The response of morphological characteristics of some Soybean Varieties (*Glycine max* (L.) Merrill) a vegetative phase in waterlogging condition

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Abstract. Indonesia's microclimate change issues base the big impending for inundation to happen when precipitation is too extraordinary in the area of soybean farming, which can give an influence soybean production. Inundation is a major difficulty in many parts of the entire world and soybeans are delicate to inundation. The use of plant growth regulators (PGR) can respond to soybean plant alteration to inundation stresses. This research was conducted from June to September 2020 in the irrigated rice fields of Kwal Sememe Deli Tua, Deli Serdang District, using a Randomized Block Design (RBD) one factor consisting of Anjasmoro, Grobongan, Deja 1, Devon 1 varieties with 96 h of inundation, with the application of PGR GA3 and Salicylic Acid. The parameters observed were plant height, number of leaves, and number of adventitious roots. The results showed that inundation had an effect on the cultivar used. Anjasmoro cultivar showed the best response to plant height variables while Grobogan cultivar showed the opposite response.

1. Introduction

*Soy* (*Glycine max* L. Merril) is one type of legume plant that has an important role in the pattern of food consumption in the world. Soybean is one of the commodities needed as nutritious food, animal feed, and industrial raw materials. In Indonesia, soybean is one of the main food crop commodities after rice and maize, because soybean seeds contain high nutritional content, especially vegetable protein content of around 35%. Along with the increase in population and the development of soybean processing industries such as making soy sauce, soybean fermentation, and tofu. The need for national soybeans each year tends to increase. However, the increase in soybean demand has not been matched by domestic production [1].

Soybean plants cultivated in Indonesia have characteristics including seasonal plants, upright plants with a height between 40 cm-90 cm, branching, having single leaves and three leaves, not too dense hair on the leaves and pods and plant age between 72-90 d. The introduced soybeans generally do not have branching or very little and some dense stroma both on leaves and pods [2].

The average demand for soybeans per year is 2.2 million tons, while domestic soybean production in 2017 only reached 920 thousand tons with average productivity of 1.6 tons/ha. This achievement is still much lower than that of the United States, which has a soybean production of 119 million tons with an average production rate of 3.2 tons/ha; soybean production in Brazil reached 112 million tons with a productivity of 3 tons/ha, and Argentine soybean production reached 54 million tons with a
productivity of 3.1 tons/ha [3]. Flooded land has a large and differently negative effect on the growth of soybean cultivation and a decrease in soybean cultivation yield depending on the growth of soybeans during inundation and soybean tolerance to inundation stress[4]. The low soybean production in Indonesia is partly due to the lack of knowledge of farmers in the use of production technology that supports sustainable agriculture and the reduction of fertile land resources due to the continuous use of inorganic fertilizers [5].

Inundated land means stress conditions that occur in the environment due to changes in interactions in plant cells caused by standing water around the plant. The concentration of oxygen (O\(_2\)), CO\(_2\), reactive oxygen species (ROS), and ethylene changes after inundation and can occur in various combinations, as determined by the level of inundation [6]. A genotype that is tolerant of inundation is a genotype that has high yielding power in flooded conditions. To obtain a soybean genotype that is tolerant of inundation, it must be carried out based on special characteristic characters that have a close relationship with tolerance based on the stress tolerance index (STI). One of its special traits may be used in the form of biochemical markers [7].

Soybean cultivation in paddy fields after rice harvest is very significant in increasing the efficiency of using rainfed or simply irrigated rice fields so that it can increase the Planting Index (IP) which is only 170% to 200-250% per year, with a rice-soy-rice cropping pattern. The results showed that soybean farming in paddy fields had good prospects because besides short-lived soybeans (2.5-3 months), the production in paddy fields was higher than in dry land, namely 2.5-3.0 t/ha. Another advantage that is obtained is the break in the life cycle of pests and diseases of rice and can carry out efforts to optimize cropping patterns in soybean fields [8].

2. Materials and methods

2.1 Experimental design
This research was conducted at Sememe Deli Tua, North Sumatra, Medan in June-September 2020. Four varieties of soybean were used (Anjasmoro, Grobogan, Deja 1, Devon 1), and planted in irrigated-controlled rice fields. The materials used in this study were fertilizers: Urea, TSP, KCl, insecticide, PGR Gibberellic acid, and salicylic acid. The tools used were, hoe, camera, ruler, marker, bag, pen, paper. This study used a non-factorial completely randomized design with some varieties factor with a total number of 144 plants. Each variety were applied with gibberellic acid and salicylic acid before put in waterlogging condition. Sample of 4 varieties were taken random consisting of Soybean Varieties, such as:

- \(V_1\): Anjasmoro
- \(V_2\): Grobogan
- \(V_3\): Deja 1
- \(V_4\): Devon 1

2.2 Waterlogging method
When the soybean plant in V5 growth phase (leaves fully open at the fifth node), it is irrigated by submerging the four varieties in irrigated land for 96 hours in the fifth week after planting.
3. Results and discussion

3.1 Plant height
The plant height on the fifth week (before inundation) and the seventh week (after inundation) was observed as shown in table 1.

| Treatment | Plant Height (5th week) | Plant Height (7th week) |
|-----------|-------------------------|-------------------------|
| V₁        | 40.94                   | 56.92                   |
| V₂        | 47.91                   | 57.17                   |
| V₃        | 32.78                   | 48.39                   |
| V₄        | 32.94                   | 39.22                   |

The Anjasmor (V₁) variety on the 7th week (after being flooded) had an average highest plant height of (56.92 cm), while the Devon (V₄) variety had the lowest plant height of (39.22 cm). The height of the Anjasmor plant was higher than other varieties. Plant growth after flooding has a very significant effect on plant height growth. Variety is one of the main technologies that can improve the productivity of soybean, and GA₃ application is effectively used to improve plant growth and seed production [10]. The excess water in the field causes the plant photosynthesis rate to be low so that the allocation of photosynthate to plant organs is also low. With the low allocation of photosynthate to roots, stems and leaves, it will suppress growth in the vegetative growth, roots, stems and leaves [8].

3.2 Number of leaves
The number of leaves on the fifth week (before inundation) and the seventh week (after inundation) was observed as shown in table 2.

| Treatment | Leaves (5th week) | Leaves (7th week) |
|-----------|-------------------|-------------------|
| V₁        | 6.28              | 13.44             |
| V₂        | 6.78              | 7.56              |
| V₃        | 6.00              | 9.50              |
| V₄        | 6.28              | 8.72              |

The Anjasmor (V₁) variety at the seventh week (after flooding) had the highest average number of leaves (13.44) while for the Grobogan (V₂) variety had the lowest leaf average (7.56). Plant growth after flooding has a significant effect on the number of leaves on the plant. The difference in the number of leaves can occur because of the influence of the genotype of each variety and the environment. This is by the statement of Damanik [11], the difference in the number of leaves occurs due to the influence of the plant's growing environment resulting in changes and differences in growth.

3.3 Adventitious roots
The number of adventitious roots on the seventh week after planting (after inundation) was observed as shown in table 3.

The appearance of adventitious roots in plants showed in all varieties, indicates that they are well adapted to puddles or tolerant of stagnation water. In the condition of stagnant plants, there is a morphological change, namely the emergence of adventitious roots which function to maintain the continuity of water and mineral supply and replace the function of the main roots. This is by [1], which states that adventitious root formation has the potential to replace the main root which is considered one of the responses generated by plants that are underwater stress, which shows that plants are morphologically adapted to inundation stress.
Table 3. The number of adventitious roots.

| Treatment | Adventive Roots |
|-----------|-----------------|
| V₁        | 5.44            |
| V₂        | 5.78            |
| V₃        | 5.83            |
| V₄        | 5.39            |

4. Conclusions
The application of PGR on waterlogging soybean has a significant effect on the variable plant height, the number of leaves, and adventitious roots. It shows that during the inundation, Grobogan (V₂) tends to decrease. Based on the results, the Anjasmoro variety (V₁) showed the best results compared to other varieties. The appearance of adventitious roots in plants indicated that they are well adapted to puddles or tolerant of stagnation.

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