RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
56 (4) 1654-1660, 2024
http://doi.org/10.54910/sabrao2024.56.4.30
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

EFFECT OF HORSE MANURE VERMICOMPOST ON THE GROWTH AND YIELD TRAITS OF SHALLOT (*ALLIUM ASCALONICUM* L.)

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SUMMARY

The presented study determined the effects of shallot cultivars and levels of horse manure vermicompost on its growth and production traits. The developed shallot cultivars came from true seeds. The research materialized from June to October 2022 at the Agricultural Technology Research and Development Institute (IP2TP) in Kelara District, Jeneponto Regency, South Sulawesi, Indonesia. This study employed a factorial design with two factors and three replications. The first factor included four doses of vermicompost: 0, 5, 10, and 15 t ha^{-1}. The second factor consisted of three shallot cultivars (Lokananta, Maserati, and Sanren-F1). The results revealed that the shallot cultivar Sanren-F1 recorded the highest average plant height, bulb weight, diameter, and yield. The horse manure vermicompost treatment with the 15 t ha^{-1} dose also emerged with the maximum average plant height, number of leaves, bulb weight, and bulb diameter over other applications. However, the horse manure vermicompost (10 t ha^{-1}) gave the foremost bulb yield.

Keywords: Growth, horse manure vermicompost, shallot cultivars, seed, variety, yield

Key findings: Three shallot cultivars responded differently to the horse manure vermicompost applications. However, the genotype Sanren-F1 generally has the best growth and production. The single application of horse vermicompost (10 t ha^{-1}) increased the shallot production without using inorganic fertilizers.

Communicating Editor: Dr. Osama Osman Atallah

Manuscript received: August 18, 2023; Accepted: April 11, 2024.

Citation: Nur M, Syam'un E, Sjam S (2024). Effect of horse manure vermicompost on the growth and yield traits of shallot (*Allium ascalonicum* L.). *SABRAO J. Breed. Genet.* 56(4): 1654-1660. http://doi.org/10.54910/sabrao2024.56.4.30.

INTRODUCTION

Shallots are one of the most essential vegetable commodities produced in Indonesia. In 2021, Indonesia's shallot production reached 2,004,590 t, at a harvested area of 194,570 ha, with the largest production area in Central Java. Shallots are an export commodity, and their fresh and processed volumes reached 47,955 t in Indonesia (Central Bureau of Statistics of Indonesia, 2022). Domestic demand for shallots constantly rises with the increasing population, and the various processed forms cause a shortage at certain times. Therefore, shallot ranks among the seven essential commodities that significantly affect inflation in the country when supply is insufficient (Kustiari, 2017).

Generally, shallot cultivation uses many bulbs as a planting material; however, economically, it could be more profitable (Marlin *et al*., 2018; Billa *et al*., 2022; Fairuzia *et al*., 2022; Maharijaya *et al*., 2022). Additionally, the shortage of seed bulbs on a national scale always occurs from year to year, especially when shallot cultivation is simultaneous in all regions (Pangestuti and Sulistyaningsih, 2011). Therefore, using botanical seeds can be an alternative solution to the growing area requirements.

Shallots have a shallow root system, and the soil's physical properties are fundamental for unhampered growth and bulb formation. The long-term use and high doses of mineral fertilizers have a negative impact, with a drastic decline in soil fertility, and sometimes pollute the environment (Mariana *et al.,* 2012). Therefore, efforts can focus on overcoming these problems and reducing the dependency on inorganic inputs by adding organic fertilizers.

Vermicompost is an organic material that can be helpful; however, the raw material for making such compost must be readily available in large volumes (Nugroho *et al.,* 2019). Horse manure is one of the materials used to produce vermicompost. The District of Jeneponto, Indonesia has a large-scale horse raising that ensures immense quantities of horse manure from that area. Vermicompost is compost that can come from various decomposing basic materials with the help of worms. Vermicompost contains several essential macronutrients in the form of nitrogen, phosphorus, and potassium. In addition, it can retain the nutrients longer than other conventional composts. The resulting compost also has a lower ratio of C and N (Blouin *et al.,* 2019; Thakur *et al.*, 2021). Preparing the vermicompost is easy and shorter than the conventional one. It is a given that the degradation process due to the presence of humic acids, which support humification, certainly contributes to converting the organic matter (Singh and Singh, 2018).

Several past studies have shown the positive effects of vermicompost application in plantations. Research conducted by Ruan *et al.* (2021) showed that applying vermicompost had a higher photosynthetic rate and better rice production than control treatments. In addition, the chlorophyll a, b, and carotenoid contents were also optimal, improving the root length, diameter, and volume. Furthermore, a study conducted by Faried *et al.* (2021) also found a positive effect of vermicompost application on shallots, and its application at the rate of 15 t ha^{-1} can increase shallot plant growth. Based on the above discussion, the presented research sought to analyze and evaluate the development and production of various shallot cultivars using vermicompost-applied seeds with horse manure as the basis.

MATERIALS AND METHODS

Research location and experimental design

The latest research proceeded from June to October 2022 at the Agricultural Technology Research and Development Institute (IP2TP), Kelara District, Jeneponto Regency, South Sulawesi, Indonesia. The study employed a factorial design with two factors and three replications. The first factor included four doses of vermicompost, i.e., 0 t ha^{-1} (k0), 5 t ha^{-1} (k1), 10 t ha^{-1} (k3), and 15 t ha^{-1} (k4). The second factor was the three shallot cultivars from seeds consisting of Lokananta (v1), Maserati (v2), and Sanren F1 (v3). The shallot cultivars originated from true seeds. Overall, the two treatment factors produced 12 treatment combinations.

Vermicompost preparation

Horse manure, the main ingredient in vermicompost production, directly came from the area around the study. Vermicompost production continued in a greenhouse by making a square-shaped tub bounded with wood. The tub size was 1 m × 2 m. The raw material for making vermicompost consists of 50 kg of horse manure mixed with 50 kg of soil. Afterward, the evenly mixed material reached the tub. The worm species used as decomposers was *Eudrilus eugeniae*/ African night crawler (ANC), obtained from local breeders. The worm size was 5 to 7 cm long. Then, the amount of worms placed into the tub containing the media weighed 12.5 kg. Worm maintenance included feeding in the form of tofu dregs as much as 5 kg/tub every two days. The media was dry, with its humidity continuously controlled by sprinkling water. After four weeks, horse vermicompost harvesting followed, and its chemical analysis appears in Table 1.

Cultivation process

The experimental beds measured 1 m x 3 m with a height of 30 cm. Horse vermicompost application transpired before planting with treatments of 1.5 kg plot^{-1} (5 t ha^{-1}), 3 kg plot^{-1} (10 t ha^{-1}), and 4.5 kg plot^{-1} (15 t ha^{-1}). The beds applied with vermicompost received a cover with plastic mulch. The spacing was 10 cm × 15 cm, with 120 planting holes per experimental plot. Shallot seeds at 45 days old after sowing incur transplanting into the beds. Dead or abnormal seeds attained replanting no more than two weeks after the transplanting.

The study eliminated the process of secondary fertilization in the form of inorganic fertilizers. Maintenance in the form of watering ensued two times a day, in the morning and evening. Then, hand weeding continued, with pests and disease control using chemical pesticides. Harvest of plants occurred at the physiological maturity, with the criteria of dry leaves, softened pseudostems, and bulbs starting to appear on the ground.

Parameters studied and data analysis

Parameters observed in this study included plant height (cm) using a tape measure, number of leaves, bulb weight (g) using analytical scales, bulb diameter (mm) using a caliper, and bulb yield (t ha^{-1}) as the result of conversion from production per plot. Data recording on the plant height and number of leaves per plant came from 14, 28, and 42 days after planting (DAP). All the recorded data assessments underwent analysis of variance (ANOVA). The treatment means' further comparison and separation engaged Duncan's Multiple Range Test (DMRT) with an alpha of 0.05. The entire data processing procedure used the R Studio (4.2.1) program (R Core Team, 2022).

Table 1. Chemical analysis of horse manure vermicomposting.

Parameters	Result
N	0.96 %
P_2O_5	0.45 %
K_2O	0.80 %
C	8.40 %
Water Content	18.60
C/N	10.86
pH	8.54

RESULTS AND DISCUSSION

Based on the analysis of variance, the interaction between shallot cultivars and the vermicompost doses significantly influenced plant height and number of leaves per plant traits (Table 2). However, individually, these factors also have a significant effect. The results further revealed that cultivar Sanren-F1 had the highest average plant height; however, it was not significantly different from other shallot cultivars, Lokananta and Maserati. In addition, the observations about the number of leaves at 42 DAT attained effects from the shallot cultivars. The highest average number of leaves per plant emerged in the cultivar Sanren-F1, which was nonsignificantly different from other cultivars.

Based on research conducted by Medayanti *et al.* (2022), the study reported that three cultivars of shallots developed from seeds disclosed similar results. The shallot cultivar Sanren-F1 has an average plant height and number of leaves, making it better than the cultivar Maserati. The cultivars also influenced differences in growth, plant height, and number of leaves per plant. Research conducted by Hail *et al.* (2014) also found significant variations among the several shallot cultivars for plant height and number of leaves. The study also revealed that the local shallot variety has the shortest average plant height.

Based on the ANOVA, the treatment of horse manure vermicompost also remarkably affected the plant height of shallot genotypes at 14 and 42 DAT (Table 3). The vermicompost also significantly influenced the number of leaves per plant at 28 and 42 DAT. Applying horse manure vermicompost at 15 t ha^{-1} occurred with the highest average plant height at 14 and 42 DAT. In contrast, the control treatment (without horse manure

Table 2. Effect of cultivars on the plant height and number of leaves of *Allium ascalonicum* L.

Cultivars	Plant height (cm)		
	14 DAT	28 DAT	42 DAT
Lokananta	15.9a	32.2	43.3
Maserati	17.1ab	32.4	44.2
Sanren F1	17.7b	34.1	45.6
	Number of leaves		
Lokananta	3.4	4.6	7.4a
Maserati	3.2	4.7	8.6b
Sanren F1	3.3	4.6	7.9ab

Note: Means followed by the same letter are not significantly different for p ≤ 0.05 according to Duncan's multiple range test. DAT: Days after transplanting.

Table 3. Effect of horse manure vermicompost on the plant height and number of leaves of *Allium ascalonicum* L.

Vermicompost	Plant height (cm)		
	14 DAT	28 DAT	42 DAT
0 t ha^{-1}	15.4a	30.7	41.8a
5 t ha^{-1}	17.1a	32.5	42.9ab
10 t ha^{-1}	17.8ab	34.2	45.8ab
15 t ha^{-1}	17.3ab	34.1	46.8b
	Number of leaves		
0 t ha^{-1}	3.2	4.2a	7.3a
5 t ha^{-1}	3.2	4.5ab	7.7ab
10 t ha^{-1}	3.5	4.8b	8.5b
15 t ha^{-1}	3.2	4.9b	8.4ab

Note: Means followed by the same letter are not significantly different for p ≤ 0.05 according to Duncan's multiple range test. DAT: Days after transplanting.

vermicompost) provided the shortest average plant height. Similar results were also evident for the number of leaves per plant. Treating vermicompost at the rate of 15 t ha^{-1} was recorded with the highest average number of leaves at 28 DAT compared to other treatments. However, the vermicompost at 10 t ha^{-1} appeared with the highest average number of leaves per plant at 42 DAT.

Increasing the horse manure vermicompost dose seemed to affect boosting proportionally the plant height and number of leaves per plant. The higher the vermicompost dose, the more significant the impact on the shallot plants. Based on chemical analysis of horse manure vermicompost, it was evident that the content of N, P, and K was relatively high. These three essential macronutrients certainly have a positive impact on plant growth traits. According to Fathi (2022), nitrogen is a well-known essential nutrient vital in forming assimilates. Nitrogen can also enhance the photosynthetic process, leaf area, and photosynthetic net assimilation. Additionally, nitrogen is a significant component of various compounds, such as amino acids, proteins, and nucleic acids.

Analysis of variance showed no interaction effects between the shallot cultivars and horse vermicompost doses, which substantially affected the bulb weight, diameter, and yield (Table 4). However, the two treatment factors, individually, have a significant effect. As compared to other shallot cultivars, the cultivar Sanren-F1 resulted with the highest average bulb weight, diameter, and yield. Research conducted by Yeshiwas *et al.* (2022) also found different effects on the production characteristics of shallot plants in several cultivars, and each shallot cultivar responded differently to the treatments and the environments.

The horse manure vermicompost treatment at 15 t ha^{-1} emerged with an enormous average bulb diameter and weight and appeared significantly different from other vermicompost doses. However, the highest production was apparently in treating horse manure vermicompost at 10 t ha^{-1}, which was also remarkably different from the control treatment. The findings of Faried *et al.* (2021) also revealed a trend toward an increase in bulb weight and diameter, which was directly proportional to the rise in the vermicompost dose. The study also found that applying vermicompost with 15 t ha^{-1} had the best effect compared to doses less than that.

In general, correlation among the different parameters has a close relationship (Figure 1). However, the correlation values of bulb yield with the plant height, number of leaves per plant, bulb weight, and bulb diameter were 0.65, 0.42, 0.70, and 0.35, respectively. Schober *et al.* (2018) also classified the moderate to strong correlations. The highest correlation value was evident between bulb production and bulb weight. Elizani and Sulistyaningsih (2019) also described a positive correlation between bulb weight and shallot bulb productivity per hectare.

Table 4. Effect of cultivars and horse manure vermicompost on the bulb weight, bulb diameter, and yield of *Allium ascalonicum* L.

Cultivars	Bulb weight (g)	Bulb diameter (mm)	Yield (t ha^{-1})
Lokananta	25.0a	37.3a	6.8a
Maserati	26.3a	35.1a	7.9ab
Sanren F1	28.6b	40.2b	8.3b
Vermicompost	Bulb weight (g)	Bulb diameter (mm)	Yield (t ha^{-1})
0 t ha^{-1}	24.4a	35.2a	6.3a
5 t ha^{-1}	26.6ab	37.7b	8.0b
10 t ha^{-1}	28.0b	38.7bc	8.3b
15 t ha^{-1}	29.4b	39.8c	8.1b

Note: Means followed by the same letter are not significantly different for p ≤ 0.05 according to Duncan's multiple range test.

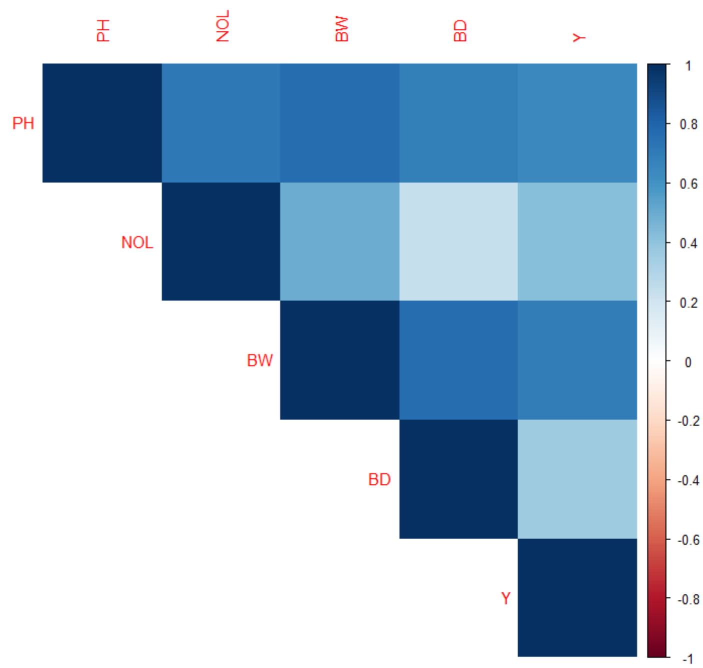

Figure 1. Correlation among the various parameters of *Allium ascalonicum* L. Red indicates a negative relationship, while blue indicates a positive one.

CONCLUSIONS

The study's findings do not demonstrate the relationship between the treatment of horse dung vermicompost and shallot cultivars originating from seeds. However, the individual treatment factors significantly influenced the shallot growth and yield-related traits. The shallot cultivar Sanren-F1 has shown the best growth and production compared to the two other cultivars, i.e., Lokananta and Maserati. The vermicompost application at 10 t ha^{-1} was notable for the highest bulb production; however, the vermicompost dose of 15 t ha^{-1} significantly enhanced plant growth.

ACKNOWLEDGMENTS

The authors thank the Directorate of Research and Community Service, the Directorate General of Higher Education, Indonesian Ministry of Education, Culture, Research, and Technology for funding research assistance.

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