

The Impact of Vermicompost and NPK Fertilisation on the Growth and Bulb Yield of Shallots (*Allium Ascalonicum* L.) in Rote Ndao Regency

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ABSTRACT: This study examines the effects of vermicompost and NPK fertiliser, both individually and in combination, on the growth and bulb yield of shallots (*Allium ascalonicum* L.) in Rote Ndao Regency, Indonesia. A factorial randomised block design was employed, consisting of 16 treatment combinations replicated three times in field trials. Key growth parameters assessed included plant height, leaf length, number of leaves, as well as fresh and dry bulb weights. In addition, soil chemical properties were analysed before and after treatment application. The results demonstrated a significant synergistic interaction between vermicompost and NPK fertiliser, leading to enhanced plant growth and yield. The K3N3 treatment (15,000 kg/ha vermicompost + 750 kg/ha NPK) produced the highest fresh and dry bulb weights, whereas the K1N3 treatment (5,000 kg/ha vermicompost + 750 kg/ha NPK) resulted in the tallest plants. Soil analyses revealed improvements in pH, organic carbon, total nitrogen, available phosphorus, and potassium levels, indicating enhanced soil fertility. These findings underscore the effectiveness of integrated nutrient management as a sustainable strategy to improve shallot productivity while maintaining soil health in dryland agricultural systems.

KEYWORDS: vermicompost, NPK, shallot, growth, yield

INTRODUCTION

Agriculture plays a vital role in Indonesia's food security and economy, particularly through the horticulture sub-sector. Red onion (*Allium ascalonicum* L.) is a high-value horticultural commodity with stable market demand [1]. Additionally, red onion contains bioactive compounds such as flavonoids and sulfur, which are beneficial for human health [2-3]. Rote Ndao Regency is a major red onion production center in eastern Indonesia, but its production has remained stagnant at 2,221 tons for two consecutive years [1]. This situation is believed to be related to suboptimal fertilization practices, particularly the excessive use of inorganic fertilizers, which negatively impacts soil fertility [4-5].

The application of balanced fertilization combining organic and inorganic fertilizers is one strategy that can sustainably increase crop productivity. Vermicompost or worm castings contain macro and micro nutrients beneficial to soil [6], enhance microbial activity [7], and maintain soil moisture [8]. Inorganic fertilizers such as NPK are still necessary to meet nutrient needs quickly. The combination of vermicompost, inorganic fertilizers, and phosphate-solubilizing bacteria has been proven to increase red onion bulb yields [2-3; 5]. Therefore, the application of balanced fertilization combining vermicompost and NPK fertilizers is an important strategy to enhance red onion bulb growth and yield while maintaining soil health in a sustainable manner. The combination of vermicompost, inorganic fertilizer, and phosphate-solubilizing bacteria has been proven to increase shallot bulb yield [2-3; 5]. Thus, the application of balanced fertilization that combines vermicompost and NPK fertilizer is an important strategy for improving shallot bulb growth and yield while maintaining soil health in a sustainable manner.

This study aims to determine the effect of applying vermicompost and NPK, both individually and in combination, on the growth and yield of red onion bulbs in Rote Ndao Regency, as well as to identify the most effective and environmentally friendly fertilizer composition for local farmers.

The Impact of Vermicompost and NPK Fertilisation on the Growth and Bulb Yield of Shallots (*Allium Ascalonicum* L.) in Rote Ndao Regency

RESEARCH METHODS

This study was conducted experimentally on farmland in Busalangga Village, Rote Barat Laut Subdistrict, Rote Ndao District, East Nusa Tenggara, from July to October 2024. The experimental design used was a factorial Randomized Block Design (RBD) with two factors and three replications, resulting in 48 experimental plots.

The first factor was the application rate of vermicompost: K0 = no fertilizer, K1 = 5,000 kg/ha, K2 = 10,000 kg/ha, and K3 = 15,000 kg/ha. The second factor was the NPK fertilizer dose: N0 = 0 kg/ha, N1 = 200 kg/ha, N2 = 500 kg/ha, and N3 = 750 kg/ha.

The materials used included local shallot seeds, NPK fertilizer, and vermicompost. The tools used included measuring instruments (tape measure, ruler), scales, hoes, buckets, and writing instruments. The land was cleared and tilled until loose, then plots measuring 1x1 m were made with a planting distance of 20x20 cm. The seeds were selected and planted at a depth of 3–5 cm. Plant maintenance included watering, weeding, thinning, and pest control. Fertilization was carried out according to the treatment. Harvesting was conducted when the leaves dried and the tubers were fully mature.

The observed variables consisted of:

1. Soil chemical properties: pH, organic carbon, total nitrogen, available phosphorus, and potassium, analyzed before and after treatment using standard methods.
2. Plant growth: plant height, number of leaves, and leaf length, observed starting two weeks after planting (MTS) on a regular basis.
3. Crop yield: fresh tuber weight and dry tuber weight per plant, measured at harvest.

Data were analyzed using analysis of variance (ANOVA). If significant or highly significant effects were observed, Duncan's multiple range test at the 5% level was conducted. If no interactions were present, the BNT test at the 5% level was performed to assess the effects of each factor.

RESULTS

Plant height, leaf length, number of shallot leaves, fresh weight and dry weight of the plant

The study revealed that the interaction between vermicompost (K) and NPK fertiliser (N) had a highly significant effect on plant height, leaf length, number of shallot leaves, and fresh weight of the plant. The K1N3 treatment combination produced the highest plant height (24.38 cm), while the lowest was found in K0N2 (18.75 cm). The greatest leaf length was observed in the K3N2 combination (21.50 cm), while the shortest was recorded in K0N2 (17.47 cm).

The highest number of leaves was found in the K3N3 treatment (25.47 cm), whereas the lowest was recorded in K2N2 (19.27 cm). The K3N3 treatment combination resulted in the highest fresh weight, measuring 20.92 cm, whereas the lowest value was recorded in the K0N0 combination, at 13.92 cm. The K3N3 treatment combination produced the highest dry weight, reaching 3.29 g, whereas the lowest value was recorded in the K1N1 treatment, at 1.13 g.

Table 1. The interaction effect of vermicompost and NPK fertiliser on the plant height, leaf length

Treatment	Plant Height (cm)				Leaf Length (cm)			
	N0	N1	N2	N3	N0	N1	N2	N3
K0	22.58 a (ab)	20.55c (bc)	18.75d (c)	21.57b (c)	19.77a (a)	18.85a (ab)	17.47a (b)	19.02a (b)
K1	24.07a (a)	24.18b (a)	18.87b (c)	24.38a (a)	21.11a (a)	20.33a (a)	19.01b (b)	21.13a (ab)
K2	20.99c (b)	21.41d (b)	20.41d (b)	22.65a (b)	19.39a (b)	19.21a (ab)	19.26a (b)	21.33a (a)
K3	21.48b Ab	19.00a (c)	22.50a (a)	20.45c (d)	19.73a (ab)	17.93b (b)	21.50a (a)	20.40a (ab)

Notes: Lowercase letters presented in rows indicate horizontal comparisons, while those in parentheses indicate vertical comparisons. Numerical values followed by identical letters denote statistically significant differences in treatment effects at the 5% level based on the LSD test.

The Impact of Vermicompost and NPK Fertilisation on the Growth and Bulb Yield of Shallots (*Allium Ascalonicum* L.) in Rote Ndao Regency

Table 2. The interaction effect of vermicompost and NPK fertiliser on the number of shallot leaves, fresh weight of the plant

Treatment	Number of shallot leaves			Fresh Weight (cm)				
	N0	N1	N2	N3	N0	N1	N2	N3
K0	23.93a (a)	23.00a (ab)	19.20b (b)	22.48a (b)	13.92b (b)	14.25b (b)	20.50a (a)	18.25ab (ab)
K1	22.80a (ab)	24.93a (a)	20.05b (b)	24.47a (ab)	18.25ab (ab)	17.17b (b)	17.25b (b)	19.00ab (ab)
K2	20.47a (bc)	22.13a (ab)	19.27a (b)	22.07a (b)	19.33ab (a)	18.00b (ab)	18.83ab (ab)	18.83ab (ab)
K3	21.20b (c)	20.20b (b)	25.40a (a)	25.47a (a)	17.42ab (ab)	19.58a (a)	19.08ab (ab)	20.92a (a)

Notes: Lowercase letters presented in rows indicate horizontal comparisons, while those in parentheses indicate vertical comparisons. Numerical values followed by identical letters denote statistically significant differences in treatment effects at the 5% level based on the LSD test.

Table 3. The interaction effect of vermicompost and NPK fertiliser on the dry weight

Treatment	Dry Weight (gram)			
	N0	N1	N2	N3
K0	23.93a (a)	23.00a (ab)	19.20b (b)	22.48a (b)
K1	22.80a (ab)	24.93a (a)	20.05b (b)	24.47a (ab)
K2	20.47a (bc)	22.13a (ab)	19.27a (b)	22.07a (b)
K3	21.20b (c)	20.20b (b)	25.40a (a)	25.47a (a)

Notes: Lowercase letters presented in rows indicate horizontal comparisons, while those in parentheses indicate vertical comparisons. Numerical values followed by identical letters denote statistically significant differences in treatment effects at the 5% level based on the LSD test.

Soil Chemical Properties Before and After Treatment

The initial soil pH was recorded at 6.67. Following treatment applications, pH levels increased to a range between 6.99 and 7.31, which falls within the neutral range. The highest pH value (7.31) was observed in the K2N0 treatment, indicating that vermicompost effectively buffered soil acidity. Organic carbon content increased from an initial 2.69% to a maximum of 3.48% under the K0N1 treatment. However, lower values were recorded in K3N2 and K3N3, possibly due to overapplication or accelerated decomposition rates of organic matter. Total nitrogen content rose from 0.18% to 0.29% under the K2N0 treatment, demonstrating the potential of vermicompost to sustainably enhance nitrogen availability in the soil.

The highest available phosphorus concentration (4.75 mg/kg) was detected in the K3N2 treatment, while the lowest (0.95 mg/kg) occurred under K1N3. These results suggest that phosphorus availability is influenced by the interaction between vermicompost and NPK levels. Available potassium content increased substantially from an initial 0.94 me/100g to 218.33 mg/kg in the K3N3 treatment. This significant rise illustrates the effectiveness of NPK fertiliser, particularly when combined with adequate organic matter, in enhancing potassium availability.

Table 4. Results of Soil Chemical Properties Analysis Prior to the Application of Vermicompost and NPK Fertilisers

Organic Carbon	Total Nitrogen Available	Available Phosphorus	Available Potassium	Soil pH
2,69	0,18	74,88	0,94	6,67

The Impact of Vermicompost and NPK Fertilisation on the Growth and Bulb Yield of Shallots (*Allium Ascalonicum* L.) in Rote Ndao Regency

Table 5. Organic Carbon Analysis and Total Nitrogen Results Following the Application of Vermicompost and NPK Fertiliser Treatments

Treatment	Organic Carbon (%)				Total Nitrogen (%)			
	N0	N1	N2	N3	N0	N1	N2	N3
K0	2.61b (a)	3.48a (a)	3.04ab (ab)	3.05ab (ab)	0.12b (b)	0.20ab (ab)	0.22a (a)	0.19ab (ab)
K1	2.84ab (ab)	3.05bc bc	3.04ab (ab)	3.27ab (a)	0.20ab (ab)	0.23a (ab)	0.22a (a)	0.20ab (ab)
K2	2.80ab (ab)	3.03bc (bc)	2.81bc (bc)	3.04ab (ab)	0.29a (a)	0.21ab (ab)	0.22a (a)	0.20ab (ab)
K3	3.04a (a)	3.04bc (bc)	2.62c (c)	2.63b (ab)	0.23a (a)	0.19b (b)	0.21ab (ab)	0.21a (ab)

Notes: Lowercase letters presented in rows indicate horizontal comparisons, while those in parentheses indicate vertical comparisons. Numerical values followed by identical letters denote statistically significant differences in treatment effects at the 5% level based on the LSD test.

Table 6. Analysis Results of Available Phosphorus and Potassium After Application of Vermicompost and NPK Fertilisers

Treatment	Available Phosphorus (ppm)				Available Potassium (ppm)			
	N0	N1	N2	N3	N0	N1	N2	N3
K0	1.32ab (ab)	1.48b (b)	3.30a (a)	1.87a (ab)	146.41c (c)	177.21bc (bc)	197.91abc (abc)	171.87bc (bc)
K1	0.96b (b)	2.27ab (ab)	3.55a (b)	0.95b (ab)	167.11bc (bc)	201.24ab (ab)	202.84ab (ab)	175.74bc (bc)
K2	2.36a (a)	1.48b A	3.67a (a)	1.60ab (a)	172.64bc (bc)	212.49ab (ab)	208.56ab (ab)	163.94c (c)
K3	1.36ab (ab)	1.98ab (b)	4.75a (ab)	2.28a (a)	205.20a (a)	175.20bc (bc)	211.59a (a)	218.33a (a)

Notes: Lowercase letters presented in rows indicate horizontal comparisons, while those in parentheses indicate vertical comparisons. Numerical values followed by identical letters denote statistically significant differences in treatment effects at the 5% level based on the LSD test.

Table 7. Soil pH Analysis Results Following the Application of Vermicompost and NPK Fertiliser Treatments

Treatment	Soil pH			
	N0	N1	N2	N3
K0	7.07a (bc)	7.05a (bc)	7.06a (bc)	7.03a (b)
K1	7.16a (ab)	6.9c9a (c)	7.15a (ab)	7.13a (ab)
K2	7.31a (a)	7.10b (ab)	7.10b (abc)	7.20ab (a)
K3	7.09ab (bc)	7.12a (a)	7.07b (bc)	7.09ab (ab)

Notes: Lowercase letters presented in rows indicate horizontal comparisons, while those in parentheses indicate vertical comparisons. Numerical values followed by identical letters denote statistically significant differences in treatment effects at the 5% level based on the LSD test.

DISCUSSION

Synergistic Effect of Vermicompost and NPK Fertilizer

The interaction between vermicompost and NPK fertiliser had a highly significant effect ($P < 0.01$) on vegetative growth parameters, including plant height, leaf length, and number of leaves. A significant effect ($P < 0.05$) was also observed on fresh weight, indicating a synergistic interaction between organic and inorganic nutrient sources.

These findings are supported by Singh et al. [9], who reported that the combined application of vermicompost and NPK improved plant height, leaf area, fruit weight, and shelf life in tomatoes. Similarly, in Ethiopia, a comparable response was observed in shallot

The Impact of Vermicompost and NPK Fertilisation on the Growth and Bulb Yield of Shallots (*Allium Ascalonicum* L.) in Rote Ndao Regency

plants treated with NP fertiliser and vermicompost combinations [10]. A meta-analysis by Blouin et al. [11] further confirmed that vermicompost application enhanced crop yield by 26%, shoot biomass by 78%, and root biomass by 57%. Beyond productivity, vermicompost has also been shown to improve soil health by increasing microbial diversity and reducing nutrient leaching [12]. In this study, the K1N3 treatment produced the tallest plants (24.38 cm), suggesting that moderate vermicompost combined with high NPK application is optimal for plant growth. Conversely, the K0N2 treatment resulted in the shortest plants (18.75 cm), highlighting that moderate doses of chemical fertiliser alone are insufficient without the presence of organic matter.

Effect of Vermicompost and NPK Fertilizer

Vermicompost application alone had a significant effect on plant height, leaf length, soil pH, and total nitrogen (N-total), and a notable influence on the number of leaves, fresh weight, organic carbon (C-organic), and potassium availability. These results are consistent with previous studies highlighting vermicompost's capacity to enhance soil fertility and crop performance [12-15].

Compared to conventional compost, vermicompost contains higher nutrient concentrations due to the biochemical processes involved in earthworm digestion. This process produces more stable organic matter, neutralises soil pH, and enriches microbial populations. For example, soil pH increased from 6.67 to 7.31 under the K2N0 treatment, while total nitrogen rose from 0.18% to 0.29%, reflecting the positive influence of vermicompost on soil quality.

However, no significant effect was observed on dry weight and available phosphorus. This may be attributed to the relatively low phosphorus content in vermicompost or its predominance in organic-bound forms, which require microbial mineralisation before becoming plant-available [16].

NPK fertilizer significantly improved plant height, leaf length, C-organic, phosphorus (P), and potassium (K) availability, and also influenced leaf number and fresh weight. These results align with previous findings emphasizing the importance of balanced macro-nutrient application [17-20].

Nitrogen is essential for chlorophyll and protein synthesis, promoting vegetative growth. Phosphorus supports root formation and energy transfer, while potassium helps in enzyme activation and osmoregulation. Treatment K3N3 produced the highest available potassium (218.33 me/100g).

Interestingly, NPK also increased C-organic content, possibly due to enhanced root growth and higher biomass input into the soil [21]. Nevertheless, NPK had no significant effect on dry weight and N-total, likely because it provides fast-available nutrients rather than building long-term soil fertility.

CONCLUSIONS

The combination of vermicompost and NPK fertiliser was proven to significantly enhance the growth and bulb yield of shallots. The K3N3 treatment yielded the highest bulb weight, while K1N3 produced the tallest plants. This fertilisation approach also improved soil chemical properties, including pH, organic carbon, nitrogen, and potassium levels. Balanced nutrient application is therefore recommended as an effective and environmentally friendly strategy to increase shallot productivity in dryland areas.

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The Impact of Vermicompost and NPK Fertilisation on the Growth and Bulb Yield of Shallots (*Allium Ascalonicum* L.) in Rote Ndao Regency

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