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Efficiency of vermicompost and chemical fertilizers in sustainable onion cultivation in the western zone of Uttar Pradesh, India

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Abstract

The present study evaluated the effect of different levels of chemical fertilizers and vermicompost on the growth and yield attributes of onion. The results revealed significant differences among treatments; with the integrated application of NPK and vermicompost (T_8) recording the highest values for plant height (49.83 cm), number of leaves (8.90), stem girth (2.15 cm), fresh weight (129.11 g), and dry weight (11.91 g). Yield parameters were also superior under T_8 , with maximum fresh bulb weight (97.41 g), dry weight (12.18 g), bulb diameter (4.54 cm), and bulb yield (28.65 t/ha). The enhanced performance may be attributed to the synergistic effect of inorganic fertilizers and vermicompost, which improve nutrient availability, stimulate microbial activity, and enhance root development, thereby promoting vegetative growth and biomass accumulation. Treatments with either NPK or vermicompost alone showed moderate improvement compared to the control (T_9), which consistently recorded the lowest growth and yield. Statistical analysis confirmed the superiority of integrated nutrient management (INM), as indicated by significant differences at 5% CD and low CV values (1.07-3.11%). These findings align with earlier studies, emphasizing that INM enhances physiological processes, nutrient use efficiency, and bulb productivity in onion. The study suggests that combining chemical fertilizers with vermicompost is a sustainable strategy for improving onion growth and yield under similar agro-ecological conditions.

Keywords: Onion (*Allium cepa* L.), vermicompost, chemical fertilizers

Introduction

Onion (*Allium cepa* L.) is one of the oldest cultivated vegetable crops and belongs to the family Alliaceae. For centuries, it has been valued not only as a food ingredient but also for its nutritional and medicinal qualities (Singh & Khar, 2022) ^[17]. Among the numerous members of the *Allium* genus, onion stands out because of its versatility, wide adaptability, and economic relevance. Globally, it ranks second only to tomato in terms of importance, reflecting its role as a vital crop in agriculture and trade (Ochar, & Kim, 2023) ^[13]. In India, onions are a part of almost every meal and are grown across diverse agro-climatic zones, with major production concentrated in states such as Uttar Pradesh, Odisha, Karnataka, and Rajasthan (Baba, 2024) ^[4]. This broad adaptability, combined with high demand in fresh and processed forms, makes onion a cornerstone of the agricultural economy. Like most crops, onion production is closely tied to soil health and nutrient management. For a long time, farmers have depended heavily on chemical fertilizers to achieve higher yields. However, the overuse of inorganic fertilizers has caused problems like soil degradation, nutrient imbalance, and environmental concerns. This has increased the focus on organic farming practices and sustainable alternatives. Organic manures, especially compost and vermicompost, are increasingly recognized for their ability to improve soil fertility, texture, and microbial activity. Vermicompost, produced through the breakdown of organic matter by earthworms, is particularly effective in enriching the soil. It provides macro- and micronutrients, enhances aeration, improves water retention, and stimulates beneficial microbial populations (Mulatu, & Bayata, 2024) ^[12]. When combined with balanced chemical fertilizers, vermicompost supports a steady supply of nutrients, ensuring better crop growth, healthier bulb formation, and higher yields. Such integrated nutrient management practices are

not only productive but also environmentally friendly, securing long-term soil sustainability. From a nutritional standpoint, onions contribute significantly to human health. They are rich in carbohydrates, which act as an energy source, and contain moderate amounts of proteins, vitamins, and essential minerals. Vitamin C is abundant in onions, serving as a powerful antioxidant and boosting immunity. Minerals like phosphorus and calcium further add to their nutritional profile, aiding in bone health and metabolic functions (Akram *et al.*, 2020) ^[1]. Beyond basic nutrition, onions are valued for their medicinal qualities. Traditional medicine systems have long recognized their healing potential, and modern research continues to confirm these benefits. One of the reasons onions are so significant is their dual role as both a food and a natural remedy. In culinary practices, they enhance flavor and aroma while also improving the taste of other ingredients. On the medicinal side, onions contain bioactive compounds such as flavonoids and sulfur compounds, which have been linked to reduced risks of lifestyle-related diseases (Chakraborty *et al.* 2022) ^[5]. Quercetin, a flavonoid present in high amounts, has strong antioxidant effects, protecting cells from oxidative stress. Sulfur compounds, on the other hand, support cardiovascular health by lowering cholesterol, reducing blood pressure, and preventing excessive blood clotting.

In the context of public health, onions are particularly beneficial in addressing modern lifestyle challenges. Their high fiber content and low-calorie value make them suitable for weight management. Fiber promotes satiety, improves digestion, and regulates appetite, making onions a supportive food for individuals battling obesity (Kim *et al.*, 2023) ^[7]. They also contribute to blood sugar regulation by improving insulin sensitivity and slowing sugar absorption in the intestines, which is beneficial for people with diabetes. Additionally, several studies suggest that regular onion consumption reduces the risk of certain cancers, particularly stomach and colorectal cancers. Organosulfur compounds in onions are believed to suppress tumor growth, induce cell death in cancerous cells, and limit cancer spread. Their antioxidant activity further reduces free radical damage, which is a known contributor to cancer and other chronic diseases.

Despite their importance, onion cultivation faces challenges. Productivity is often hindered by declining soil fertility, pest infestations, diseases, and erratic weather patterns. To tackle these issues, sustainable practices are necessary. Integrating organic amendments like vermicompost with chemical fertilizers is an effective way forward. This method not only improves yield and bulb quality but also minimizes environmental risks and reduces dependence on costly external inputs. By utilizing locally available organic resources, farmers can lower production costs while maintaining soil health and long-term productivity.

Materials and Methods

The present experiment was carried out at the experimental site of the School of Agriculture and Environmental Sciences, Shobhit University, Gangoh, Saharanpur, Uttar Pradesh (India). The site is geographically located at 29°58' N latitude and 77°32' E longitude, with an altitude of 284 meters above mean sea level. This region falls under the north-western plains sub-region of the Upper Gangetic Plains, which is known for its fertile soils and favorable climatic conditions for vegetable

cultivation, particularly onion. The soil of the experimental field was sandy loam in texture with a slightly acidic reaction, recording a pH of 6.0, which provides a suitable medium for bulb development and nutrient availability.

The field experiment was laid out in a randomized block design (RBD) with three replications to ensure precision and minimize experimental error. A total of nine treatments were imposed, consisting of both organic and inorganic nutrient sources applied either individually or in combinations. The treatments included: T₁ - Vermicompost @ 10 t/ha, T₂ - Vermicompost @ 10 t/ha + N @ 100 kg/ha, T₃ - Vermicompost @ 10 t/ha + P @ 100 kg/ha, T₄ - Vermicompost @ 10 t/ha + K @ 120 kg/ha, T₅ - N @ 100 kg/ha, T₆ - P @ 100 kg/ha, T₇ - K @ 120 kg/ha, T₈ - Vermicompost @ 10 t/ha + N @ 100 kg/ha + P @ 100 kg/ha + K @ 120 kg/ha, and T₉ - Control (without any manure or fertilizer application). These treatments were selected to study the individual and combined effects of organic manure and chemical fertilizers on the growth and yield performance of onion.

The onion variety Pusa red was chosen for the study due to its popularity, adaptability, and consumer preference in the region. Healthy seedlings were transplanted into the well-prepared field with a spacing of 20 cm between rows and 10 cm between plants, which ensured optimum plant population and proper aeration. All recommended agronomic practices such as irrigation, weeding, and plant protection measures were followed uniformly across all treatments to maintain crop health and minimize biotic and abiotic stress. During the course of experimentation, regular observations were recorded on plant growth parameters, bulb development, and yield attributes to assess the performance of each treatment. This approach not only provides insights into improving yield but also emphasizes sustainable agriculture by reducing excessive dependence on chemical fertilizers.

Results and Discussion

Growth parameters

The data presented in Table 1 and Fig. 1 clearly demonstrate the significant influence of different levels of NPK and vermicompost on the growth attributes of onion. Among the treatments, T₈ recorded the maximum values for all the studied growth parameters, including plant height (49.83 cm), number of leaves (8.90), stem girth (2.15 cm), fresh weight (129.11 g), and dry weight (11.91 g). This superior performance may be attributed to the synergistic effect of inorganic nutrients with vermicompost, which improves nutrient availability, enhances microbial activity, and promotes root proliferation, ultimately supporting better vegetative growth. Similar findings were reported by Singh *et al.* (2019), who observed improved growth and yield of onion under integrated nutrient management.

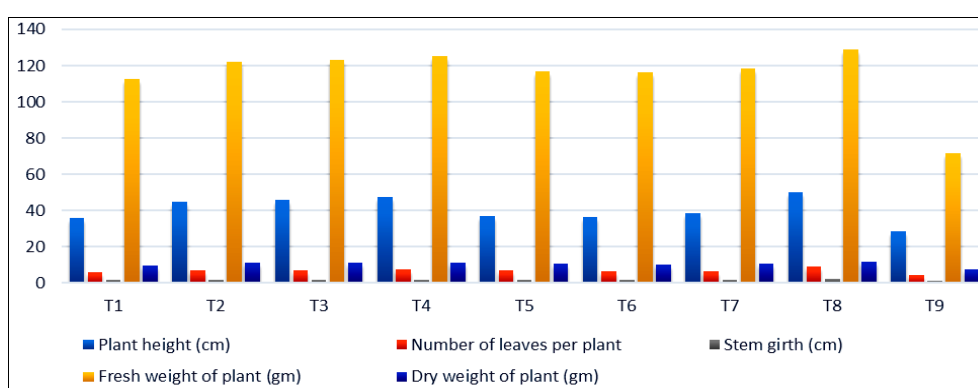
The lowest growth was recorded in T₉(control), which exhibited reduced plant height (28.55 cm), leaf number (4.55), stem girth (1.19 cm), and fresh (71.48 g) and dry weight (7.56 g). This clearly indicates the poor growth performance of onion under nutrient deficiency. The significant differences observed with respect to C.D. at 5% confirm the positive impact of integrated nutrient application compared to control treatments. In terms of plant height, treatments T₂-T₄ and T₈ showed statistically superior performance compared to T₁, T₅, and T₆, reflecting the importance of balanced nutrient application.

Table 1: Effect of NPK and vermicompost on growth parameters of onion

Treatments	Plant height (cm)	Number of leaves per plant	Stem girth (cm)	Fresh weight of plant (gm)	Dry weight of plant (gm)
T ₁	35.87	5.66	1.44	112.65	09.59
T ₂	44.54	6.98	1.64	121.85	10.95
T ₃	45.78	7.12	1.74	123.14	11.12
T ₄	47.65	7.52	1.89	125.23	11.05
T ₅	36.85	6.88	1.68	116.58	10.38
T ₆	36.44	6.52	1.53	116.24	10.25
T ₇	38.55	6.35	1.56	118.56	10.66
T ₈	49.83	8.90	2.15	129.11	11.91
T ₉	28.55	4.55	1.19	71.48	07.56
C.D. at 5%	1.38	0.05	0.09	5.21	0.56
S.Em. $\pm$	0.46	0.02	0.03	1.72	0.19
C.V. (%)	1.95	1.07	3.11	2.60	3.08

Likewise, the number of leaves and stem girth were significantly higher in treatments receiving combined application of NPK and vermicompost, which is consistent with the findings of Kumar *et al.* (2021) ^[8], who highlighted that organic-inorganic nutrient integration enhances physiological processes and biomass accumulation in bulb crops. The fresh and dry weight of plants followed a similar trend, where T₈ recorded the highest biomass

accumulation. This may be due to improved photosynthetic efficiency and carbohydrate partitioning towards the bulb, facilitated by optimum nutrient availability. On the other hand, treatments with only NPK or vermicompost (T₁, T₅, T₆, T₇) showed moderate improvements compared to the control, suggesting partial but not sufficient contribution when applied alone.

**Fig 1:** Effect of NPK and vermicompost on growth parameters of onion

Yield parameters

The data presented in Table 2 & Fig. 2 reveal that the application of NPK in combination with vermicompost significantly influenced yield parameters of onion. The maximum fresh bulb weight (97.41 g), dry weight (12.18 g), bulb diameter (4.54 cm), and bulb yield (28.65 t/ha) were recorded under treatment T₈, which consisted of the integrated application of NPK + vermicompost. This treatment was statistically superior to all other treatments, indicating a synergistic effect of chemical fertilizers and organic amendments. On the other hand, the lowest performance was observed in T₉ (control), where fresh

bulb weight (52.12 g), dry weight (9.22 g), bulb diameter (2.75 cm), and bulb yield (15.24 t/ha) were significantly reduced. This reduction may be attributed to inadequate nutrient availability in the absence of external inputs. Intermediate treatments such as T₂, T₃, and T₄ showed moderate improvement in bulb yield (26.78-27.56 t/ha), highlighting the beneficial role of balanced NPK fertilization. Treatments involving vermicompost alone (T₅-T₇) also enhanced growth over control, but the combined application (T₈) proved most effective, emphasizing the importance of integrated nutrient management.

Table 2: Effect of NPK and vermicompost on yield parameters of onion.

Treatments	Fresh weight of bulb (gm)	Dry weight of bulb (gm)	Diameter of bulb (cm)	Bulb yield t/ha
T ₁	89.32	09.86	3.41	24.11
T ₂	92.14	11.59	4.12	26.78
T ₃	92.65	11.54	4.25	27.23
T ₄	93.41	11.89	4.28	27.56
T ₅	90.78	10.13	3.45	24.28
T ₆	91.13	10.36	3.71	25.65
T ₇	91.21	10.85	3.87	26.55
T ₈	97.41	12.18	4.54	28.65
T ₉	52.12	09.22	2.75	15.24
C.D. at 5%	0.05	0.09	5.21	0.56
S.Em $\pm$	0.02	0.03	1.72	0.19
C.V.%	1.07	3.11	2.60	3.08

These findings are in line with the reports of Singh *et al.* (2019) and Kumar *et al.* (2021)^[8], who observed that the integration of organic manures with chemical fertilizers enhances nutrient use efficiency, improves soil physical properties, and results in higher bulb yields of onion. The improvement in dry matter accumulation and bulb diameter under integrated nutrient management may be attributed to the slow and steady release of nutrients from vermicompost along with the immediate availability from chemical fertilizers (Choudhary *et al.*, 2020)^[6]. The coefficient of variation (CV) ranged between 1.07-3.11%, indicating high experimental precision. The significant differences as shown by CD (5%) and low S.E.m. values confirm that the variation among treatments was due to applied nutrient sources rather than experimental error.

The findings highlight that integrated nutrient management (INM) through the combined use of NPK and vermicompost is more effective in enhancing onion growth and yield than sole applications. These results align with earlier studies (Sharma *et al.*, 2020; Meena *et al.*, 2024)^[16, 11] and suggest that the integrated application of NPK with vermicompost (T₈) can be recommended for achieving higher productivity in onion cultivation under similar agro-ecological conditions.

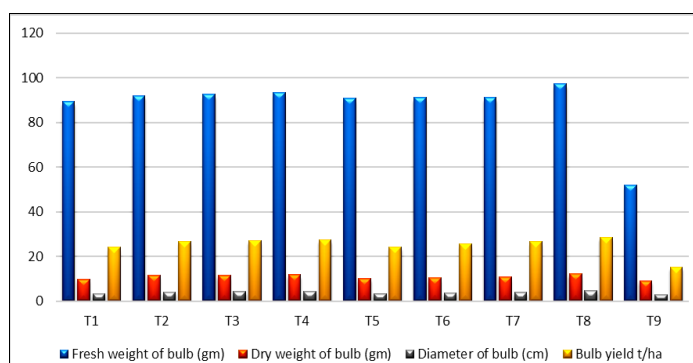


Fig 2: Effect of NPK and vermicompost on yield parameters of onion.

Summary and Conclusion

The study highlights the significant role of integrated nutrient management in onion cultivation. Among all treatments, the combined application of NPK and vermicompost (T₈) proved superior in enhancing growth attributes such as plant height, leaf number, and biomass, as well as yield parameters including bulb weight, diameter, and productivity. This integrated approach not only improved nutrient availability but also ensured better physiological functioning and efficient partitioning of assimilates, ultimately resulting in higher bulb yield (28.65 t/ha). In contrast, the control treatment (T₉) exhibited poor growth and yield, reflecting the adverse effect of nutrient deficiency. Treatments with sole application of NPK or vermicompost provided partial improvements but were less effective than their combined use. Overall, the results strongly recommend the integrated application of NPK with vermicompost for sustainable onion production, as it enhances nutrient efficiency, improves soil health, and maximizes productivity compared to conventional or sole nutrient applications.

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