

Making Compost of Sago Ella Granule Enriched with Compound Fertilizer 15:15:15 and Its Application to Shallot Cultivation

Maimuna La Habi ^{a,1}, Rudy Soplanit ^{b,2}, Hermina N. Taihuttu ^{b,2}, Joan J. Grace Kailola ^{b,2},
Nureny Goo ^{b,2} Martha Amba ^{b,2}, Sugeng Prijono ³

¹ maimunalahabi10@gmail.com *; ² soplanitruddy@gmail.com, taihuttuhermina@gmail.com , ; ³ sugengprijono@gmail.com
* corresponding author : maimunalahabi10@gmail.com

ABSTRACT

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Effort to reduce the high dependence of farmers on urea fertilizers is adding sago pith waste granular compost as organic fertilizer. This research is conducted to develop granular-enriched compost and evaluate the effectiveness of granular-enriched compost on red onion cultivation. The application of granular-enriched compost was designed in a Randomized Block Design with three replicates. Treatments included 1) without fertilizers (KGES1); 2) the granular- enriched compost (8 t/ha) (KGES2); 3) recommended dosage of inorganic fertilizers such as Urea, SP-36, and KCl (KGES3); 4) inorganic fertilizer + granular-enriched compost (8 t/ha) (KGES4); 5) ½ x dosage of inorganic fertilizer + granular-enriched compost (8 t/ha) (KGES5); 6) 2× dosage of inorganic fertilizer + granular-enriched compost (8 t/ha) (KGES6); 7) ½× dosage of inorganic fertilizer + granular-enriched compost (12 t/ha) (KGES7) and 8) 2× dosage of inorganic fertilizer + granular-enriched compost (4 t/ha) (KGES8). The granular-enriched compost used in this research has characteristic such as N 2.43 %, P 0.59 %, and K 0.87 %. Based on this study it could be stated that reduction a half dose of inorganic fertilizer combined with compost granule 12 t/ha (KGES7) could give profitable dry bulb yield (13 t/ha) or increased 32% over the inorganic fertilizer. This combination could possibly reduce the amount of the inorganic fertilizer; therefore, it can be used for improving the effectiveness of fertilizer application on the red onion cultivation.

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1. Introduction

This Shallots are a major vegetable commodity, contributing the third largest share of total vegetable crop production in Indonesia (9.08%). In 2009, total production reached 965,164 t/ha, a 13.07% increase from the previous year. However, in 2008, it fell to 9.28 t/ha (Directorate General of Horticulture, 2010). Based on research obtained by the Vegetable Crops Research Institute, this yield can be increased to a potential 12-15 t/ha with technological improvements (Suwandi and Moekasan, 2008).

One of the most common technological improvements in shallot cultivation is fertilization. Farmers generally apply excessive amounts of inorganic fertilizers in an effort to achieve higher yields. Several studies have shown that the continued use of high doses of chemical fertilizers can actually have negative impacts, including reduced crop quality, creating a favorable environment for the development of diseases such as *Fusarium oxysporum* and *Alternaria porri* (Suryaningsih and Asandhi, 1992), increasing shallot production costs (Suwandi, 1998), causing micronutrient deficiencies, imbalances in soil physicochemical properties and unsustainable crop production (Jeyathilake et al., 2006), and damaging soil structure and causing environmental pollution due to

the rapid loss of synthetic N, P, and K fertilizers through evaporation and leaching (Aisha et al., 2007). Stevenson and Cole (1999) also added that the main factors causing the loss of nutrients from the soil, especially N, are biological and chemical denitrification, NH₃ volatilization, leaching, and erosion. In agricultural environments, more than two-thirds of the nitrogen added through fertilizer cannot be absorbed by plants during the growing period, or half of the applied fertilizer has been lost.

One way to reduce farmers' dependence on inorganic fertilizers is to add organic fertilizers. Adding organic fertilizers can improve soil structure and increase the activity of beneficial soil microorganisms. Granulated compost is an inexpensive and easy-to-make organic fertilizer, due to the abundant availability of raw materials, such as sago palm leaf compost. However, this organic fertilizer has a disadvantage: its low nutrient content and slow plant availability, making it difficult to achieve high economic returns. Granulated compost, like other organic fertilizers, has a low macronutrient content (N, P, and K) (less than 10%). The nutrient content and decomposition rate (C/N ratio) of sago palm leaf compost are similar to those of other agricultural waste, with a total N content of 1.74% and a C/N ratio of 22.9 (Agustia et al., 2006). Therefore, finding the right combination of inorganic and organic fertilizers is crucial. Jeyathilake et al. (2006) emphasized that the integrated use of biological fertilizers, organic fertilizers and chemical fertilizers can result in increased agricultural crop yields compared to the exclusive application of chemical fertilizers.

Diversifying organic fertilizer products, such as the production of enriched granular compost by adding Phonska fertilizer to the compost, is one step taken to improve its nutrient content. Basic compost analysis results indicate that the organic matter content in sago palm compost is relatively high, at 26.85%. Meanwhile, the nutrient content of N, P, and K in sago palm compost is 1.56%, 1.03%, and 0.69%, respectively (La Habi et al., 2006; La Habi et al., 2012). The addition of NPK fertilizer to enriched granular compost has been shown to increase the NPK content to 3.8%, 1.5%, and 1.8%, respectively (La Habi et al., 2012). The results of the enriched sago palm granule compost production need to be tested on agricultural commodities, so the aim of this study is to test and evaluate the enriched sago palm granule compost in improving soil fertility in shallot cultivation in Inceptisol.

2. Method

2.1. Treatments and Experimental Design

The study consisted of laboratory and field experiments. Granular compost production was conducted at the Composting Unit (UPT Kompos) of Pattimura University, Ambon. Laboratory experiments, soil analysis, and plant analysis were conducted at the Chemistry/Biology and Soil Physics Laboratory of the Faculty of Agriculture, Brawijaya University, Malang. Field experiments were conducted in Telaga Kodok District, Central Maluku, with Ultisol soil. The study was conducted from January to July 2025. The planting material used was a variety of shallots planted with a spacing of 70 x 30 cm. The fertilizer composition applied, both granular and inorganic, depended on the treatment. Enriched sago palm granular compost was applied twice: 50% at planting time and 50% 30 days after planting (DAP). Phosphorus fertilizer was applied simultaneously at planting time, while nitrogen and potassium fertilizer were applied three times: 50% at 10DAP, 30% at 30DAP, and 20% at 40DAP.

The research design used was a Randomized Block Design (RBD) with eight treatments and three replications. The treatments consisted of: no fertilizer (KGES1), sago pith waste granular compost (8 t/ha) (KGES 2), inorganic fertilizer (urea, SP-36, and KCl) recommended dose (KGES 3), inorganic fertilizer + sago pith waste granular compost (8 t/ha) (KGES 4), $\frac{1}{2} \times$ dose of inorganic fertilizer + sago pith waste granular compost (8 t/ha) (KGES 5), 2 times the dose of inorganic fertilizer + sago pith waste granular compost (8 t/ha) (KGES 6), $\frac{1}{2} \times$ dose of inorganic fertilizer + sago pith waste granular compost (12 t/ha) (KGES 7) and 2 times the dose of inorganic fertilizer + sago pith waste granular compost (4 t ha) (KGES 8).

2.2. Observations

Observations were conducted starting at 14 days after planting (DAP), followed by observations every ten days until 54 days after planting, with harvesting at 65 days after planting. Observation variables included plant height (cm), number of leaves, and per plant, number of clumps per plant, number of tubers per plant and tuber yield or dry weight of harvest (t/ha).

2.3. Data Analysis

The data obtained during the experiment were compiled using Microsoft Excel and analyzed for variability using Genstat 12th for Windows. Analysis of variance (ANOVA) was performed, in accordance with the experimental design and pattern used, using RBD. If significant differences were observed, Duncan's multiple range test was used at the 5% level. Correlation and regression analyses were used to determine the closeness and nature of the relationship between the treatments and the observed variables.

3. Results and Discussion

3.1. Preparation and Quality of Enriched Granular Compost

Based on the results of the basic analysis of the quality of the nutrients of the sago palm compost, the pH of the compost tends to be slightly alkaline (pH H₂O 7.7 and pH KCl 7.6). This indicates that the application of sago palm compost can function to increase soil pH and reduce the detrimental effects (decrease in soil pH) due to the application of urea or ZA fertilizers. The organic matter content in sago palm compost is relatively high at 26.85%. As for its nutritional content, the concentration of N, P, and K nutrients in sago palm compost is 1.57%, 1.04%, and 0.69%, respectively. When compared to the nutrient content of animal manure such as cow and chicken, the N and P content of sago palm granular compost tends to be higher, while the K element is still lower than chicken manure, but higher than cow manure. The compost produced has a C/N ratio of 10, which means that the fertilizer is of high quality and decomposes quickly, thus providing nutrients more quickly. Nutrient enrichment is carried out through the addition of NPK increasing the N and K content, respectively to 2.42% and K 0.87%.

3.2. Plant Growth

At the beginning of growth, the treatments did not show a significant response in terms of plant height, leaf number, or number of clumps because shallots still require a small amount of nutrients during the initial growth phase. As the vegetative phase progresses, the nutrient supply required for plant growth increases. Analysis of variance results showed that the fertilizer and enriched sago palm granular compost treatments significantly affected plant height starting at 24 days after planting and leaf number at the end of the growth phase, but had no significant effect on the number of clumps per plant (Tables 1, 2, and 3). The inorganic fertilizer treatment showed rapid plant length growth at the beginning of growth (24 days after planting) compared to the treatments without fertilizer (KGES 1) and compost alone (KGES 2) (Table 1).

Table 1. Effects of applying inorganic fertilizer and enriched sago stem waste compost on red onion plant height

Treatment	Average Plant Height (cm)				
	14DAP	24DAP	34DAP	44DAP	54DAP
KGES 1	16.44	22.83 a	27.85 ab	32.45 ab	31.59 a
KGES 2	15.85	22.84 a	29.23 ab	33.67 ab	35.46 b
KGES 3	16.76	26.66 b	35.43 c	36.65 bc	42.03 c
KGES 4	16.23	25.84 ab	33.36 bc	39.35 cd	41.89 c
KGES 5	15.94	25.72 ab	34.69 c	40.09 cd	41.99 c
KGES 6	17.27	27.08 b	36.68 c	39.38 cd	42.88 c
KGES 7	17.29	27.65 b	36.29 c	41.83 d	43.34 c
KGES 8	16.97	28.23 b	37.25 c	42.27 d	45.27 c
JND 5%	tn				

Description: The numbers followed by the same letter notation in the same column are not significantly different at 5% level of DMRT.
tn = not significant.

In the early stages of plant growth and development, the release and availability of nutrients contained in inorganic fertilizers are higher. Therefore, research results show that shallot plants treated with compost (KGES2) initially showed slow growth, but later in the plant growth was similar to plants treated with inorganic fertilizer alone or a combination of compost and inorganic fertilizers. These results align with experiments conducted by Seran et al. (20011) that found that shallot plants fertilized with compost alone exhibited slow growth, but there was no significant difference in subsequent stages compared to those treated with inorganic fertilizers. Arisha et al. (2003) confirmed that inorganic fertilizers can accelerate the initial growth of shallot plants, followed by organic fertilizers that stimulate growth in subsequent stages.

Table 2. Effects of applying inorganic fertilizer and enriched sago stem waste compost on red onion number of leaves

Treatments	Average number of leaves per plant				
	14DAP	24DAP	34DAP	44DAP	54DAP
KGES 1	17.94	30.48	21.74	25.18	32.94
KGES 2	16.88	28.81	22.38	27.78	45.11
KGES 3	16.48	31.28	21.01	29.81	52.64
KGES 4	17.61	31.61	23.81	30.74	56.51
KGES 5	18.08	32.71	23.61	30.08	54.61
KGES 6	18.87	31.88	25.44	30.94	47.88
KGES 7	17.48	33.04	25.51	26.38	58.41
KGES 8	19.98	33.21	27.18	32.28	55.74
JND 5%	tn	tn	tn	tn	*

Description: The numbers followed by the same letter notation in the same column are not significantly different at 5% level of DMRT. *tn* = not significant.

Organic fertilizers activate many species of soil microorganisms, which release phytohormones to stimulate plant growth and improve plant nutrition. These soil organisms also require nitrogen for growth and reproduction (Ouda and Mahadeen, 2008).

However, at the end of the observation, it was clear that compost alone was unable to keep up with the growth rate of plant length compared to inorganic fertilizer alone or a combination of both. Nutrient supply in this treatment depended on the nutrient content of the soil and compost, which decreased as the plant's needs for growth and development increased.

Observations of leaf number and number of clumps per plant revealed that the combination of inorganic fertilizer and compost (KGES4, KGES5, KGES6, KGES7, and KGES8) yielded similar results to the inorganic fertilizer alone (KGES3), compost alone (KGES2), and even the uncombined treatment (Table 2). This indicates that the soil nutrient content was sufficient for the development of leaf and clump numbers per plant. The nutrient status of the enriched granular compost applied was also adequate for plant availability.

Laboratory analysis shows that granular compost made from sago palm leaves has higher N, P, and K content than chicken manure. While diversifying the enriched compost into granular form increases the NPK content to 3.9%, 1.6%, and 1.9%, respectively, compared to regular waste compost, with a C/N ratio of 10 (La Habi et al., 2012). Compost with a C/N ratio of 10 indicates good quality and rapid decomposition, thus providing nutrients to plants more quickly. The availability of N is crucial and necessary throughout the plant's life. Sardi and Timar (2005) added that onions require high N for high yields, especially during the vegetative phase. Nitrogen plays a crucial role because this nutrient is actively involved in various metabolic processes in plants, such as protein and carotenoid synthesis. Furthermore, N availability will affect the availability of other essential nutrients, such as P and K.

3.3. Shallot Bulb Yield

Based on the analysis of variance, the number of bulbs per plant showed no significant difference (Figure 1). This result was positively correlated with previous growth results, namely the number of clumps per plant, which also showed a similar response to all treatments.

Table 3. Effects of applying inorganic fertilizer and enriched sago stem waste compost on red onion number of planting Clumps

Treatment	Average number of planting clumps				
	14DAP	24DAP	34DAP	44DAP	54DAP
KGES1	5,68	6,21	6,81	7,82	7,94
KGES2	5,28	6,14	7,14	8,15	8,18
KGES3	5,31	5,91	7,44	8,45	9,68
KGES4	5,14	5,84	7,28	8,29	9,71
KGES5	5,64	6,04	8,11	9,12	9,31
KGES6	5,58	5,71	7,44	8,45	9,31
KGES7	5,38	6,14	7,78	8,76	9,64
KGES8	5,78	6,21	8,28	9,29	10,44
JND 5%	tn	tn	tn	tn	*

Description: The numbers followed by the same letter notation in the same column are not significantly different at 5% level of DMRT. *tn* = not significant.

In contrast to the results obtained by Seran et al. (2010), compost application increased the number of tubers by 33% compared to inorganic fertilizer alone. However, the average number of tubers produced in this study was higher (10-14 tubers per plant) compared to the study by Sersan et al. (2010), which only produced 6-9 tubers per plant.

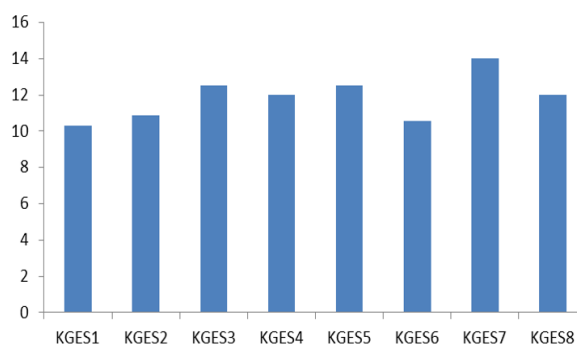


Figure 1. Application of sago pith waste granular compost with compound fertilizer on the number of harvested tubers per plant.

The highest number of bulbs was obtained from the treatment of 12 t/ha compost combined with $\frac{1}{2}$ the recommended dose of inorganic fertilizer (KGES7). Gamiely et al. (1991) stated that the number and size of bulbs formed can be increased by adding nitrogen and potassium after planting. In addition, the increase in shallot bulbs is also accelerated by the addition of organic fertilizer, because this plant is a plant that responds well to organic fertilizer (Purseglowe, 1972). The application of compost containing a lot of organic material can provide an optimal environment for the life and activity of soil microorganisms and improve soil porosity, while the enrichment of NPK in the compost increases the availability of nutrients more quickly so that shallot plants easily form a greater number of bulbs per plant. The application of granular compost alone (KGES2) produces the same dry weight of bulbs (t/ha) as the inorganic fertilizer treatment (KGES3). This indicates that the nutrient content in the enriched compost is able to provide plant nutrient needs.

Inorganic fertilizer combined with granular compost can increase yields by 30-47% compared to the application of inorganic fertilizer or granular compost alone. Similar results were also obtained from research by Seran et al. (2011) who found that the combination of compost and inorganic fertilizers provided more profitable shallot yields compared to compost alone, although less significantly different from the treatment of inorganic fertilizer alone and supported by the results of previous research on shallots (Abbey and Kanton, 2004; Gambo et al., 2008).

It is understandable that the combination of inorganic and organic fertilizers can support each other, ensuring that plants do not lack nutrients during their growth period. Inorganic fertilizers quickly release and provide the necessary nutrients at the right time, while compost containing high organic matter can improve the physical, chemical, and biological properties of the soil, namely improving soil aeration and increasing water retention capacity. From a soil chemical perspective, organic matter can increase the negative charge, thereby increasing the cation exchange capacity (CEC). Biologically, organic matter can also enhance the growth and activity of soil microorganisms. The compost applied in this study is a diversified version of compost enriched with NPK nutrients, so in addition to supplying organic matter to the soil, it can also provide available nutrients for plants. Therefore, its application to shallots yields higher yields than inorganic fertilizer alone.

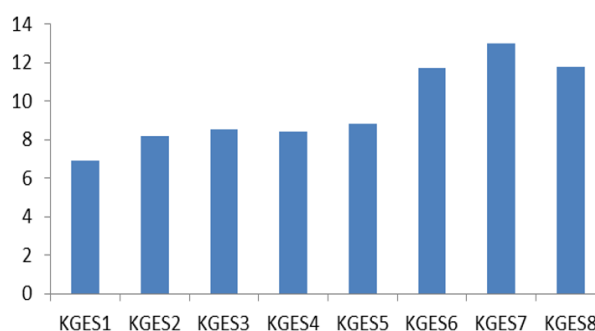


Figure 2. The effect of applying sago pith waste granular compost with compound fertilizer on the yield of shallot bulbs.

Based on the results of this study, the application of excessive inorganic fertilizer, namely twice the recombination dose (KGES2 and PKGES8) did not show significant results in increasing bulb weight (Figure 2). This result is in accordance with the findings of Ashandi and Koestani (1990) who have proven that the method of fertilizing shallot farmers with excessive doses was not significantly different from the method of balanced fertilization. Thus, the application of excessive inorganic fertilizer does not provide benefits in terms of its effect on the growth and yield of shallots. In contrast, reducing the optimum dose of inorganic fertilizer by half combined with the provision of granular compost of 8 t/ha (KGES5) and 12 t/ha (KGES7) showed the same results as the same granular compost treatment as the granular compost treatment combined with the optimum dose of inorganic or twice the optimum dose. Reducing the optimum dose of inorganic fertilizer by half combined with granular compost of 8 t/ha (KGES5) and 12 t/ha (KGES7) was each able to increase yields by 6% and 32% compared to applying inorganic fertilizer alone (KGES3).

4. Conclusion

Enriched granular compost, applied either singly or in combination with inorganic fertilizer, compared to inorganic fertilizer and granular compost alone showed the same response on the growth and number of shallot bulbs. The combination of granular compost and inorganic fertilizer was able to increase yields by 30-47% compared to the application of inorganic fertilizer or granular compost alone. Excessive application of inorganic fertilizer did not show significant results in increasing bulb weight. Based on the results of this study, reducing the dose of inorganic fertilizer by half combined with granular compost at 12 t/ha resulted in the highest dry bulb weight (13 t/ha) or increased yield by 32% compared to inorganic fertilizer application. This combination is expected to reduce the use of inorganic fertilizers, thereby increasing the effectiveness of fertilizer use in shallot cultivation.

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