International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; SP-9(8): 526-530
www.biochemjournal.com
Received: 08-05-2025
Accepted: 11-06-2025

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Effect of integrated nutrient management using vermicompost, wool waste and NPK on cucumber (*Cucumis sativus* L.) growth and yield in protected cultivation

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DOI: https://www.doi.org/10.33545/26174693.2025.v9.i8Si.5201

Abstract
The field experiment was conducted in the shade net house at National Seed Project, Department of Horticulture, College of Agriculture, SKRAU, Bikaner during *kharif* season 2024. The experiment comprised nine treatment combinations, each replicated three times. It was laid out in randomized block design with three levels of inorganic fertilizers (Control, 50% NPK and 100% NPK) and two treatments of organic manures (Wool waste @ 10 t/ha and Vermicompost @ 10 t/ha). The experimental results revealed that the treatment T_9 (NPK-100% + 10t/ha wool waste) gave significant maximum results in growth parameter *viz;* vine length at final harvest (3.59 m), no. of primary branches per vine (6.42), days to first flower initiation (32.10), days to first fruit set (35.01), days to first fruit harvest (42.87) and per cent fruit set (94.46%) yield and yield attributes *viz;* number of fruits per vine (12.88), fruit length (17.88 cm), fruit diameter (4.58), weight of fruit (138.99 g), number of pickings (7.12), fruit yield per vine (1.79 kg) fruit yield per plot (53.47 kg) and fruit yield per hectare (59.60 t/ha).

Keywords: *Cucumis sativus* L., yield, vermicompost, wool waste and NPK

Introduction
In the context of evolving global challenges, ensuring nutritional security has emerged as a critical aspect of sustainable agriculture. Vegetables, which may be annual, biennial or perennial, consist of edible parts such as immature or mature roots, stems, leaves, flowers, seeds and fruits. These herbaceous plants are consumed either raw or cooked and are integral to human diets due to their richness in essential vitamins, minerals, phytochemicals and dietary fiber (Dias, 2011) [6]. Consistent vegetable consumption is associated with reduced risks of chronic diseases including cancer, cardiovascular disorders, and overall mortality (Aune *et al*., 2017) [4].

Cucumber (*Cucumis sativus* L.), locally known as 'Khira', is an annual, monoecious vine from the *Cucurbitaceae* family. With a chromosome number of 2n = 2x = 14, it has a long cultivation history dating back over three millennia, particularly in its center of origin—India—where diverse landraces and its close relative, *Cucumis hystrix*, are still found (Adetula & Denton, 2003) [1]. Being a thermophilic crop, cucumber thrives best at temperatures exceeding 20 °C and is sensitive to frost (Tatlioglu, 1993) [15]. The immature fruits are widely consumed in salads and pickles and are valued for their medicinal attributes, including cooling effects and benefits against constipation, jaundice and indigestion (Rana, 2008) [11].

Cucumber is nutritionally significant, comprising about 95% water and 4-6% dry matter, which includes carbohydrates, vitamins B and C, calcium, phosphorus and trace elements like iodine. It contains bioactive compounds such as cucurbitacin and key aromatic compounds like 2, 6-nonadienal and 2-hexanol, which contribute to its flavor and aroma (Rana, 2008) [11]. The peel is rich in vitamin C, offering nearly 10% of the daily recommended intake (Ali & Jahan, 2001) [3].

Protected cultivation, including shade net house systems, provides favorable microclimates for enhanced crop performance and quality, supporting both off-season and year-round production. As fertilizer costs make up a substantial portion of cucumber cultivation expenses, ensuring adequate nutrient management is vital. Due to the crop's high productivity potential, balanced nutrition—especially involving nitrogen (N), phosphorus (P), and potassium (K)—is essential for optimizing growth and fruit yield.

Vermicompost, produced through the decomposition of organic waste by earthworms, is a sustainable, non-toxic soil amendment rich in macronutrients (approximately 2.5% N, 1.5% P_2O_5 and 1.5% K_2O) and micronutrients including magnesium, iron, zinc, manganese, boron and copper (Ali & Jahan, 2001) [3]. Wool waste, characterized by its fibrous and protein-rich composition, is also a biodegradable material beneficial for soil health. Its application as hydrolyzed wool has shown positive effects on seedling vigor and plant development (Nustorova *et al.*, 2014) [10].

Materials and Methods

The present investigation entitled "Effect of Integrated Nutrient Management Using Vermicompost, Wool Waste and NPK on Cucumber (*Cucumis sativus* L.) Growth and Yield in Protected Cultivation'' was conducted at the shade net house at National Seed Project, Department of Horticulture, College of Agriculture, Bikaner, SKRAU, Bikaner during *kharif* season 2024. The experiment was laid out in a Randomized Block Design with nine treatments and three replications (Table no. 1) under Bikaner agro climatic condition.

Table 1: Details of the treatments used in study

S. No.	Treatment Notation	Treatment Combination
1.	T_1	Control
2.	T_2	NPK-50%
3.	T_3	NPK-100%
4.	T_4	10t/ha Vermicompost
5.	T_5	NPK-50% + 10t/ha Vermicompost
6.	T_6	NPK-100% + 10t/ha Vermicompost
7.	T_7	10t/ha Wool waste
8.	T_8	NPK-50% + 10t/ha Wool waste
9.	T_9	NPK-100% + 10t/ha Wool waste

A basal dose of 10 t/ha vermicompost and 10t/ha wool waste was applied in relevant treatment combination plots before sowing of seeds. Nitrogen was applied in the form of urea in two split doses out of which half dose applied at the time of planting and rest was applied during flowering stage. Phosphorus and potassium were applied in the form of di-ammonium phosphate and muriate of potash respectively at the time of sowing. The fertilizer as per treatments was thoroughly mixed in the soil with the help of weeding hoe.

Results and Discussion

Growth parameters

The results of the current study demonstrated that the application of various organic manures and chemical fertilizers had a significant impact on key growth attributes in cucumber including vine length (m), number of primary branches per vine, days to first flower initiation, first fruit set, first harvest and percentage of fruit set at different growth stages. As shown in Table 2, the integration of wool waste with recommended doses of NPK fertilizers notably enhanced these parameters.

Treatment T_9 (100% NPK + 10 t/ha wool waste) resulted in the greatest vine elongation (3.59 m) and the highest number of primary branches (6.42), closely followed by T_6 (100% NPK + 10 t/ha vermicompost). In contrast, T_1 (control) exhibited the lowest values for vegetative traits. The substantial improvements in plant growth under T_9 and T_6 could be attributed to improved soil physicochemical properties and enhanced nutrient availability, resulting from the combined effect of organic and inorganic fertilization. Additionally, the favorable conditions provided by protected cultivation (shade net house) likely contributed to improved vine development and branching. These outcomes are consistent with the observations made by Singh *et al.* (2020) [13], Vamsi *et al.* (2021) [16] and Ahmad & Prasad (2022) [2].

The initiation of flowering is a critical determinant for achieving early fruit production. With regard to reproductive parameters (Table 2), treatment T_9 (100% NPK + 10 t/ha wool waste) showed the earliest initiation of flowering (32.10 days), fruit set (35.01 days) and harvest (42.87 days) again followed by T_6. Conversely, the control treatment (T_1) was significantly delayed in flowering (40.31 days), fruit set (43.27 days) and first harvest (52.07 days). The observed earliness in T_9 may be due to a more favorable nutrient environment and improved growing conditions provided by the shade net structure. These findings align with previous studies by Sahu *et al.* (2020) [12] and Choudhary *et al.* (2024) [5], who reported similar advancements in cucumber under nutrient-enriched and protected environments.

Furthermore, the highest fruit set percentage (94.46%) was recorded under T_9 (100% NPK + 10 t/ha wool waste), while the lowest (64.49%) occurred in the control treatment. The improved fruit set under T_9 could be due to enhanced nutrient absorption and possibly the stimulation of endogenous hormones such as auxins and gibberellins, promoted by the organic-inorganic nutrient synergy and optimal climatic conditions. These findings are supported by similar trends observed by Nagar *et al.* (2017) [9] in bottle gourd cultivation.

Yield Parameters

The application of various organic and inorganic fertilizers significantly influenced the yield and associated parameters of cucumber. Among the different treatments, T_9 (100% NPK + 10 t/ha wool waste) was found to be the most effective, leading to the highest performance across multiple yield traits. Specifically, this treatment recorded the maximum number of pickings (7.12), fruits per vine (12.88), fruit diameter (4.58 cm), fruit length (17.88 cm) and average fruit weight (138.99 g), all of which collectively contributed to enhanced yield potential.

Regarding overall productivity, treatment T_9 (100% NPK + 10 t/ha wool waste) also resulted in the highest fruit yield per vine (1.79 kg), per plot (53.47 kg) and per hectare (59.60 t/ha), followed by T_6 (100% NPK + 10 t/ha vermicompost). In contrast, the control treatment (T_1) yielded the lowest values across all yield parameters. These observations are summarized in Table 3.

The integrated application of organic manures and chemical fertilizers appeared to enhance fruit development by improving nutrient availability, particularly nitrogen, phosphorus and potassium. These nutrients likely promoted chlorophyll synthesis and amino acid formation, which in turn improved photosynthetic efficiency. The improved translocation of assimilates from source (leaves) to sink (fruits) resulted in greater fruit number, size and weight. Consequently, a higher number of fruits per vine and

increased average fruit weight contributed to enhanced yield per vine, plot and hectare.
The superior cucumber yield observed in the present study can be attributed to the synergistic effect of organic amendments (wool waste and vermicompost) and inorganic nutrients, which may have stimulated photosynthesis, enhanced hormonal activity, and improved nutrient uptake. These results align closely with the findings of Kanaujia and Daniel (2016) [7], Kharga *et al.* (2019) [8], Sunda *et al.* (2021) [14] in bottle gourd and Choudhary *et al.* (2024) [5] in cucumber.

Table 2: Effect of Vermicompost, Wool Waste, and NPK on Growth of Cucumber under Protected Cultivation

Treatments	Vine Length (m)	No. of Primary Branches/Vine	Days to first Flower Initiation	Days to first Fruit Set	Days to first Fruit Harvest	Fruit Set%
T_1	2.24	3.78	40.31	43.27	52.07	64.49
T_2	2.46	4.31	39.36	42.45	50.83	73.41
T_3	2.89	5.05	37.45	40.56	49.04	81.18
T_4	2.45	4.46	39.07	42.05	50.86	74.05
T_5	3.12	5.38	36.06	39.28	47.55	86.79
T_6	3.37	6.07	33.91	36.97	44.74	92.80
T_7	2.63	4.74	38.67	41.19	49.65	78.79
T_8	3.16	5.87	34.34	37.67	46.05	90.33
T_9	3.59	6.42	32.10	35.01	42.87	94.46
SE.m.±	0.01	0.12	0.09	0.08	0.05	0.41
CD(p = 0.05)	0.03	0.35	0.28	0.25	0.15	1.22

Table 3: Effect of Vermicompost, Wool Waste, and NPK on Yield of Cucumber under Protected Cultivation

Treatments	No. of Fruits/Vine	Fruit Length (cm)	Fruit Diameter (cm)	Weight of Fruit (g)	Number of Pickings	Fruit Yield/vine (kg)	Fruit Yield/plot (kg)	Fruit Yield (t/ha)
T_1	7.52	13.51	3.57	104.21	5.21	0.78	23.40	26.00
T_2	8.22	14.13	3.73	113.87	5.35	0.93	27.90	31.00
T_3	9.81	16.33	3.97	119.35	5.75	1.17	35.10	39.00
T_4	8.38	14.31	3.71	114.69	5.33	0.96	28.80	32.00
T_5	10.90	16.83	4.12	122.67	6.02	1.33	39.90	44.30
T_6	12.34	17.51	4.49	131.97	7.03	1.62	48.60	54.00
T_7	8.91	15.52	3.83	116.89	5.45	1.04	31.20	34.63
T_8	11.68	17.07	4.31	126.71	6.33	1.47	44.10	49.00
T_9	12.88	17.88	4.58	138.99	7.12	1.79	53.70	59.60
SE.m.±	0.17	0.14	0.03	1.01	0.06	0.02	0.66	0.73
CD(p = 0.05)	0.50	0.41	0.08	3.01	0.17	0.07	1.99	2.18

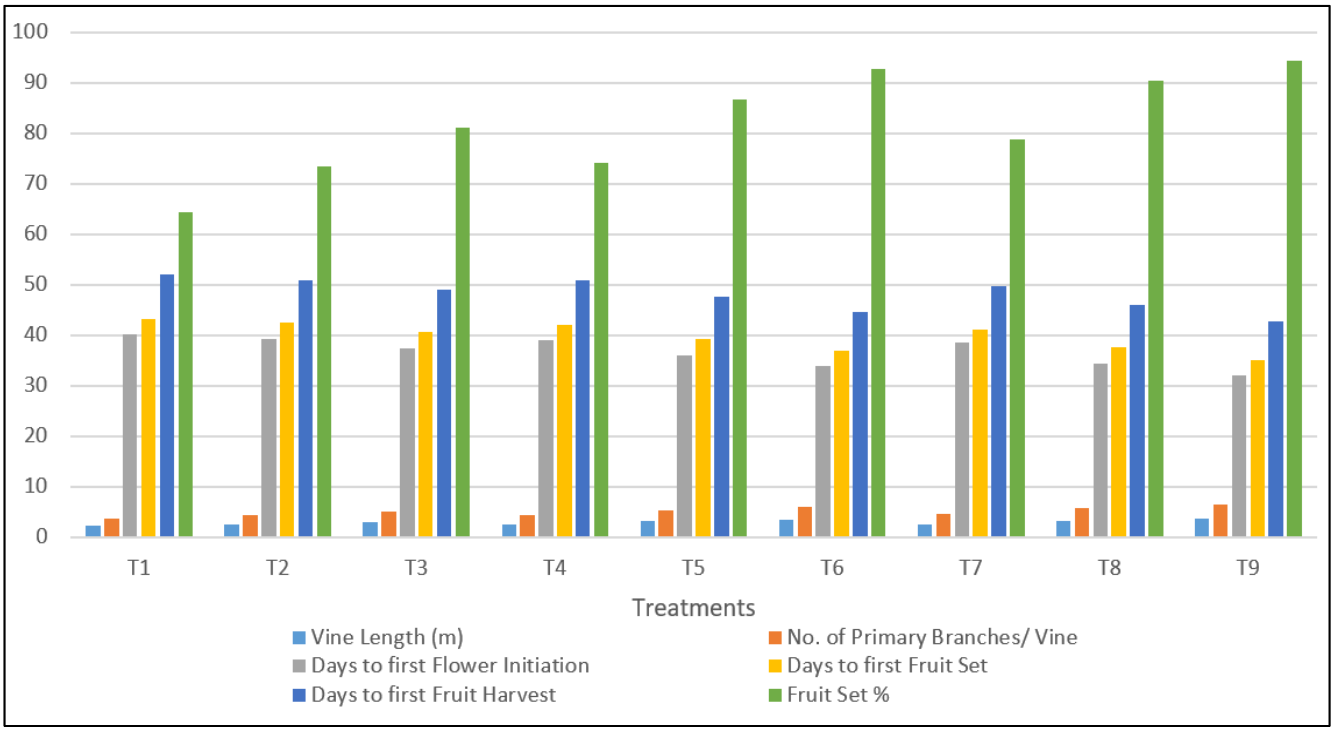

Fig 1 : Effect of Vermicompost, Wool Waste, and NPK on Growth of Cucumber under Protected Cultivation

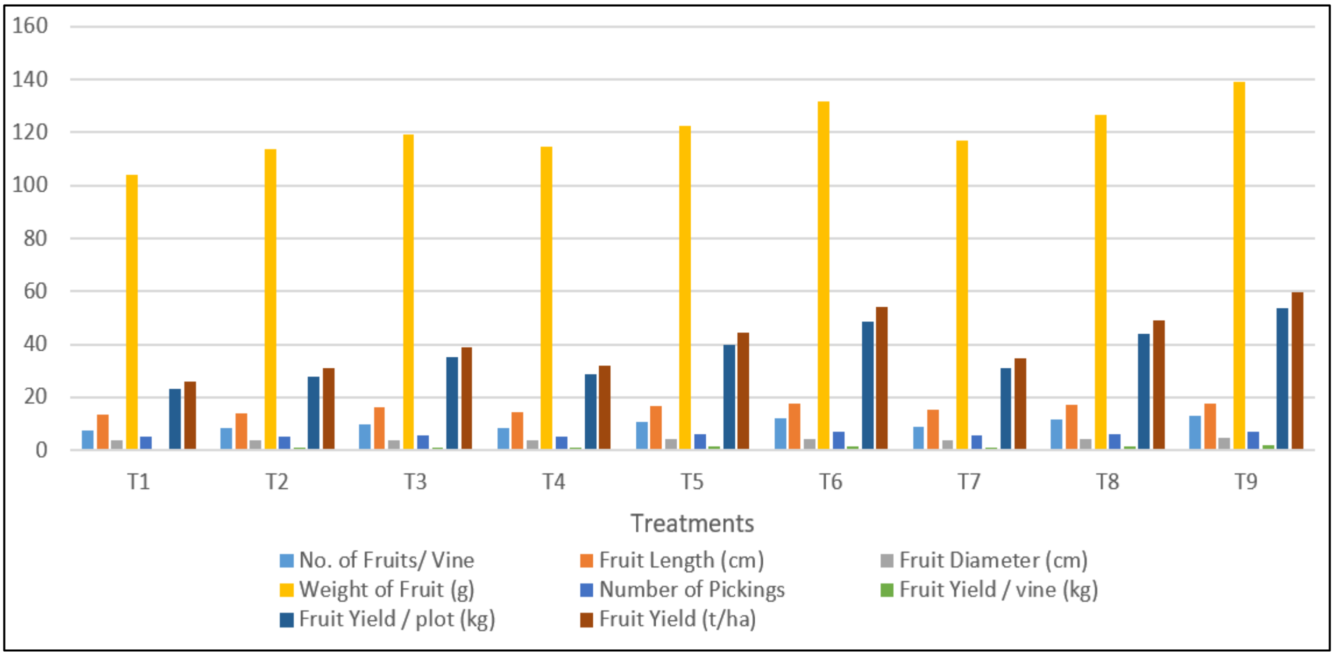

Fig 2: Effect of Vermicompost, Wool Waste, and NPK on Yield of Cucumber under Protected Cultivation

Conclusion

Based on the findings of the present study titled "Effect of Integrated Nutrient Management Using Vermicompost, Wool Waste and NPK on Cucumber (*Cucumis sativus* L.) Growth and Yield in Protected Cultivation'', it is evident that the combined application of 100% recommended dose of NPK along with 10 t/ha wool waste proved to be the most effective treatment. This integrated nutrient strategy significantly enhanced vegetative growth, yield components and overall fruit yield of cucumber.

The observed improvement can be attributed to the synergistic interaction between readily available nutrients from inorganic fertilizers and the slow-release, organic nitrogen from wool waste. This combination not only supported vigorous plant development and high productivity but also contributed to nutrient-use efficiency and long-term soil health. The integration of organic residues like wool waste with chemical fertilizers thus offers a sustainable approach to nutrient management.

Hence, the use of 100% NPK in conjunction with 10 t/ha wool waste is recommended for maximizing cucumber performance, yield and profitability under protected cultivation systems.

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