Normal distribution of agronomic characters and plant heritability of soybean F2 population hybridization between salt resistance genotype and Anjasmoro variety

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Abstract. The increase of soybean production should be pursued continuously, including the utilization of marginal land such as saline soils. This study aimed to estimate the frequency of normal distribution and heritability of agronomic characters of soybean F2 population hybridization salt resistance genotype and Anjasmoro variety to support the expansion of planting area in the saline land. The research was conducted at the Faculty of Agricultural land experiments using saline soil as planting media with salinity levels 5-6 dS/m was conducted in March to May 2015. The data were analysed using chi-square test for suitability distribution normal. The results showed the frequency of character plants height, the number of productive branches, flowering dates follow a normal distribution, while the frequency distribution of harvesting, number of seeds/plant and seed weight/plant does not follow a normal distribution. Heritability belonging to the high criteria on plant height, number of productive branches, harvesting, the flowering dates, number of seeds/plant and seed weight/ plant belonging to the moderate criteria. The results showed the genetic potential of plants to be developed in saline land in support of the expansion of soybean planting in saline soil.

1. Introduction

Soybean (Glycine max L. Merr.) is one of the important leguminous plant. It is also considered as a good source of vegetable protein and oil since it has the highest level of protein in comparison with the other leguminous plants [1]. Increased production in quantity and quality can be reached through the use of improved varieties. Selection for developing superior variety can be done through plant breeding programs. The crossing is an important process in breeding because the cross serves as a source to generate genetic diversity in the offspring in addition to the potential to produce homozygous lines that underlie the formation of new varieties [2].

Selection for developing superior variety can be directed to resistance to environmental stresses such as salinity. Utilization salinity becomes a limiting factor of growth of soy, which inhibits the growth through the reduction of biomass [3], thus lowering the yield [4].

In agronomy, the strategy for tackling the problems of marginal land by using plants that are tolerant to salinity [4-5]. However, efforts the use of saline-tolerant varieties are still constrained by the limited availability of superior soybean varieties of high yielding and tolerant of salinity. Utilization of saline land into agricultural land has many obstacles. Salinity is the concentration of dissolved salts in large
quantities that can affect the growth of most plants. Effect of salinity on the plant is very complicated. Salinity will cause stress ion, osmotic stress and oxidative stress [6-7].

In addition to demonstrating growth disturbance, the response of sensitive soybean genotypes of saline conditions is also a reduction in the rate of photosynthesis [8]. The most certain character of crop seed yield needs to be identified to determine the normal distribution of the resulting soy derivatives [9-10].

Development of breeding programs to increase tolerance to salinity is also supported by some ways such as efficiency screening techniques, identification of genetic variability, inheritance resistant properties, as well as the strategy of breeding to transfer desirable traits [11-12]. Besides, it is important to know the normal distribution of each derivative hybridization.

According to Mahendra [13], F2 seed is a segregating population. The distribution of genotype frequencies illustrates level and extensive recombinant segregation in the F2 generation. The frequency distribution can be used as an estimate of the pattern of inheritance and some genes involved in the control of a trait [14]. Agronomic characters of a plant are grouped into two: the character of the qualitative and quantitative character. The qualitative character controlled by one or two genes follow Mendelian ratios or modification. Quantitative trait controlled by many genes that do not follow the pattern segregating or modification Mendelian ratio [15]. Sriwidarti research [16] shows the character number of pods per plant, grain weight per plant to plant beans are spread normal quantitative character with one peak and is controlled by many genes. Marquez-Ortiz et al. [18] reported high heritability means that genetic factors greater influence than environmental factors. Besides, heritability is also important in selecting plants. Heritability is one of the most important considerations in plant breeding activities. Heritability is the ratio between the genetic variance of the phenotypic variance. Phenotypic variance influenced by genetic and environmental factors.

Selection is a process of plant breeding and is the basis of entire crop improvement to obtain new superior cultivars [19]. Segregation of a character is one of the genetic parameters that need to be known concerning the selection process [20]. Because it is an estimate of the normal distribution of agronomic characters and heritability of F2 salt tolerance genotypes of soybean with Anjasmoro variety needs to be done as the basis for selection. This study aimed to estimate the frequency of normal distribution and heritability of agronomic characters of F2 salt tolerance genotype soybean with varieties Anjasmoro to support the expansion of planting area in saline land.

2. Materials and Methods
Research conducted at the Experimental Farm, Faculty of Agriculture Universitas Sumatera Utara using a planting medium saline soils with salinity levels 5-6 dS/m which was conducted from March to July 2015. The seed used is F2 population of hybridization salt resistance genotypes of soybean with Anjasmoro variety. The experimental design used was a design without replicates because the seed used is the F2 seeds are still experiencing segregation [21].

The research starts from the hybridization of soybean genotypes resistant with Anjasmoro variety. Source of female elders obtained from Rahmawati [22] research who managed to select salt resistance genotypes that have been tested molecularly. Results hybridization (F1) are grown to produce F2 seed. This research is still up to the second generation were planted on saline soils with salinity levels 5-6 dS/m.

The research starts with the determination of the location, land preparation, planting, maintenance, fertilizing and harvesting. Agronomy observed character are plant height, the days to flowering, harvesting, number of seeds per plant and weight of seeds per plant.

Data were analysed by Normal distribution fit test. Conformance testing normal distribution used chi-square test [23] as follows.
\[ x^2 = \sum_{i=1}^{p} \frac{(f_i - F_i)^2}{F_i} \]  

(1)

Where, \( f_i \) = frequency of observation; \( F_i \) = the expected frequency for the- i class.

\( x^2 \) calculated value compared to the value table \( X^2 \) with degrees of freedom (p-3), when \( x^2 \) calculated < \( X^2 \) table the characters are analysed normal distribution. Otherwise, \( x^2 \) calculated >\( X^2 \) table then analysed the characters are not normally distributed.

Probalititas curve of normal distribution was analysed using statistical software Minitab version 17. Moreover, the heritability was analysed using the following formula :

\[ h^2 = \frac{\sigma^2_g}{\sigma^2_p} = \frac{\sigma^2_g}{\sigma^2_g + \sigma^2_e} \]  

(2)

Where the criteria of heritability :

\( h^2 > 0.5 \) : high

\( h^2 0.2-0.5 \) : moderate

\( h^2 < 0.2 \) : low

3. Results and Discussion

Normality test results of agronomic characters of F2 population hybridization salt resistance genotype and Anjasmoro variety indicate the characters that follow the normal distribution such as plant height, days to flowering, number of seeds per plant and seed weight per plant, while the characters do not follow distribution, ie normal productive branch number and time of harvest (Table 1).

| No | Agronomic Characters                  | \( X^2 \) | Distribution |
|----|--------------------------------------|----------|-------------|
| 1  | Plant height                         | 13.93    | Normal      |
| 2  | Number of productive branch          | 22.54    | Non-normal  |
| 3  | Days to flowering                    | 9.80     | Normal      |
| 4  | Days to harvest                      | 54.21*   | Non-normal  |
| 5  | Number of seeds per plant            | 11.78*   | Normal      |
| 6  | Seed weight per plant                | 11.37*   | Normal      |

\( X^2 \) Table : 14.067

Character flowering dates, number of seeds per plant and seed weight per plant including quantitative trait controlled by many genes, each of which genes affect the expression of a character [25]. According to Baihaki [21], the quantitative character is a character that is controlled by many genes, and each gene contributes to the appearance of the characters are analysed, with the role of each gene is not great. This causes segregation patterns for the characters days to flowering, number of seeds per plant and seed weight per plant challenging to identify and inheritance is not as simple as in Mendelian genetics.

Quantitative trait generally follows a normal distribution because many genes control it, in contrast to the qualitative character that often does not follow a normal distribution, because controlled by a few genes. A character in the frequency distribution of F2 population showed a normal distribution, and these characters are controlled by many genes and a quantitative character [26, 24]. According to Baihaki [21], the quantitative characters, each gene has a small contribution in the inheritance of a character, so that the individual effects cannot be detected by the Mendelian method. Fehr [15] states
that the appearance of quantitative trait is influenced significantly by the environment. Because of the segregation pattern of this character do not follow Mendelian ratios or modification.

Heritability indicates the proportion of genetic and environment on the phenotype of the plant. Heritability of this study show Table 2.

| No. | Characters                      | H     | Criteria   |
|-----|--------------------------------|-------|------------|
| 1.  | Plant height                   | 0.20  | Moderate   |
| 2.  | Number of productive branch    | 0.89  | High       |
| 3.  | Days to flowering              | 0.31  | Moderate   |
| 4.  | Days to harvest                | 0.19  | Low        |
| 5.  | Number of seeds per plant      | 0.38  | Moderate   |
| 6.  | Seed weight per plant          | 0.29  | Moderate   |

Heritability of plant height, days to flowering, number of seeds per plant and seed weight per plant are moderate heritability values, shows that the proportion of genetic and environmental factors controlling the agronomic characters. Only the number of branches that have high heritability values, indicating genetic factors more influence the character compared to the influence of environmental factors. Roy [27] states that the diversity of genetic factors controlled determines the success of selection.

As for the time of harvest is known with low heritability value of 0.19. This suggests environmental factors affect the soybeans harvest time. This can be caused by stress, environmental factors, in this case, the salinity accelerates its life cycle. Phang et al. [4] states that for plants exposed to abiotic and biotic stress will accelerate the life cycle to preserve their offspring.

The results of this study show on F2 with high heritability value on the number of branches and harvesting respectively of 0.89 and 0.51. This indicates that genetic factors influence the characters compared with environmental influences. Marquez-Ortiz et al. [18] reported high heritability means that genetic factors more significant influence than environmental factors. The number of branches is the character that greatly affects soybean production. The more the number of branches will increase soybean production.

In this study, the heritability of the branches number in the high criteria showed the potential to be developed for the cultivation in saline land. This is because genetic factors than environmental factors more influence the number of branches in the F2 hybridization of salt resistance genotype and Anjasmoro variety. Ceccarelli et al. [28] suggested that selection of the stress environment conducted in the target environment to maximize the expression of genes that control the yield and crop adaptability.

4. Conclusions
Plant height, days to flowering, number of seeds per plant and seed weight per plant shows the normal distribution that could potentially be developed in saline soil because of many genes with the standard distribution control some characters. Heritability of plant height, number of branches, flowering dates, number of seeds per plant and seed weight per plant is high and is indicating the genetic potential of plants to be developed in saline land to support the expansion of planting area of soybean in the saline land. However, the character of the age of flowering with low heritability values that show the effect of salinity affect harvesting.

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