Potassium fertilizer doses and local microorganism concentration affecting growth and yield of shallot (*Allium ascalonicum* L.)

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Abstract. This study aimed to determine the effect of potassium fertilizer doses, Local Microorganism concentrations, and the interaction between the two factors on the growth and yield of shallots. The study applies Randomized Block Design with 3 x 4 Factorial and 3 replications. The observed factors were potassium fertilizer at 3 levels each of control, 100, and 200 kg ha⁻¹ and Local Microorganisms at 4 levels each of 0, 75, 150, and 225 ml L⁻¹. The highest yield potential of the shallots was found at a dose of 100 kg ha⁻¹ potassium fertilizer. The highest diameter of shallot bulbs was initiated at 150 ml L⁻¹ of Local Microorganism concentration, but it was not significantly different from the control treatment. The combination of a potassium fertilizer dose of 200 kg ha⁻¹ and a local liquid microorganism concentration of 75 ml L⁻¹ provide the highest growth and yield of shallots.

1. Introduction
Shallot (*Allium ascalonicum* L.) is one of the vegetable commodities that has many benefits for human life, is used as an additive in foods, and has a high economic value. The demand for shallots increases every year, but the production has not been able to meet the market demand [1]. For this reason, its production needs to be optimized by applying a combination of organic fertilizers such as Local Microorganisms and inorganic fertilizers, such as potassium fertilizer. Potassium can stimulate root growth and development, increases plant size, number, and production of fruit and bulbs. The potassium also increases the transportation of sugar and amino acid to plant storage organs [2]. The application of potassium fertilizer has a real effect on growth and yield that was best found at 100 kg ha⁻¹ [3],[4]. Increasing the yield of shallot can also be done by using organic fertilizer such as manure, liquid organic fertilizer, which is intended to improve the inefficiency of using inorganic fertilizer [5]. Applying 20 tons ha⁻¹ manure and 200 kg ha⁻¹ KCl fertilizer was the prime dose in increasing weight of fresh bulbs and organic materials stored in bulbs [6].

The use of local microorganisms can fertilize the soil and improves soil structure. This can be the solution for farmers in realizing sustainable agriculture. The Local Microorganism solution is a fermented solution which helps to decompose certain substrates that come from available resources in the environment such as banana peel, banana tuber, decomposed fruits, and vegetables [7]. Banana peels contain 15% potassium and 12% more phosphorus than there is in fruit flesh Error! Reference source not found.. In the local microorganism fermentation process, banana peels were also added EM₁ (Effective Microorganisms 4), containing fermentation bacteria from the genus of *Lactobacillus*, phosphate solubilizing bacteria, photosynthetic bacteria, and fermentation fungal from *Actinomycetes* class [8]. The existence of these microorganisms accelerates the process of organic matter decomposition in the soil to increases soil fertility and plant productivity [10].

Based on the description above, the exact doses of potassium fertilizer and the concentration of Local Microorganisms to increase the production of shallots are being studied. It is expected that combining
potassium fertilizer with the local microorganism, increase the production of shallots. It is necessary to conduct to get the precise combination of potassium fertilizer doses and local microorganism concentration. The objective of the study was to find out potassium fertilizer doses, Local Microorganism concentrations, and the interaction between the two factors to impact shallot growth and yield.

2. Materials and method
2.1. Location and period
The location where the study conducted was the Experimental Field and Plant Physiology Laboratory of the Faculty of Agriculture, Universitas Syiah Kuala, Banda Aceh, Indonesia during the period of April to July 2019.

2.2. Supplies and equipment
Supplies and equipment used during the experiment were meters as measure, hoes for land preparation, pH meters for measuring organic fertilizer dilution, digital scales for scaling weight of shallot and biomass, and other equipment such as dipper, measuring cups, calipers, ovens, and stationaries. The materials used were shallot bulb of Bima Brebes variety of 3 kg, manure of 103.6 kg, urea fertilizer of 0.93 kg, SP-36 fertilizer of 0.80 kg, and KCl fertilizer of 1.55 kg. Whereas the ingredients for making local microorganism solution are 20 kg of kepok banana peel waste, 0.5 kg granulated sugar, 0.5 kg brown sugar, 50 L coconut water, and 1 L EM₄ (Effective Microorganism 4).

2.3. Preparation of local microorganism
The raw materials of local microorganism are 20 kg of banana peel, 1 kg of sugar, 50 L of coconut water, and 1 L of EM₄. The banana peel is sliced and pounded first using a mortar. Gradually 1 kg of sugar and 50 L of coconut water was added, then all the materials were crushed in a blender. Then all the ingredients were poured into a container and closed tightly. The Local Microorganism solution was fermented for 30 days, and every day the local microorganism was stirred and stored in a place that was not exposed to direct sunlight. The Local Microorganism considered at organic fertilizer is characterized by the changing smell to sour. Furthermore, Local Microorganism is filtered before being applied in the field.

2.4. Field culture, planting, and harvesting
Land preparation was done one week before planting. The soil was first cleared from weeds. Furthermore, plots were made with a size of 120 cm x 120 cm as many as 36 plots. The distance between plots was 40 cm and the distance between blocks is 40 cm. Then, as much as 2.88 kg of manure was applied per plot. Healthy bulbs were selected and cut off one-third from the top, then one bulb was planted per hole with a spacing of 20 cm x 20 cm apart. SP-36 fertilizer applied at doses of 153 kg ha⁻¹, and KCl doses per the treatment (0, 100, and 200 kg ha⁻¹) were given at planting time. Urea fertilization with a dose of 180 kg ha⁻¹ was applied twice (at the planting day and 21 DAP). A Local microorganism solution that had been fermented for 30 days, was applied per the treatment dose of 75, 150, and 225 ml L⁻¹ when the shallot is 14, 21, 28, and 35 DAP as much as 3 L per plot. Maintenance was implemented regularly including watering, controlling pests and weeding. The shallot was harvested at 70 DAP.

2.5. Experimental design
This research used Randomized Block Design factorial 3 x 4 with 3 replications so that there were 12 treatment combinations and 36 experimental units. Five plants from each experimental units were taken as a sample for this study. There were two factors of application, the first factor was the doses of potassium fertilizer (K) consists of 3 levels, consisted of K₀ = Control, K₁ = 100 kg ha⁻¹, and K₂ = 200 kg ha⁻¹ and the second factor was the concentration of local microorganism solution (M) consists of 4 levels, M₀ = without giving of local microorganisms (Control), M₁ = 75 ml L⁻¹ water, M₂ = 150 ml L⁻¹ water and M₃ = 225 ml L⁻¹ water. Analysis of Variance (ANOVA) was applied to determine the effect
of treatment using F-test. Least Significant Difference (LSD) test at 5% probability level was further applied if the treatment had a significant effect. SPSS version 21.0 was used for data analysis.

2.6. Observed parameters

The parameters observed in this study were plant height and the number of leaves (calculated at 14, 21, 28, 35, and 42 DAP), number of saplings per clump (at 30 and 40 DAP), fresh biomass weight per clump (at 70 DAP), dry biomass weight per clump that had been dried in the oven for 3 x 24 hours at 60°C until a constant weight was obtained, number of bulbs per clump (at 70 DAP), bulb diameter from each sample measured by calipers, fresh bulb weight of the shallot (at 70 DAP), the dry-bulb weight of the shallot observed after the bulbs were drained for ten days. The yield potential was calculated by fresh weight of the shallot bulbs per net plot and then furtherly calculated according to the following formula:

\[
\text{Yield potential (ton ha}^{-1}\text{)} = \frac{\text{Land area of 1 ha} - 20\%}{\text{Spacing intercrop}} \times \text{Net plot yield} \quad (1)
\]

3. Results and discussion

3.1. Potassium effect on shallot growth and yield

The result showed that there is a very significant effect of doses of potassium fertilizer on the yield of shallot, but not significant on plant height and leaves total number respectively at 14, 21, 28, 35, and 42 DAP, sapling total number per clump at 30 and 40 DAP, biomass fresh weight per clump, biomass dry weight per clump, bulbs total number per clump, diameter of bulbs, bulbs fresh weight per clump, and bulb dry weight per clump. Table 1 shows shallot average growth and yield as affected by the application of potassium fertilizer.

| Parameters                      | Potassium fertilizer doses (kg ha\(^{-1}\)) | LSD \(_{0.05}\) |
|---------------------------------|--------------------------------------------|-----------------|
|                                 | 0                                          | 100             | 200             |
| Plant height (cm)               | 14 DAP                                     | 8.21            | 9.18            | 8.97 |
|                                 | 21 DAP                                     | 12.79           | 13.92           | 13.17 |
|                                 | 28 DAP                                     | 19.82           | 19.49           | 18.98 |
|                                 | 35 DAP                                     | 21.78           | 21.58           | 22.04 |
|                                 | 42 DAP                                     | 21.74           | 22.16           | 22.60 |
| Number of leaves                | 14 DAP                                     | 4.62            | 4.05            | 4.92 |
|                                 | 21 DAP                                     | 8.62            | 7.30            | 8.90 |
|                                 | 28 DAP                                     | 11.60           | 11.47           | 12.62 |
|                                 | 35 DAP                                     | 14.55           | 15.02           | 15.45 |
|                                 | 42 DAP                                     | 14.75           | 15.93           | 17.13 |
| Number of saplings per clump    | 30 DAP                                     | 3.97            | 3.90            | 4.12 |
|                                 | 40 DAP                                     | 4.98            | 4.78            | 4.70 |
| Fresh biomass weight per clump  |                                            | 17.58           | 17.41           | 19.09 |
| Dry biomass weight per clump    |                                            | 12.12           | 13.11           | 14.42 |
| Bulb diameter (mm)              |                                            | 16.43           | 15.90           | 16.99 |
| Number of bulbs per clump       |                                            | 6.00            | 6.18            | 6.95 |
| Fresh bulb weight per clump     |                                            | 13.90           | 14.37           | 15.37 |
| Dry bulb weight per clump       |                                            | 11.55           | 12.57           | 13.92 |
| Yield potential (ton ha\(^{-1}\))|                                            | 4.43 \(_{a}\)   | 5.08 \(_{ab}\)  | 6.13 \(_{b}\)  |

Notes: The same letter after the number in the same row indicate that the difference is not significant based on the LSD test at the 5% level.

Potassium fertilizer significantly affect shallot yield potential and the highest yield which was found at the dose of 200 kg ha\(^{-1}\) which was significantly different from the control and was not significantly different from 100 kg ha\(^{-1}\). It can be caused by the application of 100 kg ha\(^{-1}\) potassium fertilizer dose which can meet the needs of the potassium which plays a role in the process of formation and
proliferation of new cells in the growth phase of shallot. Potassium, which help balancing nutrient in the soil, plays an important role in the synthesis of carbohydrates and proteins, thus helping translocation and enlargement of shallot bulbs [11].

The height of shallot at 45 DAP, the weight of fresh and dry biomass of shallot were best found at 100 kg ha\(^{-1}\) of potassium fertilizer doses [12]. With the same fertilizer dose, the addition of KCl fertilizer at the dose of 100 kg ha\(^{-1}\) increases the rate of plant growth, K nutrient uptake by the plant, fresh and dry bulb weight, and yield of shallot [13]. Absorption of potassium by plants from the soil depends on several factors such as soil structure, soil aeration, and shallot varieties. KCl fertilizer dose of 100 kg ha\(^{-1}\) with Petrogenic fertilizer 5 t ha\(^{-1}\) is the optimal dose to increase the yield of Bima varieties of shallot [14]. KCl fertilizer dose of 125 kg ha\(^{-1}\) with the manure of 15 t ha\(^{-1}\) was optimum for increasing the yield of shallot [15].

The nutrient K is needed in the formation, enlargement, and lengthening of shallot bulbs [16]. The deficiency of potassium in shallot will inhibit leaf growth and the photosynthesis process and resulting in small shallot bulb size. Figure 1-4 shows the doses of potassium in different treatment along with Local Microorganism concentration treatment.

**Figure 1.** Comparison of potassium fertilizer dose (\(K_0=control, K_1=100\) kg ha\(^{-1}\), \(K_2=200\) kg ha\(^{-1}\)) with control of local microorganism (\(M_0\)).

**Figure 2.** Comparison of potassium fertilizer dose with concentration of local microorganism of 75 ml L\(^{-1}\) (\(M_1\)) treatments.

**Figure 3.** Comparison of potassium fertilizer dose with concentration of local microorganism of 150 ml L\(^{-1}\) (\(M_2\)) treatments.

**Figure 4.** Comparison of potassium fertilizer dose with concentration of local microorganism of 225 ml L\(^{-1}\) (\(M_3\)) treatments.

3.2. The effect of concentration of local microorganism on shallot growth and yield

There is a significant effect of Local Microorganisms concentration on the bulb diameter of shallot, but not significant on plant height, number of leaves respectively at the age of 14, 21, 28, 35, and 42 DAP, sapling total number per clump at 30 and 40 DAP, biomass fresh weight per clump, biomass dry weight per clump, bulbs total number per clump, bulb fresh weight per clump, bulb dry weight per clump and potential yield of shallot plants. Table 2 shows the effect of Local Microorganism concentration on average growth and yield of shallot. Figure 5-7 shows the concentration of Local Microorganism along with potassium doses treatment.

The result showed that the shallot bulb diameter was found highest at Local Microorganism concentration of 150 ml L\(^{-1}\) which was not significantly different from without treatment and Local Microorganism concentration of 75 ml L\(^{-1}\), but significantly different from the concentration of Local Microorganism of 225 ml L\(^{-1}\). The result showed the control was not significantly different from the Local Microorganism of 150 ml L\(^{-1}\). It was expected that the nutrition in the soil has been fulfilled. The addition of Local microorganisms to the soil does not have a significant effect on the treatment. The
optimal application of fertilizer to plants is determined by how much nutrients are absorbed by these plants, and how it can be utilized for the growth process [17]. Each plant requires nutrients in different concentrations of local microorganisms impact on average growth and yield of shallot. 

| Parameters                        | Concentration of Local Microorganisms (ml L⁻¹) | LSD 0.05 |
|-----------------------------------|-----------------------------------------------|----------|
| Plant height (cm)                 |                                               |          |
| 14 DAP                           | 9.56, 8.51, 8.86, 8.20                       |          |
| 21 DAP                           | 14.14, 13.49, 13.16, 12.37                    |          |
| 28 DAP                           | 19.79, 19.17, 19.55, 19.21                    |          |
| 35 DAP                           | 21.66, 22.22, 21.84, 21.49                    |          |
| 42 DAP                           | 22.16, 22.70, 22.41, 21.40                    |          |
| Number of leaves                  |                                               |          |
| 14 DAP                           | 4.47, 4.71, 4.60, 4.33                       |          |
| 21 DAP                           | 8.18, 8.72, 8.24, 7.93                       |          |
| 28 DAP                           | 11.53, 13.82, 11.35, 10.87                    |          |
| 35 DAP                           | 15.69, 15.64, 14.38, 14.31                    |          |
| 42 DAP                           | 16.27, 16.33, 15.53, 15.62                    |          |
| Number of saplings per clump     |                                               |          |
| 30 DAP                           | 4.07, 4.16, 3.73, 4.02                       |          |
| 40 DAP                           | 5.04, 4.93, 4.62, 4.69                       |          |
| Fresh biomass weight per clump   |                                               |          |
| 17.68, 17.47, 18.28, 18.67       |          |          |
| Dry biomass weight per clump     |                                               |          |
| 12.78, 13.58, 13.68, 12.83       |          |          |
| Bulb diameter (mm)               |                                               |          |
| 16.25 ab, 16.76 ab, 17.43 b, 15.33 a | 2.09    |          |
| Number of bulbs per clump        |                                               |          |
| 6.33, 6.69, 5.80, 6.69           |          |          |
| Fresh bulb weight per clump      |                                               |          |
| 13.66, 15.19, 14.97, 14.37       |          |          |
| Dry bulb weight per clump        |                                               |          |
| 12.24, 12.63, 13.53, 12.31       |          |          |
| Yield potential (ton ha⁻¹)        |                                               |          |
| 4.97, 5.54, 5.25, 5.10           |          |          |

Notes: The same letter after the number in the same row indicate that the difference is not significant based on the LSD test at the 5% level.
plants, and how it can be utilized for the growth process [17]. Each plant requires nutrients in different amounts and the accuracy of providing nutrients such as fertilizers and Local Microorganisms must be optimum [18].

### 3.3. The effect of interaction of potassium fertilizer dose and concentration of local microorganisms on growth and yield of shallot.

The interactions of the potassium fertilizer dose and Local Microorganism concentration significantly affects plant height at 42 DAP, sapling total number per clump at ages of 30 and 40 DAP, biomass dry weight per clump, bulbs total number per clump, diameter of bulb, fresh weight of bulb, and dry bulb weight of shallot, and very significantly affect plant height at age of 35 DAP, leaves total number at 14, 21, 28, 35, and 42 DAP, biomass fresh weight per clump, and yield potential of shallot, but no significant effect on plant height at 14, 21, and 28 DAP. The relationship of shallot growth and yield as affected by the application of potassium doses and Local Microorganism concentration can be seen in Figure 8-15.

#### Figure 8. The interaction of potassium dose and concentration of local microorganism affecting plant height at 42 DAP.

#### Figure 9. The interaction of potassium dose and concentration of local microorganism affecting biomass fresh weight per clump (g).

#### Figure 10. The interaction of potassium dose and concentration of local microorganism affecting dry biomass weight per clump (g).

#### Figure 11. The interaction of potassium dose and concentration of local microorganism affecting number of bulbs per clump.
The results showed that height of plant at the age of 35 and 42 DAP, number of leaves at the age of 28, 35, and 42 DAP, number of saplings at the age of 30 and 40 DAP, fresh biomass weight per clump, number of bulbs per clump, fresh weight of the bulb, dry weight of the bulb, and yield potential of shallot is found higher at the combination of 200 kg ha$^{-1}$ potassium fertilizer dose with a Local Microorganism concentration of 75 ml L$^{-1}$. The number of leaves at the age of 14 and 21 DAP, the biomass dry weight per clump, diameter of bulb was found higher in the combination of potassium fertilizer dose of 200 kg ha$^{-1}$ with a Local Microorganism concentration of 150 ml L$^{-1}$.

The application of Local Microorganism improved organic matter to the soil, which the improve the soil structure and the soil can bind water more, increases soil pH so that inorganic nutrients such as cations become available to plants such as potassium, calcium and magnesium nutrients which eventually can be absorbed by plants to increase their growth. The application of Local Microorganism concentration at the 75 ml L$^{-1}$ increases several vegetative parameters such as plant height, dry biomass weight, and weight of pods per plot in sweet potato plants and long yard bean plants [19] [20]. The availability of cation from the element of K$^+$, Ca$^{2+}$, Mg$^{2+}$, Fe$^{2+}$, Mn$^{2+}$, Zn$^{2+}$, and Cu$^{2+}$ plays a role in the biosynthesis of carbohydrate and protein which will help the enlargement of shallot bulbs [21]. It can be seen that the appropriate of using inorganic and organic fertilizers maintain fertility and

**Figure 12.** The interaction of potassium dose and concentration of local microorganism affecting bulb diameter.

**Figure 13.** The interaction of potassium dose and concentration of local microorganism affecting fresh weight of bulb.

**Figure 14.** The interaction of potassium dose and concentration of local microorganism affecting dry weight of bulb.

**Figure 15.** The interaction of potassium dose and concentration of local microorganism affecting potential of yield.
physicochemical of soil and maintain the stability of crop production [22]. The application of organic input combined with chemical fertilizers is a better choice than the application of these respective fertilizers [23].

4. Conclusion
The doses of potassium had a significant effect on the yield potential of shallot, in which the highest yield was found at a dose of 100 kg ha⁻¹. The concentration of Local Microorganisms had a significant effect on bulb diameter, in which the highest bulb’s diameter was found in 150 ml L⁻¹ of the concentration of Local Microorganisms, but not significantly different from the control treatment. The interaction of potassium dose and concentration of Local Microorganism had a significance effect on the plant height at the age of 35 and 42 DAP, the number of leaves at the age of 14, 21, 28, 35, and 42 DAP, the number of saplings at the age of 30 and 40 DAP, the weight of fresh and dry biomass per clump, the number of bulbs per clump, bulb diameter, fresh weight of the bulb, dry weight of the bulb, and the yield potential of shallot. The highest plant growth and yield of shallot were found at the combination of a potassium fertilizer dose of 200 kg ha⁻¹ with a Local Microorganism concentration of 75 ml L⁻¹.

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