The effect of ameliorant kind and its application time on soybean growth in tidal land soil

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Abstract. Tidal swampland is one type of suboptimal land that can be developed to increase food crop production in Indonesia. However, tidal land contains a lot of $\text{Al}^{3+}$ because it has acid soil reactions. Previous research found that the critical period for soybean plants against $\text{Al}^{3+}$ stress was at the beginning of growth until 20 days after planting. This study aims to obtain the appropriate ameliorant to overcome $\text{Al}^{3+}$ stress during the critical period of soybean growth. An experiment on the types of ameliorant and the application time was arranged in a randomized block design repeated three times. The kinds of ameliorant tested were no ameliorant, dolomite, husk charcoal, husk ash, and straw. Each ameliorant was given 2 tonnes ha$^{-1}$ before planting in dry cultivation (DC), before planting in saturated soil culture (SSC), 10 days after planting (DAP) on DC, 10 DAP for SSC, 20 DAP on DC, and 20 DAP on SSC. The experiment results are consistent with studies of saturated soil culture, which show that soybean in water-saturated culture has better growth than dry cultivation. In all kinds of ameliorant and at all times, saturated soil culture had more effect on the growth and production of soybeans. The kind of ameliorant only affected the number of branches, and the highest number of branches was obtained in soybean treated with dolomite ameliorant. However, it was not significantly different from other ameliorants.

1. Introduction

Research on tidal swampland use in Indonesia has made significant progress [1–5]. Soybean is a food crop commodity that is of concern to be cultivated in tidal swamps [6–13]. This commodity is vital for Indonesia because it is the third food crop commodity after rice and corn. However, this plant cannot compete with other commodities in the fertile land. Therefore, the use of tidal swampland is a solution for the present and future of Indonesian soybean.

The tidal land problems are soil and water, namely pyrite content, low pH, $\text{Al}^{3+}$, Fe, and others. So, the cultivation of soybean in tidal swamplands must consider good management of soil and water. The study of reference [6] stated that the environment (climate) in tidal areas is not an obstacle and even supports soybean growth. Therefore, soil and water are limiting factors in tidal fields. Researchers on tidal lands concluded that macro and micro water management systems [14], land management [15], amelioration and fertilization [16], and saturated soil culture technology [8] were essential to be applied to this fields.

Researchers [17,18] studied and concluded that the earlier soybean experienced $\text{Al}$ stress, the more disrupted growth was. The critical phase of soybean growth to $\text{Al}$ is the initial growth phase until 20 days after planting. Furthermore, this critical phase is intended to be used as the basis for input application time, especially ameliorants, to overcome $\text{Al}$ stress in soybeans in tidal fields. Besides, the
selection of inputs located around the planted area is an effort to increase soybean production efficiency. This study aims to find the right time of application, kind of ameliorant and cultivation system to overcome Al stress during the critical period.

2. Materials and methods

The experiment was carried out in a plastic house on land in Dramaga District, Bogor Regency, West Java Province, Indonesia. The study was conducted from February to November 2017. The soybean genotype used in this experiment was the national commercial genotype, namely Tanggamus.

2.1. Design of experiment and data analysis

Soybeans were planted in a polybag containing the soil medium. Pots were arranged in a factorial randomized block design with three replications. The first factor was the application time of amelioration and the cultivation system, namely before planting on dry cultivation, before planting in saturated soil culture, 10 days after planting (DAP) in dry cultivation, 10 DAP in saturated soil culture, 20 DAP in dry cultivation, 20 DAP in saturated soil culture. The second factor was the kinds of ameliorant, namely no ameliorant, dolomite, husk charcoal, husk ash, and straw. All ameliorations were applied at the same dose of 2 tonnes/ha.

Data were analysed for a variance to determine the significance of the treatment and continue with the Duncan Multiple Range Test (DMRT) with a 5% confidence for the difference of means.

2.2. Procedures

The growth medium (soil) was taken from tidal swampland at Muliasari Village, Tanjung Lago District, Banyuasin Regency, South Sumatra Province, Indonesia. The soil was put into 30 cm x 40 cm polybags. The soil was taken using a unique tool designed so that the lifted soil follows the pot's size and shape (figure 1). So, the position of the top and bottom layers of soil was not reversed and mixed. The soil-grabbing tool was made of a semi-circular of the polybag's shape.

Amelioration was applied to the soil according to treatment. Seeds were planted two seeds per pot. Under the polybags, a water catcher is provided for water-saturated cultivation conditions.

3. Results and discussion

The time of amelioration application did not show a significant effect on the growth and production of soybeans. Plant height and plant height growth at B2, B4, and B6 were not significantly different (figure 2). The difference in figure 2 occurs between the group of B1, B3, B5, and the group of B2, B4, B6. These groups were a difference between cultivation systems. Soybeans in B1, B3, and B5 were grown using a dry cultivation system. In comparison, the soybeans in B2, B4, and B6 are grown with a saturated water cultivation system.

Figure 1. Soil-grabbing tool.
Figure 2. Plant height (A) and plant height growth (B) in the cultivation technique and time of ameliorant application treatment. B1 = before planting on dry cultivation; B2 = before planting in saturated soil culture; B3 = 10 days after planting (DAP) in dry cultivation; B4 = 10 DAP in saturated soil culture; B5 = 20 DAP in dry cultivation; B6 = 20 DAP in saturated soil culture.

The number of branches also had the same pattern with plant height in the cultivation system and the application time of ameliorant treatment. The number of branches was significantly different between the soybean grown under the dry cultivation system and the saturated soil cultivation system. However, it was not significantly different between ameliorant application times in the same culture (figure 3A). The number of branches was significantly different between soybeans applied ameliorant and those that were not applied. However, the ameliorant type did not produce a different number of branches (figure 3B).

Figure 3. The number of branches in the cultivation technique and time of ameliorant application treatment (A) and kind of ameliorant (B). B1 = before planting on dry cultivation; B2 = before planting in saturated soil culture; B3 = 10 days after planting (DAP) in dry cultivation; B4 = 10 DAP in saturated soil culture; B5 = 20 DAP in dry cultivation; B6 = 20 DAP in saturated soil culture.

The ameliorant application time did not produce a significantly different number of nodes and pods (figures 4A and 4B). The number of nodes and the number of pods had the same pattern as the parameters for plant height and branches. The cultivation system has a more significant effect on all of these parameters. All soybeans planted with saturated soil cultivation systems (B2, B4, and B6) had significantly better growth than conventional cultivation.
Figure 4. The number of nodes (A) and pods (B) of soybean in the cultivation technique and time of ameliorant application treatment. B1 = before planting on dry cultivation; B2 = before planting in saturated soil culture; B3 = 10 days after planting (DAP) in dry cultivation; B4 = 10 DAP in saturated soil culture; B5 = 20 DAP in dry cultivation; B6 = 20 DAP in saturated soil culture.

The number of seeds per plant also has the same pattern as the last parameter. The ameliorant application time did not have a significant effect on each cultivation system (Figure 5). All soybeans grown under saturated soil cultivation technology (B2, B4, and B6) produced significantly different numbers of seeds than soybeans grown using conventional (dry) cultivation.

Figure 5. The number of seeds of soybean in the cultivation technique and time of ameliorant application treatment. B1 = before planting on dry cultivation; B2 = before planting in saturated soil culture; B3 = 10 days after planting (DAP) in dry cultivation; B4 = 10 DAP in saturated soil culture; B5 = 20 DAP in dry cultivation; B6 = 20 DAP in saturated soil culture.

Chlorophyll content of soybean leaves was not significantly different in all treatments of ameliorant application time and cultivation system except for B6. However, the different types of ameliorant affected different chlorophyll levels. Husk charcoal and rice straw produced significantly higher chlorophyll content compared to other types of ameliorant. Without ameliorant, chlorophyll content's value was not significantly different from that of husk and straw charcoal (Figure 6). Dolomite did not significantly increase the chlorophyll of soybean leaves even though dolomite significantly increased the number of branches (Figure 3B).
Figure 6. Chlorophyll content of soybean in the cultivation technique and time of ameliorant application treatment (A) and kind of ameliorant (B). B1 = before planting on dry cultivation; B2 = before planting in saturated soil culture; B3 = 10 days after planting (DAP) in dry cultivation; B4 = 10 DAP in saturated soil culture; B5 = 20 DAP in dry cultivation; B6 = 20 DAP in saturated soil culture.

Figure 7. Photosynthesis rate of soybean in the cultivation technique and time of ameliorant application treatment. B1 = before planting on dry cultivation; B2 = before planting in saturated soil culture; B3 = 10 days after planting (DAP) in dry cultivation; B4 = 10 DAP in saturated soil culture; B5 = 20 DAP in dry cultivation; B6 = 20 DAP in saturated soil culture.

The photosynthesis rate was not significantly different in all the cultivation system and the application time of ameliorant treatments. Unlike other parameters, the photosynthetic rate was not influenced by water availability in saturated soil culture. There are differences in the results of this parameter with previous studies by reference [6]. This difference was caused by environmental conditions related to the rate of photosynthesis. The location of the application of saturated water cultivation carried out by reference [6] is tidal land with high temperature and sun intensity.

4. Conclusions
The experiment results are consistent with studies of saturated soil culture, which show that soybean in water-saturated culture has better growth than dry cultivation. In all kinds of ameliorant and at all times, saturated soil culture had more effect on the growth and production of soybeans. The kind of ameliorant
only affected the number of branches, and the highest number of branches was obtained in soybean treated with dolomite ameliorant. However, it was not significantly different from other ameliorants.

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