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Research Note

Selection of soybean genotypes for yield, size, and oil and protein contents

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Abstract

A set of experiments was developed involving a randomized block design with three replications to evaluate 17 soybean genotypes for yield, size, and oil and protein contents. Soybean genotypes Conquista, CD 223 AP, Elite, Garantia, Bioagro, M-Soy 8400, M-soy 8001, Nambu, Sambaíba, Esplendor, UFVS 2006, UFVS 2005, UFVTN 102, UVF 18, UFV 16, Valiosa RR, and Vencedora were tested. The genotypes were compared and correlated with the following variables: plant height (PH), first pod height (FPH), yield, and oil and protein contents. The genotypes with the highest PH and FPH were Sambaíba, UFV 18, and Garantia, which, together with M-Soy 8001, also had the highest grain oil contents of 20.93, 21.16, 21.02, and 21.95, respectively. Genotype Bioagro had the highest grain protein content, and the genotypes Elite and Nambu were the most productive. Oil content had a negative correlation with protein content, and yield had a positive correlation with plant size in the evaluated soybean genotypes.
Soybean (*Glycine max* (L.) Merrill) is one of the main oilseeds produced in the world, and is being used in the production of oils, cosmetics, and human and animal feed, making the plant highly important for the economic development of producing and consuming countries. In Brazil, soybean development has occurred effectively through genetic breeding programs, which have increased yield through the selection of genotypes adapted to the edaphoclimatic conditions of each region (Vasconcelos et al., 2015; Finoto et al., 2017).

Keywords: adaptability; genotype x environment interaction; *Glycine max*; principal components; stability.

Most of the studies do not adequately address the chemical composition of soybean grains and genotypes with a high potential for oil and protein production, and the association of these traits with plant growth and crop yield. According to Delarmelino-Ferraresi et al., (2014), protein and oil ratios in soybean grains indicate the relationship between the chemical composition and the physiological quality. The constituents vary with the lot, cultivar, and soybean genotype used for cultivation.
The chemical quality of seeds, which is directly related to the vigor and initial performance of plants under cultivation (Henning et al., 2010), needs to be analyzed. Additionally, plant size, relevant to crop management, and grain yield need to be evaluated and correlated to identify genotypes adapted to the needs of the producer. Several experiments were conducted to select genotypes with a high production potential and satisfactory oil and protein contents, as well as to determine their correlations with production components.
The survey was conducted at the Polo Apta Centro Norte, Pindorama, São Paulo, located at the geographical coordinates 21°13′ S and 48°55′ W from November 2014 to January 2015.
The study was replicated in five experiments to increase the reliability of the obtained results. The seeds were sown, and the experiments were conducted on pre-established dates: 11/03/2014, 11/20/2014, 12/07/2014, 12/23/2014, and 01/09/2015.
Seventeen soybean genotypes were used in the research (Conquista, CD 223 AP, Elite, Garantia, Bioagro line, M-Soy 8400, M-soy 8001, Nambu, Sambaíba, Esplendor, UFVS 2006, UFVS 2005, UFVTN 102, UVF 18, UFV 16, Valiosa RR, and Vencedora). Each experiment consisted of three replications, and the experimental units comprised five rows of 5 m long, spaced 0.90 m from each other, at a population density of 14 plants per meter.
The area was mowed, plowed, and harrowed before sowing the soybean seeds to incorporate all remaining plant biomass residues in the soil surface layer. A base fertilizer was added after soil analysis by applying 250 kg ha^{-1} of the 04–20–20 (N–P–K) formula. Sowing was performed manually, and inoculation was carried out directly on the seeds by spraying liquid inoculant. Thinning was performed

Table 1. Mean values of plant height (PH), first pod height (FPH), yield, and oil and protein contents of soybean genotypes.

Genotype	PH (cm)	FPH (cm)	Oil content (%)	Protein content (%)	Yield (kg ha^{-1})
Elite	63.53 b	9.33 c	19.82 b	41.29 d	3521.67 a
Bioagro	46.00 d	7.60 d	19.28 b	48.55 a	2040.00 o
Nambu	61.40 b	9.47 c	19.84 b	41.38 d	3407.20 a
Esplendor	58.40 b	9.00 c	20.23 b	42.35 c	2726.47 j
Sambaíba	67.87 a	11.00 b	20.93 a	40.95 d	3176.33 c
UFV 16	45.47 d	6.40 e	20.44 b	40.90 d	2247.93 m
UFV 18	71.67 a	12.47 a	21.16 a	40.67 d	3024.33 f
UFVS 2005	53.80 c	8.60 d	19.80 b	40.79 d	2415.07 l
UFVS 2006	42.13 d	5.47 e	19.77 b	41.61 d	2134.93 n
UFVTN 102	53.07 c	8.27 d	20.54 b	43.49 c	2742.27 j
M-Soy 8001	51.67 c	7.53 d	21.95 a	41.18 d	2976.93 g
M-Soy 8400	59.27 b	7.67 d	20.31 b	41.50 d	3067.00 e
Garantia	66.27 a	10.53 b	21.02 a	43.43 c	3396.67 b
Vencedora	56.27 b	7.47 d	19.32 b	42.90 c	2902.07 h
CD 223 AP	41.27 d	9.33 c	19.54 b	45.46 b	2140.13 n
Conquista	53.67 c	7.60 d	20.04 b	41.94 d	2793.87 i
Valiosa	61.33 b	9.47 c	20.12 b	42.63 c	3112.27 d

Means followed by the same lowercase letter in the columns and uppercase letter in the rows do not differ from each other by the Scott-Knott test (p<0.05).

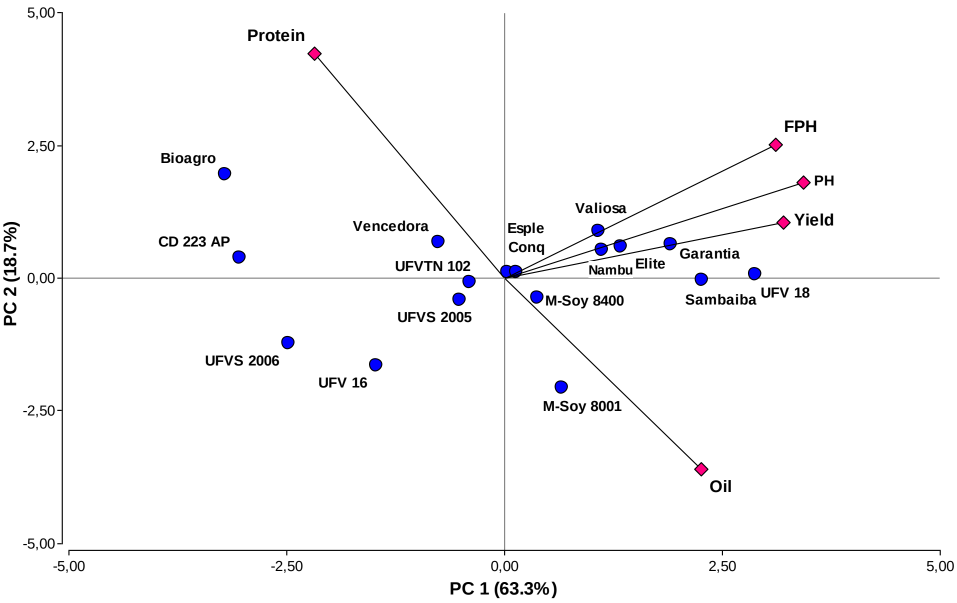

Fig 1. Biplot showing the projection of the variables (PH - plant height, FPH - first pod height, Yield, and oil and protein contents) in the first two principal components with the discrimination of the evaluated genotypes.

in the second week after plant emergence to reach the defined population density.

The variables plant height (PH, cm), first pod height (FPH, cm), and grain yield (kg ha^{-1}) were evaluated in all experiments and genotypes. Samples from each experimental unit were selected for the determination of oil and protein contents of grains in dry mass (DM%). The Goldfish method was used to determine the oil content (ethereal extract), while the Kjeldahl method was used to determine crude protein (Brum et al., 2009).

A joint analysis was performed between the trials after the data collection, and the coefficients of variation between the replications of each treatment in the five experiments were determined. A homogeneous variance was observed between the experiments since the relationship between the mean-squared residual between variables of each experiment was lower than 7.0 (Pimentel-Gomes, 1990). Similarly, the coefficients of variation between replications were always lower than 10%, allowing statistically analyzing the treatments from the mean of the five experiments, i.e., the replication one (R1) of each genotype corresponded to the mean of each R1 of the five experiments.

The data were submitted to the Kolmogorov-Smirnov normality test to confirm normality. The analysis of variance was performed after determining the normal distribution, and the treatments were grouped and compared by the Scott-Knott test at 5% probability after observing a significant effect, using the statistical program Sisvar (Ferreira, 2011). The multivariate analysis of principal components was applied to determine the correlation between genotypes and the analyzed variables using the statistical package Infostat (Di-Rienzo, 2008).

We identified different groups of soybean genotypes in all analyzed variables (Table 1). Four groups (G) were formed for the plant height (PH): G1 – Sambaíba, UFV 18, and Garantia, with values between 66 and 72 cm; G2 – Elite, Nambu, Esplendor, M-Soy 8400, Vencedora, and Valiosa, with values between 59 and 64 cm; G3 – UFVS 2005, UFVTN 102, M-Soy 8001, and Conquista, with values between 50 and 54 cm; and G4 – Bioagro, UFV 16, UFVS 2006, and CD 223 AP, with values between 41 and 46 cm.

Genotype UFV 18 had the highest value (12.47 cm) for the first pod height (FPH), followed by the group composed of genotypes Sambaíba and Garantia (FPH>10 cm). Five genotypes with FPH values from 9.0 to 9.47 cm were also grouped, followed by the remaining genotypes with FPH values below 8.5 cm (Table 1).

For the grain oil content, only two groups emerged: Sambaíba, UFV 18, M-Soy 8001, and Garantia, which presented the highest values (higher than 20.9% oil), and the other genotypes with similar values between 19.28 and 20.54% oil (Table 1).

Genotype Bioagro had the highest mean protein content (48.55%), followed by CD 223 AP (45.46%), the group formed by the genotypes Esplendor, UFVTN 102, Garantia, Vencedora, and Valiosa (42.35 to 43.49% protein), and the group with values lower than 40% protein (Table 1). The yield was the variable with the highest level of significance, resulting in a high variation among the tested genotypes. Genotypes Elite and Nambu, with values above 3400 kg ha^{-1}, were the most productive when compared to the other. The genotypes Sambaíba, UFV 18, M-Soy 8400, Garantia, and Valiosa had yields between 3000 and 3400 kg ha^{-1}. The yield of the remaining genotypes was lower than 3000 kg ha^{-1}.

The principal components PC1 and PC2, demonstrating the correlation between genotypes and variables (Figure 1), explained 82% of the variance. According to Cliff (1998), the principal components analysis is efficient when 70 to 100% of the variance between the data is explained. Thus, the treatments in this study can be separated. The PC1 explained 63.3% of the data variability, correlated with plant height (PH), first pod height (FPH), oil content, and yield, while PC2 explained 18.7% of the total data variability correlated with protein content.

A direct positive correlation was observed between yield, PH, and FPH. Also, FPH was correlated with oil content. A negative correlation was observed between oil and protein contents. The genotypes Esplendor, Conquista, Valiosa, Nambu, Elite, and Garantia were directly correlated with FPH, PH, and yield. Genotypes M-Soy 8001, M-Soy 8400, Sambaíba, and UFV 16 were correlated with oil content. Genotypes Bioagro, Vencedora, UFVTN 102, and CD 223 AP showed a correlation with protein content. UFV 16, UFVS 2005, and UFVS 2006 presented a low correlation with the studied variables.

The results on oil and protein contents provide information on soybean genotypes used in Brazil. All genotypes were superior to the seven commercial soybean cultivars tested by Faria et al., (2018) for protein content. However, these seven cultivars were superior to all genotypes tested in this study for oil content. This result confirms the negative correlation between soybean oil and protein found in this study, indicating that the edaphoclimatic conditions of the experiment favored an increase in protein in the grains of all evaluated soybean genotypes. The increase in protein possibly resulted in a decrease in grain oil content, as reported by Delarmelino-Ferraresi et al., (2014).

The chemical composition of soybean might reflect the interaction between genotype and environment (Barbosa et al., 2011) or predict the industrial yield (Monteiro et al., 2017) when the plants are grown in different conditions. Pinheiro et al., (2013) evaluated 11 soybean varieties in the state of Tocantins, and observed that the oil content was influenced by environmental factors.

According to Finoto et al., (2017) it is important to test soybean genotypes to evaluate oil and protein levels in the seeds: the results may be beneficial in soybean breeding programs, aiming at the production of agronomically superior plants.

Therefore, the genotypes Sambaíba, UFV 18, and Garantia presented the largest plant size in the field according to height (higher than 66 cm) and first pod height (higher than 10 cm). Also, together with M-Soy 8001, theses genotypes presented the highest grain oil content. Genotype Bioagro had the highest protein content, and Elite and Nambu were the most productive genotypes under the experimental conditions. Similarly, the oil content was negatively correlated with protein content in soybean genotypes, and yield was positively correlated with plant height and first pod height.

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