Effect of potassium application on morphophysiological two varieties of soybean under drought stress

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Abstract. Domestic soybean production is getting weaker due to drought stress which affects all aspects of plant growth and metabolism, besides using adaptive plant varieties, increasing plant nutrition, especially potassium, also affects increasing plant tolerance to drought. The research aimed to examine the effect of potassium application on the morphophysiological of two varieties of soybean under drought stress. The research was conducted in a plastic house, Deli Serdang Regency, North Sumatra, using a randomized block design with three factors. The first factor was soil water content condition, which consisted of 80% and 40% field capacity. The second factor was variety, consisted of Grobogan and Dering-1. The third factor was the application of potassium, consisted of without potassium 100, 200, 300 kg KCL ha⁻¹. Result showed that drought stress decreased potassium uptake, the relative water content (RWC) of leaf and plant height. Grobogan variety more adaptive to drought stress with the highest plant height (71.49 cm), K content (1.77%), K uptake (43.85 mg/plant), and leaf RWC (37.91%). Application of K at a dose of 200 kg ha⁻¹ was the most appropriate to encourage the growth of soybean plants under drought stress with the highest total K (1.76%) and leaf RWC (44.40 mg/plant).

1. Introduction
Soybeans are one of the strategic leading commodities, the need for the domestic food industry for this commodity is quite high. Currently, the average amount is 2.3 million tons of dry beans/year. Meanwhile, the average domestic production in the last five years has been 982.47 thousand tons of dry beans or 43% of the total needs [1]. Domestic soybean production is getting weaker due to the problem of drought stress which affects all aspects of plant growth and metabolism including osmotic balance [2].

Potassium has a very important physiological function and role to plant water. Potassium (K) is an essential nutrient that affects most of the biochemical and physiological processes that influence plant growth and metabolism. It also contributes to the survival of plants exposed to various biotic and abiotic stresses [3].

Beside of potassium fertilization, genetic factors (varieties) are also a concern in overcoming drought stress. The adjustments made by plants to drought are highly dependent on the level of stress experienced, the length of stress, the plant growth phase when experiencing stress and the type or variety of plants. Adjustments made by plants to the effects of drought are a form of adaptation to survive in drought-stressed conditions. The adaptations of plants when under drought stress will have a major impact on the yield of these plants [4].
Based on the above, this research is important to obtain information related to the use of potassium fertilizer for two soybean varieties, namely Dering-1 (drought-tolerant variety) and Grobogan (drought-susceptible variety) which was tested under drought stress conditions.

2. Materials and methods
This research was conducted using a plastic house in Aras Kabu Village, Deli Serdang, Medan from January-April 2020. The experimental design used was a randomized block design consisting of three factors. The first factor was soil water content condition, which consisted of 80% and 40% FC (Field Capacity). The second factor was variety, consisted of Grobogan and Dering-1-1. The third factor was the application of potassium, consisted of 0, 100, 200 and 300 kg KCL ha\(^{-1}\). Each experimental unit was repeated three times to obtain 48 experimental units.

2.1. Planting, fertilization and drought treatment
Soybean was planted two seeds/polybags in a plastic house using topsoil as much as 10 kg after sieving, added 2.5 g dolomite/polybag (500 kg ha\(^{-1}\)) and incubated for 3 weeks. The planting was done simultaneously with the application of potassium and SP-36 fertilizers, drought treatment was carried out in the V2-R5 phase using the gravimetric method. Fertilization was done by placing around the planting hole with apart7-10 cm. The dose of N was 25 kg ha\(^{-1}\) of urea was applied 2 weeks after planting and the P dose was 150 kg ha\(^{-1}\) of SP-36.

2.2. Plant maintenance
Maintenance includes staking, weeding at 2 weeks after planting, fertilizing urea and phosphorus simultaneously with planting. Pest and disease control was adjusted to the intensity of pests and diseases.

2.3. Observation of morphological character
Observation of morphological character such as plant height at 5 weeks after planting. Each physiological character at the vegetative end includes K uptake using the Atomic Absorption Spectrophotometry (AAS) method, and leaf Relative Water Content (RWC) using the gravimetric method with the equation below [5].

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\text{RWC} = \frac{(\text{wet weight-dry weight})}{(\text{saturated weight-dry weight})} \times 100\% 
\]

2.4. Data analysis
Data processing using the SPSS statistical program (ver. 20). The data obtained were analysed using variance at the level of \(\alpha = 5\%\). If there is a significant effect between the test treatments, continue with Duncan's Multiple Range Test (DMRT) [6].

3. Results and discussion

3.1. Plant height
Plant height was affected by the degree of drought and variety (Table 1). Drought treatment of 40% FC resulted in a significant reduction in plant height, namely 64.69 cm compared to the optimum soil water condition of 80% FC which resulted was 71.06 cm. The use of Dering-1 variety under drought conditions resulted in a significant reduction in plant height, namely 64.26 cm, while Grobogan's variety was 71.49 cm.

The vegetative phase is the phase of active development and division of cells so that they are very vulnerable to water deficiency. According to [7], drought stress conditions in the vegetative phase can reduce plant height. Sharifah and Muriefah [8], states that drought stress inhibits plant growth, causing plants to become stunted. Soybean plant height decreases with increasing drought stress. The inhibition of plant growth is caused by the disruption of the photosynthesis process due to lack of water.
Table 1. The effect of drought stress and varieties on soybean plant height at 5 WAP

| Drought stress (% of field capacity) | Variety | Mean |
|-------------------------------------|---------|------|
|                                     | V₁ (Grobogan) | V₂ (Dering-1) |      |
|                                     | 73.50    | 68.63 | 71.06 b |
|                                     | 69.48    | 59.90 | 64.69 a |
| Mean                                | 71.49 b  | 64.26 a |

Note: The numbers followed by different letters show significant differences according to Duncan's Multiple Range Test at the level of α = 5%.

3.2. Potassium content and uptake

Application of potassium fertilizer had no significant effect on K uptake but there was a significant effect on K content. Potassium application at a dose of 200 kg ha⁻¹ (K₂) resulted in the highest K content of 1.76% which was significantly different from without potassium application (K₀) was 1.49% and there was a decrease if the K fertilizer dose was given higher or lower. This suggests that a dose of 200 kg ha⁻¹ is the best dose to increase K content (Table 2). In line with previous study of [9] that the best K dose to increase K content is 25.53 g/plant which produces 1.87% in plants and a decrease in K content will occur at a dose of 34.03 g/plant (1.63%), 8.5 g/plant (1.26%) and without K (0.91%).

Table 2. The effect of potassium application, drought stress and varieties on soybean K content and uptake

| Treatment | K Content (%) | K Uptake (mg/plant) |
|-----------|---------------|---------------------|
| Potassium (kg KCl ha⁻¹) |               |                     |
| K₀ (0)    | 1.49 a        | 43.05 a             |
| K₁ (100)  | 1.63 ab       | 39.71 a             |
| K₂ (200)  | 1.76 b        | 41.24 a             |
| K₃ (300)  | 1.65 ab       | 42.3 a              |

| Drought stress (% of field capacity) | K Content (%) | K Uptake (mg/plant) |
|-------------------------------------|---------------|---------------------|
| D₁ (80)                             | 1.62 a        | 46.54 b             |
| D₂ (40)                             | 1.64 a        | 36.61 a             |

| Variety | K Content (%) | K Uptake (mg/plant) |
|---------|---------------|---------------------|
| V₁ (Grobogan) | 1.77 b        | 43.85 a             |
| V₂ (Dering-1)  | 1.49 a        | 39.30 a             |

Note: The numbers followed by different letters show significant differences according to Duncan's Multiple Range Test at the level of α = 5%.

Drought stress had no significant effect on K content but had a significant effect on K uptake. At 80% FC resulted in plant K uptake of 46.54 mg/plant, which was significantly different from 40% FC (36.61 mg/plant). Decreasing soil water content inhibits the process of transporting potassium nutrients to plant tissues, where the process of transporting potassium through mass flow and diffusion mechanisms are both closely related to soil water content conditions. Kirkham [10], states that drought stress will affect plant physiological processes, namely changing water potential, osmotic potential, cell turgor potential, which can affect stomata behavior, mineral nutrient absorption and translocation, transpiration and photosynthesis as well as photosynthe translocation. Greenland [11] emphasized that
there are at least three important things that must be considered to manage the availability of potassium in the soil, including groundwater content, tortuosity of the diffusion pathway (chaotic curves in the soil/irregularity of the paths through which cations move in the soil), and the concentration of the ions that will diffuse in the soil solution. The results of [12] stated that 100% FC of soil water content produced significant K uptake, which was 2.95% higher than 50% FC of soil water content.

The use of varieties had no significant effect on K uptake, but had a significant effect on plant K content. Grobogan (V1) produced K content of 1.77%, which was significantly different from Dering-1 (V2) which was only 1.49%. Plants are essentially a genetic and environmental constitution, while plant growth and production are influenced by the photosynthetic process in plants as stated by [13]. Differences in response for each variety can occur due to genetic differences in soybean varieties [14].

The response of plants to the environment differs depending on the type and cultivar of the plant. Plants can respond positively or negatively to changes in the growing environment. These various responses lead to interactions between the environment and the genotype, and this phenomenon was often encountered in multilocation testing. The response can be seen from the physical changes in plants in the form of changes in growth and changes in plant phenotypes. Plant responses can also be seen from changes in physiological processes such as the speed of photosynthesis and photosynthate translocation [15].

### 3.3. Leaf RWC

There is a significant interaction of the effect of drought, variety, and potassium on leaf RWC (Table 3). The application of potassium 200 kg ha⁻¹ in Grobogan variety can increase leaf RWC by 70% compared to without potassium application at 80% FC and Dering-1 at 40% FC variety yields leaf RWC 118.87% higher than control. The application of potassium, in general, was proven to increase leaf RWC both at 80% FC and 40% FC in Grobogan and Dering-1 variety. The potassium dose of 200 kg ha⁻¹ gave the highest leaf RWC yield (53.33%) and there was a decrease at both lower and higher doses. This shows that the best dose of fertilization to increase leaf RWC was found in the K₂ treatment (200 kg ha⁻¹).

**Table 3. The interaction effect of drought stress, variety and potassium on leaf RWC**

| Drought stress (%) of field capacity | Variety      | Potassium (kg KCl ha⁻¹) |
|-------------------------------------|--------------|-------------------------|
|                                     |              | K₀ (0)      | K₁ (100)    | K₂ (200)    | K₃ (300)    |
| D1 (80)                             | V₁ (Grobogan)| 31.19 abc  | 53.33 e     | 53.33 e     | 50.95 e     |
|                                     | V₂ (Dering)  | 37.78 cd   | 35.56 cd    | 50.00 e     | 20.00 a     |
| D2 (40)                             | V₁ (Grobogan)| 33.33 bcd  | 21.67 ab    | 29.29 abc   | 30.16 abc   |
|                                     | V₂ (Dering)  | 20.56 a    | 27.30 abc   | 45.00 de    | 36.51 cd    |

Note: The numbers followed by different letters show significant differences according to Duncan's Multiple Range Test at the level of α = 5%.

Based on the analysis results (Table 2), it is known that the K content of the Grobogan (1.77 %) and Dering-1 (1.49 %), this is what later becomes evidence that Grobogan surpasses the growth of Dering-1 because Grobogan can survive better during drought stress. Subandi [16], states that the nutrient plays an important role in increasing plant resistance to abiotic stress (lack of water and Fe poisoning). Plants that have sufficient K can retain water content in their tissues, because they can absorb moisture from the soil and bind water so that plants are resistant to drought stress [3]. The results of the analysis (Table 3) show that the application of K1 g/plant (200 kg KCL ha⁻¹) was successful in helping plants to maintain the leaf relative water content (RWC) significantly at 44.40% and without K application only...
30.71%. Because of the high leaf RWC, Grobogan (37.91%) grew better than Dering-1 (34.09%) under drought stress. The response of plants to drought depends on the type of variety and the phase at which the drought occurs. Varieties that are said to be drought-tolerant may not be tolerant in all phases of their life and vice versa for susceptible varieties. The research results [17], show that the drought treatment of Dering-1 varieties (tolerant) is not as good as Grobogan (susceptible) varieties in the early reproductive phase (R1), namely Dering-1 plant height (25.1 cm) and Grobogan (41.0 cm) but in the final reproductive phase (R6) the result was Dering-1 (68.4 cm) better than Grobogan (63.6 cm) at drought stress 40% field capacity. The method of adaptation of plants to drought varies depending on the type of plant and the stages of plant development [2].

In accordance with Hasanah et al (2020), the result showed that the treatment of Kieserite under dryland condition give the difference response of soybean varieties. The difference in response of each variety can occur due to genetic differences [14].

4. Conclusions
Potassium application at a dose of 200 kg KCL ha\(^{-1}\) produced plants with the highest K content and leaf RWC. Grobogan variety more adaptive to drought stress with the highest plant height, K content and leaf RWC. Drought stress of 40% FC reduced plant K uptake, leaf RWC and plant height. The interaction of 200 kg ha\(^{-1}\) potassium and Dering-1 variety can maintain leaf RWC in severe drought stress conditions (40% FC).

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