Analysis on rhizome shrinkage of two expected kencur (Kaempferia galanga) accessions from east java using MgSO₄ fertilizer under shading

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Abstract. Kencur (Kaempferia galanga L.) is one of the plants that mainly can be used as the main ingredient in medicine, food, drinks, and spices with benefits. Environmental conditions are a supporting factor for cultivating kencur. Nutrient needs are important factors for plant cultivation. A good environment is an environment that fulfills macro and micronutrients. It is also an important thing in kencur cultivating plants. We should know in which condition the plant can show the best result so the kencur plant is tested under shade. One of the macro nutrients needed by plants are sulfur (S) and magnesium (Mg). The purpose of this research is to determine if there is an interaction between accessions and Sulfur (MgSO₄) at two different shades levels. The design used in this study was a Split Plot Design with the main plot: kencur plant with Blitar and Banyuwangi accessions, sub plots: MgSO₄ fertilizer with dose of 0, 60, 90 and 120 kg ha⁻¹, land under shade. The shrinkage of the rhizomes that occurred with a dose of sulfur fertilizer ranged from 13% to 19% and without a dose of sulfur fertilizer decreased 34% with results showing that the treatment with a dose of 90 kg ha⁻¹ of sulfur fertilizer resulted in lower shrinkage.

1. Introduction

Kencur (Kaempferia galanga L.) is one of the plants that is mainly used as the main ingredient for traditional medicine in Indonesia. Kencur counts as a medical herb cultivated mainly in south China, Malaysia, India and Thailand [1]. The part that is being consumed is called a rhizome. According to [2], rhizomes can be used for hypertension, asthma and rheumatism. Kencur is called a medical herb because it consists of chemical compounds essential oils, saponins, flavonoids, polyphenols for a treatment like mild pain such as catching a cold, by turning it into a traditional drink called beras kencur [3]. Indonesia is one of the producers that cultivate kencur because there are many in the kencur plant. In Indonesia, it’s already being cultivated all over Java, Kalimantan, Sumatra, Sulawesi and other small islands. Based on the data obtained by [4], kencur production fluctuates from 2014 until 2019. In 2014, number of productions of kencur plant reached 37.715.653 kg, at 2015 it decreases to 35.971.956 kg, then it increases in 2016 to 2017 reached 36.655.028 kg, then it decreases for 2 years straight with a production...
of 35,296.213 kg. Several factors causing kencur productions to fluctuates are not being able to apply suitable cultivation methods, variety of product quality, a minor business that is being spread and done by individuals [5], there’s need to be an improvement for kencur cultivating technique to get maximum production quality result and to fulfill market demand for a medical plant like kencur.

In Indonesia, there are many types of kencur, based on the leaf type; there are 2 types of kencur, narrow and wide leaf. Commonly, kencur with a type of wide leaf is mainly cultivated in West Java while the narrow leaf is mainly cultivated in East and Central Java. This different type of growth is caused by the environment where the kencur is being cultivated. Kencur plants can adapt well by providing natural and artificial shade, one which is natural shade is teak and for artificial is the use of paranet 25% to 50%. Based on research conducted by [6], accessions of kencur plants, namely Blitar and Banyuwangi have optimal results by providing shade for teak plants compared to the results carried out in open land. Good environment supports plants to have a higher quality result, every plant has a different level of tolerance for the environment [7]. The problem that is often faced in kencur plants is the weight of the rhizome shrinkage during the storage period, which always increases all the time so that the kencur plant does not last long to be stored. Therefore, one way that can be done is the addition of fertilizers in the growth process. One element of macro fertilizer that can improve the quality of kencur is sulfur (S). Element S can help reduce shrinkage during storage and enlarge tubers. Generally, plants need relatively little S element, but if the plant lacks S element, it will cause a deficiency and vice versa if the plant has an excess of S element it will cause toxic [8]. These research purposes were to test MgSO₄ doses at different accessions of kencur under shading.

2. Material and methods
This research was carried out from November 2020 to May 2021 in Agro Techno Park Faculty of Agriculture, University Brawijaya, Jatikerto Village, Kromengan District, Malang Regency. The tools that were used in this research were analytical scales, oven, camera, meter or ruler, hoe, bamboo, calipers, measuring cup, LAM (Leaf Area Meter), and shade. The materials that were used were kencur rhizome seed accession Banyuwangi and Blitar, fertilizer S (MgSO₄), manure, urea, SP36 and KCl. This research used a Split Plot Design. The main plot was accession Banyuwangi (Bw) and Blitar (BL), for the sub plots was the dose of fertilizer S (MgSO₄) which is 0, 60, 90 and 120 kg ha⁻¹. This research parameter consisted of fresh rhizome weight (g plant⁻¹) and rhizome shrinkage weight 7 day after harvest (DAH) to 28 DAH (g plant⁻¹). The data obtained were analyzed using analysis of variance (ANOVA) at a level of 5%. If the treatment has a significant effect, it was continued with the BNT test with a level of 5%.

3. Results
Based on this research, the weight loss of rhizomes gave a significant response from 7 DAH to 28 DAH between the two accessions with different doses of sulfur fertilizer. The weight loss that has been obtained has decreased in the range of 13% to 34%, in, the treatment that was not given sulfur fertilizer experienced a higher shrinkage of 34% in the accession of Banyuwangi. In comparison the fertilizer dose of 90 kg ha⁻¹ experienced lower shrinkage in both accessions, rhizome, shrinkage from harvest to 28 days after harvest was around 13%. These results are in accordance with research conducted by [9], tuber weight loss from harvest to the fourth week after harvest experienced a shrinkage of 22%-23% which based on the results of statistical tests showed that the shrinkage tuber weight was influenced by the element S. Fertilizer treatment sulfur affects the weight of plant losses so that galangal plant do not experience too much shrinkage, this is following [10] statement, that treatment of S sources can increase plant storage weight because element S is an important part of ferrodoxin, namely Fe complex compounds and S contained in chloroplasts which function as carbohydrate catabolism in the formation of optimal photosynthesis results will be allocated to all parts of the plant and will be stored in the rhizome of galangal plant.

Rhizomes weight of shades simultaneously get the same result it is known that at the level of 90 kg ha⁻¹ give a better result other than any level of sulfur fertilization, it is also known that when the level of sulfur fertilizer is increased to the level of 120 kg ha⁻¹ the value of rhizomes weight is decreased. This also happened to ginger plants in the [11], when the dose of sulfur fertilizer was increased to 60 kg ha⁻¹, the
dry weight yield of ginger plants decreased by 8.21%. According to [12], rhizome plants were given Mg fertilizer to add dry weight value to the plants, it was proven by the results of 79.9% greater plant weight than without fertilizer application.

The Result of regression between the dosage of sulfur fertilizer with plant fresh weight on two galangal accessions under shade (Figure 1.), shows different response between two accessions. Banyuwangi accession shows equation $y = -0.0022x^2 + 0.2944x + 17.81$ with $R^2 = 0.89$ which can be explain that fertilizer application for Banyuwangi accession with a condition under the shade affect rhizome fresh weight by 89% and 11% affected by other factors. Average fresh weight of rhizomes with no addition of sulfur fertilizer was 17.81g. Result of Blitar accession shows addition of sulfur fertilizer got a fresh weight 17.81 g. The accession Blitar shows equation $y = -0.0002x^2 + 0.0652x + 25.124$ with a value of $R^2 = 0.759$ means Blitar accession and dose of sulfur fertilizer under the shade can affect rhizome fresh weight by 76% and the other 24% affected by other factor. The value of 25.124 from the regression equation is the intercept value, which means if galangal is not treated with sulfur fertilizer it will produce the average fresh rhizome weight of 25.12 g.

### Table 1. Kencur of Galangal Plant Accession and Sulfur Fertilizer Dosage on Galangal Rhizome Weight After 28 Days Storage under shading.

| Treatment | Storage Time on the DAH (Day After Harvest) | Rhizome Weight (g plant$^{-1}$) |
|-----------|---------------------------------------------|-------------------------------|
|           | Harvest 7                                   | 14                            | 21                            | 28                            |
| B$_w$S$_0$ | 18.07a (100%)                               | 16.77a (92.80%)               | 14.17a (78.41%)               | 12.90a (71.38%)               | 10.60a (58.66%)               |
| B$_w$S$_{60}$ | 25.97b (100%)                             | 24.33bc (93.68%)              | 22.70bc (87.40%)              | 21.17b (81.51%)               | 17.83bc (68.65%)              |
| B$_w$S$_{90}$ | 28.43bc (100%)                             | 27.20c (95.67%)               | 25.30c (88.99%)               | 23.70c (83.36%)               | 20.70c (72.81%)               |
| B$_w$S$_{120}$ | 20.50a (100%)                             | 19.43ab (94.78%)              | 17.13ab (83.56%)              | 15.83ab (77.21%)              | 13.30ab (64.87%)              |
| B$_L$S$_0$  | 25.33b (100%)                               | 23.07b (91.01%)               | 20.67b (81.60%)               | 18.97b (74.89%)               | 16.43b (64.86%)               |
| B$_L$S$_{60}$ | 27.10bc (100%)                             | 25.47bc (93.98%)              | 23.43bc (86.45%)              | 21.40b (78.96%)               | 18.47bc (68.15%)              |
| B$_L$S$_{90}$ | 31.13c (100%)                               | 29.80c (95.72%)               | 27.93c (89.72%)               | 25.57c (82.13%)               | 23.00c (73.88%)               |
| B$_L$S$_{120}$ | 29.60bc (100%)                             | 27.77c (93.81%)               | 25.27c (85.37%)               | 23.63c (79.83%)               | 20.63c (69.69%)               |
| BNT (5%)     | 4.32                                        | 3.82                          | 3.90                          | 3.72                          | 3.57                          |
| KK (%)       | 11.74                                       | 11.81                         | 13.26                         | 15.06                         | 16.32                         |

**Note:** (B$_w$): Accession Banyuwangi; (B$_L$): Accession Blitar; S0: Sulfur 0 kg ha$^{-1}$; S60: Sulfur 60 kg ha$^{-1}$; S90: Sulfur 90 kg ha$^{-1}$; S120: Sulfur 120 kg ha$^{-1}$; Numbers that accompanied by the same letter in the same column and row sho no significant difference, based on the 5% BNT test.
The research result show also gave a significant response from 7 to 28 DAH between the two accessions with a different doses of sulfur fertilizer (Table 2.). Rhizomes weight loss at 28 DAH from Banyuwangi accessions is about 27 - 41%. At the same time the weight loss from Blitar accessions reduced by 17 – 36% of their original weight. Rhizomes weight loss from both accessions reduced more weight at the dose of 0 kg ha\(^{-1}\) level of sulfur fertilizer. In comparison, rhizome weight that sustains more of its original weight is at the level of 90 kg ha\(^{-1}\) of sulfur fertilizer. Besides adding the viability of sulfate in the soil, the addition of sulfur fertilizer also increases crop yields and determines the formation of sulfur-containing protein [9]. Based on the function of sulfur of a constituent of volatile compounds in plants, sulfur acts as a compound that maintains rhizomes weight when it’s already harvested. There is a significant variation in stored sulfur content between cultivated plant species ranging from 0.1 to 20 g of dry matter in plants is the influence of plants and the role of sulfur [13].

The result of the regression equation affected by the dose of sulfur fertilizer on two galangal accessions under the shade gives different responses to rhizome shrinkage which is shown in Figure 2. Rhizome shrinkage at 7 DAH until 28 DAH found that Banyuwangi accession has a coefficient of determination around 0.87-0.90 which can explain that shrinkage under the shade was affected by accession and sulfur application by 87-90%. While Blitar accession about 71-28%. The result of regression equation at 28 DAH for Banyuwangi accession get an equation of \(y = -0.002x^2 + 0.2719x + 10.33\) with the value of \(R^2 = 0.87\) it’s show that 87% of shrinkage is affected by application of accession and addition of sulfur fertilizer while the other 13% was affected by external factors. The regression value there’s a value of 10,334, which is an intercept value. Meaning that if no accession and sulfur application will produce rhizome shrinkage of about 10,33 g. Blitar accession shows that the equation of \(y = -0.0003x^2 + 0.0832x + 16.5\) with the value of \(R^2 = 0.7079\). It can be explained that the weight loss at 28 HSP in Blitar accession was affected by the accession treatment and sulfur fertilizer by 71% while the 29% is affected by external factors.
Figure 2. Relation of Galangal accession and MgSO₄ Fertilizer Under Shade for Rhizome Shrinkage at 7, 14, 21 dan 28 DAH.

Figure 3. Percentage of Banyuwangi and Blitar Accession Rhizome Shrinkage Under the Shade.

4. Conclusion
Based on this research, it can be concluded that the accession of Banyuwangi and Blitar optimal rhizome growth with a dose of sulfur fertilizer treatment and decreased rhizome weight with a dose of sulfur fertilizer of 13% to 19% and in the treatment without sulfur fertilizer it decreased up to 34% at under shading and decreased up to 41% at under shading. With the dose of sulfur fertilizer 90 kg ha⁻¹ generates lower shrinkage of rhizomes weight loss compared to other sulfur treatments.

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