown in field at a spacing of 1.00 m x 0.50 m. The RDF applied was 100:60:60 kg $N:P_2O_5:K_2O$ per hectare, based on standard crop requirements. Organic sources used were FYM at 25 tonnes/hand vermicompost at 10 tonnes/ha on 100% basis. Growth attributes (vine length, number of branches, number of branches per plant, leaf length and leaf width) were recorded at 60 days after sowing. Yield attributes such as days to first fruit formation, number of fruits per plant, fruit length, fruit width, fruit weight, fruit yield per plant, per plot, and quintal per hectare were observed. Quality parameters including total soluble solids (Hand refractometer method) and shelf-life content were estimated. The statistical analysis was performed according to Panse and Sukhatme.

Results and Discussion

Effect of INM on growth parameters

Result showed that significant variation in growth parameters of cucumber under different INM treatments. The growth traits evaluated at 60 DAS included vine length, number of leaves per plant, number of branches per plant, leaf length, and leaf width. Among all treatments, application of T_9 consistently recorded the highest vine length, a greater number of leaves per plant, number of branches, leaf length and leaf width Table 1. This can be attributed to the synergistic effect of inorganic and organic nutrient sources. The application of RDF ensures the immediate availability of essential nutrients like nitrogen, phosphorus, and potassium, while the addition of FYM and vermicompost improves soil structure, microbial activity, and moisture retention, leading to enhanced nutrient uptake and plant vigor. These findings are in line with the results reported by Choudhary *et al*. (2024) [4] who also reported significant improvement in vine length and leaf number in cucumber when RDF was partially substituted with organic manures. Also Aboyeji *et al*. (2025) [1] also reported that 75% organics + 25% inorganics gave maximum vine length and minimum days to first harvest under protected cucumber cultivation, supporting the present findings. Similarly, Eifediyi and Remison (2010) [6] emphasized that vermicompost combined with NPK and wool waste significantly enhanced vegetative growth traits such as vine length (~2.5 m) in cucumber under polyhouse conditions.

Application of $T_{10}$and T_6also showed considerable enhancement in growth traits, indicating that higher proportions of vermicompost are particularly effective in stimulating vegetative growth. Vermicompost releases nutrients slowly and continuously, which supports sustained growth, while also enhancing the hormonal activity in plants. The lowest growth performance was recorded in the T_1, which received no nutrients. This under scores the critical role of nutrient management in promoting early and vigorous growth of cucumber. The superior performance of INM treatments, particularly those with a balanced blend of inorganic and organic sources, confirms the hypothesis that integrated nutrient application supports both immediate nutrient needs and long-

term soil fertility a conclusion echoed by Pramanik *et al*. (2020) [17] in their field studies on cucurbits. Thus, the present study clearly establishes that integration of organic manures with chemical fertilizers plays a crucial role in sustaining vegetative growth of cucumber by improving both nutrient supply and soil health.

Effect of INM on yield parameters

The yield parameters of cucumber were significantly influenced by the different INM treatments. Yield attributes including number of fruits per plant, fruit length, fruit width, average fruit weight, fruit yield per plant, fruit yield per plot, and total fruit yield per hectare showed marked improvement under INM treatments compared to the control. Among all treatments, the T_9 treatment recorded the maximum yield in every parameter, including fruit yield per hectare. The highest fruit yield per hectare was recorded in T_9, followed by T_{10}Table 2, while the lowest was recorded in the control T_1. This significant enhancement in yield can be attributed to improved nutrient availability throughout the growth period, especially nitrogen and potassium, which play vital roles in fruit development, cell enlargement, and translocation of assimilates. Moreover, the synergistic effect of FYM and vermicompost likely enhanced microbial activity, leading to better nutrient mineralization and uptake. These results are in agreement with the findings of Jat *et al*.(2020)who also observed maximum cucumber yield (28.7 t/ha) under 75% RDF + 12.5% FYM + 12.5% Vermicompost in Jaipur conditions. Recent findings by Eifediyi and Remison. (2010) [6] support these observations, reporting that the integration of vermicompost with NPK improved fruit length, diameter and yield under polyhouse conditions. Rajawat *et al*. (2021) also confirmed that 50% organics + 50% inorganics improved cucumber yield and soil fertility simultaneously.

The control treatment (T_1) recorded the lowest yield (66.3 q/ha), demonstrating the inadequacy of native soil fertility to support optimal cucumber productivity under Jaipur's semi-arid conditions. This improvement may be due to better synchronization of nutrient release, particularly nitrogen and phosphorus, from FYM and vermicompost along with chemical fertilizers, leading to better flowering, fruit set, and fruit development. Jaiswal *et al*. (2022) [8] and Pandey *et al*. (2001) had earlier reported similar yield enhancements under integrated nutrient systems. In line with these results, Singh *et al*. (2018) [19] also observed maximum cucumber yield (28.7 t/ha) under 75% RDF + 12.5% FYM + 12.5% Vermicompost in Jaipur conditions. (Chakma *et al.* 2022) [3].

Effect of INM on quality of Cucumber

The quality of cucumber fruits, evaluated in terms of TSS and Shelf Life, was significantly influenced by the various INM treatments. The treatment T_9 recorded the highest TSS (3.84°Brix) and maximum shelf life (7.86 days) Table 3, indicating a superior effect of balanced nutrient application on internal fruit quality and storability. These combination of chemical and organic nutrients not only enhances the growth and yield of cucumber but also improves its market value and post-harvest characteristics. The cucumber fruits produced under T_9 not only had better yield but also superior post-harvest quality. More recent studies, such as by Aboyeji *et al*. (2025) [1], demonstrated that integrated application of organic and inorganic fertilizers improves fruit quality parameters along with soil nutrient status, which aligns well with the present results (Naegele and Wehner 2016) [11].

Treatments T_{10} and T_6 also resulted in high fruit quality parameters, lower than T_9. This reinforces that even partial integration of organic components into chemical fertilizer schedules positively impacts fruit quality. On the contrary, T_1 (Control) fruits has the lowest TSS (2.48°Brix) and minimum shelf life (5.02 days), highlighting the inadequacy of soil nutrients to maintain fruit quality without supplementation. The role of organic matter in enhancing microbial activity, improving soil structure, and supplying secondary nutrients contributes to better physiological functioning of plants, thereby improving fruit quality attributes (Gurmu, 2019) [7].

Effect of INM on economics of Cucumber

The economic evaluation of the INM treatments revealed substantial differences in profitability, as influenced by yield output and input costs. The parameters considered include cost of cultivation, gross return, net return, and benefit-cost (B:C) ratio. The treatment T_9 emerged as the most economically viable, registering the highest gross return (₹ 2,02,701/ha), net return (₹1,52,076/ha), and B:C ratio (4.00, Table 4). This is due to its highest yield (253.38 q/ha), which offset the moderately higher cost of cultivation. The synergy between the quick availability of nutrients from RDF and the sustained nutrient release from organics such as FYM and vermicompost led to better growth, fruiting, and ultimately greater economic returns. These findings are consistent with the work of the superior economic performance of INM treatments is mainly due to higher yield with relatively low additional input costs of FYM and vermicompost compared to the revenue generated. Similar economic advantages of INM in cucumber were reported by Parvathi (2022) [15] and Sharma *et al*. Also, Kumar *et al*. (2015) [10] also showed that cucumber cultivation under integrated nutrient management in protected conditions provided higher net returns and B:C ratio compared to open field conditions, reinforcing the present findings.

The treatment Application of 50% RDF + 25% FYM + 25% Vermicompost also performed well, with a B:C ratio of 3.74. This confirms that even when input costs are higher, profitability is still achievable if yields are significantly improved a key advantage of balanced nutrient management. Treatment T_6 also showed excellent profitability (net return ₹1,25,352/ha), and its economic performance was statistically comparable to T_9, making it a suitable alternative where FYM availability is limited. On the other hand, T_1 (Control) recorded the lowest economic performance, with a net return (₹22,900/ha) and a B:C ratio of 1.58. This reaffirms the need for external nutrient inputs in cucumber cultivation under the nutrient-deficient soils of semi-arid regions of Rajasthan the results demonstrate that the integrated use of organics and inorganics not only enhances yield and quality but also improves the economic sustainability of cucumber farming, especially under resource-limited and environmentally sensitive conditions.

Table 1: Effect of integrated nutrient management on growth characters of cucumber

Treatment	Vine Length (cm)	Number of Leaves/Plant	Number of Branches/Plant	Leaf Length (cm)	Leaf Width (cm)
T_1: Control	127.14	23.18	3.01	11.43	9.62
T_2: RDF (100:60:60 kg NPK/ha)	148.67	27.45	3.76	13.82	11.74
T_3: FYM @25 t/ha	136.42	25.33	3.42	12.67	10.81
T_4: Vermicompost @10 t/ha	139.55	26.18	3.59	12.96	11.15
T_5: 75% RDF + 25% FYM	163.71	30.67	4.41	15.45	13.28
T_6: 75% RDF + 25% Vermicompost	184.21	33.47	5.33	16.83	14.01
T_7: 50% RDF + 50% FYM	171.24	31.76	4.76	15.92	13.39
T_8: 50% RDF + 50% Vermicompost	176.33	32.65	5.12	16.24	13.66
T_9: 75% RDF + 12.5% FYM + 12.5% Vermicompost	192.67	35.72	5.68	17.64	14.76
T_{10}: 50% RDF + 25% FYM + 25% Vermicompost	188.35	34.15	5.42	17.21	14.33
C.D. (p=0.05)	21.60	3.62	0.54	1.83	1.63

*RDF (Recommended dose of fertilizer)

Table 2: Effect of integrated nutrient management on yield characters of cucumber

Treatment	Days to 1st Fruit Formation	Number of Fruits/Plant	Fruit Length (cm)	Fruit Width (cm)	Average Fruit Weight (g)	Fruit Yield/Plant (kg)	Fruit Yield/Plot (kg)	Total Fruit Yield (q/ha)
T_1: Control	46.18	4.2	14.37	4.37	92.25	0.39	7.8	97.2
T_2: RDF (100:60:60 kg NPK/ha)	43.75	5.5	16.92	4.86	124.36	0.68	13.68	136.8
T_3: FYM @25 t/ha	45.62	5.12	15.84	4.63	115.18	0.59	11.79	117.94
T_4: Vermicompost @10 t/ha	44.84	6.52	16.15	4.77	136.25	0.89	17.77	177.67
T_5: 75% RDF + 25% FYM	41.22	6.1	17.98	5.12	128.05	0.78	15.62	156.22
T_6: 75% RDF + 25% Vermicompost	40.26	7.33	18.92	5.63	148.45	1.09	21.76	217.63
T_7: 50% RDF + 50% FYM	42.34	5.32	17.63	5.34	120.22	0.64	12.79	127.91
T_8: 50% RDF + 50% Vermicompost	41.56	6.78	18.26	5.46	141.42	0.96	19.18	191.77
T_9: 75% RDF + 12.5% FYM + 12.5% Vermicompost	38.45	8	19.84	5.92	158.36	1.27	25.34	253.38
T_{10}: 50% RDF + 25% FYM + 25% Vermicompost	39.12	7.61	19.21	5.76	152.25	1.16	23.17	231.72
C.D. (p=0.05)	5.39	1.01	2.59	0.69	16.47	0.1	2.22	28.49

Table 3: Effect of INM on quality characters of cucumber.

Treatment	TSS (°Brix)	Shelf Life (Days)
T_1: Control	2.48	5.02
T_2: RDF (100:60:60 kg NPK/ha)	2.92	5.94
T_3: FYM @25 t/ha	2.63	5.43
T_4: Vermicompost @10 t/ha	2.74	5.56
T_5: 75% RDF + 25% FYM	3.32	6.72
T_6: 75% RDF + 25% Vermicompost	3.62	7.45
T_7: 50% RDF + 50% FYM	3.41	6.91
T_8: 50% RDF + 50% Vermicompost	3.47	7.13
T_9: 75%RDF + 12.5% FYM + 12.5% Vermicompost	3.84	7.86
T_{10}: 50% RDF + 25% FYM + 25% Vermicompost	3.71	7.63
C.D. (p=0.05)	0.09	0.22

Table 4: Effect of INM on economics of cucumber

Treatment	Cost of Cultivation (₹/ha)	Gross Return (₹/ha)	Net Return (₹/ha)	B:C Ratio
T_1: Control	39,500	62,400	22,900	1.58
T_2: RDF (100:60:60 kg NPK/ha)	43,500	1,09,437	65,937	2.52
T_3: FYM @25 t/ha	47,000	94,355	47,355	2.01
T_4: Vermicompost @10 t/ha	64,500	1,42,136	77,636	2.2
T_5: 75% RDF + 25% FYM	44,375	1,24,977	80,602	2.82
T_6: 75% RDF + 25% Vermicompost	48,750	1,74,102	1,25,352	3.57
T_7: 50% RDF + 50% FYM	45,250	1,02,331	57,081	2.26
T_8: 50% RDF + 50% Vermicompost	54,000	1,53,412	99,412	2.84
T_9:75%RDF+12.5%FYM+12.5%Vermicompost	50,625	2,02,701	1,52,076	4.00
T_{10}:50%RDF+25% FYM + 25% Vermicompost	49,625	1,85,380	1,35,755	3.74

Conclusion

On the basis of results which obtained from the study and it concluded that the treatment T_9- 75% RDF + 12.5% FYM + 12.5% vermicompost was found superior in terms of growth, yield and quality of cucumber and also increases the net return. So, in was concluded that the treatment combination T_9- 75% RDF + 12.5% FYM + 12.5% Vermicompost are best for cucumber cultivation.

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