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AMMONIUM SULPHATE (ZA) AND ORGANIC FERTILIZER TO IMPROVE YIELD AND QUALITY OF SHALLOT BULB (*Allium ascalonicum* L.) ON RECOVERED ULTISOLS

Nilla Kristina*, Elara Resigia, Netti Herawati

Department of Agronomy, Universitas Andalas, Padang, Indonesia

*Corresponding author
Email: nillakristina@agr.unand.ac.id

Abstract*. In principle, shallot can adapt to all altitudes. But in West Sumatera, it is generally cultivated in the highland. The problem is the area in the highland is very limited while the area in lowland land is dominated by Ultisol soils. The type of soil in Agricultural Faculty experimental field at Andalas University is Ultisol (250 asl) but the chemical properties slightly change, such as nitrogen, phosphor and potassium higher than usual otherwise SO_4^{2-} and Ca-dd is still very low. This study aimed to obtain the best organic fertilizer and ZA fertilizer on the growth, yield and quality of shallot bulb on recovered Ultisols. The research was a-two factorial experiment with 3 replications in Completely Randomized Design. The first factor is the application of various types of organic fertilizer, which include three levels which are guano, chicken manure, and oil palm empty bunches (OPEB). The second factor is ZA fertilizer dosage (0, 100, and 200 kg/ha). Data were analyzed using the F test with a 5% level, and if there were significant differences, the analysis continued with the Duncan's New Multiple Range Test (DNMRT) at a 5% level. The result showed that the development of shallots on recovered Ultisols brings hope. The yield of chicken manure and guano are higher than oil palm empty bunches and in accordance with the description of Bima Brebes varieties around 9 t/ha. Even guano could produce dry bulbs around10,54 t/ha without giving ZA. Moreover, guano fertilizer gave the best Sulphur content on every dose of ZA.*
Keywords: *chicken manure; organic fertilizer; sulfuric acid; ultisol*

1. Introduction

One of the vegetable products in Indonesia with high economic worth is the shallot which is used as a spice and food additive. It is a well-known plant species that is utilized all over the world for medicinal too (Moldovan *et al.*, 2022). The plant's chemical makeup reveals that the most significant components are organosulphur compounds such as allicin, diallyl disulphide, S-allyl cysteine, and diallyl trisulfide (Mikaili *et al.*, 2013). Garlic's antibacterial activity is assumed to be primarily caused by allicin and other Sulphur compounds. Wide-ranging antifungal specificity has been demonstrated for allicin (diallyl-dithiosulfinate), which is generated by the garlic enzyme alliinase from the alliin (Appel *et al.*, 2010). The anticancer properties of diallyl sulfides (DAS), diallyl disulfides (DADS), and diallyl trisulfides (DATS) produced from garlic have been demonstrated (Lai *et al.*, 2012). One study mentioned that garlic's organosulphur compounds (such as diallyl trisulfide) display hypolipidemic effects by inhibiting fatty acid and cholesterol synthesis (Lii *et al.*, 2012). Recent studies have demonstrated the extensive pharmacological effects of Allicin and other organosulphur compounds found in *A. sativum*.

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During this time, the development of shallots in West Sumatra is more on the highlands, with soil types of Andisol and Inceptisol. The soil has a high organic matter content, so that it becomes more fertile and crumbs. However, the highland is very limited, so it is necessary to develop shallots on the lowlands. In addition, the air temperature in the lowlands during the rainy season remains higher than in the highlands so the risk of crop failure due to the attacks of diseases such as powdery mildew is much reduced compared to plantings carried out at high levels at the same time. But the problem of lowlands is dominated by Ultisol soil type. Ultisol in Limau Manis was dominated by clay; besides, the SO_4^{2-} is still low (3.50 ppm), so it is not enough for the development of shallot.

Sulphur is an element that acts as a constituent of essential amino acids such as cystine, cysteine and methionine. It plays a role in protein synthesis, chlorophyll formation, certain vitamins and volatile compounds. Amino acid cysteine is the main organic molecule. Mishu *et al.* (2013) and Tripathy *et al.* (2013) state that getting the use of Sulphur on shallots can improve the yield of bulbs. The quality of onion bulbs depends on the spicy taste. The spicier onion is preferred. The spicy taste is strongly related to the content of pyruvate acid and it is associated with Sulphur fertilization treatment. Lee *et al.* (2009) shows that the additional Sulphur fertilizers of 40 and 50 kg/ha produce the highest pyruvate acid content in onion bulbs.

Sulphur nutrients can be found in the plant and animal residues. The provision of chicken manure, Guano and OPEB is the effort to improve Podzolic soils' physical, chemical and biological properties, especially to increase Sulphur contents. Guano is organic matter from seabird manure (for example, *Larus argentatus*) and bat (for example, *Phylloncyteris aphylla*), while OPEB is organic matter from oil palm empty bunches. Small organic matter can be spread evenly on the ground so that it can release bonds between soil particles and it is able to improve the texture of the soil to be more crumbs. In addition, organic matter can reduce the pressure of soil particles against the roots of shallot plants, improve the capacity of soil to hold water, soil mass density, and total porosity, improve the stability of soil aggregates and increase the content of soil humus, a condition desired by vegetable crops. Different organic matter has different nutrient and different effect to the soil and plant. The addition of organic matter can improve pH and P's solubility in acidic soil. It has been effectively used to increase and promote plant production for centuries (Tabitha *et al.*, 2018).

Another Sulphur source that is often used in the cultivation of shallots is ZA ($(NH_4)_2SO_4$) which has the advantage of containing high Sulphur and Nitrogen nutrients that are 23% N and 21% S respectively, so it is preferred for the cultivation of shallots. The problem with ZA fertilizer is reacts acidic and can increase soil acidity. Karimizarchi *et al.*, (2014) shows the application of

elemental sulphur at a rate of 0.5 g S kg-1 soil decreased soil pH from 7.03 to 6.29, but considerably enhanced Mn and Zn availability by 0.38% and 0.91%, respectively. Further pH reduction due to the acidifying character of elemental sulphur at addition rates of 1 and 2 g kg-1 soil increased Mn and Zn availability, but significantly decreased maize performance. This study aimed to understand about the physiological effects of ZA fertilizer on shallot in recovered Ultisols and the relation with organic fertilizer. The interaction between doses of ZA and organic fertilizers is expected to improve the growth, yield and quality of bulbs of onion crops in Ultisol.

2. Methods

2.1. Description of experimental area

The experiment was conducted at the Experimental Garden of the Faculty of Agriculture, Andalas University, Padang at 250 meters above sea level in the rainy season (rainfall 325 mm in the first month and 780 mm in the second month after planting). This soil has been used as a research area for ten years so the physical properties have changed a little. Characteristics of the soil are pH 5.8, N total 0.24% (medium), P_2O_5 Bray 14.97 ppm (high), Ca-dd 0.29 me/100g (very low), K total 14.48 me/100g (very high), SO_4^{2-} 3.5 ppm (very low), C/N 8.6 (low).

2.2. Experimental treatments and design

The experiment used a complete 3 x 3 factorial design compiled in a randomized design complete with three replications. The first factor is a type of organic fertilizer consisting of chicken manure, guano fertilizer, and OPEB fertilizer. The second factor consists of the dose of fertilizer with ZA of 0, 100, 200 kg/ha. The first and second factor consist of three levels, so there are 27 experimental units. Plant samples were taken randomly, with each of five plants. The observations were conducted with ANOVA with $\alpha = 5$ % when there is a real difference followed by a Duncan's New Multiple Range Test (DNMRT).

2.3. Planting preparation and fertilizer application

The materials needed for this experiment are large shallot seed bulbs from the Bima Brebes variety (>1.8 cm diameter). The bulb must be healthy, not rotten, uniform and single bulb. Planting is done with a predetermined planting distance of 20 x 20 cm before planting the first seedlings selected uniformly in the form of single bulbs with a diameter of bulbs about 1.5 cm. The tip of the clove to be planted was cut into 1/3 part then two layers of outer skin were removed to stimulate the growth of roots and shoots. Every planting hole was filled with one bulb of shallots.

We used 10 t/ha (equivalent to 40 grams per plant) of chicken manure, guano and OPEB as a basic organic fertilizer that was given to the planting hole. Inorganic fertilizers provided were Urea (45% N) 200 kg/ha, TSP (46% P_2O_5) 200 kg/ha, KCL (60% K_2O) 200 kg/ha that were given in the first week after planting. ZA (23% N and 21% S) fertilizer was applicated ten days after

planting with the appropriate treatment dose (0, 100 and 200 kg/ha). Shallots are ready for harvesting approximately 57 days after planting, the foliage turns yellowing and flops over. Lift the bulbs before the foliage dies down completely.

3. Results and Discussion

3.2. Plant height and number of leaves

The examination of the data revealed that there is no relationship between the amount of ZA fertilizer and the different types of organic fertilizers in terms of the quantity and size of leaves on shallot plants. The single treatment of this type of organic fertilizer gives an influence on the height and number of leaves of the shallot plant. Figure 1 illustrates the plant's typical height and quantity of leaves.

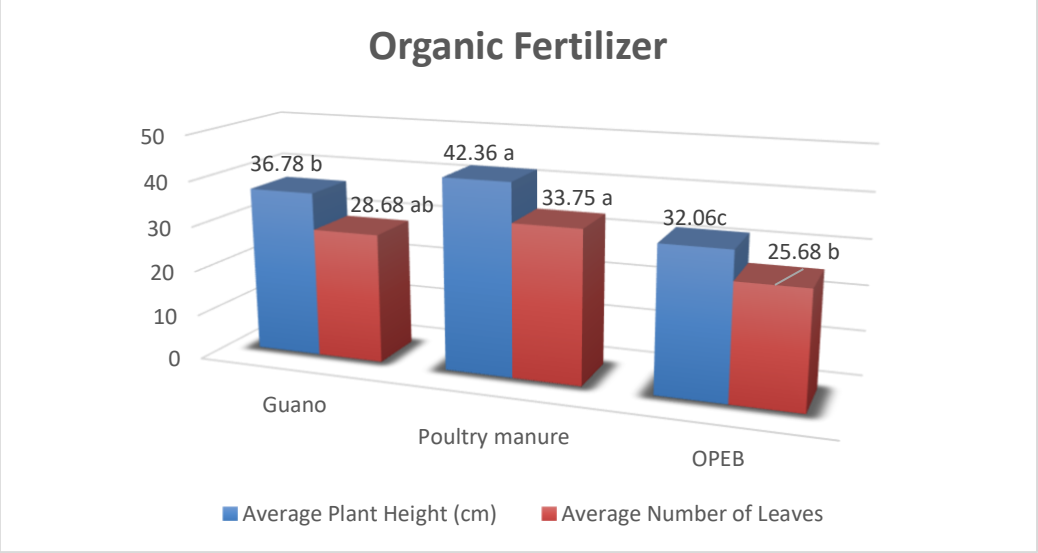

Figure 1. Diagram of the shallot height and number of leaves in different types of organic fertilizer

At the bottom of the bulbs, there is a true stem called a discus. From here, comes pseudo stems composed of leaf fronds. Pseudo-stems are in the soil and changed in shape and function into layered bulbs. The leaves of shallot are small cylindrical-shaped extending between 50-70 cm, perforated and pointy ends, light green to old and the location of the leaves attached to the stalk is relatively short. Measurement of the height of the plant starts from the base of the bulbs to the highest tip of the leaves.

Based on **Error! Not a valid bookmark self-reference.**, it can be concluded that the height of shallot plants in Ultisol is in the description range of red onion varieties of Bima Brebes which is 25 - 44 cm (Putrasamedja & Suwandi, 1996). This means that although planted on marginal soil, varieties of Bima Brebes can still reach its high potential and the height of plants that get treatment of chicken manure was significantly higher than plants that get treatment of guano and OPEB

fertilizer., plants given OPEB fertilizer produced the shortest stems.

Table 1. Analysis of chicken manure, guano, and OPEB

Elements	Chicken manure	Guano manure	OPEB
N total (%)	4.64	2.77	1.78
P total (%)	2.07	1.65	1.54
K (%)	2.56	1.07	1.26
S (%)	1.87	1.77	1.72
Mg (%)	1.44[a]	0.54[a]	0.45[a]
Ca (%)	1.57[a]	0.23[a]	0.84[a]

[a]Wiryanta *et al.* (2002)

Chicken manure contains higher nitrogen nutrients than guano and OPEB fertilizers. Nitrogen is an important element in the formation of chlorophyll, protoplasm and nucleic acids. All living networks' growth and development depend heavily on this component (Weil & Brady, 2017). The process of cell division will run quickly with sufficient availability of N. Nitrogen makes the plant part fresh and greener because it contains a lot of chlorophyll which is important in the process of photosynthesis, accelerate the growth of plants (height, number of saplings, branches, etc.) as well as increase the protein content of the crop.

Chicken manure produced the largest number of leaves and did not differ markedly from the treatment of guano fertilizer, while plants given OPEB fertilizer had the least number of leaves. The number of leaves produced has been in the description of Bima Brebes varieties which are 14 - 50 strands (Putrasamedja & Suwandi, 1996). From the data, the number of leaves and the height of the shallot plant can indicate that the growth of shallots is quite good in lowland Ultisol. The lower number of leaves in plants given OPEB fertilizer maybe can be caused by lower nutrient content of Magnesium and they are still low in Ultisol. On the contrary, chicken manure contained the highest Magnesium so it was able to produce 33.75 leaves.

Magnesium plays a key role in photosynthesis and the subsequent transfer of photo assimilates in plants (Cakmak & Marschner, 1992, Tränkner *et al.*, 2016). Plants need Mg in the process of photosynthesis because Mg is one of the important components of chlorophyll. The part of plants that contain Mg is a tissue which is rich in chlorophyll and that part is leave. The result of photosynthesis can be determined by the amount of chlorophyll content on the leaves. If the chlorophyll content of the leaves increases then it will be followed by the increase of photosynthesis results. For example, a lack of magnesium inhibits the transfer of sucrose from source leaves to sink organs like roots (Cakmak & Kirkby, 2008).

Magnesium (Mg) deficiency results in chlorosis is starting from the lower stem, usually followed by the death of certain parts or leaves entirely. Mg deficiency can decrease yields and inhibit protein synthesis. Generally when plants lack Mg, it will decrease the proportion of N-

protein and N-non-protein, increasing yellow on the leaves that do not start from the base but from the tip, while the bone of the leaves remains green (Dwidjoseputro, 1978). Symptoms of Mg deficiency are seen in plants that are given OPEB fertilizer so that two weeks before harvest, half of the leaves of the plant are yellowing and dead, so the plants grow shorter.

3.3. Number of bulbs

The results of the data analysis showed that there is an interaction between various kinds of organic fertilizer and the dose of ZA fertilizer to the number of shallot bulbs. The average number of plant bulbs can be seen in Table 2.

Table 2. The number of plant bulbs on different types of organic fertilizer and doses of ZA

Organic Fertilizer	ZA (kg/ha)		
	0	100	200
Guano	7.53 A A	7.60 A ab	7.50 A b
Chicken	5.80 B A	8.13 A a	9.03 A a
OPEB	7.13 A A	6.08 A b	6.05 A b

Note: The numbers in the column followed by the same lowercase letter and the numbers in the row followed by the same uppercase letter are not real according to DNMRT advanced test level 5%

Based on the description of the red onion varieties of Bima Brebes, the bulbs per clump range from 7 -12 pieces. The number of bulbs from Guano and OPEB treatment was not different on all ZA treatments. However, chicken manure treatment shows that the number of bulbs increased by giving ZA and was higher than OPEB and Guano treatment. Most bulbs were produced on chicken manure treatment, and 200 kg/ha of ZA was as much as 9.03 bulbs. The status of Ca in the soil is low, but chicken manure that contains a high element of Ca can increase the number of bulbs. Calcium from the organic matter is essential for the plant. The signal transduction pathways of many environmental and developmental stimuli in plants are affected by the changes in cytosolic Ca^{2+} levels. It also serves as a counter-cation for inorganic and organic anions in the vacuole. Deficiency symptoms were observed in (a) young expanding leaves, such as in `tip burn' of leafy vegetables, (b) enclosed tissues, such as in `brown heart' of leafy vegetables or `black heart' of celery, or (c) tissues fed principally by the phloem rather than the xylem, such as in `blossom end rot' of watermelon, pepper and tomato fruit, `bitter pit' of apples and `empty pod' in peanut. That happens because Ca cannot be released from aging tissues and transported through the phloem. As a result, the growing tissues are compelled to rely on the xylem's immediate Ca supply, which is reliant on transpiration. In immature leaves, enclosed tissues, and fruit, transpiration is minimal (White & Broadley, 2003).

Sulphur and nitrogen, two important macronutrients, were found in Za. Plant tissues have a

total S concentration ranging from 0.3% to 7.6% (Zhao *et al.*, 2008). By being a component of the amino acids cysteine and methionine, S is specifically of major relevance for the main structure of proteins and the functioning of enzymes (Giordano & Raven, 2014). S-Glucosinolates in the Cruciferae family and alliins in the Liliaceae are two examples of secondary plant products that include Sulphur.

Organic Sulphur in soil is a heterogeneous mixture of soil organisms and partially decomposed plants, animals and microbial residues and represents the majority of total S in most agricultural soils (Haneklaus *et al.*, 1998; Solomon *et al.*, 2001). Organic Sulphur is the main S-binding form in soils (Scherer, 2009) and contributes up to 95% of total soil Sulphur in cultivated soils. The Sulphur mineralization rate in soil increased by adding more elemental S when there was no organic matter present. Organic matter provides S-oxidizing bacteria with energy, which in turn spurs on their activity and accelerates the pace at which S-mineralization occurs in soil (Gharmakher *et al.*, 2009). The rate of S-mineralization that resulted from the addition of only organic matter was dominated by the combined application of organic matter and elemental Sulphur. In addition, Singh *et al.* (2009) observed that the addition of organic matter accelerated the rate of S-mineralization. Type of organic matter influences availability of Sulphur. If the plant lacks Sulphur then the production of plant protein decreases and the growth of plant cells is less active and chlorosis develops on the plant's leaves (Singh *et al.*, 2009).

3.4. Dry weight of bulbs per hectare

The results of the data analysis showed that there was no interaction between various kinds of organic fertilizer and ZA fertilizer dose against the dry weight and diameter of bulbs shallots. However, the single treatment of this type of organic fertilizer gave a real influence on the dry weight of the onion bulbs. The average dry weight of wind bulbs can be seen in Table 3.

Table 3. Dry weight of shallot bulbs per hectare at 57 DAP due to the administration of several types of organic fertilizer and doses of ZA fertilizer

Organic Fertilizer	ZA Fertilizer (kg/ha)			Mean
	0	100	200	
	----------t/ha----------			
Guano	10.54	8.60	8.52	9.22 ab
Chicken	9.65	10.03	9.51	9.73 a
OPEB	4.51	4.52	4.52	4.52 c

The numbers in the column followed by the same lowercase letter are not real according to DNMRT advanced test level 5%

Harvesting shallots was done three days faster because of the high and continuous rainfall. This made onion bulbs were quickly enlarged/broken and they contained a lot of water, so it could decrease the quality of bulbs and caused bulbs easily rot. Bulbs on shallots are modifications of the leaves. These bulbs are called layer bulbs because they show a multilayered arrangement

consisting of leaves that have become thick, soft and fleshy. The thick, soft and fleshy part of the leaves is the bulbs that store food reserves (Tjitrosoepomo, 2005). Assimilate formation for filling bulbs are strongly influenced by the presence of photosynthetic leaves. The leaves of the small cylindrical-shaped shallot plant extend between 50 – 70 cm.

The highest weight of crop bulbs per hectare is produced in the treatment of chicken manure of 9.73 t/ha but there was no real difference from the weight of bulbs in guano fertilizer treatment of 9.22 t/ha. This is in line with the number of leaves and higher plant height in the treatment of chicken drum fertilizer. The results obtained in the treatment of chicken manure and guano fertilizer have approached the description of Bima Brebes variety yield of 9.9 t/ha**.** Even Guano could produce dry bulb of 10,54 t/ha without giving ZA.

Manure is an affordable source of organic material and it is easily available from the surrounding environment. Organic fertilizers such as manure are intended to preserve the land by improving the chemical, physical, and biological properties of the soil. Based on airy observations, it was found that the state of the soil in the treatment of chicken manure is more crumby and more moist than other treatments. Such conditions are excellent for the enlargement of bulbs. In addition, manure can improve the biological properties of soil by increasing the population of biota in the soil. Manure may also improve the physical properties of soil by loosening soil structures and improving aeration and drainage (Supramudho *et al*., 2011).

Visible bulbs from plants on the treatment were larger and contained a lot of water but the color of the bulbs was less purple. However, bulbs containing a lot of water would easily rot. The dry weight of the onion bulbs from the guano treatment was no different from the plants that were given chicken manure. However, plants in the treatment of OPEB fertilizer produced small bulbs even though the color of the bulbs was more purple and the bulbs were denser.

Compared to Guano and OPEB fertilizers, chicken manure has a greater potassium content. One of the most important nutrients for plant growth is potassium, which also aids in the activation of various soil enzymes. If plants have access to adequate potassium, the stomata can function as intended throughout infections with different airborne pathogens. During photosynthesis, potassium controls the opening and shutting of stomata, which in turn controls CO2 absorption. In plants, it aids in the production of carbohydrates. It acts as a quality factor by enhancing the fruit's quality (Farooq *et al.*, 2018; Surucu *et al.*, 2020).

3.5. Diameter of bulbs

The results of the data analysis showed that there was no interaction between the administration of various kinds of organic fertilizer and za fertilizer dose to the diameter of shallot bulbs. Nevertheless, the single treatment of this type of organic fertilizer gave a real influence on

the diameter of shallot bulbs. The average diameter of shallot bulbs, can be seen in Table 4.

Table 4. Diameter of shallot bulbs at 57 DAP due to the administration of several types of organic fertilizer and doses of fertilizer ZA

Organic Fertilizer	ZA Fertilizer (kg/ha)			Mean
	0	100	200	
	----------mm----------			
Guano	28.65	24.85	25.32	26.27 a
Chicken	24.23	24.60	25.25	24.69 a
OPEB	19.67	20.69	19.91	20.09 b

The numbers in the column followed by the same lowercase letter are not real according to dnmrt advanced test level 5%

The resulting photosynthetic from photosynthetic cells are transported to other organs or tissues so that they can be used by those organs or tissues for growth or stockpiled as a spare material (Lakitan, 2018). Onion bulbs are one of the organs that hoard food reserves. The size of the bulbs can be influenced by the number of bulbs per clump. The more the number of bulbs per clump, generally the smaller the size of the bulbs, especially when the availability of plant nutrients is at the critical point of crop needs. This is because assimilates were divided for each bulb on every clump.

The quality of bulbs produced is not only related to consumers or used for direct consumption but also must meet the quality aspects of bulbs to be used as seed bulbs so that farmers do not depend on the seeds of others. Farmers must have independence in terms of seeding. Measurement of the diameter of the bulbs is carried out a week after the bulbs are lightened. To be used as a seed, drying is carried out for 2-3 months. In terms of the size of bulbs, bulbs produced by guano fertilizer and chicken coops meet the requirements of seed bulbs and many are large for both seed bulbs and consumption bulbs. Table 4 shows that the diameter size of the onion bulbs using the guano fertilizer was the largest and did not differ markedly from the treatment of chicken manure. The durability of bulbs from guano treatment was also better than chicken coop during storage. Bulbs produced by chicken manure easily rotted starting at the base of the bulbs and experienced a larger weight of bulbs than guano.

Plants given OPEB fertilizer produced the smallest diameter of bulbs. Of all the parameters, plants given OPEB fertilizer showed symptoms of poor growth. But strangely, OPEB bulbswere much harder than other treatments and had the most of red color, even many were purple. Although OPEB was able to improve the texture and structure of soil around the rooting of plants and it contained high nitrogen and potassium nutrients, it was not able to improve the growth of shallots in Ultisol. These constraints could not be overcome by the use of OPEB fertilizer because of nutrient interaction. It is in accordance with the "minimum Liebig" law stating that the growth of a plant will be determined by essential nutrients that are in the minimum amount. Moreover, in acid soils with low pH, the availability of Mg nutrients is limited.

3.6. Sulphur content in shallot bulb

Sulphur is an element that is needed by onion plants in large quantities. Sulphur plays an important role in plant metabolism which is associated with several parameters determining the nutritional quality of vegetable crops (Figure 2).

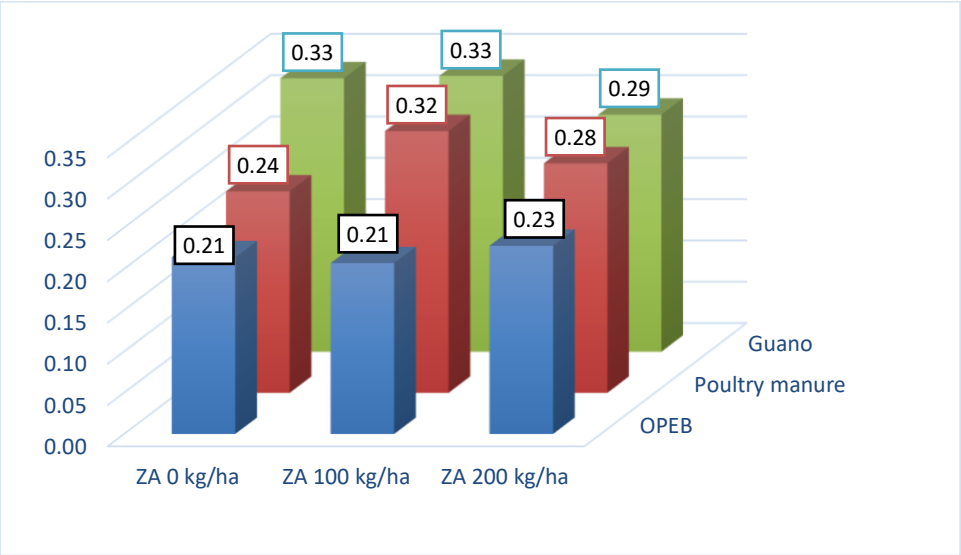

Figure 2. Sulphur Content in Shallot Bulbs (%)

In general, the Sulphur content in guano fertilizer treatment was higher than other organic fertilizers, especially in the treatment of 100 kg/ha ZA. Meanwhile, the Sulphur content on OPEB treatment was the lowest at all levels of ZA administration. This is line with Table 1. which shows that OPEB had the lowest sulphur content too. The quality of onion bulbs depends on the spicy taste. The more spicy onion was preferred. The spicy taste is strongly related to the content of pyruvate acid associated with Sulphur fertilization treatment. Thangasamy *et al.*, (2013) also found that pyruvate acid content is closely related and positively correlated with Sulphur fertilization (Thangasamy *et al.*, 2013). Sulphur impacts crop productivity, flavor, and perfume of foods including cruciferous vegetables, garlic (*Allium sativum* L.), and onions (*Allium cepa* L.), as well as the color and smell of flowers and vegetables. In bulbs, Sulphur serves to improve the quality of bulbs such as improving the color, aroma, taste and size of bulbs, bud formation and chlorophyll formation (Marschner, 2012).

4. Conclusions

The development of shallots in Ultisol that has been recovered brings hope. The yield of chicken manure and guano are higher than oil palm empty bunches and in accordance with the description of Bima Brebes varieties around 9 t/ha. Even guano could produce dry bulbs of 10,54 t/ha without giving ZA. Guano fertilizer gave the best Sulphur content on every dose of ZA.

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