The Growth of Several Soybean Genotypes in the Saline Soil

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Abstract: One of the strategic efforts to increase soybean production towards self-sufficiency with 2.8 million tons of production is through the expansion of suboptimal planting areas, among others, by using saline soil. The area of potential saline land in Indonesia is 140,300 ha. This study aims to determine the growth of several genotypes at a salinity soil level of 10 dS/m. This experiment was conducted using a randomized block design (RBD) repeated three times. The treatments tested were genotypes consisting of Deja 2, Dering, Karat 13, Panderman, GepakKuning, DaunLancip, Dega1 and Tanggamus. Variables observed in this study include: plant height, root length, stover weight, root dry weight and soil salinity level at the age of 24 days, 45 days, 60 days and 75 days. All genotypes still live up to 45 days, but at 60 days after Dering, Tanggamus, Gepakkuning is dead, and only DaunLancip can survive up to 75 days.

1 INTRODUCTION

One strategic efforts to increase soybean production towards self-sufficiency with 2.8 million tons of production is through the expansion of planting areas, considering that fluctuations in national production have been closely linked to fluctuations in harvested areas, and in the past six years (in 2009-2015) soybean harvested area was only 493-723 thousand hectares with low productivity, 1.2-1.3 t/ha. Based on calculations, to achieve soybean self-sufficiency, national productivity needs to be increased to 1.4-1.5 t/ha in the 2.0 million ha harvested area (BPS, 2017). Expansion of the area can be done by utilizing marginal land such as dry land, acid dry land, and saline land. In Indonesia it is estimated that the total of saline land 440.300 ha which were 304.000 ha rather saline and 140,300 ha saline (Rachman et al., 2008).

The intensity of soil salinity was depend on the kind of soil texture. The coarse-textured soil better on the ion transportation than fine-textured soil, that the entry of most solute into the effluent was faster in coarse-textured soil. The coarse-textured soils have relatively low total porosity, macro pores which results in a relatively high volume of leaching and salt removal. Then clay- textured that used to maintaining and transporting soil ions. In other hand, light-textured soils with low clay content and small buffer capacity had higher K+ concentration than heavy-textured soils in the soil solution, its seems caused by cation exchange (Hoseini and Delbari, 2015).

Salinity decreased acid phosphatase activity in cotyledon during 24 hours after germination. Salinity also affected percentage and rate of germination in Lettuce. Length and fresh weight of root and shoot were reduced significantly with salt treatment in two lettuce varieties. Biochemically analysis shows that in the root, acid phosphatase activity could increased or decreased depend on the genotypes but on shoot its enzim activity had no difference with the control (Nasri et al 2015). Tsegay and Gebreslassie (2014) also report that the percentation of germination, shoot length and root length of Lathyrus sativus and Pisum sativum var. abyssinicum decreased with an increase in salinity level. The germination of both declined with increasing salinity levels, although reduction in root length was higher than reduction in shoot length. Soybean has a varying response to salinity. Each genotype shows specific to respond to salinity.

Several genotypes can germinate in saline condition but inhibited on growth for the next stage. Other genotypes that tent to tolerant on salinity get well on germination and germinate and get great growth vigorously although on saline condition. Ichiyou sensitive genotype on salinity condition, while Baluran was tolerant up to 125 mM NaCl based on sprout length and fresh weight (Putri et al. 2017). Salinity conditions delays soybean seed germination

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by negatively regulating gibberellin (GA) while positively mediating abscisic acid (ABA) biogenesis, which leads to a decrease in the GA/ABA ratio. Different soybean genotype showed a similar repressed phenotype during seed germination under exogenous NaCl application. Salinity conditions led to high MDA (malondialdehyde) level during germination and the post-germinative growth stages. Salinity conditions also changed catalase, superoxide dismutase, and peroxidase activities. It condition made the transcription levels of ABA and GA biogenesis and signaling genes were altered. Salinity condition also considerably down-regulated active GA_1, GA_3, and GA_4 levels, whereas the ABA content was up-regulated; and therefore ratios, such as GA_1/ABA, GA_3/ABA, and GA_4/ABA, are decreased. Hence, FLUN partially rescued the delayed-germination phenotype as consistently with the hormonal quantification (Shu et al. 2017). Kumar (2017) report that the increasing of salinity level delayed the beginning and ending of germination and reduced final germination percentage because Nacl and Na_2SO_4 reduced both germination and seedling growth in both the soybean varieties. Yuniati (2004) report that the ratio between fresh weight (FW) and dry weight (DW) become indicator that genotype tolerant to salinity condition. The high value of ratio between fresh weight (FW) and dry weight (DW) shows that there's no inhibition on water uptake prosses. Wilis that indicate as tolerant genotype has FW/DW ratio higher than Tidar (indicated as sensitive genotypes). But FW/DW value of Wilis also decreased with increasing NaCl concentration. The shoot length of soybean germination decreased 2.2%, 2.2%, 4.4%, and 22.2% at treatment of NaCl 70 mM, 80 mM, 90 mM and 100 mM respectively from normal condition. In other hand, FW/DW of Wilis decreased 30%, 31.1%, 32.2%, 33.3% as treat 70 mM, 80 mM, 90 mM and 100 mM NaCl on shoot respectively from normal condition. Furthermore, the FW/DW ratio value of Wilis root decreased 13.9%, 18.3%, 24.7%, 28% with 70 mM, 80 mM, 90 mM and 100 mM NaCl treatment respectively from normal condition. Then the FW/DW ratio value of Wilis root decreased 3.7%, 20%, 13.8%, 26.3% with 70 mM, 80 mM, 90 mM and 100 mM NaCl treatment respectively from normal condition.

Salinity stress causes changes morphology of soybean genotype. Stress salinity affect the roots, canopy of plants soybeans and plant height decreased (Purwaningrahayu and Taufiq,2017; Bustingorri and Lavado, 2011; Hashi et al., 2015, Sabagh et al., 2015; Farhoudi and Tafti, 2011, Aini, 2014[b]). Legumes have different respons against stress salinity depend on both interspecies and varieties. Based on decreasing yield, critical point salinity stress on soybean, peanut, and green beans are 5 dS/m, 3.2 dS/m, and 1–2.65 dS/m respectively (Kristiono et al., 2013). At the soil salinity 3.91 dS m-1 soybean biomass could decreased up to 48.14% (Aini et al., 2014). Plant height and number of leaves have not decrease yet at the level of salinity of 3 dS/m up to the fourth week of Dering1, Demas1, Devon1 varieties. But the number of pods, pod weight and 100 seeds that genotypes were decreased since at level 3 dS/m of soil salinity (Yunita, 2018). The research objective was to study the growth of several genotypes at 10 dS/m soil salinity level.

2 MATERIALS AND METHODS

The study was carried out in a greenhouse Balitkabi in July - September 2017 used slight alfisol soil from MunengProbolinggo. The soil was dried and put in polibag 12 kg capacity, filled with 8 kg of soil. The soil in polybag was irrigated up to 100% moisture content. Phonska inorganic fertilizers were applicated alongside the plants during planting. Each pot is fertilized as much as 4 g per pot. At the beginning of planting, each pot planted with four seeds and then thinned at 15 days so that there were only two plants per pot. Saline water was applied when entering V1 phase (after the first trifoliate is fully formed). During the study, the crop is protected from pest, disease and weed disturbances for getting optimal growth of plants.

The study was arranged using a Randomized Block Design with the various of genotype as treatment. The various of genotypes were Deja 2, Dering, Karat 13, Panderman, GepakKuning, DaunLancip, Dega1 and Tanggamus. Variables observed in this study include: plant height, root length, stover weight, root dry weight and soil salinity level at the age of 24 dap, 45 dap, 60 dap and 75 dap.

3 RESULTS AND DISCUSSION

There were variety response of several genotypes in this research. That response show that every genotype have different defense attact to salinity. Firstly, all genotypes still alive at 45 days after planting (dap), but at 60 dap Dering, Tanggamus, Gepakkuning were dead, and only genotype DaunLancip could survive up to 75 dap.

3.1 Plant Height

When it was 24 dap, Karat 13 was the highest plant among 7 other genotypes, it was 23,9 cm. Then, when at 45 dap, the height of the Gepak Kuning and Tanggamus didn't increased since 24 dap, which is about 16 cm. While the height of Deja 2, Dering, Karat 13, Panderman, DaunLancip, Dega1 increased 97.9%; 18.2%; 13.9%; 1.0%; 88.6%; and 76.9% fromthe height plant at 24 dap. It very slight increased plant growth when entering 60 dap, Deja 2 only increased by 4.3%; Karat 13 increased by 3.4%, Panderman increased by 0.3%; DaunLancip increased by 2.2%; and Dega 1 increased 1.6% compared to 45 dap, while Dering, Tanggamus, GepakKuning were dead. Then at 75 dap, the height of DaunLancip increased 12.2% compared to 60 dap, while the others had died (Figure 1).

Similarity result was repoted by Abdelhamid et al. (2013) that the plant height of faba bean decreased with increasing salinity. At application NaCl 50 mM and 100 mM, plant height of faba decreased 18.1% and 22.9 % respectively from normal condition. Dolatabadian et al. (2011) reported that the plant height of soybean decreased since at 50 mM NaCl consentration parallel with increasing NaCl concentration. At level concentration of NaCl 25 mM, 50 mM and 100 mM, the plant height of soybean decreased 0%; 11.9% and 33.3 % respectively from normal condition. Queiroz et al. (2012) also reported that the plant height of soybean decreased 15.6%; 25.8%; 33.9% from the normal condition at applying NaCl 50 mM, 100 mM and 200 mM respectively. El Sabagh (2015) also reported that shoot dry weight of genotypes were positively affected by increasing salinity level. NaCl treatment stress highly significant on soybean growth. It revealed that the shoot dry matter was decreased with the increasing salinity levels.

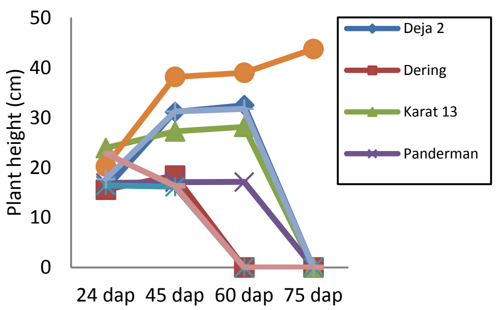

Figure 1. The Plant height of several genotypes at several observation

3.2 Root Length

Only Deja 2 and Daunlancip whose roots continued to grow up from 24 dap to 45 dap, that were 42.4% and 112% respectively. While Dering, Panderman, Gepakkuning, Daunlancip, Dega1 and Tanggamus approximately decreased 29.0%, 42.9%, 20.3%, 16.9% and 60.8% compared to the root length at 24 daprespectively. The root length of Karat 13 tends to be stable until 60 dap. Generally, the root length of the plant decreases at 60 dap, it could caused by the roots begin to fragile before the plant dies (at 75 dap). The only one DaunLancip that still alive but also get decreasing the length of roots at 75 dap. It was 31.3% decreased length of root compared to 60 dap (Figure 2).

Agarwal et al. (2015) report that salinity has differentially affected on root length growth depend on genotypes tolerance. The inhibitory effect of salinity gradually increases at 6 and 7.2 dS/m but failed to produce roots at 10 dS/mand beyond. Queiroz et al. (2012) also reported that the root length of soybean decreased with increasing NaCl concentration. At level concentration of NaCl 50 mM, 100 mM and 200 mM, the root length of soybean decreased 8.9 % 23.2% and 15.9% respectively from normal condition.

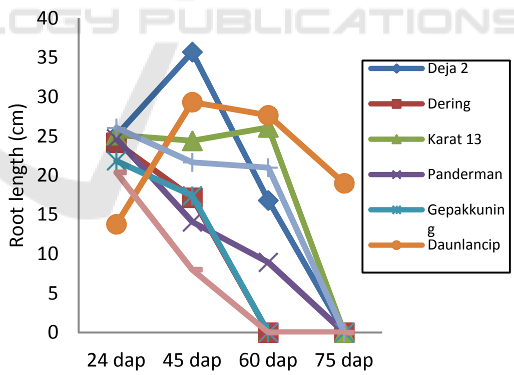

Figure 2. The Plant height of several genotypes at several observation

3.3 Plant Dry Weight

When it was 24 dap, the Dega had the highest stover weight compared to 7 other varieties, but at the age of 45 dap, all genotypes decreased dry stover weight except Gepakkuning and Daunlancip genotypes. Deja 2, Dering, Karat 13, Panderman, Dega1 and Tanggamus decreased dry stover weight up to 20.4%; 49.4%; 29.2%; 6.0%; 38.0%; and 69.2% respectively compared to 24 dap. Whereas Gepakkuning andDaunLancip increased dry stover by 2.3% and 102.2% compared to 24 dap respectively. Then at the 60 dap, GepakKuning was dead, while dry stover weight of Karat 13 and DaunLancip increased dry stover weight 96% and 206.3% compared to 45 dap. While Deja 2, Pandeman, and Dega1 decreased dry stover weight by 51.1%; 29.0% and 14.2% compared to 45 hst. At 75 hst, only daunlancip genotypes that survived but also get dry stover weight reduction by 29.1% compared to 60 dap (Figure 3).

Abdelhamid et al. (2013) reported that the plant dry weight of faba bean decreased with increasing salinity. At application NaCl 50 mM and 100 mM, plant dry weight of faba decreased 17.8% and 48.4 % respectively from normal condition. Dolatabadian et al. (2011) also reported that the plant dry weight of soybean decreased with increasing NaCl concentration. At level concentration of NaCl 25 mM, 50 mM and 100 mM, the weight of dry plant decreased 50.6%; 71.4% and 88.9 % respectively from normal condition. Queiroz et al. (2012) also reported that the weight of soybean dry plant decreased with increasing NaCl concentration. At level concentration of NaCl 50 mM, 100 mM and 200 mM, the weight of soybean dry plant decreased 31.4% 40.9% and 62% respectively from normal condition.

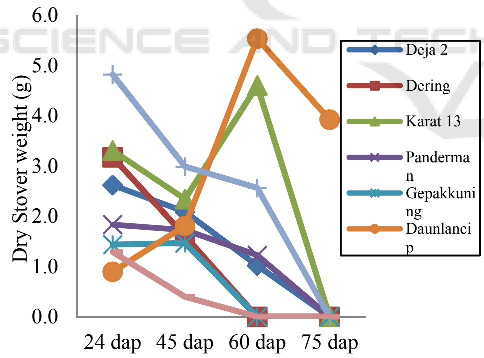

Figure 3. The dry stover weight of several genotypes at several observation

3.4 Root Dry Weight

Dega 1 was the genotype which has the highest root dry weight compared to the other seven genotypes at 24 dap, which is about 0.58 g/polybag. However, at the age of 45 days after planting Deja 2 was a genotype that had the highest dry root weight of 1.4 g/polybag or an increase of 441% from the 24 dap. The growth of roof of DaunLancip was the highest of other although it wasn't the most drystover weight, butit increase 651,5% compared by 24 dap, its about 0,8 g/polybag. Dering, Karat 13, Panderman, GepakKuning, Dega 1 and Tanggamus only increased 47.3%, 160.7%; 265.6%; 188.9%; 103.4% and 140.5% respectively compared to 24 dap or 0.6 g/polybag; 0.8 g/polybag; 0.8 g/polybag; 0.4 g/polybag; 1.2 g/polybag; and 0.3 g/polybag. At 60 dap, only Karat 13 and Daunlancip genotypes that increased the dry weight of roots, as many as 49.1% and 54.8% compared to 45 dap as much as 1.15 g/polybag and 1.28 g/polybag. Deja 2, Panderman and Dega 1 decreased dry root weight by 73% ; 62.0% and 44.1% compared to 45 dap or about 0.4 g/polybag; 0.3 g/polybag; and 0.7 g/polybag. Dering, GepakKuning and Tanggamus are dead on this time (60 dap). At the age of 75 days, onlygenotypes Daunlancip that still alive and get decreasing dry root weight 47.7% compared to 60 dap or 0.7 g/polybag(Figure 4).

Dolatabadian (2011) result that the root dry weight of soybean decreased with increasing NaCl concentration. At level concentration of NaCl 25 mM, 50 mM and 100 mM, the weight of dry root decreased 45.1%; 76.8% and 90.2 % respectively from normal condition. Queiroz et al. (2012) also reported that the weight of root dry of soybean decreased with increasing NaCl concentration. At level concentration of NaCl 50 mM, 100 mM and 200 mM, the dry root weight of soybean decreased 36.4% 42.4% and 45.5% respectively from normal condition.

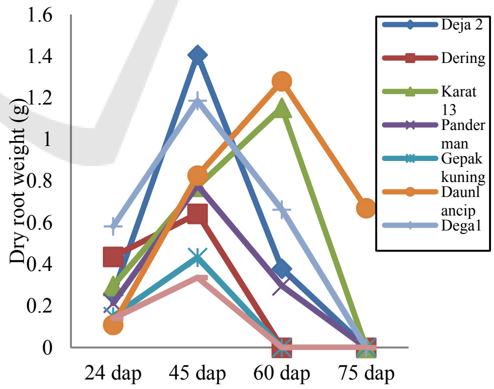

Figure 4. The dry root weight of several genotypes at several observation

3.5 Soil Salinity

Until the age of 24 dap, all genotypes still have the same soil salinity which is 10 dS/m then get decreasing at the age of subsequent observations. At 45 dap, the hardest decreased had occurred on Karat

13, Daunlancip and Dega 1 genotype. These three genotypes have soil salinity content between 4.3 dS/m - 4.6 dS/m. While the other five genotypes have soil salinity content ranging from 5.5 dS/m - 8.8 dS/m. The soil salinity content of Daunlancip and Dega 1 more decreased at 60 dap, it about 3.2 to 3.7 dS/m. While Deja 2, karat 13, Panderman, has soil salinity ranging from 4.7 dS/m - 7.23 dS/m. Dering, GepakKuning and Tanggamus are dead from the age of 45 dap, its caused the soil salinity does not change from the age of 60 hst up to 75 dap.

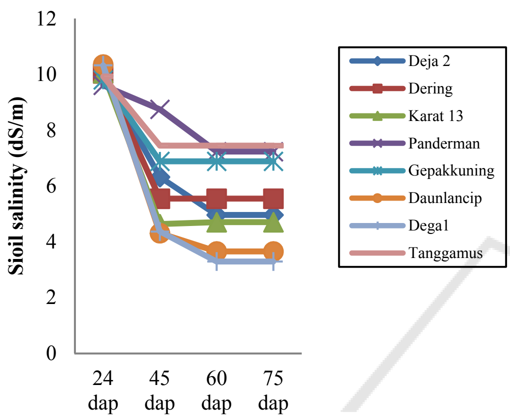

Figure 5. The soil salinity at several observation

3.6 Discussion

Daunlancip was categorized as resistant plant to high salinity and Karat 13 was categorized as rather resistant. Dering, Tanggamus, GepakKuning, Deja 2, Panderman and Dega 1 were not resistant. Plants that can survive at saline condition were plants that can absorb the salt content in soil and able to excrete it. These plants relatively has low level of electrical conductivity in the soil and get high dry biomass weight. For these plants, K^+ and Na^+ content are needed for efficiency of cell membrane osmosis regulation and growth of leaf area (Shabala et al., 2010). This plant willhave stability of K^+ and Na^+ content although the soil electrical conductivity levels were added (Aini et al., 2014[a]).

Genotypes that are not resistant to salinesoil will get thinning cortex, thickening of cuticle and xylem. The decreasing of cortex thickness caused by salinity stress. In otherside, salinity stress caused a greater deposition of lignin in vascular tissues and/or xylem development. So, its condition induced acceleration of the development of xylem stems. (Dolabadian, 2011). Furthermore, J. López-Portillo et al (2005) report that conductivity will decreases if stems are fullfilled with lignin of extreme salinities. This condition may inhibited the the growth, where water is the main element needed by plants to carry out photosynthesis. Otherwise the genotypes that tolerant on salin soil will get relatively lower ion leakage through roots, larger vascular region area, and wide metaxylem vessel in roots and stems. Its also had greater phloem and pith cell area in stems that increased midrib thickness, cortical cell area, metaxylem, and vascular bundle area area in leaves with increase in salinity level. Furthermore, the vascular region area in roots, vascular region thickness, leaf thickness, epidermal thickness, in leaves were better in with an increase in salinity levels (Younis et al., 2013).

Na^+ and Cl^- content were generally increased with an increasing salinity level. Its concentration in shoot was higher than in roots. In the roots decreased and in shoots increased under salt stress conditions. In this salinesoil conditions, plant cells utilize K^+ as a metabolite to maintain turgor to escape from osmotic shock (El Sabagh et al., 2015). But for genotype that tolerant in salinesoil, it could be low contents of Na^+ and Cl^- in the tissues, and non-invasive micro-test technique. Its revealed that the roots had higher ability to extrude Na^+ and Cl^- (Chen et al.2013).

The high K^+ and Na^+ content in plant also reduced N and Mg uptake, where those are macro element that needed on photosynthesis process (Anitha and Usha, 2012, Subramanyam et al., 2012, Aini et al. 2014[a], Taufiq et al. 2015). Amirjani (2010) report that salinity also decreased contents of Ca^{2+} and Mg^{2+}. Decreased on that contents were significantly as salinity level increased. The contents of Ca^{2+} decreased by 36, 46 and 57% when applied with 50, 100 and 200 mM NaCl, respectively of the control. The content of Mg^{2+} 36, 38 and 33%when applied with 50, 100 and 200 mM NaCl respectively of the control.

Mannan et al. (2013) report that salinity decrease in Relatif Water Conten (RWC) and exudation on plant. Decrease of RWC was pronounced especially at the later stages of plant growth and at high concentrations of salinity. The exudation rate of a plant becomes slower with increase salinity. Decreasing exudation rate of plant results in a lower water uptake by the plant. Water required for plant cell turgidity and photosynthesis process. If plant were not get enough water then the cell turgor will be low and stomatal will close. Stomatal closure caused the CO2 supply constrained, then resulted photosynthetic prosess decreased (Aini et al. 2014). The other side, a wide xylem diameter will reduce cohesion speed that will affect the arrival of water to the leaves then caused water uptake decreased (Totoa and Yulismab, 2017; Hang and Mai, 2016; Khan et al., 2015). Furthermore, salinity inhibited activation of rubisco enzyme due to the decrease of rubisco activase content that became an important limiting factor of photosynthesis (Chen et al.2013) beside water. These phenomenon that caused the weight of soybean biomass and its growth decreased since 45 dap.

4 CONCLUSION

The soil salinity was decreased plant height, root length, dry stover weight and dry root weight of soybean. Decreasing of it variable were varied based on potential defences of it genotype. Based on this research could be said that all genotypes still live up to 45 days, but at 60 dap, Dering,Tanggamus, Gepakkuning was dead, and only DaunLancip can survive up to 75 days**.**

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