The role of sulfur and paclobutrazol on the growth of shallots (Allium ascalonicum (L.) Sanren F-1 varieties from true shallot seed

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Abstract. The latest technological developments in shallot cultivation can be done using True Shallot Seed (TSS). The obstacle is the character experiencing difficulty in senescence and long harvesting age. The presence of growth inhibitor is necessary to focus the energy on tuber formation. This research aimed to evaluate the effect of sulfur and paclobutrazol on the growth of shallots from TSS. The research was conducted using polybag in the community land in Medan, using a factorial randomized block design with 2 factors and 3 replications. The first factor was sulfur (0, 75, 150 kg ZA/ha) applications, and the second factor was paclobutrazol (0, 15, 30 ppm) applications.

The results showed that 150 kg ZA/ha sulfur application increased the plant length 1-5 weeks after transplanting. The treatment of paclobutrazol and the interaction between paclobutrazol and sulfur applications had no significant effect on plant length and leaf number at 1-4 weeks after transplanting.

1. Introduction

Shallots are classified as a horticultural commodity as well as a superior spice that acts as a food seasoning, a mixture of the food industry and a source of biopharma. As a source of biopharmaceuticals, shallots contain bioactive compounds such as flavonoids, saponins, essential oils, alliin, allicin, and quercetin [1-5]. Quercetin in shallots is effective for the prevention and treatment of diabetes, cancer, coronary heart disease, obesity, hypercholesterolemia, hypertension, allergies, asthma, arthritis, neurodegenerative disorders, osteoporosis, cataracts, indigestion, and leukemia [6-9].

The prospect of shallots is currently very good, indicated by higher consumer demand along with the increasing population. The average consumption of shallots is 2.57 kg/capita/year (2017), with a population of Sumatera Utara citizen of 14,262,147 people [10], hence the need for shallots reaches 36,653.7 tons/year. Meanwhile, the production of shallots in 2017 was 16,103 tons. This means that Sumatera Utara had a deficit of 20,550.7 tons. Therefore, it is necessary to accelerate the increase in shallot production to achieve shallots self-sufficiency.

The main obstacle in increasing the productivity of shallots; is no guarantee of the bulbs availability as high-quality planting material throughout the growing season and the presence of bulb borne pathogens [11]. The continuous use of tubers as planting material can reduce the quality of bulb yields, due to diseases caused by Colletotrichum sp., Fusarium sp., and Alternaria sp., as well as viruses often carried by bulbs originating from the parent plant, resulting in the decreased of plant productivity [12].
The latest technological developments in shallot cultivation can be done using True Shallot Seed (TSS). Planting with TSS has not been developed much, even though it has the advantage that the yield of bulbs is up to two times higher than that of using tuber seeds (production 26 tons/ha), seeds volume used is less (seed requirement is about 7.5 kg/ha compared to about 1.5 t/ha of tubers), cheaper transportation costs, easier storage, stronger and healthier because it is virus-free, produces larger tubers [13,14]. The longer storability (seeds storability up to 1-2 years) compared to bulbs which can only be stored for 4 months [15,16].

The problem of shallots cultivation from TSS namely; has the characteristics of having difficulty experiencing senescence and long harvesting life. The shoots are not senescent indicate that there is still potential for assimilates accumulating in the leaves and has the potential to be translocated to the tubers. Tuber formation is influenced by the balance of stimulatory and inhibitor hormones in plants. The presence of growth inhibitors is necessary to focus the energy on tuber formation. The use of paclobutrazol as a growth inhibitor can increase the translocation of assimilates from leaves to bulbs hence it is expected to accelerate senescence and indirectly increase bulb production [17].

Increased production and quality of shallot yields are also influenced by sulfur (S). S nutrient plays a very important role in increasing the translocation of assimilates to enlarge tubers, forming essential amino acids (cysteine, thiamin and methionine), forming protein, giving a distinctive aroma and the level of spiciness of shallots. The aroma is obtained from sulfoxide compounds [18]

Until now, there is still a very limited study on the role of paclobutrazol and sulfur in the growth of shallot plants from TSS. Based on this background, this research aimed to identify the role of paclobutrazol and sulfur in the growth of shallots from TSS.

2. Materials and methods

2.1. Research site and materials

The research was conducted at community land Tanjung Sari, Medan Selayang, Medan with an altitude of ± 32 m above sea level from June to September 2020. The materials used were TSS Sanren F-1 variety, top soil, rice husks, NPK fertilizer, ZA, paclobutrazol, liquid organic fertilizer, compost, water and other materials that support this research. The tools used were polybag, hoes, knives/cutters, samples labels, gauges, analytical scales, watering can, and other supporting tools.

2.2. Design experiment and management of crop

This research used a factorial randomized block design with 2 factors and 3 replications. The first factor was sulfur fertilizer, consists of S0 (0 kg ZA/ha), S1 (75 kg ZA/ha), and S3 (15 kg ZA/ha). The second factor was the concentration of paclobutrazol, consisting of P0 = without paclobutrazol, K1 = 15 ppm of paclobutrazol, and K2 = 30 ppm of paclobutrazol.

The first phase activities were carried out by making nursery-beds with a width of 100-120 cm. The husks were sprinkled on the beds with a thickness of 15-20 cm and then burned at a hotspot distance of 1 m until they were completely burned for 1 night. After leaving it overnight, watering it sufficiently, then tilling the soil. The seeds were sown by spreading 0.5 g/plot of seeds but first mixed them with a fungicide. The flow of the seedlings was closed using fine soil/compost/husk. Seedlings were ready for transplanting after 35-42 DAS. Seeds were planted as much as 1 seedling/planting-hole with a spacing of 10x15 cm. The seedlings should be sturdy, fresh green in color and have 4-6 leaves. Watering is done in the morning and evening. The sulfur application was carried out at 7 days after transplanting. The paclobutrazol application was carried out at 20 and 35 days after transplanting according to the treatment. Fertilization was carried out 4 times, namely at 7 days after transplanting (DAT) in the form of organic fertilizer (mixed in the beds), 14 ; 28 and 42 DAT in the form of NPK (16:16:16) 750 g/200 l of water ; 1 kg/200 l of water and 1 kg/200 l of water and KCl 750 g/200 l of water (by watering it), respectively. Weed control was carried out at 14-21
DAT. Integrated pest control was carried out with pesticides according to the types of pests and diseases that attack. Harvest is done after 75% of the upper leaves have fallen at the age of 60-70 days after transplanting, by pulling the tubers carefully, tied and dried in the sun for 7 days according to weather conditions. The observed variables consisted of plant length and number of leaves.

2.3. Data analysis
Data were analyzed using the Analysis of Variance. If the analysis of variance results showed a significant effect, then proceed with the mean difference test based on the Duncan Multiple Range Test (DMRT) at the level of $\alpha = 5\%$.

3. Results and discussion

3.1. Results

3.1.1. Plant length. Based on table 1, it can be identified that the application of sulfur, paclobutrazol and the interaction between them had no significant effect on plant length at 1-5 weeks after transplanting. Although not significant, there was a general tendency that application of sulfur up to 150 kg ZA/ha has been increased for plant length (Figure 1). This indicates that the role of S in the photosynthetic process that produces assimilates can increase plant growth which indicates by an increase in plant length.

| Week after transplanting (WAP) | Sulfur application (kg ZA/ha) | Paclobutrazol application P_0(0ppm) | P_1(15ppm) | P_2(30 ppm) | Mean |
|-------------------------------|-------------------------------|-----------------|------------|-------------|------|
| 1                             | S_0 (0)                       | 16.30           | 16.95      | 17.07       | 16.77|
|                               | S_1 (75)                      | 16.83           | 16.97      | 16.97       | 16.92|
|                               | S_2 (150)                     | 18.00           | 16.24      | 17.77       | 17.34|
|                               | Mean                          | 17.04           | 17.04      | 17.27       |      |
| 2                             | S_0 (0)                       | 16.56           | 17.79      | 17.93       | 17.43|
|                               | S_1 (75)                      | 17.29           | 17.51      | 17.51       | 17.44|
|                               | S_2 (150)                     | 18.36           | 17.20      | 17.22       | 17.59|
|                               | Mean                          | 17.40           | 17.50      | 17.55       |      |
| 3                             | S_0 (0)                       | 18.36           | 18.93      | 20.08       | 19.12|
|                               | S_1 (75)                      | 18.75           | 18.72      | 18.72       | 18.73|
|                               | S_2 (150)                     | 20.98           | 19.23      | 21.49       | 20.57|
|                               | Mean                          | 19.36           | 18.96      | 20.10       |      |
| 4                             | S_0 (0)                       | 22.40           | 23.31      | 26.26       | 23.99|
|                               | S_1 (75)                      | 23.81           | 24.15      | 24.15       | 24.04|
|                               | S_2 (150)                     | 25.95           | 23.03      | 25.22       | 24.73|
|                               | Mean                          | 24.05           | 23.50      | 25.21       |      |
| 5                             | S_0 (0)                       | 29.38           | 30.53      | 31.85       | 30.59|
|                               | S_1 (75)                      | 31.04           | 31.79      | 31.79       | 31.54|
|                               | S_2 (150)                     | 34.31           | 29.74      | 31.01       | 31.69|
|                               | Mean                          | 31.58           | 30.69      | 31.55       |    |
Stated that the element of sulfur (S) can increase the vegetative growth of plants because the element of S is an important part of ferredoxin, namely a complex of Fe and S contained in chloroplasts used in carbohydrate catabolism [19]. With the formation of chlorophyll and favorable environmental conditions, the photosynthesis process can take place well hence produce optimal photosynthate. Photosynthate is translocated to parts of the plant which require it, for example, to increase plant length. In addition, ZA fertilizers contain nitrogen which can increase the absorption of S elements. The presence of nitrogen nutrients will increase the absorption of S elements, thereby increasing photosynthesis.

Paclobutrazol did not significantly affect plant length because it was only applied at 3 weeks after transplanting. At 5 WAP, it was identified that the plant length was still increasing in the 30 ppm paclobutrazol treatment. Paclobutrazol is a type of retardant which is expected to suppress vegetative growth, thereby reducing the use of photosynthesis products for increased length of plant segments and causing plants to become shorter, larger in stem diameter and prevent toppling. In addition, paclobutrazol is also able to reduce gibberellin synthesis, accelerate flowering, increase the number of flowers, the number of fruit [20].

3.1.2. The number of leaves. Based on table 2, it can be identified that the application of sulfur, paclobutrazol and the interaction between them had no significant effect on the number of leaves at 1-
5 WAP. Although not significant, there was a general tendency that the application of sulfur up to 150 kg ZA/ha increased the number of leaves (figure 2).

**Table 2.** Number of leaves of shallot from TSS with application of sulfur and paclobutrazol.

| WAP | Sulfur application (kg ZA/ha) | Paclobutrazol application | Mean |
|-----|-------------------------------|---------------------------|------|
|     | P₀ (0 ppm) | P₁ (15 ppm) | P₂ (30 ppm) | leaves |
| 1   | S₀ (0)    | 2.62  | 2.71  | 2.43  | 2.59  |
|     | S₁ (75)  | 2.62  | 2.76  | 2.76  | 2.71  |
|     | S₂ (150) | 2.62  | 2.71  | 2.38  | 2.57  |
|     | Mean      | 2.62  | 2.73  | 2.52  |
| 2   | S₀ (0)    | 2.81  | 2.81  | 2.67  | 2.76  |
|     | S₁ (75)  | 2.71  | 2.71  | 2.71  | 2.71  |
|     | S₂ (150) | 2.90  | 2.67  | 2.76  | 2.78  |
|     | Mean      | 2.81  | 2.73  | 2.71  |
| 3   | S₀ (0)    | 3.71  | 3.57  | 3.62  | 3.63  |
|     | S₁ (75)  | 3.62  | 3.67  | 3.67  | 3.65  |
|     | S₂ (150) | 3.71  | 3.57  | 3.62  | 3.63  |
|     | Mean      | 3.68  | 3.60  | 3.63  |
| 4   | S₀ (0)    | 4.33  | 4.29  | 4.29  | 4.30  |
|     | S₁ (75)  | 4.48  | 4.14  | 4.14  | 4.25  |
|     | S₂ (150) | 4.48  | 4.38  | 4.14  | 4.33  |
|     | Mean      | 4.43  | 4.27  | 4.19  |
| 5   | S₀ (0)    | 5.33  | 5.38  | 4.95  | 5.22  |
|     | S₁ (75)  | 5.33  | 5.29  | 5.29  | 5.30  |
|     | S₂ (150) | 5.71  | 5.19  | 5.29  | 5.40  |
|     | Mean      | 5.46  | 5.29  | 5.17  |

**Figure 2.** The relationship between sulfur fertilizers and number of leaves 5 WAP

This indicated that the role of sulfur in the formation of chlorophyll which is closely related to photosynthesis is very important for plant growth. Under the statement of Abadie and Tcherkez [21] which stated that the role of S (related to photosynthesis and photorespiration) is to increase the
availability of N, P and K nutrients, and also increase growth in drought stress conditions [22], thus affecting plant growth phase, plays a role in photosynthesis and electron transport systems as well as in coenzymes and prosthetic groups such as ferredoxin which are important for nitrogen assimilation [23,24]. S deficiency directly interferes with the efficiency of photosynthesis because it affects RuBisCo activity [25].

The paclobutrazol application tends to decrease the number of leaves at 4-5 WAP, because of the paclobutrazol role as a retardant that inhibits plant growth. The application of paclobutrazol will change the hormonal and morphophysiological balance in plants [26], the manipulation of this physiological activity will result in change of photosynthate translocation hence it will increase plant productivity [27,28].

4. Conclusions

The application of sulfur 150 kg ZA/ha increased the plant length 1-5 WAP. The application of paclobutrazol and the interaction between paclobutrazol and sulfur applications had no significant effect on plant length and leaf number at 1-5 weeks after transplanting.

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