Potassium nutrition differentially affect early growth and leaf greenness of shallot under micro sprinkle fertigation in dry land

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Abstract. Potassium (K+) is an essential nutrition play great role on osmotic adjustment affecting plant growth. Maintaining adequate of Potassium could be drought mitigation in dry land. The field experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. The treatment consisted of Potassium of 50, 75, 100, 125, and 150 kg.ha⁻¹ under micro sprinkle fertigation system and 100 kg.ha⁻¹ as basal dose recommendation under conventional irrigation system as control. Result revealed that plant height and number of leaves varied significantly due to the various level of Potassium at four weeks after planting. Treatment of 50 kg.ha⁻¹ of basal dose Potassium under micro sprinkle fertigation showed maximum of total dry matter at 24 days after planting as well as Absolute Growth Rate (AGR), Crop Growth Rate (CGR) and Relative Growth Rate (RGR) during 12 - 24 days after planting. Response of soil plant analysis development (SPAD) value as chlorophyll content showed an opposite trend of plant height, number of leaves, total dry matter, AGR, CGR and RGR.

Keyword: CGR, RGR, Allium cepa L. var Aggregatum group, vegetative stages

1. Introduction
Agriculture in dry land at Banten occupies an 50% of total area [1]. The dependence has been associated with main problems, such as water deficit and soil erosion [2][3]. Shallot (Allium cepa L. aggregatum group) is one of main crop cultivated in Banten. Shallot productivity in Banten was lower compared to national data.

Due to critical problem of water deficit in dry land, fertigation is one of irrigation technology to minimize water consumption [4]. In last decade, beneficial fertigation systems are generally applicated to increase growth and yield of crops in dry land [5] [6]. There are many reports concerning the Fertigation application for increase on growth and yield of crops such as corn [6], wheat [7], tomato [8], etc.

Potassium is an essential nutrition plays high significant role on osmotic adjustment affecting plant growth and yield [9] [10] [11]. Previous study reported that fertigation claimed to enhance Potassium content and increase yield [12] [13]. So, it is so clear that maintaining adequate of Potassium could be a drought mitigation in dry land. However, few studies concerning of Potassium effectiveness application under fertigation system on shallot in dry land have been reported.

Evaluation of Fertigation application on shallot in dry land is extremely important to instead of water availability and soil fertility maintenance in dry land. Therefore, we evaluated the effect of Potassium

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nutrition differentially on early vegetative stage on growth and leaf greenness of shallot cultivated in dry land under micro sprinkle fertigation system. It is expected that the findings of micro sprinkle fertigation application with different Potassium basal doses levels on shallot would give useful information for further effectiveness of Potassium and water source on shallot in dry land.

2. Materials and Methods

2.1 Experimental Design
The experiment was conducted in the Research Field, Department of Agrotechnology, University of Sultan Ageng Tirtayasa, Indonesia from August to November 2020. The field experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. The treatment consisted of Potassium of 50, 75, 100, 125, and 150 kg.ha$^{-1}$ under micro sprinkle fertigation system and 100 kg.ha$^{-1}$ as basal dose recommendation under conventional irrigation system as control.

2.2 Procedure
Plant material was shallot cultivar “Bima Brebes”. The land was prepared by plugging once and harrowing to break the clods and bring the soil. The plots were 2.0 m x 1.0 m. The fresh bulb was hand planted at a spacing of 10 cm x 20 cm.

The field was irrigated depending on treatments. The basal dose of Potassium was mixed with irrigation (Fertigation) in the water tank. The field was irrigated by micro sprinkle from the water tank in the morning and afternoon. The water discharge was 0.7 L/second.

| Amount of Water (L/day) | Time |
|-------------------------|------|
| 0-10 day after planting (dap) | 3.2 | 18 second |
| 11-20 dap | 3.2 | 18 second |
| 4-30 dap | 4.3 | 21 second |

2.3 Measurements

2.3.1 Growth parameters
The data recorded consist of plant height and number of leaves per plant. The plant height was measured from ground level to tip of longest leaf (when held vertically) every week. The numbers of leaf were counted manually every week.

Data recorded on 12 and 24 days after planting consist of total dry matter. The samples were kept into an oven at 80 ± 2 ºC for 72 hours. Absolute growth rate (AGR), Crop growth rate (CGR), Relative growth rate (RGR) were determined using the following formulas [17]:

\[
\text{AGR} = \frac{(W_t - W_i)}{(T_f - T_i)} \quad \text{g day}^{-1}
\]

Where,

\[
W_i = \text{Dry weight of the plant at time} \ 'T_i'
\]

\[
W_f = \text{Dry weight of the plant at time} \ 'T_f'
\]

\[
T_i \text{ and } T_f = \text{Time interval in days}
\]

\[
\text{Ln} = \text{Natural logarithm}
\]

\[
\text{CGR} = \frac{(W_{t_2} - W_{t_1})}{(T_{t_2} - T_{t_1})} \times \frac{1}{A} \quad \text{g m}^{-2} \text{ day}^{-1}
\]

\[
\text{RGR} = \frac{(\text{Ln } W_{t_2} - \text{Ln } W_{t_1})}{(T_{t_2} - T_{t_1})} \quad \text{mg g}^{-1} \text{ day}^{-1}
\]

2.3.2 Leaf greenness
Leaf greenness was measured by soil plant analysis development (SPAD) value as chlorophyll content.
2.3.3 Statistical analysis
All data were statistically analyzed using the analysis of variance procedure to assess the differences of treatments. Duncan’s Multiple Range Test would be tested to determine the significant differences among treatment means Growth parameters.

3. Results
This study evaluated effect of different Potassium basal doses level on growth and yield of shallot under micro sprinkle fertigation system. According to Figure 1, there was significant differences among Potassium basal doses level under micro sprinkle fertigation on plant height. The plant height ranged from 36.4 to 43.8 cm. Likewise, sum of leaves was not difference among treatments. It ranged from 12.9 to 20.9 leaves per plant.

![Figure 1. Plant height and number of leaves of shallot under different treatments in early vegetative stage](image)

Plant height and number of leaves was maximum at 75 kg.ha$^{-1}$ of Potassium dose under micro sprinkle fertigation system at 4 weeks after planting. However, it was significantly higher than Potassium basal doses recommendation (100 kg.ha$^{-1}$) under conventional system or control. The minimum of plant height and number of leaves showed at 150 kg.ha$^{-1}$ of Potassium basal dose.

![Figure 2. Weight of dry matter at 12 and 24 days after planting (dap)](image)

There is no difference among treatments on weight of dry matter at 12 days after planting. It ranged from 0.3990 until 0.6695 g. In contrast, there is difference among treatments on weight of dry matter at 24 days after planting. Treatment of 50 kg.ha$^{-1}$ Potassium basal dose under micro sprinkle fertigation showed the heaviest of total dry matter at 24 dap. It peaks at 2.9998 g. Moreover, it was no differences from 75, 100 and 125 kg.ha$^{-1}$ Potassium basal dose and control. In other hand, the lightest of dry matter showed by
150 kg ha\(^{-1}\) Potassium basal dose under sprinkle fertigation system. It significantly decreased 24.3% compared to conventional system.

In plant physiology, the speed of plant growth is quantified by Absolute Growth Rate, Crop Growth Rate and Relative Growth Rate. CGR is growth rate relative to space while relative growth rate is growth rate relative to size. In this study, treatment of 50 kg ha\(^{-1}\) of Potassium basal dose under micro sprinkle fertigation increased significantly 41.8% of Absolute Growth Rate (AGR) compared to control at 12-24 dap. It was as well as on Crop Growth Rate (CGR). In contrast, treatment of 150 kg ha\(^{-1}\) of Potassium basal dose under micro sprinkle fertigation decreased of AGR and CGR compared to control. Also, 150 kg ha\(^{-1}\) of Potassium basal dose decreased significantly on relative growth rate compared to control. The highest rate showed by 50 kg ha\(^{-1}\) of Potassium basal dose followed by 75 kg ha\(^{-1}\) of Potassium basal dose. It peaks at 0.16653 g/g/day. Moreover, 75 kg ha\(^{-1}\) of Potassium basal dose was no difference from 100 and 125 kg ha\(^{-1}\) of Potassium basal dose and control.

Figure 3. Absolute Growth Rate, Crop Growth Rate and Relative Growth Rate of shallot among treatments during early vegetative stage

Figure 4. Soil Plant Analysis Development (SPAD) value among treatments
In this study, chlorophyll content response measured using Soil Plant Analysis Development (SPAD) value. SPAD value showed that there was difference among treatments. It ranged from 45.7 to 52.5. Treatments of 150 kg.ha\(^{-1}\) of Potassium basal dose showed the highest SPAD value followed by 125, 75 and 50 kg.ha\(^{-1}\) of Potassium basal dose. It peaks at 52.5. However, it was no difference from 100 kg.ha\(^{-1}\) of Potassium basal dose and control. It is so clear that SPAD value showed an opposite trend of plant height, number of leaves, total dry matter, AGR, CGR and RGR.

4. Discussion
Understanding how shallot responds to the different level of Potassium basal dose under different irrigation system is essential for further effectiveness of Potassium and water application on shallot in dry land. Results revealed that there were differences among treatments both of plant height and number of leaves per plant of shallot. Plant height and number of leaves was maximum at 75% of Potassium basal dose recommendation under micro sprinkle fertigation system in early vegetative growth. This result agreed with researchers who reported that fertigation system increased growth parameters of tomato [13], *Populus tomentosa* [5], and maize [6].

The heaviest of dry matter was showed significantly by 50 kg.ha\(^{-1}\) of Potassium basal dose treatment. It was no difference from conventional irrigation system. It could be good potential that fertigation system could significantly decreasing of 50% Potassium basal dose. These results reflect in a higher growth of tomato [8]. Hence, fertigation system was more effective and efficient on water and nutrition application on crops [14].

Treatment of 50% lower of Potassium basal dose recommendation under micro sprinkle fertigation increased significantly of AGR, CGR and RGR. It reflected that Potassium uptake significantly increased when it applied in fertigation system. In addition, fertigation system increased the effectiveness of fertilizer application [14]. These results reflect in a higher growth parameters of sun flower [11], cotton [15], camelina [16]. In contrast, higher Potassium basal dose recommendation decreased of AGR, CGR and RGR. The obtained results indicated that higher basal dose level disturbed plant growth. SPAD value showed an opposite trend of plant growth parameters. SPAD value increased positively with basal dose of Potassium. Although leaf greenness was high, on higher dose level of fertilizer, shallot growth parameter showed decreasing. So, right basal dose of fertilizer application is necessary.

5. Conclusion
In conclusion, treatment of 50% lower of Potassium basal dose recommendation under micro sprinkle fertigation increased significantly of total dry matter at 24 days after planting as well as Absolute Growth Rate (AGR), Crop Growth Rate (CGR) and Relative Growth Rate (RGR) during 12 - 24 days after planting. Response of soil plant analysis development (SPAD) value as chlorophyll content was an opposite trend of plant height, number of leaves, total dry matter, AGR, CGR and RGR.

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