Response of Growth and Yield of Shallots to Various Types of Fertilizer in North Minahasa regency

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Abstract. Shallot (*Allium cepa* L.) is one of the strategic horticultural commodities in North Sulawesi which has high economic value with increasing demand Increased demand must be balanced with increased production that can meet the community's need for shallots. Increasing the production of shallots can be done by fertilizing. The study aimed to examine the growth and yield response of shallots to various types of fertilizers. The research was conducted in Pamuli Village, North Minahasa Regency, with an altitude of 100 m above sea level from April to December 2018. The study used a Randomized Completely Block Design (RCBD) with 4 treatments. The treatment was repeated four times so that 16 experimental plots were obtained. The results showed that from 4 fertilization treatment used, the best treatment was D = NPK *Ponska* + *KCl* + *Feripos* + Manure 10 t ha^{-1} gave the highest growth, gave the highest growth, namely, plant height, number of leaves and number of t bulb and also the highest yield.

1 Introduction

Shallot is included in the group of non-substituted spices that function as food seasonings as well as ingredients for traditional medicines. The nature of shallots, which do not have substitutes, makes the development of shallot business have bright prospects. North Minahasa Regency, is one of the largest horticultural product-producing districts in the form of fruits, compared to other districts in North Sulawesi Province. Apart from fruits, other horticultural commodities such as chilies and shallots are also grown in this district

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and are spread across Kauditan and Wori sub-districts. The average shallot production at the farm level is still low when compared to the research level.

From BPS data of North Sulawesi Province [1], the shallot harvest area in North Minahasa Regency was recorded as 11 ha with a production of 216.00 kg, very small when compared to Minahasa Regency which is the central shallot-producing area in North Sulawesi Province where the harvested area is recorded at 171.00 ha with a production of 17,738.00 kg. Furthermore, when compared to production at the research level, it reached 9.9 t ha^{-1} production for the Bima Brebes variety, and the super Philip variety could reach 17.60 t ha^{-1} [2,3].

Shallots are commodities that have a high selling value in the market. The shallot business and its production centers need to be increased considering that consumer demand from time to time continues to increase in line with the increase in population and increasing purchasing power. In order to meet the increasing demand for shallots, it is necessary to have a breakthrough in cultivation technology that is able to increase the production of shallots [4,5]. Excessive use of inorganic fertilizers causes damage to the physical, chemical, and biological properties of the soil. Soil that is given too much inorganic fertilizer will harden its structure making it difficult for roots to grow and absorb nutrients. In addition, chemical residues left behind can inhibit performance and reduce the diversity of microorganisms that are beneficial to plants [6]. stated, that excessive application of inorganic fertilizers will leave residues in the form of heavy metals such as Cd and Pb in the soil which is harmful to the environment and human health. Increasing shallot production can be done by reducing the use of inorganic fertilizers. One of the organic materials commonly used to improve soil conditions or fertility is manure.

Chicken manure is an organic fertilizer that has advantages in providing nutrients, such as levels of Nitrogen (N), Phosphorus (P), Potassium (K), and Calcium (Ca) which have relatively fast decomposition properties [7]. In addition, the chicken manure is mixed with leftover chicken food and husks as a base for the cage which can contribute additional nutrients to the chicken manure [8]. The combination of organic matter or compost and chemical fertilizers can have a good influence on the nutritional balance of plants and increase soil fertility [9]. In addition, the use of organic fertilizers is also to substitute for NPK fertilizers [10]. Bua et al. [11], stated that organic fertilizers have a positive effect on the growth and production of onions. Wet weight, dry weight, bulb diameter, and onion bulb production were higher in plots treated with manure. Eldardiry [12] added the application of 15 tons ha^{-1} of manure and its combination with a 50% dose of NPK fertilizer had a very significant effect on all growth and production variables. Yassen and Khalid [13] stated that the use of manure was able to increase the vegetative growth of onions. This study aims to determine the effect of several combinations of fertilization on the growth and yield of shallots.

2 Methodology

2.1 Time and location

The research was conducted in Pamuli Village, North Minahasa Regency, with an altitude of 100 m above sea level from April to December 2018.

2.2 Method

The study used a Randomized Completely Block Design (RCBD), the treatment consisted of four combinations of fertilization, each A = NPK Mutiara 300 g ha^{-1} + *KCl* 100 kg ha^{-1} +

Fertipos 120 kg ha^{-1} + chicken manure 5 ton ha^{-1}; B = NPK Mutiara 300 kg ha^{-1} + *KCl* 100 kg ha^{-1} + *Fertipo*s 120 kg ha^{-1}+ C = *Ponska NPK* 300 kg ha^{-1} + *KCl* 100 kg ha-1 + *Fertipos* 120 kg ha^{-1} + chicken manure 5 tons ha^{-1} and D = *Ponska* NPK 300 kg ha^{-1} + *KCl* 100 kg ha^{-1} + fertipos 120 kg ha^{-1} + chicken manure 10 t ha^{-1} and repeated four times so that 16 experimental plots were obtained. Liquid organic fertilizer (LOF) used is *Biolove*, where the composition is made of Aloe vera and seaweed with a concentration of 5 ml L^{-1} of water sprayed on plants aged 15 days after planting, 30 days after planting, and 40 days after planting. Before planting, shallot bulbs selection is carried out first to remove rotten, defective, and exposed to plant-disturbing organisms. The variety used is a superior local Lansuna variety. Shallot The technological components used were (1) 20 cm x 20 cm spacing, (2) using plastic mulch, (3) the seeds were cut at the ends and put in a dithiane solution containing 80% mancozeb for 30 minutes after soaking into the soil 2/3 of the bulb, (4) fertilization application is divided into two stages, namely as basic fertilizer in the form of manure, and 1/2 dose of inorganic fertilizer given two weeks before planting. The next stage is fertilizing after 1/2 dose of the remaining basic fertilizer given at the age of 10-15 days after planting, at 30 days after planting, and at 45 days after planting and (5) Pest and disease control, if the pest population has exceeded the threshold, then control with pesticides is carried out as recommended.

2.3 Data collection and analysis

Data collections were made on 10 plants on each of the plants aged 15, 35 and 65 days after planting. The observed variables include growth components namely plant height (cm), number of leaves (strands), number of bulb and bulb diameter (cm), while the resulting components include weight fresh bulbs (gr per clump), dry bulbs weight (gr per clump) and bulb yield (production) (ton ha^{-1}). Data processing is done using SPSS software version- 23 application. The observation data were analyzed with the F test while differences between treatments were tested with Duncan Multiple Range Test (DMRT) at a rate of 5% [15].

3 Results and discussion

3.1 Plant height, Number of leaves, bulb, and bulb diameter

Table 1. Average Height of Plants, age 15 days after planting, 30 days after planting and at 65 days after planting of the four fertilizations treatments in Pamuli Village, North Minahasa Regency

Fertilization Treatment	Plant Height (cm)		
	15 days after planting	30 days after planting	65 days after planting
A	7.48^{a}	27.10^{a}	29.00^{ab}
B	8.00^{a}	28.33^{b}	29.45^{a}
C	7.07^{a}	29.31^{c}	32.43^{bc}
D	8.00^{a}	31.60^{d}	35.65^{c}

Means with the same letter(s) are not significantly different at 5% level of probability by DMRT

Analysis of variance showed that each fertilization treatment did not affect plant height 15 days after planting (Table 1). Furthermore, the combination fertilization treatment had a significant effect on the age of 35 days after planting (Table 1). The highest average plant height was found in treatment D (NPK *Ponska* 300 kg ha^{-1} + *KCl* 100 kg ha^{-1} + *fertipos* 120 kg ha^{-1} + chicken manure 10 tons ha^{-1}) with an average height of 31.60 cm and significantly different from treatment A (*NPK Mutiara* 300 g ha^{-1} + *KCl* 100 kg ha^{-1} + *Fertipos* 120 kg ha^{-1} + chicken manure 5-ton ha^{-1}) with an average height of 27.10 cm. The last observation before the harvest was 65 days after planting (Table 1). The highest average plant height

was in treatment D (NPK *Ponska* 300 kg ha^{-1} + *KCl* 100 kg ha^{-1} + *fertipos* 120 kg ha^{-1} + chicken manure 10 tons ha^{-1}), and significantly different from treatment A (NPK Pearl 300 g ha^{-1} + *KCl* 100 kg ha^{-1} + *Fertipos* 120 kg ha^{-1} + chicken manure 5-ton ha^{-1}) with an average height of 29.00 cm.

Table 2. Average Number of leaves, Number of bulb and Bulb diameter aged 65 days after planting of the four fertilizations treatments, in Pamuli Village, North Minahasa Regency.

Fertilization treatment	Parameters		
	Number of leaves (stands)	Number of bulbs	Bulb diameter (cm)
A	27.71^{ab}	6,62^{a}	2.40^{a}
B	27.16^{a}	6,94^{a}	2.01^{a}
C	28.10^{b}	7,07^{a}	2.12^{a}
D	30.05^{c}	8.43^{b}	2.81^{a}

Means with the same letter(s) are not significantly different at 5% level of probability by DMRT

Based on the analysis of variance, fertilization treatment gave a significant effect on the number of bulbs (Table 2). The highest average number of bulbs in treatment D (NPK *Ponska* 300 kg ha^{-1} + *KCl* 100 kg ha^{-1} + *fertipos* 120 kg ha^{-1} + chicken manure 10 t ha^{-1}) with an average number of bulbs was 8.43 (seeds) and the lowest was in treatment A (NPK Mutiara 300 g ha^{-1} + *KCl* 100 kg ha^{-1} + *Fertipos* 120 kg ha^{-1} + chicken manure 5 t ha^{-1}) with an average number of bulbs 6.62 (seeds).

The analysis of the variance of the fertilization treatment gave a significant influence on the bulb diameter parameters (Table 2). The highest average bulb diameter was in treatment D (*NPK Ponska* 300 kg ha^{-1} + *KCl* 100 kg ha^{-1} + *fertipos* 120 kg ha^{-1} + chicken manure 10 t ha^{-1}), with an average diameter of 2.81 cm and the lowest was in treatment B (NPK Mutiara 300 kg ha^{-1} + *KCl* 100 kg ha^{-1} + *Fertipos* 120 kg ha^{-1}+ LOF) with an average diameter of 2.01 cm.

The results of observations of the average plant height at the age of shallots 35 days after planting and 65 days after planting, the number of leaves, number of bulbs, and bulb diameter were highest in treatment D (*NPK Ponska* 300 kg ha^{-1} + *KCl* 100 kg ha^{-1} + *fertipos* 120 kg ha^{-1} + chicken manure 10 t ha^{-1}) compared to other treatments A, B and C, which only used 5 t ha^{-1} manure and liquid organic fertilizer (LOF). Plant height is one part of the growth that shows a change in the agronomic character of a plant variety and to support this growth it is necessary to add manure [16].

Some research results support the addition of organic fertilizers can increase the plant height, number of leaves, number of bulbs, and bulb diameter. From the research results of Sataral et al [17], treatment of 2000 g chicken manure + 25 g NPK was able to increase the height of shallot plants from two weeks after planting to six weeks after planting, which was 18.73 to 42.50 cm. This is also supported by the results of research conducted by Budianto et al. [18], which stated that the application of chicken manure at a dose of 10 t ha-1 resulted in better plant height, number of leaves, number of bulbs, and production.

Chicken manure contains nitrogen, phosphorus, and potassium which is higher than other manure [19]. In addition, chicken manure can improve the physical properties of the soil which increases the pore space, thus affecting root development and making it easier for the roots to absorb nutrients properly [20]. Lasmini et al. [21] stated that the combination of organic and inorganic fertilizers can increase growth, soil quality, and increase fertilization efficiency.

Sukmawati [22] stated that the growth of shallots in the formation of the number of leaves requires nutrients N, P, and K because they can help convert carbohydrates produced in the photosynthesis process into a protein. So that it will help increase the number of leaves, leaf diameter, and leaf length. Giving chicken manure can provide the nutrients that plants need for their growth. In this study, we used 10-ton ha^{-1} combined with *phonska*, *KCl*

and *fertipos*. Because manure has a low nutrient content and its availability is relatively long, so it needs to be combined with inorganic fertilizers. It is hoped that with the use of manure, it can reduce the excessive use of chemical fertilizers and improve the physical, chemical, and biological properties of the soil. N and P play a role in increasing plant vegetative growth, especially in leaves, and roots, and stimulating shoots and plant height [23,24]. Plant growth will be stunted if not enough N is absorbed by plants. N deficiency in plants can be seen in plants becoming stunted and their growth is stunted [25-27]. Nitrogen plays the most important role in various biological processes such as increasing the number of leaves, plant height, and other vegetative growth [28]. In addition, Mg contained in chicken manure also has an important role in the synthesis of carbohydrates contained in bulbs. So, Mg also affects the process of photosynthesis and carbohydrates in plants [29].

This is in accordance with the research that has been done that the use of NPK combined with chicken manure increases plant growth. Because chicken manure is a fertilizer that decomposes quickly and has sufficient nutrient levels so that it can increase nutrients in the soil.

3.2 weight of fresh bulbs, dry bulb weight, and bulb yield

The results of the variance of fertilization treatment gave a significant effect on the parameters of the weight of fresh bulbs harvested at the age of 65 days after planting (Table 3). The highest average fresh bulb weight was in treatment D (*NPK Ponska* 300 kg ha^{-1} + *KCl* 100 kg ha^{-1} + *fertipos* 120 kg ha-1 + chicken manure 10 t ha^{-1}) with an average weight fresh bulbs of 56, 15 g $clump^{-1}$, and the lowest was in treatment B (NPK Mutiara 300 kg ha^{-1} + *KCl* 100 kg ha^{-1} + *Fertipos* 120 kg ha^{-1}+ Liquid organic fertilizer (LOF) with an average weight fresh bulbs of 54.18 g $clump^{-1}$.

The results of the variance of fertilization treatment gave a significant effect on the parameters of dry bulb weight stored for 1 month or 30 days after harvest (Table 3). The highest average dry bulb weight was in treatment D (*NPK Ponska* 300 kg ha^{-1} + *KCl* 100 kg ha^{-1} + *fertipos* 120 kg ha^{-1} + chicken manure 10 t ha^{-1}) with an average fresh bulb weight of 44 .80 g/clump and the lowest was in treatment A (NPK Mutiara 300 g ha^{-1} + *KCl* 100 kg ha^{-1} + *Fertipos* 120 kg ha^{-1} + chicken manure 5 t ha^{-1}) with an average dry bulb weight of 43.60 g $clump^{-1}$.

The results of the variance of fertilization treatment gave a significant effect on the total production parameters (table 3). The highest average bulb yield was in treatment D (NPK *Ponska* 300 kg ha^{-1} + *KCl* 100 kg ha^{-1} + *fertipos* 120 kg ha^{-1} + chicken manure 10 tons ha^{-1}) with an average weight fresh bulbs of 12.02 t ha^{-1} and the lowest was in treatment A (NPK Mutiara 300 g ha^{-1} + *KCl* 100 kg ha^{-1} + *Fertipos* 120 kg ha^{-1} + chicken manure 5 t ha^{-1}) with an average bulb yield of 11.18 t ha^{-1}.

Table 3. The average weight of fresh bulb g/clump, dry bulb weight g/clump, and bulb yield of t ha^{-1} of the four fertilizations treatments, in Pamuli Village, North Minahasa Regency

Fertilizer Treatment	Result Components		
	Weight fresh bulbs (g $clump^{-1}$)	Dry bulbs weight (g $clump^{-1}$)	Bulb Yield (t ha^{-1})
A	54.20[a]	43.60[a]	11.18[a]
B	54.18[a]	43.65[a]	11.39[a]
C	54.91[b]	43.83[a]	11.39[a]
D	56.15[c]	44.80[b]	12.02[b]

Means with the same letter(s) are not significantly different at 5% level of probability by DMRT

The results of observations on the average weight of fresh bulbs, dried bulbs, and the highest total production were in the D fertilization treatment (*NPK Ponska* 300 kg ha^{-1} + *KCl* 100 kg ha^{-1} + *fertipos* 120 kg ha^{-1} + chicken manure 10 tons ha^{-1}), compared to other treatments A, B, and C, which used 5-ton ha^{-1} manure and liquid organic fertilizer. Several supporting statements from the research results with the addition of the concentration of manure increased crop yields. The results of the study from Jazilah et al [30], the application of inorganic fertilizer (NPK 15:15:15) increased the dry weight of bulbs per clump. The highest yield was obtained at a dose of 200 kg ha^{-1} (P3) inorganic fertilizer with 20 tons ha^{-1} manure. Further, Sharma et al. (2003) [31], reported on shallots grown in the North-Western Himalayas, India showing that the best bulb yields were obtained from a combination of 100% NPK (125 kg N, 33 kg P, and 50 kg K) with 20 tons of bulb manure. The best is 19.87 tons ha^{-1} compared to the use of 150% NPK which only produces 18.82 tons.

Phosphorus is essential for bulb formation and development. Element P or Phosphorus is a component of enzymes and proteins ATP, RNA, DNA, and phytin which have important functions in the process of photosynthesis, the use of sugar and starch, and energy transfer. Elemental P also plays a role in the growth of shoots, roots, flowers, and fruit. The effect on the roots is by improving the root structure so that the absorption capacity of shallot plants for nutrients becomes better. There are no other nutrients that can replace the function of phosphorus in plants, so plants must get enough phosphorus to increase root development and plant carbohydrate content which ultimately increases plant growth and yield [32]. Magdi et al. [33] also reported that organic fertilizers will produce shallots bulbs that are heavier than inorganic fertilizers. Furthermore, El-shatanofy [34] stated that the wet and dry weights of shallots would be higher in the application of manure. Shallots are very responsive to the application of N. This is because N plays an important role in the preparation of chlorophyll which is an important element in carbohydrate synthesis. In addition, N also plays a role in the formation of proteins through the preparation of amino acids. Furthermore, according to Arifin et al. [35], the higher the number of plants, the higher the photosynthetic process and the more photosynthate and bulb filling, resulting in more bulb formation.

The high bulb yield of shallots is due to an increase in the rate of photosynthesis and assimilation of the product into plant tissues [26,36]. The presence of manure applied to the soil can increase the availability of nutrients in the soil solution that supports plant growth thereby increasing the yield of shallots [23-25]. The results of research by Santosa et al., [37] stated that inorganic fertilizers combined with organic fertilizers can increase the highest shallot yields compared to inorganic fertilizers alone. The use of 10 tons ha^{-1} combined with *KCl* significantly increased the number of bulbs by 6.5% and the yield index by 2.3% [38].

The nutrients nitrogen, phosphorus, and potassium can increase bulb size, fresh weight, and bulb yield per hectare. Potassium has an important role in protein formation, facilitating photosynthesis and increasing the translocation of photosynthate to plant parts, which can further increase the fresh weight and yield of shallots [39,40].

4 Conclusions

The results showed that the fertilization treatment D = *Ponska NPK* 300 kg ha^{-1} + *KCl* 100 kg ha^{-1} + *fertipos* 120 kg ha^{-1} + chicken manure 10 t ha^{-1} gave the highest growth, namely, plant height 35.65 cm, number of leaves 30.05 and number of bulbs 8.43, and the highest yield was 12, 02 t ha^{-1}. A combination of organic and inorganic fertilizers is needed to increase plant growth and yields.

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