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Increasing Shallot Production in Marginal Land Using Mulches and Coconut Husk Fertilizer

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ABSTRACT

The study aimed to obtain the type of mulch and the doses of liquid organic fertilizer proper waste coconut husks in modifying microclimate around crops to obtain the maximum yield of shallot in the dryland. The research was used a factorial randomized complete block design consisting of two factors. The first factor consisting mulches, M1 = silver-black plastic mulch and M2 = straw mulch. The dose of liquid organic fertilizer from coconut husks was the second factor. It is consisting of S0 = without fertilizer, S1 = 500 L ha^{-1}, S2 = 750 L ha^{-1} and S3 = 1000 L ha^{-1}. The results showed that the application of a combination of mulch and liquid organic fertilizer coconut husk waste significantly affected plant height, number of leaves per plant, number of tillers, and the bulb yield. Straw mulch with coconut husks waste dose of 1000 L ha^{-1} resulted in plant height, number of leaves per plant, number of tillers and highest bulb yield compared with other treatments. The highest bulb yield was obtained with 9.63 t ha^{-1}.

1. INTRODUCTION

Palu valley shallot (*Allium cepa* L. var. *aggregatum*) is a raw material of fried shallots known to be very typical compared to other shallots in Indonesia. It grows well in various regions in Central Sulawesi, but its production from year-to-year decreases. Shallot production is steadily declining because, among other cultivation technology, it is not optimal as fertilization and irrigation, in this case, the nutrient needs and unmet water and climatic factors, mostly on dryland agro-ecosystem conditions. The element microclimate of the most influential in shallot cultivation in Central Sulawesi is the air temperature. To overcome extreme temperatures can be done by mulching, while the lack of nutrients needed by the plants can be done with a balanced fertilizer and organic matter.

Mulching is mostly used to cover the land to improve soil moisture, which can ultimately improve soil fertility and plant productivity [1, 2]. The existence of mulch on the soil surface reduces soil temperature fluctuations between day and night, maintains soil moisture, and prevents weed growth [3]. Besides, the mulch will maintain a relative humidity of air at the surface continues to rise so that the evaporation speed can be limited [4]. Ram et al. [5] revealed that the mulch reduces soil temperature increases to minimize the evaporation, which causes groundwater levels not to decrease rapidly

Organic mulch is preferred, especially in organic farming systems. Organic mulch widely used is plant debris, straw, rice husk, sawdust, and other organic wastes. Several studies have reported that rice straw mulch can increase the yield on potato crops [6], soybeans [7], tomatoes [8], and maize [1]. The application of straw mulch will provide a good growth environment for plants because it can increase soil water content, reduce water evaporation and reduce soil temperature [5, 9], reduce soil carbon emissions [10], ensuring the availability of groundwater and nutrients [11], decreasing soil evaporation and increasing transpiration [4], and increasing soil microbial populations [6].

Organic farming develops organic fertilizer as compost, green manure, crop residues (straw, stover, corn cobs, sugarcane bagasse, and coconut husk), animal waste, and agricultural, industrial wastes applied to substitute chemical fertilizers. Coconut husks are planting materials that can absorb water in large quantities, improve aeration in agricultural land, and store water high [12]. Coconut husk contains cellulose, hemicellulose, lignin, and pectin [13]. It is also having potassium with low nitrogen and phosphorus [14]. When immersed in water, it will produce soaking water containing potassium, which is very good if given as a substitute for inorganic fertilizer [15].

Potassium is one of the macro fertilizers needed to enhance the growth and yield of shallot, but given K fertilizer rate still varies depending on soil type, season and way of planting, and shallot varieties used. The combination of N fertilizer dose of 150 kg ha^{-1} and K fertilizer dose of 120 kg ha^{-1} delivers growth and shallot yield, which is high compared with other doses [16]. Kamboj et al. [17] recommend using fertilizer K and P dose 125% of recommended doses to obtain growth and better results in the shallot crop. Furthermore, the use of organic fertilizers 5 t ha^{-1}+ urea 100 kg ha^{-1}+ SP-36 200 kg ha^{-1}+ NPK Phonska 300 kg ha^{-1} gives higher bulb yield than without organic fertilizer on shallot [18], while Dapaah et al. [19] recommend 15 t ha^{-1} of poultry manure and 450 kg ha^{-1} NPK fertilizer for growing shallots, as well as the optimum dose of K fertilizer on sorghum crop was obtained at 90 kg ha^{-1} [20], and 300 kg ha^{-1} in shallots [21].

The use of coconut husk as a liquid organic fertilizer that contains potassium macroelements is an alternative technology that can be considered to substitute the use of inorganic fertilizers, especially potassium fertilizer [15]. The potential of coconut husk in Indonesia is very large considering that the country is known as the largest coconut producer in the Asian region. If coconut husk is used, it will reduce environmental pollution and increase the economic value of coconut husk waste. Here, the mulch and liquid organic fertilizer's effectiveness from coconut husk was determined to improve the growth and yield of shallot on marginal land.

2. MATERIALS AND METHODS

2.1 Study site and meteorological condition

The study was conducted from January 2017 to November 2017 in the Bulupountu Jaya village, Central Sulawesi, Indonesia (119°57'10" E, 1°1'51" E) with an altitude of 120 m above sea level. The soil is classified as Inceptisol.

2.2 Experimental design

A factorial randomized complete block design was applied in this study. Two factors were assessed. The first factor is the type of mulch that consists of two levels: M1= silver-black plastic mulch, and M2= rice straw mulch. The dose of liquid fertilizer, as the second factor, consisting of four levels: S0= without fertilizer, S1= dose of 500 L ha^{-1}, S2= dose of 750 L ha^{-1}, and S3= dose of 1000 L ha^{-1}. Of the two factors obtained, eight combined treatment with three replications, so that there are 24 experimental units.

Before planting shallots, first conducted experiments raised beds measuring 2 x 4 meters. Two weeks before planting, cow manure was given as much as 5 t ha^{-1} as a basic fertilizer. Silver-black plastic mulch was installed one week before planting, and liquid manure waste coconut husks were given one week after planting with appropriate treatment doses.

Shallots are planted in experimental plots measuring 2 × 4 m with a 15 × 20 cm spacing, so there are 360 plants in each plot. Plant maintenance was applied, such as watering, weeding, and pest and disease control adapted to the condition of crops in the field.

2.3 Observation and data analysis

The parameters observed were the growth and yield components, which were consisted of: (i) plant height, (ii) number of leaves per plant, (iii) number of tillers, and (iv) yield production of shallot. Plant height and number of leaves were observed at the age of 2 to 7 weeks after planting (WAP), the number of tillers was observed at the age of 5 to 7 WAP, and production of bulb yield was observed at harvest. Plant height was measured by the meter from ground level up to the highest growing point. The number of leaves per plant was counted by the number of leaves in each clump of the plant. The number of the tillers was calculated by the number of tillers per clump of a plant. The shallot bulbs yield was observed at harvest by measuring the weight of fresh bulbs per plot sample and then converted to a hectare.

Data of growth and yield observations were collected and analyzed by F test. If the test of analysis of variance (ANOVA) differs significantly, by honestly significant difference (HSD) test with 95% confidence interval.

3. RESULTS

3.1 Effect of mulch and liquid organic fertilizer on shallot growth

A significant effect of the combination of mulch with the dosage of coconut husk liquid organic fertilizer on plant height, number of leaves per plant, and number of tillers per clump was recorded in this study. In contrast, there was no interaction between mulch and coconut husk liquid organic fertilizer.

The highest plant was 32.26 cm, the highest number of leaves was 27.03 strands, and the highest number of tillers was 6.37 obtained in the combination treatment of rice straw mulch with a dose of organic fertilizer from coconut husk liquid waste 1000 L ha^{-1}. That treatment result was significantly different from others except for the number of tillers, which was not significantly different from the combination of silver-black plastic mulch treatment and the dose of liquid organic fertilizer from coconut husk waste of 1000 L ha^{-1} (Table 1).

The straw mulch contributed to the highest plant height of 25.23 cm (Table 2), the highest number of leaves per plant was 22.43 (Table 3), and the highest number of tillers was 5.45 tiller (Table 4) compared to black-silver plastic mulch. In the treatment of liquid organic fertilizer at a dose of 1000 L ha^{-1} (S3), the highest plant height was 27.92 cm (Table 2), the highest number of leaves per plant was 22.92 (Table 3), and the highest number of tillers was 6.07 tiller (Table 4) compared with other treatment doses.

Table 1. Effect of combination of mulches and liquid organic fertilizer doses on shallot growth

Treatment	Plant height (cm)	Number of leaves (strands)	Number of tillers (tiller)
M1S0	16.22 a	13.30 a	4.17 a
M2S0	21.70 bc	18.70 c	4.73 ab
M1S1	18.05 ab	14.20 ab	4.77 abc
M2S1	22.57 c	20.87 cd	5.13 bcd
M1S2	21.01 bc	17.17 bc	4.93 abc
M2S2	24.51 c	23.10 d	5.57 cde
M1S3	23.76 c	18.80 c	5.77 de
M2S3	32.26 d	27.03 e	6.37 e
HSD 0.05	4.33	3.95	0.80

Notes: The numbers followed by the same letter in the same column are not significantly different at test HSD 5%.

Table 2. Effect of mulches and liquid organic fertilizer doses at aged of 2-7 weeks after planting (WAP) on shallot height (cm)

Treatment	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP	7 WAP
M1	10.86 a	13.10 a	14.99 a	17.80 a	19.47 a	19.73 a
M2	11.48 b	15.05 b	17.19 b	20.18 b	23.30 b	25.23 b
HSD 0.05	0.38	0.72	1.26	1.37	1.49	4.39
S0	9.62 a	12.55 a	14.38 a	15.73 a	18.50 a	18.87 a
S1	11.15 b	13.75 b	15.37 ab	17.80 b	20.27 ab	20.40 ab
S2	11.50 b	14.40 bc	16.35 b	19.72 bc	22.13 b	22.73 ab
S3	12.40 c	15.60 c	18.27 c	22.72 c	24.63 c	27.92 b
HSD 0.05	0.54	1.02	1.78	1.94	2.10	6.22

Notes: The numbers followed by the same letter in the same column are not significantly different at test HSD 5%.

Table 3. Effect of mulches and liquid organic fertilizer doses at aged of 2-7 weeks after planting (WAP) on number of leaves per plant (strands)

Treatment	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP	7 WAP
M1	9.43 a	11.53 a	12.69 a	13.25 a	15.64 a	15.87 a
M2	11.28 b	13.09 b	16.42 b	18.03 b	22.37 b	22.43 b
HSD 0.05	0.38	0.72	1.26	1.37	1.49	4.39
S0	9.45 a	10.32 a	12.12 a	13.43 a	15.70 a	16.00 a
S1	10.12 b	11.88 b	13.98 b	14.98 ab	17.45 ab	17.53 ab
S2	10.68 b	13.07 c	14.92 bc	15.73 b	20.13 b	20.13 b
S3	11.17 c	13.98 c	17.20 c	18.40 c	22.73 b	22.92 c
HSD 0.05	0.61	1.23	1.69	1.94	2.81	2.79

Notes: The numbers followed by the same letter in the same column are not significantly different at test HSD 5%.

Table 4. Effect of mulches and liquid organic fertilizer doses at aged of 5-7 weeks after planting (WAP) on number of tillers (tiller)

Treatment	5 WAP	6 WAP	7 WAP
M1	3.79 a	4.53 a	4.91 a
M2	4.48 b	5.18 b	5.45 b
HSD 0.05	0.23	0.36	0.40
S0	3.45 a	4.15 a	4.45 a
S1	4.10 b	4.58 ab	4.95 ab
S2	4.35 b	4.98 b	5.25 b
S3	4.65 bc	5.72 c	6.07 c
HSD 0.05	0.33	0.51	0.57

Notes: The numbers followed by the same letter in the same column are not significantly different at test HSD 5%.

3.2 Effect of mulch and liquid organic fertilizer on shallot yield

The yield of bulbs significantly affected the combination of mulch types with liquid organic fertilizer from coconut husk waste. The combined application of straw mulch with a liquid organic fertilizer at a dose of 1000 L ha^{-1} resulted in the highest shallot bulb weight, namely 9.63 t ha^{-1} (Table 5).

Table 5. Effect of combined mulches and liquid organic fertilizer doses on shallot bulb yield (t ha^{-1})

Treatment	Bulb yield (t ha^{-1})
M1S0	4.27 a
M2S0	4.83 ab
M1S1	5.17 bc
M2S1	6.93 d
M1S2	5.83 c
M2S2	8.10 e
M1S3	7.63 de
M2S3	9.63 f
HSD 0.05	0.76

Notes: The numbers followed by the same letter in the same column are not significantly different at test HSD 5%.

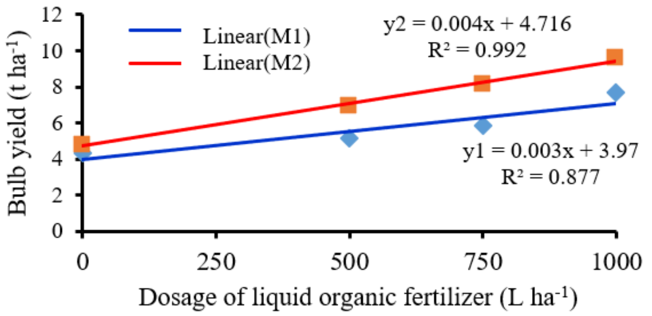

Figure 1. The relationship between the dose of liquid organic fertilizer coconut husk waste and the yield of shallot bulbs

Further analysis with regression on each mulch application shows that black-silver plastic mulch (M1) responded to variations in the dosage of coconut husk liquid organic fertilizer in the form of a linear function, namely y1 = 0.003x + 3.97 with R^2 = 0.877 and rice straw mulch (M2) with the linear function, namely y2 = 0.004x + 4.716 with R^2 = 0.992 (y1 is the yield of bulb t ha^{-1} in silver-black plastic mulch application, and y2 is the yield of blub t ha^{-1} in straw mulch application; x is the dose of liquid organic fertilizer) (Figure 1). The regression analysis showed that the use of liquid organic fertilizer from coconut husk waste at a dose of 1000 L ha^{-1} gave the best response to the yield of shallot bulbs.

4. DISCUSSION

4.1 Effect of mulch and liquid organic fertilizer on shallot growth

One way to increase shallot production is to improve cultivation techniques with fertilization and mulch. Fertilization can use organic and inorganic fertilizers. To overcome dependence on the use of inorganic fertilizers is to provide organic fertilizers. Straw mulch produces more bulbs and more plant leaves than silver-black plastic mulch. Straw mulch can reduce evaporation so that moisture around the plant is maintained, which causes shallot plants to use water to support their growth. Kader et al. [22] suggested that one way to reduce water evaporation in the soil to make it more efficient is to use mulch. Furthermore, several studies have shown that organic fertilizer and rice straw can increase the growth and yields of shallots [23, 24].

Liquid organic coconut husk fertilizer at 1000 L dose ha^{-1} showed an increase in plant height and plant leaves. A possible explanation for this might be that potassium contained in coconut coir waste plays a direct role in forming amino acids, proteins, nucleic acids, enzymes, nucleoproteins, and alkaloids needed for plant growth, especially leaf development, adding to the green color as well as branch formation [25, 26]. Lack of N and K can limit cell division and enlargement so that the addition of N and K fertilizers is sufficient to stimulate optimal plant growth [27].

Bassiony [28] suggested that shallot growth increases gradually with an increasing amount of K fertilizer. K fertilizer can increase the vegetative growth of shallot plants. The application of K fertilizer in the soil is sufficient to make the growth of shallots more optimally [29]. The addition of high doses of potassium shows good results because potassium plays an essential role in helping the photosynthesis process, forming new organic compounds transported from storage organs to the bulb. Another effect of potassium fertilization is that it helps produce high-quality bulbs [21, 30].

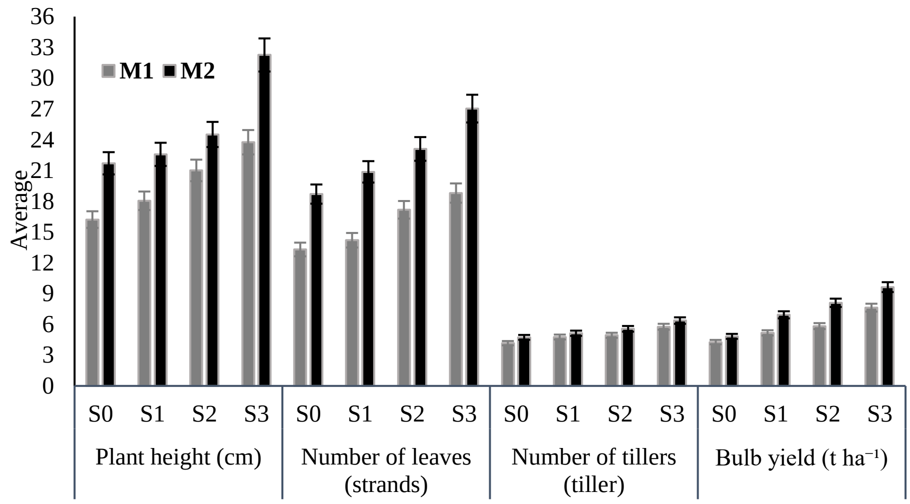

Figure 2. Effect of mulches and liquid organic fertilizer doses on shallot growth and yield

The mulch of rice straw and liquid coconut husk waste up to a dose of 1000 L ha $^{-1}$ increased plant height, number of leaves per plant, and number of tillers (Figure 2) when compared to other treatments. Plant growth has a positive correlation with increasing the dose of potassium fertilizer. Potassium plays a vital role as an activator of several enzymes in plant metabolism, such as potassium plays a role in protein and carbohydrate synthesis and increases the transport of photosynthate translocation to all parts of the plant [31]. Potassium is also important for maintaining cell turgor pressure and plant moisture content, and drought and increasing crop yield and quality [16, 32, 33].

4.2 Effect of mulch and liquid organic fertilizer on shallot yield

The availability of potassium in the rare earth is sufficient to support essential processes such as sugar transport from leaf to the bulb, enzyme activity, protein synthesis, and cell enlargement, ultimately determining yield and quality. The absorption of potassium by plants is influenced by soil texture, soil moisture and temperature, and soil pH and aeration [34].

Potassium status has a significant effect on the yield of shallot plants. The higher the potassium, the higher the yield of shallot plants produced (Figure 2). This occurs because the provision of sufficient potassium in the soil is crucial to increase shallot plants' growth [16, 33]. The function of potassium is directly involved in regulating the biochemical and physiological processes of plant growth. Potassium can also render plants less technical, more resistant to disease, and environmental stress [35, 36]. The higher the soil potassium status, the higher the yield ball. Low bulb yields obtained on soils with low potassium status are caused by nutrient deficiency plants, which play an important role in translocation and assimilation storage, increase in bulb size, number, and yield per plant [37, 38]. The need for potassium increases before harvest as it functions for photosynthesis [33, 39], and shallot plants take up potassium in the same amount as nitrogen [40-43].

5. CONCLUSIONS

The present study was designed to determine the effect of mulches and liquid organic fertilizer to increase shallot production under dryland conditions. These experiments confirmed a linear relationship between the combination of mulch and the liquid organic fertilizer dose to the yield of shallot bulbs (*Allium cepa* L. var. *aggregatum*). The higher the dose given, the higher the results obtained. The combination of mulch and liquid organic fertilizer from coconut husk waste significantly affected plant height, number of leaves per plant, number of tillers, and bulb yield. Straw mulch with coconut husk waste at a dose of 1000 L ha $^{-1}$ produced the highest plant height, number of leaves per plant, number of tillers, and yield of shallot bulb compared to other treatments. The highest bulb yield was 9.63 t ha $^{-1}$. This study's findings suggest that the cultivation of shallots in dryland needs to apply a liquid organic fertilizer to substitute inorganic fertilizers and increase the quality and quantity of shallots.

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