TESTING OF BLACK SOYBEAN SEED RESPONSE TO SALINITY STRESS IN GERMINATION STAGE

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Abstract

The objective of this research is to know the response of black soybean seed to salinity stress in germination stage and also to identify the interaction between the two factors. This research has been conducted from April to August 2016 at the Laboratory of Seed Science and Technology of the Faculty of Agriculture, Syiah Kuala University. The experiment was designed using a Factorial Random Block Design. The first factor was the four national varieties of black soybeans (Detam 1, Detam 2, Mutiara 2 and Mutiara 3) and the second factor was the concentration of NaCl (0; 2; 4; 6; 8; and 10 g L-1). There are 24 treatment combinations each repeated three times. The parameters observed were viability (maximum growth potential, germination and time to reach 50% of total germination) and vigor of growing strength (vigor index, relative growth rate, synchrony growth, primary root length of normal seedling germination and dry weight of normal seedling germination. The study showed that Detam 2 were more tolerant than other varieties based on all viability and vigor parameters of growing strength observed. The increase in NaCl concentration at level 4 g L-1 had a very significant effect on the observed parameters indicated by the decrease of viability value and vigor of growing strength. There was a very significant interaction between varieties and concentration of NaCl to viability and vigor of soybean seedling growth that is at the maximum growth potential, primary root length of normal seedling germination and dry weight of normal seedling germination.

Keywords: salinity, varietas, viability and vigor, black soybean.

BACKGROUND

Demand for soybeans increases with population growth. The average annual soybean requirement is 2.3 million tons. Soybean production in 2014 and 2015 in Indonesia respectively consume as much as 954,997 tons and 982,967 tons of dry beans, with productivity reached 1.57 tons ha-1 in 2015 (Badan Pusat Statistik, 2016). In general there are two types of soybeans known in Indonesia, namely yellow soybeans and black soybeans. Black soybean has the advantage as raw material of healthy food and raw material of good quality soy sauce industry, besides it can also improve the quality of black color in soy sauce (Adie et al., 2009). The content of anthocyanin, isoflavones and mineral Fe black soybeans is higher than that of yellow soybean (Kuo et al., 2006). However, the productivity of black soybean at farmers' level is only around 1.1 tons ha-1 (Badan Litbang Pertanian, 2008). The national soybean area in 2000 of 824,485 hectares decreased to 567,624 hectares in 2012 and increased the area of soybean by 624,848 hectares in 2015. Despite increasing land area, it has not been able to supply soybean requirement of 2.3 million tons year-1 (Badan Pusat Statistik, 2016).

One effort that can be done to overcome this is to optimize the sub optimum land potential. Tidal land, saline, peat lands and lands near the mining area are sub optimum lands (Yuniati, 2004). Saline land is one of the land that can be used for soybean planting. Saline fields contain large amounts of dissolved NaCl salts which are abiotic stress factors that interfere with plant growth and production (Neumann, 1995). The salin categories, according to Jones (2002) are divided into four levels: if the value of Electricity Supply (DHL) <1.2 dSm-1 includes non-saline; 1.2-2.4 dSm-1 including somewhat saline; 2.4-4.4 dSm-1 including medium salinity and 4.5-8.9 dSm-1 including high salinity.

Seeds grown in high-margin areas are very difficult and can't germinate, caused by water-absorption by seeds and poisoning by the salt-producing ions (Copeland, 1976). According to Sunarto (2001), efforts to overcome the conditions of saline can be achieved through the assembly of varieties that are tolerant to salinity or adapt the superior varieties that already exist in the saline conditions. Thus the use of tolerant varieties is the most effective way to harness the potential of saline land in an effort to increase national soybean production.

Based on the above description, it is necessary to have an early test to find out how big the influence of salinity to vigor growth strength of some varieties of black soybeans, so that finally obtained varieties are tolerant to high salinity.

METHODS

The research was conducted at the Laboratory of Seed Science and Technology Agrotechnology Department Faculty of Agriculture, Syiah Kuala University. Black soybean seeds of Detam 1, Detam 2, Mutiara 2 and Mutiara 3 varieties obtained from BALITKABI and BATAN, NaCl pro analysis, aquadest, stencil paper, plastics, oven, electricity conductivity meters, and germinator.

Sorting black soybean seeds of each variety that has been provided, taking into account the desired seed criteria, is physically looking good, pithy and not wrinkled. The seeds used are certified seeds that have high initial germination percentage, Detam 1 (86.66%), Detam 2 (98.66%), Mutiara 2 (94.6%) and Mutiara 3 (90.66%). The total required of seed is 1800 grain.

Preparation of NaCl solution. NaCl was weighed using an analytical scale, according to the treatment of 0 g L^{-1}, 2 g L^{-1}, 4 g L^{-1}, 6 g L^{-1}, 8 g L^{-1} and 10 g L^{-1}.

Preparation of Planting Media. The paper media substrate is moistened using a NaCl solution, according to the concentration set.

Germination of seed. Seed germination was carried out on sterilized paper media according to a NaCl concentration of 25 grains per unit, tested using the medium with a rolled-up paper test method. Then seeds are added by using germinator.

Statistical analysis. This study used a Completely Randomized Design 4x6 factorial pattern with two factors (varieties and NaCl concentration). Thus, there were 24 treatment combinations with 3 replications to obtain 72 experimental units.

RESULT

Effect of Variety on Viability and Vigor Black Soybean Seed

Effect of varieties very significant on maximum growth potential, germination, relative growth rate, synchrony growth, primary root length of normal seedling, and dry weight of normal seedling. Then, no significant effect on the vigor index and time to reach 50% of total germination. Value of viability and vigor parameters are presented in Table 1.

Tabel 1. Mean of maximum growth potential, germination, relative growth rate, synchrony growth, vigor index and time to reach 50% of total germination, primary root length of normal seedling, and dry weight of normal seedling in some black soybean varieties

Parameter	Varietas			
	Detam 1 (V_1)	Detam 2 (V_2)	Mutiara 2 (V_3)	Mutiara 3 (V_4)
Maximum potential growth (%)	94.00 a	99.33 c	95.56 ab	96.67 b
Germination (%)	49.52 a	61.26 b	58.54 b	50.56 a
Vigor Index (%)	9.07	10.05	9.20	8.94
Relative growth rate (%)	43.52 a	56.29 b	53.97 b	43.98 a
Synchrony growth (%)	21.35 a	28.39 b	22.65 a	21.36 a
Time to reach 50% of total germination (day)	1.27	1.17	1.25	1.17
Primary root length of normal seedling (cm)	18.66 a	19.26 b	19.60 b	19.59 b
Dry weight of normal seedling (g)	1.40 bc	1.20 a	1.50 c	1.32 ab

Description: The numbers followed by the same letter on the same line show no significant difference at the 0.05 chance level (DMRT Test)

Tabel 1 showed that Detam 2 was the best variety, having high vigor compared to Detam 1, Mutiara 2, and Mutiara 3. Detam 2 variety produced the highest normal seedlings on several parameters observed. The Detam 1 variety is a low viability and vigor variety and can not afford normal germination. Detam 2 is a superior variety compared to some other varieties, heaviness and vigor. It is believed that the genetic characteristics of Detam 2 varieties are more tolerant of high salinity, so as to adapt to an environment less favorable for growth. In accordance with the opinion of Sadjad *et al*. (1999) each variety has different superior properties, genetic properties are the result of the arrangement of genes in the form of varieties that are not homogeneous. Genetic arrangement of a variety determines the character of the varieties. Copeland (1976) states, genetic factors Is one of the causes of seed vigor difference. High vigor that produce tolerant seeds can grow and develop in suboptimum land conditions, in addition to being stored for a long time. Seeds that have good vigor will have a high growth rate, so the seeds will quickly germinate in a short time. Conversely, seeds that have a bad vigor will affect the physiological and morphological crops produced in the field (Camargo and Vaughan, 1973).

Effect of NaCl Concentration on Viability and Vigor Black Soybean Seed

NaCl concentration had significant effect on all observed parameters, including: maximum growth potential, germination, vigor index, relative growth rate, synchrony growth, and time to reach 50% of total germination, root length of the normal seedling and dry weight of normal seedling, presented in Table 2. The negative effect is, NaCl will decrease the percentage of normal seedlings on each of the observed benchmarks.

Tabel 2. Mean of maximum growth potential, germination, relative growth rate, synchrony growth, vigor index, time to reach 50% of total germination, primary root length of normal seedling, and dry weight of normal seedling in some NaCl concentration

Parameters	NaCl Concentration					
	0 g L^{-1}	2 g L^{-1}	4 g L^{-1}	6 g L^{-1}	8 g L^{-1}	10 g L^{-1}
Maximum potential growth (%)	98.00 c	99.00 c	96.33abc	96.67 bc	94.00 a	94.33 ab
Germination (%)	74.93 d	58.62 c	55.59 c	50.10 b	49.65 b	40.93 a
Vigor index (%)	53.03 b	0.57 a	0.57 a	0.57 a	0.57 a	0.57 a
Relative growth rate (%)	85.99 d	54.80 c	50.44 b	40.04 b	38.43 b	26.93 a
Synchrony growth (%)	16.12 b	27.71 c	25.70 c	39.52 d	29.04 c	2.21 a
Time to reach 50% of total germination (day)	0.58 a	1.03 b	1.45 c	1.49 c	1.34 c	1.42 c
Primary root length of normal seedling (cm)	21.04 d	21.48 d	21.01 d	19.59 c	18.91 b	13.63 a
Dry weight of Normal seedling (g)	1.74 c	1.39 b	1.31 b	1.25 b	1.42 b	1.02 a

Description: The numbers followed by the same letter on the same line show no significant difference at the 0.05 chance level (DMRT Test); ( ): is the number before the arcsin transformation √ (%)

Plants that live in saline conditions generally face two major problems. namely the negative water potential and high concentrations of sodium (Na^+) and chloride (Cl^-) ions. The negative water potential will spur water out of the tissue so that the plant loses the pressure of the turgor that causing the plant cells to become weak. Thus, shrinking the cytoplasm and the escape of the plasma membrane from the cell wall called plasmolysis.

Salinity greatly affects the germination of soybean seeds. Dianawati *et al*. (2013) states that. The higher the concentration of NaCl. the germination of soybean seeds is decreasing. In accordance with the results of this study. The higher the concentration given. the decreasing germination rate. Increasing the NaCl concentration may inhibit the seeds imbibition process because salt solubility can decrease the osmotic pressure so that the seed can not absorb water from the growing environment. which is necessary to activate the enzyme for germination process. In addition to blocking the process of seed imbibition. plants will become dehydrated due to the high salinity of the soil. This condition causes plants to experience hyperosmotic pressure characterized by reduced turgor pressure and water loss from the tissues (Boudsocq and Lauriere, 2005). Lubis (2008) added that the increased concentration of NaCl causes increased Na^+ and Cl^- ions absorbed into tissues that would inhibit metabolism in plants. In addition, high concentrations of salinity are capable of causing toxic effects to seeds that resulting in the germination of seeds inhibited, even able to kill seeds.

Interaction between Varieties with NaCl Concentration on Viability and Vigor of Black Soybean Seed

There is a very significant interaction between varieties and NaCl concentration on the viability and vigor of black soybean seeds on the parameters of maximum growth potential, primary root length of normal seedling, and dry weight of normal seedling. The values are presented in Table 3.

Table 3. Interaction between varieties with NaCl concentration to maximum growth potential, primary root length of normal seedling and dry weight of normal seedling of black soybean seed

Parameter	Variety	NaCl Concentration					
		0 g L^{-1}	2 g L^{-1}	4 g L^{-1}	6 g L^{-1}	8 g L^{-1}	10 g L^{-1}
Maximum potential growth (%)	Detam 1	98.67 ABc	100.00 Bc	94.67 ABbc	94.67 ABbc	86.67 Aa	89.33 Aab
	Detam 2	100.00 Ba	100.00 Ba	100.00 Ba	100.00 Ba	97.33 Ba	98.67 Ba
	Mutiara 2	94.60 Aab	96.00 Aab	97.33 ABab	98.67 Bb	93.33 Ba	93.33 ABab
	Mutiara 3	98.67 ABbc	100.00 Bc	93.33 Aa	93.33 Aab	98.67 Bbc	96.00 Babc
Primary root length of normal seedling (cm)	Detam 1	21.68 Be	20.66 Ade	20.19 Acd	19.46 Ac	18.24 Ab	11.76 Aa
	Detam 2	20.87 ABc	21.74 Bc	21.13 ABc	19.13 Ab	18.89 ABb	13.83 Ba
	Mutiara 2	20.51 Acd	21.79 Be	21.47 Bde	19.87 Abc	18.93 ABb	15.00 Ca
	Mutiara 3	21.13 ABc	21.72 Bc	21.24 Bc	19.92 Ab	19.60 Bb	13.94 BCa
Dry weight of normal seedling (g)	Detam 1	2.37 Bc	1.31 Aab	1.27 Aab	1.11 Aab	1.36 ABb	1.00 Aa
	Detam 2	1.37 Ab	1.26 Ab	1.24 Aab	1.34 ABb	1.07 Aab	0.90 Aa
	Mutiara 2	1.54 Ab	1.69 Bb	1.53 Ab	1.51 Bb	1.64 Bb	1.13 Aa
	Mutiara 3	1.68 Ab	1.30 Aab	1.22 Aab	1.05 Aa	1.62 Bb	1.07 Aa

Description: The numbers followed by the same letter (uppercase on the same column. lower case on the same line) show no significant difference at the 0.05 chance level (DMRT Test)

Table 3 shows that Detam 2 at NaCl concentration of 0 g L^{-1}. 2 g L^{-1}. 4 g L^{-1}. 6 g L^{-1}. 8 g L^{-1} have the highest maximum growth potential, but not significantly different at NaCl concentration 10 g L^{-1}. Maximum growth potential was lowest for the Detam 1 at NaCl concentration 8 g L^{-1} were significantly different from Detam 2. Mutiara 2 and Mutiara 3 at NaCl concentration 8 g L^{-1}. Based on primary root length of normal seedling, the longest root varieties contained in the treatment Detam 1 at NaCl concentration 0 g L^{-1} which is significantly different of Mutiara 2. In contrast to the Detam 2. Mutiara 2 and Mutiara 3 varieties seen decreased root length at NaCl concentration 6 g L^{-1}. These results are consistent with the statement Bernstein and Kafkafi (2002). the accumulation of salts in the soil can damage to root growth due to an osmotic effect which causes the effect of water deficit or excess salinity ions. Wang and Yamauchi (2006) adding excess salt can affect orientation root cell growth (growth anisotropy). Change anisotropy of cell growth implies that NaCl can affect for the root growth. Interaction between varieties and NaCl concentration to primary root length of normal seedling can be seen in Table 3. The highest values found in Detam 1 varieties were significantly different from Detam 2. Mutiara 2 and Mutiara 3 at NaCl concentration of 0 g L^{-1}. The lowest of dry weight of normal seedling is found in Detam 2. Dry weight of normal seedling has decreased with salinity treatment. The average value of interaction between varieties and NaCl concentration on dry weight of normal seedling can be seen in Table 3.

Follet *et al.* (1981) states that under saline conditions, water availability decreases but the rate of plant respiration tends to increase. This leads to a decrease in dry weight of normal seedlings. This result is consistent with the research of Neves *et al.* (2005) where salinity stress can significantly reduce germination. root growth and biomass weight in response to the given NaCl concentration. The decrease in dry weight of plants due to salinity stress has also been reported in rice and wheat crops (Zeng *et al*. 2002; Hu *et al*. 2006).

CONCLUSION

Conclusion

Detam 2 is the most tolerant varieties of salinity stress compared to Detam 1, Mutiara 2 and Mutiara 3. The NaCl concentration begins to affect germination at 2 g L-1. The best interaction is in the treatment of Detam 2 varieties at a concentration of 6 g L-1 NaCl due to Detam 2 is still able to tolerate salinity stress to a concentration of 6 g L-1 NaCl.

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