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POTENTIAL YIELD OF ACID-ADAPTIVE SOYBEAN PROMISING LINES IN ULTISOLS OF TANAH LAUT REGENCY, SOUTH KALIMANTAN PROVINCE, INDONESIA

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ABSTRACT

Soybean is an important food commodity after rice and corn in Indonesia. Until now soybean demand cannot be fulfilled by domestic production, although the chances of fulfillment can be attempted. One of the attempts to increase domestic production is soybean planting in acid dry land that is widely available in Indonesia. The research aimed to obtain soybean lines that are adaptive in acid dry land. A total of 10 soybean promising lines and two check varieties (Wilis and Tanggamus) were grown in acid dry land in Tanah Laut Regency, South Kalimantan Province, Indonesia. Experimental design used was randomized complete block design with four replications. The data were analyzed using analysis of variance and followed by Least Significant Different test. The results showed that the promising lines of SC5P2P3.5.4.1-5 and SC5P2P3.23.4.1-5 achieved production of 1.51 t/ha and 1.48 t/ha, respectively. These yields were higher than Wilis and Tanggamus varieties that reached 1.41 t/ha and 1.13 t/ha, respectively. These two promising lines had the potency to be developed in Tanah Laut Regency, South Kalimantan or other areas with similar soil characteristics.

Keywords: Acid dry land, soybean, Tanah Laut Regency, ultisols

INTRODUCTION

Soybean is an important food crops for Indonesia and is ranked third after rice and corn. Soybean self-sufficiency in 2017, announced by the Indonesian Government, needs to be followed up with efforts in the area of soybean planting in accordance with soybean growth requirements. Soybean has the ability to grow in areas with optimal up to suboptimal soil types. Soybean can be planted in all soil types such as Grumusols, Inceptisol, Ultisols and others. Therefore, various efforts have been and are being carried out for soybean planting in various agroecology such as paddy fields, dry land, acid dry land and tidal swamp land.

Opportunity of soybean development in acid dry land is very high, not only because of soybean ability to grow in acid dry land, but also because of the wide area of acid dry land. Acidic dry land area in Indonesia is 108.8 million ha or approximately 69.4% of the total dry land in Indonesia (BBSDLP 2012). Dry land with Ultisols and Oxisols soil types occupy the largest area in Indonesia (Hidayat & Mulyani 2002). Acidic dry land area in South Kalimantan Province is 2,189,535 ha (Mulyani & Syarwani 2013). Ultisols soil type located in South Kalimantan Province is included in soil suborder of Udults, namely Ultisols that develops in areas with udic moisture regime (Nugroho & Istianto 2009).

Soybean ability to adapt in Ultisols soil types can be reflected on soybean improvement efforts through plant breeding programs as well as the amelioration of the land that suitable for soybeans growth requirements. Usually, soybean improvement for acid dry land adaptation in breeding program is conducted by crossing, followed by the selection of segregating populations, yield trials and adaptation trials. Adaptation trial should be conducted in the target area in order to obtain the soybean promising

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lines that can adapt in this area. In this study, the target area was acid dry land in Tanah Laut Regency, South Kalimantan Province having Ultisols soil type. The research aimed to obtain soybean lines that are adaptive in acid dry land.

MATERIALS AND METHODS

Study Site

The study was carried out in Tanah Laut Regency, South Kalimantan Province (3°41'31.9" S; 114°44'00.8" E) having Ultisols soil type with soil pH (H_2O) of 5.5; Exchangeable Al and H of 0.67 me.100/g and 1.53 me.100/g, respectively. Other soil properties are shown in Table 1.

Plant Materials

Ten promising lines of SC2P2.99.5.4.5-1-6-1 (G1), SC2P2.151.3.5.1-10 (G2), SC5P2P3.5.4.1-5 (G3), SC5P2P3.23.4.1-3-28-3 (G4), SC5P2P3.23.4.1-5 (G5), SC5P2P3.48.31.1-10 (G6), SJ-5/Msr.99.5.4.5-1-6-1 (G7), Msr/SJ-5.21.3.7-3-27-1 (G8), Msr/SJ-5.23.4.1-3-28-3 (G9) and Msr/SJ-5.23.4.1-5(G10) and two check varieties Tanggamus (G11) and Wilis (G12) were used in this experiment. The ten promising lines were derived from crossing of Mansuria and SJ-5 genotypes. Tanggamus is an acid-adaptive soybean variety, while Wilis is a broadly-adaptive soybean variety.

Soil Preparation

To obtain optimal soil structure condition for ideal growth of the soybean, soil tillage was carried out by plowing the soil twice until 20 cm depth and then flatting by harrowing the soil. Drainage canals were made every 4.5 m to prevent water logging in case of hard rainfall.

Design and Planting

The experimental design applied was randomized completely block design with four replications. Plot size was 2.8 × 4.5 m and plant spacing of 40 × 15 cm with two plants per hill. Fertilizers applied were 75 kg urea, 125 kg SP36 and 75 kg KCl per ha, which were spread before planting. Control of weeds, pests and diseases were performed optimally by monitoring scheme.

Observation and Data Analysis

Observations were conducted on days to 50% flowering (then stated as days to flowering) and days to 95% maturing (then stated as days to maturing), plant height, number of reproductive nodes per plant, number of filled and unfilled pods per plant, 100 grains weight and grain yield. Data were analyzed using analysis of variance (ANOVA) and followed by Least Significant Difference test (LSD) at $\alpha = 0.05$.

Table 1 Soil properties

Soil properties	Value
pH (H_2O)	5.05
pH (KCl)	4.15
N (%)	0.13
CO (ppm)	1.48
P_2O_5 (ppm)	8.08
SO_4 (ppm)	42.30
Fe (ppm)	48.90
Mn (ppm)	245.00
Cu (ppm)	6.13
Zn (ppm)	4.20
K (ppm)	0.48
Na (me/100g)	0.21
Ca (me/100g)	5.11
Mg (me/100g)	2.06
KTK (me/100g)	34.00
Aldd (me/100g)	0.67
Hdd (me/100g)	1.53

RESULTS AND DISCUSSION

In this study, there were three genotypes having early days to flowering namely SC5P2P3.5.4.1-5, Msr/SJ-5.23.4.1-3-28-3 and Wilis with days to flowering of 34 days. On the other hand, there were four genotypes having days to flowering of 40 days or higher namely SC5P2P3.23.4.1-5, SC5P2P3.48.31.1-10, SJ-5/Msr.99.5.4.5-1-6-1 and Msr/SJ-5.23.4.1-5 (Fig. 1). Different days to flowering are affected by the genotypes, where they are affected by genes that repressing (Cao *et al*. 2015) or inducing (Na *et al*. 2013) as the response to the environmental parameters such as temperature (Lee *et al*. 2005; Xia *et al*. 2012), photoperiod and other environmental stimuli (Xia *et al*. 2012).

Days to maturing of the tested genotypes varied. Trend of days to maturing is similar to trend of days to flowering. Genotype having longer flowering days also showed longer maturing days and vice versa. However, there is one genotype (Wilis) having early flowering day and longer maturing days. Days to maturing is important in soybean because different maturing day response to the yield. Soybean is a photoperiod-sensitive and self-pollinated species. Days to flowering (DTF) and maturing (DTM), duration from flowering-to-maturing (DFTM) and plant height (PH) are crucial for soybean adaptability and yield (Zhang *et al*. 2015). Therefore, temperature is related to the maturity of soybean (Kumagaia & Sameshima 2014).

Plant height varied among the tested genotypes. The highest plant height was SC5P2P3.23.4.1-5 and the lowest plant was SC5P2P3.5.4.1-5. The check varieties Tanggamus and Wilis were included as having medium plant height in this study. Plant height is influenced by the genotypes and environment. Genes in the genotypes works to perform plant height supported by the environment. In rainy season soybean plant height is higher than in dry season (Kuswantoro & Zen 2013). In physiological point of view, plant height is also affected by solar radiation. Zhang *et al*. (2014) stated that solar ultraviolet radiation exclusion increases soybean plant height due to the internodes elongation. Plant height has relationship to grain yield as stated by many authors (Lee *et al*. 2015; Liu 2013).

The lowest number of reproductive nodes was achieved by SC5P2P3.5.4.1-5. The highest number of reproductive nodes was achieved by SC2P2.99.5.4.5-1-6-1, in which SC2P2.99.5.4.5-1-6-1 was also included as having higher plant height. Number of reproductive nodes had similar pattern to plant height (Fig. 2). Higher plant height leads to higher number of reproductive nodes, because higher plant allows more branches to grow than lower plant. In this case, the length of the main stem is the most important factor for plant height. At the R5 growth stage, nodes development on the main stem and on the branches reach the maximum (Egli *et al*. 1985). Number of reproductive nodes is affected by number of branches. Higher branch

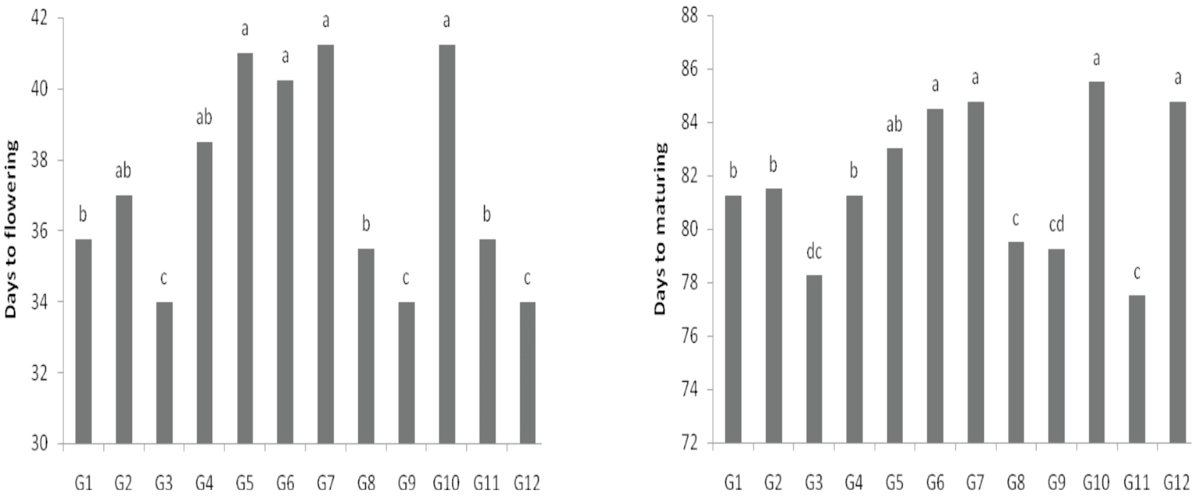

Figure 1 Days to flowering and days to maturing of acid-adaptive soybean promising lines in Tanah Laut Regency, South Kalimantan Province (rainy season 2012)

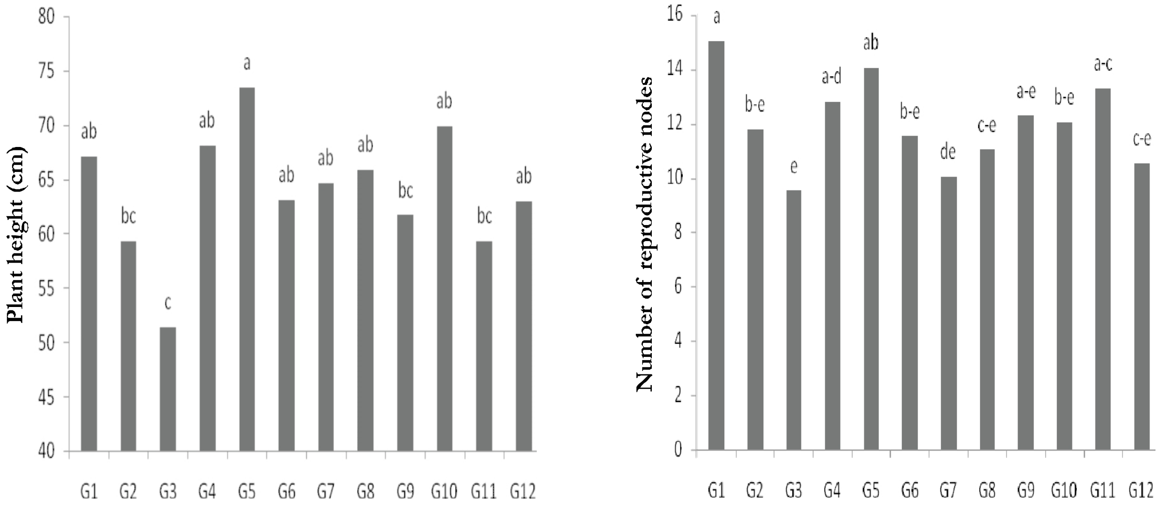

Figure 2 Plant height and number of reproductive nodes of acid-adaptive soybean promising lines in Tanah Laut Regency, South Kalimantan Province (rainy season 2012)

dry matter per plant affecting more branch nodes and branch reproductive nodes indicates that number of branches and number of reproductive nodes have a close relationship (Carpenter & Board 1997).

The highest number of filled pods was achieved by SC5P2P3.23.4.1-5, Msr/SJ-5.23.4.1-3-28-3 and Tanggamus, while the lowest was achieved by SC5P2P3.5.4.1-5. This indicated that the tested soybean lines varied in pods number trait. Numbers of filled pods in this study were lower than other study with the same soybean lines, although the soil pH is higher. This phenomenon might be due to the lower water availability (Kuswantoro & Zen 2013). Low water availability at pod filling period may accelerate senescence and shorten pod filling period (De Sousa *et al.* 1997).

The pattern of number of filled pods was not similar to the pattern of number of unfilled pods (Fig 3). SC5P2P3.5.4.1-5 had the highest number of unfilled pods and had the lowest number of filled pods. Tanggamus was the soybean variety that achieved the highest number of filled pods and unfilled pods. This difference indicated that there is no relationship between these two characters. Genetic constitution has important role in expressing the number of unfilled pods against environmental effects. It is indicated by the broad-sense heritability of unfilled pods achieving 93.1% (Sahay *et al.* 2005).

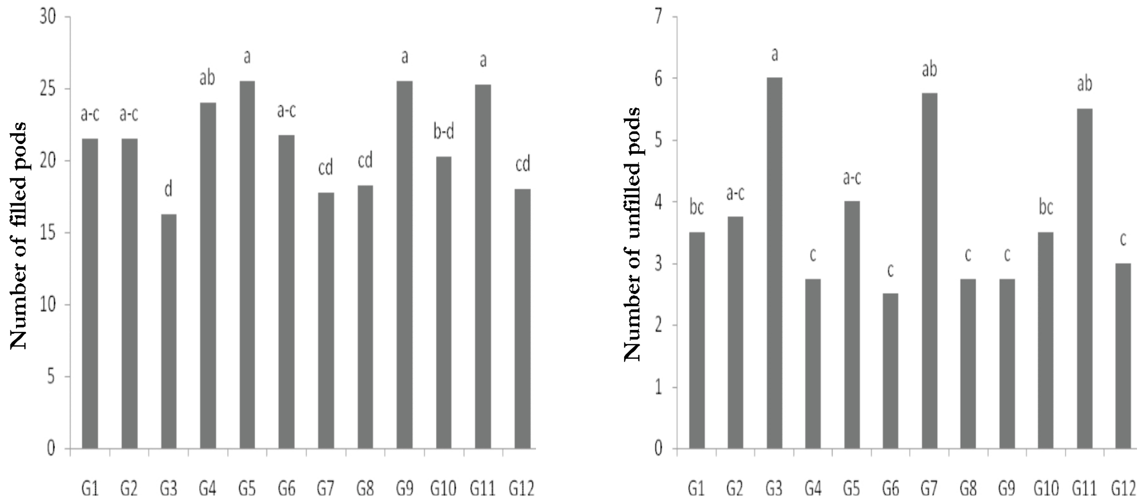

Figure 3 Number of filled pods and number of unfilled pods of acid-adaptive soybean promising lines in Tanah Laut Regency, South Kalimantan Province (rainy season 2012)

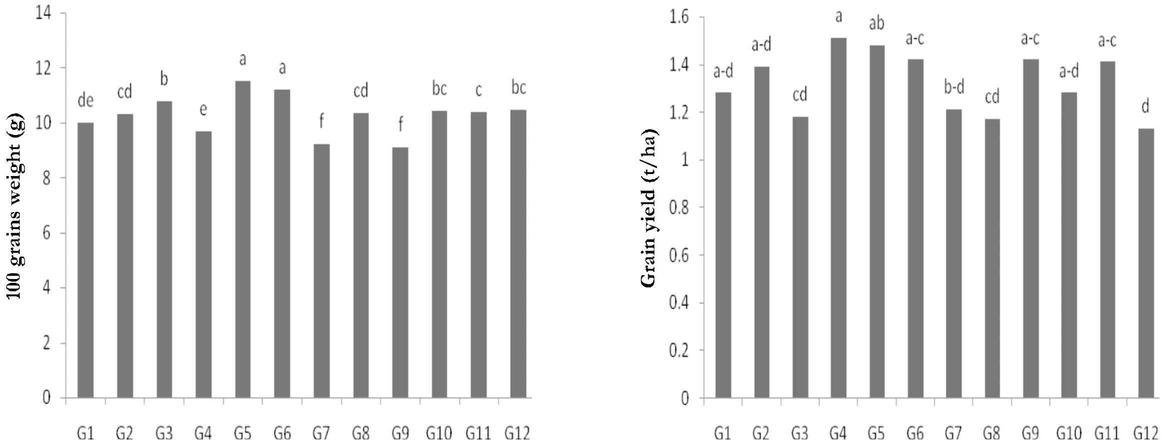

Figure 4 100-grain weight and grain yield of acid-adaptive soybean promising lines in Tanah Laut Regency, South Kalimantan Province (rainy season 2012)

The largest grain size were shown by SC5P2P3.23.4.1-5 and SC5P2P3.48.31.1-10, while the smallest were shown by SJ-5/Msr.99.5.4.5-1-6-1 and Msr/SJ-5.23.4.1-3-28-3 (Fig. 4). Grain size of the check varieties were in the middle rank of the tested genotypes. Grain size is one of the main components affecting grain yield. Grain size can decrease (Kuswantoro *et al.* 2014) or increase (Kuswantoro 2015) grain yield through modification of environmental factors such as soil acidity. Therefore, grain size is more affected by environmental factors rather than by genetic constitution (Liu *et al.* 2010). This is supported by Hakim *et al.* (2014) who found medium heritability with value of 46.3%.

The line of SC5P2P3.23.4.1-3-28-3 achieved production of 1.51 t/ha which was higher than that of Wilis and Tanggamus varieties which reached production of 1.41 t/ha and 1.13 t/ha, respectively. Other line that achieved relatively higher grain yield was SC5P2P3.23.4.1-5 with grain yield of 1.48 t/ha. Tanggamus is the check variety for wide adaptation variety. In this study Wilis had lower grain yield than that of Tanggamus, the soybean check variety for adaptability to acid soil. Grain yield is a complex character and affected by other components. The most important characters in supporting grain yield are grain size and number of grain yield. Some authors reported that there were significant correlation (Malik *et al.* 2011) and genetic correlation (Arshad *et al.* 2006) between grain yield and 100 grains weight; and a positive direct effect between 100 grains weight and grain yield (El-Badawy 2012). Similar to number of grain size, some authors also reported the relationship between grain yield and number of pods (Arslan *et al.* 2005), and positive direct effect with number of pods per plant (Valencia-Ramírez & Ligarreto-Moreno 2012).

CONCLUSIONS

The promising lines of SC5P2P3.5.4.1-5 and SC5P2P3.23.4.1-5 achieved production of 1.51 t/ha and 1.48 t/ha, respectively, which were higher than the production of Tanggamus and Wilis varieties. The yield of these two promising lines was also supported by number of filled pods. Promising lines of SC5P2P3.5.4.1-5 and SC5P2P3.23.4.1-5 has potency to be developed in Tanah Laut Regency, South Kalimantan or other areas with similar soil characteristics.

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