VARIATION IN SEED PROTEIN AND OIL CONTENTS AMONG SOYBEAN GENOTYPES AND THEIR RELATIONSHIP TO YIELD COMPONENTS

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ABSTRACT

Soybean grain with high protein and high oil contents is desirable in the global market for its special food application. In this study, we intent to determine genetic variation for seed protein and oil content and to utilize the traits to develop new improved cultivar to both traits. Thirteen genotype of soybean were grown in a randomized block design with three replications for two cropping seasons. Seed weight/plant, grain yield m^2, seed protein and oil content were observed from each plot. Except for grain yield, cropping seasons did not affect all traits observed in this study. There were large variation found among genotypes for seed weight, grain yield and seed protein content but not for seed oil content. Grain yield was positively correlated to seed weight but negatively correlated to seed protein content. Seed oil content did not significantly correlated to any traits. The result indicated that all traits may be utilized as selection criteria in a soybean breeding program and it is possible to develop a cultivar with high yield as well as high seed protein or high seed oil content.

Key words: Genotypic variation, protein content, oil content, soybean population.

INTRODUCTION

In Indonesia, soybean (*Glycine max* (L) Merr.) is utilized mainly as human diet, so that, seed quality related traits such as protein and oil contents in the seed are very crucial. High protein and oil contents are desirable characters for farmers as well as for consumers to meet special food applications and those characters are considered as important economic determinant for soybean seed. Approximately 1.7 million tons of soybean seed were imported to Indonesia in a single year, which is more than 60% of the national demand. So that it is important here to increase yield as well as to improve other desired characters such as seed protein and oil concentration via soybean breeding program.

During several years, investigators started to focus their attention on the inheritance of traits that related to chemical composition in soybean seed including factors that controls them. Recent study confirmed that soybean grain yield, and yield components were influenced by environmental condition (Rasyad and Idwar, 2010) while protein and oil contents were depends upon its genotypes and may be influenced by environmental condition (Panthee *et al*., 2005; Rotundo and Westgate, 2009; Dukic *et al*., 2010) and cultural practices such as fertilizer application (Win *et al*., 2010). Furthermore, both protein and oil concentration in the seed were also influenced by genetic environment interaction (Arslanoglu *et al*., 2011; Ning *et al*., 2003; Sogut, 2006; Kang, 1998; Kumar, 2006).

Wide variability for protein content and oil content in seed have been reported in several population of soybean. Arioglu (2007) and Arslanoglu *et al*. (2011) documented variation of seed oil content ranging from 150 to 220 mg/g and protein content from 340 to 400 mg/g for a soybean population in Turkey. Wider variability both protein and oil content had been reported by Piper and

Boote (1999) and Vollman *et al*. (2000) in which they found oil content ranging from 120 to 230 and protein from 255 to 589 mg/g. Lately, several studies reported the increasing trend of seed protein content followed by decreasing oil content in soybean seed (Li and Burton, 2002; Piper and Boote, 1999). The result reflects the existence of negative correlation between both traits on soybean as also shown in the area with high temperature by Kane *et al*. (1997) and Gunasekera *et al*. (2006). This results were recently confirmed by Aslanoglu *et al*. (2011) in a broad range of soybean maturity group. The objectives of this study were to determine the components of variation and the inheritance of several seed traits along with phenotypic and genetic correlation among the traits in a soybean population.

MATERIALS AND METHODS

Field experiments were conducted at the University of Riau Agriculture experiment Station in Pekanbaru, Indonesia during dry season of 2010 and the rainy season of 2011. Material used in the experiments was 12 genotypes consisting of five varieties and seven F_{14} lines obtained from a cross between Kipas Putih and Malabar. The material represents an adequate sample of genetic variation that exists among soybean population in the area. The cultivars were spaced planted on a plot of 5 m long and 2 m wide on 20 May 2010 and 15 September 2011. Soil type in the experiment station is Inceptisol (fluventic dystrudepts) characterized by low nitrogen and phosphorous contents. Seed of each cultivar were planted with a planting density of 20 cm within a row and 40 cm between rows. Three seed were placed in every hill and keep until 15 days after planting before thinning to a single plant per hill.

Fertilizers in the form of Urea, TSP and KCl at the rate of 25 kg N, 25 kg P_2O_5, 40 kg K_2O/ha, respectively were applied at planting date. Design used for both planting seasons was completely randomized block design with three replicates. Seed weight per plant, 100-seed weight, grain yield was obtained at harvest from each plot, then the grain yield was converted into yield m^2. To obtain crude protein and oil contents, 30 g of seed were sampled from each plot, then dried to a moisture content of 130 mg/g. The seed was ground to a fine powder by using seed grinder then placed in a plastic jar until extraction. Oil was extracted with petroleum ether (40-60^{o}C) in soxhlet apparatus for 12 hours. Resulted solution then was dried with anhydrous sodium sulphate then removed by vacuum distillation at 30^{o}C. Oil percentage was determined by calculating the weight differences as described by Welch (1977).

Seed protein was determined by converting nitrogen concentration obtained by a macro-Kjeldahl methods as described by AOAC (1980). Data were analysis by SAS General linear Model procedure for each planting season then combined analyses over two seasons due to homogeneity of the result for every single planting season (SAS User Manual, 2004).

RESULTS AND DISCUSSION

Analysis of variance presented in Table 1 indicated that cropping season did not affect all traits except for grain yield which implied that environment play a minor role for all traits other than grain yield. There were considerable differences among genotypes on all characters. Genotype by environment interaction effect was significant for grain yield and oil content, but not for other traits.

Because GE interaction was significant in this study especially for grain yield, farmers need to be cautious in selecting high yielding variety to be grown in this area of production.

Mean of the cultivar average over two cropping seasons was presented in Tabel 2. There were considerable differences among genotypes of all characters except for oil content. Seed dry weight ranged from 15.64 to 27.07 with a mean of 22.77 g/plant. The range of 100-seed weight was from 10.81 to 13.97 g with aa mean of 12.69 g, while the range for seed oil content was from around 15 to 16.4% with a mean of 15.7%. This inferred that variation for both 100-seed weight and seed oil content was relatively small in the population under study. Wide variation was shown for grain yield ranging from 786.24 to 1372 g/m^2 and seed protein content ranging from 26% to 45%. Seed protein content of the lines used in this study was comparably higher than that of Malabar, Wilis and Tanggamus.

Estimates of phenotypic and genetic correlation were almost similar in magnitude and presented in Table 3. Positive genetic and phenotypic correlation between weight of 100-seed and grain yield was obtained. Grain yield m^2 was negatively correlated to seed protein content and positively correlated with the weight of 100-seed. The negative correlation between grain yield and seed protein content was in agreement with previous investigations (Burton, 1985) but did not agree with other study (Yin and Vyn, 2005). Seed oil content was not significantly correlated to seed protein content or any other traits. This finding was in contrast to the result reported by some studies (Maestri et al., 1998).

Broad sense heritability of the traits ranged from low for seed weight per plant to moderately high for seed protein content (Table 4). Heritability is considered to be equal to zero when the value was ≤ its standard error. So that, heritability of only grain yield, seed protein content and weight of 100-seed were significantly different from zero. High heritability of protein content was also documented in several studies (Openshaw and Hadley, 1984; Li and Burton, 2002).

Recent goal of soybean breeding is to obtain varieties having high yielding ability as well as increasing seed oil and protein content. In this study, we found considerable wide variation among genotypes for specific traits which indicated that these characters were potential to improve seed protein content and/or grain yield. It was apparent from this data that negative correlation between grain yield and seed protein content may hindered the breeder to select a variety with both high yielding ability and high seed protein content. When selecting a new variety with high grain yield, a breeder will end up with a genotype having low protein content. Regardless of this negative correlation, however, we are still able to do a joint selection which would end up a genotype with high yielding and high seed protein content. For example, line G19B produced higher grain yield and highest seed protein content (Table 2). Since we did not find significant correlation between seed oil content and both grain yield and seed protein content, it is possible to select a variety with high grain yield and high seed oil content or a variety with high in both seed protein and oil content.

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