The effect of soil volume, plant density and sowing depth on soybean seedlings characters

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ABSTRACT

Plant breeding, associated with other areas, as well as the registration and protection of cultivars, have brought relevant contributions to turn soybean into one of the most important crops for the Brazilian agribusiness. Potential additional soybean descriptors for cultivar protection purposes such as the length of the hypocotyl and epicotyl have been reported in the literature. Thus, the objective of this work was to study the effect of soil volume, plant density per pot and crop and cultivar depth on the length of the hypocotyl and epicotyl and the height of soybean seedlings. The study conducted 4 experiments, in which the length of the hypocotyl and epicotyl and the height of soybean seedlings were evaluated at the V2 and V3 stages. Experimental units were submitted to pots with three volumes of soil (1, 2 or 3 dm^3), three quantities of plants per pot (1, 2 or 3), three sowing depths (1, 2 or 3 cm) and four cultivars [TMG 4185, BRSMG 68 (Vencedora), BRS 7980, BRS 8381]. Results showed that soil volume, plant density and sowing depth had no effect on hypocotyl length evaluated at the V2 stage and that sowing depth had no effect on epicotyl length. However, soil volume, plant density, sowing depth and cultivar variations had an influence on plant height, and the soybean cultivars showed distinguishability for hypocotyl and epicotyl length at the V2 and V3 stages, being considered potential soybean descriptors.

Key words: *Glycine max*, distinguishability, breeding, description characters, cultivar.

INTRODUCTION

Soybean (*Glycine max* (L.) Merr.) is an important crop for the Brazilian agribusiness. During the 2017/18 season, national production of grains was 113 million of tons (Conab 2018). Crop expansion throughout the different regions of the country for commercial production started in Rio Grande do Sul (Sediyama et al., 2009). However, currently, it can be found in the states of Rio Grande do Sul, Santa Catarina, Paraná, São Paulo, Minas Gerais, Distrito Federal, Goiás, Mato Grosso do Sul, Mato Grosso, Bahia, Piauí, Maranhão, Tocantins, Pará, Amapá, Amazonas, Acre, Rondônia e Roraima (Conab 2018), becoming one of the most important products for national agriculture.

A milestone for the Brazilian agriculture, and in special for the soybean culture, was the enactment of the Law 9.456 (Cultivar Protection Law-LPC) regulated by the Decree 2.366 (of December 5 1997), that guarantees rights to breeders of new vegetal varieties (Campos et al., 2009). According to Cunha (2011), the main objective of the Cultivar Protection Law is to add value to national research results on vegetal genetic breeding, which have already been realized with great success. In addition, it tries to attract public and private investments to increment and accelerate vegetal genetic breeding programs. Finally, it stimulates the entrance of foreign technologies in the country, mainly in areas where genetic breeding is inexistent or research is still incipient, as in the case of ornamental species and vines (Cunha 2011).

Other normative such as the Seeds and Seedlings Law Enforcement Regulation (number 10.711 of August 5, 2003 and Regulatory Decree 5.153 of July 23, 2004) and the Technological Innovation Law (number 10.973 of December 2, 2004 and respective decrees) provided support to the mechanisms implemented by the LPC (Aviani 2011). It was also emphasized that, in turn, the Innovation Law created a favorable environment to scientific research, including vegetal breeding and contributing effectively to boost

innovation in the productive sector, by facilitating the constitution of partnerships and the cooperation between public and private institutions (Aviani 2011).

The granting of protection to a cultivar must meet three basic requirements: it must be distinct, homogeneous and stable (Campos et al., 2009; Viana 2013). Nogueira et al. (2008) reported that the 38 descriptors, including the mandatory and additional, used to differentiate soybean cultivars, are insufficient for the distinction. This makes evident the need to expand the list of descriptors, which are, according to Schuster et al. (2009), morphological characters of plants. In a study focused on distinguishability among cultivars, Nogueira et al. (2008) reported as additional soybean cultivar characteristic descriptors. They included hypocotyl length, epicotyl length, petiole length of the unifoliate leaf, unifoliate leaf base form coefficient, unifoliate base width coefficient, petiole length of the first trifoliate leaf and length of the terminal leaflet rachis of the first trifoliate leaf.

These characteristics have not yet been included in the soybean descriptors table for DHE trials execution instructions on soybean cultivars made available by the National Service for Cultivars Protection of the Ministry of Agriculture, Livestock and Food Supply (MAPA 2015). Thus, studies conducted by Matsuo et al. (2012a, 2012b) and Alves et al. (2019), are some of those realized with the objective to have a better understanding of the characters introduced by Nogueira et al. (2008). In these studies, characters were evaluated at the V2 and V3 stages of development (Fehr and Caviness 1977) and the experimental unit was composed of 1, 2 or 3 plants, on average, conducted in pots with 3 dm^3 of soil capacity.

Sowing depth, in general, interferes in emergence speed and in the percentage of emerged seedlings (Oda et al., 2009). Furthermore, greenhouses are limited in size and there is a concern regarding a reduction in experimental unit size, in general in relation to pot size, without affecting experiments precision (Diefenthaler and Santos 1978). Findings on the effect of soil volume, plant density per pot and sowing depth on potential additional descriptors of soybean were not found in the literature. Therefore, studies of this nature can add knowledge on hypocotyl, epicotyl length and plant height to complement the knowledge already established.

Thus, the objective of this study was to verify the effect of soil volume, plant density per pot, sowing depth on soybean seedlings characters descriptors.

MATERIALS AND METHODS

Activities were conducted at the UFV – Rio Paranaíba, in the city of Rio Paranaíba, Minas Gerais State, in a greenhouse (19° 11' 39'' S; 46° 14' 37'' W, 1133m of altitude).

The four experiments were conducted as described below:

Experiments 1 and 2

Experiment 1 took place in February and March of 2016 (sowing on February, 15 2016) and experiment 2 in April/May (sowing on April 8, 2016), in a greenhouse. The experiments used cultivar MG/BR 46 (Conquista), and the seeds of random sizes were sowed at 2.0 cm of depth.

The following characters were analyzed: hypocotyl length (at main stem and the distance between the soil and the cotilenodary knot); epicotyl length (at the main stem and the distance between the cotilenodary knot and the unifoliate leaves pair knot) and plants height (at the main stem and at the distance between the soil and the last visible knot). Measurements were done in millimeters (mm), using a digital caliper, at the V2 and V3 stages of development (Fehr and Caviness 1977). Experiments used several pots with different volumes to study the effect of soil volume per pot. Pots were filled with 1, 2 or 3 dm^3 of soil. To study the effect of plant density per pots, the experiment considered 1, 2 or 3 plants per pot. This way, each experiment used a randomized block design with six replications, in the 3 x 3 factorial scheme with tree different soil volumes and 3 different plant density per pot, with soil previously prepared with 1/3 of organic matter and fertilized to meet the nutritional demands of the soybean culture. The experimental unit was obtained by the average of plants per pot.

Experiments 3 and 4

Experiment 3 was conducted in October/November 2016 (sowing occurred on October, 10 2016) and experiment 4 in March/April 2017 (sowing occurred on March, 20 2017), in a greenhouse, using

conventional soybean [TMG 4185, BRSMG 68 (Vencedora), BRS 7980, BRS 8381] recommended for cultivation in Brazil. Seed size was standardized to 6.5 to 7.0 mm, on a measuring tray with a round hole.

The following characters were analyzed: hypocotyl and epicotyl length and plant height, in cm, using a digital caliper, at the V2 and V3 (Fehr and Caviness 1977). Each experiment adopted a randomized blocks experimental design with six replications, in a simple factorial scheme (4 x 3), being the four cultivars mentioned before in three distinct depths (1, 2 and 3 centimeters) in pots of 3 dm³ with soil previously prepared with 1/3 of organic matter and fertilized to meet the nutritional demands of the soybean culture. The experimental unit was obtained by the plants average per pot. A unidade experimental foi obtida pela média de plantas por vaso.

Statistical analyses

An analysis of variance was conducted separately for each experiment (considering its assumptions). For the variables that has a significant effect (α <0.05, test F) in ANOVA, the Tukey Test was performed at 1 and 5% probability to identify possible differences. In addition, a simple correlation analysis was performed, and the estimates were testes by the t test at 5 % of probability. The analyses were conducted in the Genes Program (Cruz 2013).

RESULTS AND DISCUSSION

In experiments 1 and 2, where the effects of number of plants per pot and soil volume on hypocotyl and epicotyl length and plant height, no significant interaction among the factors was observed for the analyzed characters. In experiment 3 and 4, where the effects of cultivars and seeding depth were evaluated, the interaction effect was significant only for plant height in V3 in experiment 4 (Tables 1 and 2). This shows that, in general, these factors acted independently on the analyzed characters.

Coefficients of variation showed values between 13.2-22.9% for hypocotyl length, 13.3-20.4% for epicotyl length and 12.3-20.5% for plant heights. Values identified by these works are similar to those found by Nogueira et al. (2008), Matsuo et al. (2012a, 2012b). The high coefficient of variation may be associated to the non-homogenization of the characters throughout the process of cultivars development (Nogueira et al., 2008).

Significant effect for soil volume (at V3, experiment 1) was observed for hypocotyl length, with highest values being identified in pots containing the smallest volumes of soil (Table 3). As for the cultivar effect (experiments 3 and 4), the BRS 8381 showed the highest mean for hypocotyl length, the BRS 7980 the lowest mean and cultivars Vencedora and TMG 4185 as intermediaries (Table 4).

Soybean germination is epigeal and this mechanism is based essentially on a fast and vigorous initial growth of the hypocotyl-radicular axis, making the cotyledons go beyond the soil surface (Carvalho and Nakagawa 2000). The cotyledon is a live tissue that has complete enzymatic apparatus to promote the degradation and transportation of its own reserve substances, to foster the growth of the embryonic axis during the germination process (Carvalho and Nakagawa 2000). During its elevation, the cotyledons become green due to the development of photosynthetically active pigments in their plastids by light stimulus (Müller 1981a). This way, photosynthesis begins in the cotyledons a few days after germination (Müller 1981b), i.e., liquid photosynthesis (accumulation of products after the subtraction of the amount used in respiration) can only be detected after 9 to 12 days after sowing (Nelson and Rinne 1973).

Seedlings begin to live autotrophically when photosynthesis starts, after a transition period of generally three weeks, during which they produce part of their nourishment, but they depend on the reserves stored in the seeds. As soon as the seedling is established in the soil, it starts to capture more water and produce photo-assimilated compounds, becoming gradually independent of stored reserves, and its development begins slowly to be determined mainly by the genotype/environment relations (Marcos Filho 2005). There is a difference in regards to photosynthesis capacity between plants from the same soybean cultivar (Dreger et al., 1969), between cultivars (Dornhoff and Shibles 1970; Nelson and Rinne 1973) and the efficiency of the photosynthetic apparatus is controlled by determined genes, thus being hereditary (Müller 1981b). Thus. If the plant is maintained under low luminosity conditions, there will be a considerable yield reduction (Müller 1981b) since the photosynthetic rate is strongly affected by the intensity of the light (Bowes et al., 1972).

The analysis of the influence of soil volume on epicotyl length showed a difference for this trait when plants were conducted in pots with 2 and 3 dm³ of soil (Table 5).

Table 1. Summary of the analysis of variance of the hypocotyl length (HL), epicotyl length (EL), plant height (PH) and Conquista cultivar submitted to 3 volumes of soil per pot (SV) and 3 plant densities per pot (PD), evaluated at the V2 and V3 stages, in experiments 1 (EXP 1) and 2 (EXP 2), in a greenhouse in Rio Paranaíba, MG.

FV	GL	EXP 1						EXP 2					
		HL-V2	HL-V3	EL-V2	EL-V3	PH-V2	PH-V3	HL-V2	HL-V3	EL-V2	EL-V3	PH-V2	PH-V3
Blocks	5	66.5	10.8	125.7	69.5	1261.3	3437.8	10.0	22.4	23.8	54.5	296.6	224.1
PD	2	41.4^{ns}	6.6^{ns}	181.3^{*}	199.7^{*}	1394.6^{*}	1086.3^{ns}	11.4^{ns}	19.2^{ns}	15.2^{ns}	41.1^{ns}	106.4^{ns}	475.9^{ns}
SV	2	16.2^{ns}	108.5^{**}	158.0^{*}	161.9^{*}	474.9^{ns}	436.2^{ns}	15.0^{ns}	18.2^{ns}	84.7^{ns}	210.7^{ns}	1458.9^{*}	7599.7^{**}
PD*SV	4	50.8^{ns}	37.0^{ns}	15.4^{ns}	41.6^{ns}	42.8^{ns}	626.7^{ns}	5.9^{ns}	40.5^{ns}	11.3^{ns}	64.2^{ns}	52.7^{ns}	59.8^{ns}
Residue	40	21.9	17.6	46.9	43.7	409.3	499.8	16.3	24.4	38.9	72.7	440.6	583.3
Means		30.8	31.7	50.3	49.6	137.3	175.4	26.0	30.7	44.7	47.9	142.6	196.3
Coefficient of Variation (%)		15.2	13.2	13.6	13.3	14.7	12.7	15.5	16.0	13.9	17.7	14.7	12.3

**: Significant at 1% of probability by the F test, *: Significant at 5% of probability by the F test, ns: Non-significant.

Table 2. Summary of the analysis of variance of the hypocotyl length (HL), epicotyl length (EL), plant height (PH) in function of 4 cultivars (Cultivar) and 3 sowing depth (DEPTH), evaluated at the V2 and V3 stages, in experiments 3 (EXP 3) and 4 (EXP 4), in a greenhouse in Rio Paranaíba, MG.

FV	GL	EXP 3						EXP 4					
		HL-V2	HL-V3	EL-V2	EL-V3	PH-V2	PH-V3	HL-V2	HL-V3	EL-V2	EL-V3	PH-V2	PH-V3
Blocks	5	107.4	55.3	124.7	73.9	416.7	183.4	80.9	60.3	259.2	84.4	252.5	627.1
Cultivar (C)	3	195.4^{**}	160.8^{*}	727.5^{**}	772.1^{**}	1407.9^{*}	3970.5^{**}	171.6^{**}	284.0^{**}	463.3^{**}	520.3^{**}	425.7^{ns}	4539.1^{**}
Depth (D)	2	26.1^{ns}	93.2^{ns}	53.0^{ns}	9.1^{ns}	140.4^{ns}	394.8^{ns}	50.1^{ns}	61.3^{ns}	13.3^{ns}	31.1^{ns}	555.8^{ns}	52.4^{ns}
C*D	6	47.0^{ns}	83.5^{ns}	64.0^{ns}	104.7^{ns}	205.0^{ns}	347.1^{ns}	44.6^{ns}	46.5^{ns}	59.8^{ns}	33.4^{ns}	184.3^{ns}	1124.5^{*}
Residue	55	40.0	46.3	48.3	61.8	345.8	256.2	27.6	43.1	72.0	58.4	205.1	425.7
Means		83.2	87.8	203.5	204.3	503.2	1030.4	74.9	99.1	173.5	145.5	324.7	1353.7
Coefficient of Variation (%)		22.9	19.9	18.2	17.1	20.5	13.8	18.9	19.0	20.4	16.9	16.5	17.3

**: Significant at 1% of probability by the F test, *: Significant at 5% of probability by the F test, ^{ns}: Non-significant.

Table 3. Hypocotyl length (HL) means, in mm, analyzed at the V3 development stage, in 1 in function of soil volume, in dm^3, in a greenhouse in Rio Paranaíba, MG.

Soil volume	Hypocotyl length (HL, in mm)
1	34.37a[1]
2	31.53ab
3	29.48b

[1]Means followed by the same lowercase letters in the column do not differ among them by the Tukey test at 5% of significance.

Table 4. Hypocotyl length (HL) means, in mm, analyzed at the V2 and V3 development stages, in experiments 3 and 4, in function of the cultivars, in a greenhouse in Rio Paranaíba – MG

Cultivars	Hypocotyl length (HL, in mm)			
	Experiment 3		Experiment 4	
	V2 Stage	V3 Stage	V2 Stage	V3 Stage
Vencedora	29.93a[1]	35.28ab	27.73ab	34.81ab
TMG 4185	25.93ab	31.23b	27.29ab	31.20b
BRS 8381	30.82a	37.82a	31.76a	39.99a
BRS 7980	23.86b	32.27ab	24.24b	32.01b

[1]Mean in each development stage followed by the same lowercase letters in the column do not differ among them by the Tukey test at 5% of significance.

Table 5. Epicotyl length (EL) means, in mm, analyzed at the V2 and V3 development stages, in experiment 1 in function of soil volume, in dm^3, a greenhouse in Rio Paranaíba, MG.

Soil volume	Epicotyl length (EL) (in mm)	
	V2 Stage	V3 Stage
1	51.32ab[1]	51.3ab
2	52.76a	52.7a
3	47.06b	47.0b

[1]Means in each development stage followed by the same lowercase letters in the column do not differ among them by the Tukey test at 5% of significance.

For plant density, greater epicotyl means were obtained from pots with 3 plants compared to pots with 1 plant, i.e., greater epicotyl length values were observed with seedlings cultivated with a larger number of individuals per pot (Table 6). Cultivar effect, in experiments 3 and 4, was significant and indicated that epicotyl average data tended to maintain the Vencedora cultivar as that of highest mean compared to the

BRS 7980 cultivar, which presented the lowest mean (Table7).

Table 6. Epicotyl length (EL) means, in mm, analyzed in the V2 and V3 stages, in experiment 1 in function of density (number) of plants per pot, in a greenhouse, Rio Paranaíba, MG.

Plant density (number)	Epicotyl length (EL, in mm)	
	V2 stage	V3 stage
1	47.02b[1]	45.83b
2	50.80ab	50.94ab
3	53.32a	52.09a

[1]Means at each development stage followed by the same lowercase letters in the column do not differ among them by the Tukey Test at 5% of significance.

Table 7. Epicotyl length (EL) means, in mm, analyzed at the V2 and V3 development stages, is experiments 3 and, in function of cultivars, in a greenhouse, Rio Paranaíba, MG.

Cultivars	Epicotyl length (EL, in mm)			
	Experiment 3		Experiment 4	
	V2 stage	V3 stage	V2 stage	V3 stage
Vencedora	46.18a[1]	54.78a	48.98a	51.96a
TMG 4185	34.98bc	44.05b	39.55b	45.34ab
BRS 8381	39.44b	45.17b	40.01b	44.57b
BRS 7980	31.43c	39.13b	37.59b	38.83b

[1]Means at each development stage followed by the same lowercase letters do not differ among them by the Tukey test at 5% of significance.

Significant effect for seeding depth was not identified, indicating that the characters (hypocotyl and epicotyl length) were not affected by this factor, thus, being sowing possible at any of the depths studied.

According to Nogueira et al. (2008), the necessary condition for a trait to become useful for cultivars differentiation is the presence of genetic variability. This work identified the difference among means of four cultivars, for hypocotyl and epicotyl length. In other works, taking into consideration the hypocotyl and epicotyl length of plants at initial development stage, Nogueira et al. (2008) reported significant difference for 85 soybean genotypes divided into four different periods. Matsuo et al. (2012b) reported significant difference for 85 soybean genotypes divided into four different experiments. This reinforces the potential of these variables in discriminating cultivars, even when a few genetic materials are analyzed.

During the evaluation of plant height, the effect of number of plants per pot was significant for the V2 stage in experiment 1, which indicated that pots with more plants pots with less soil volume (3 plants) showed the highest means. The effect of soil volume indicated that, at the V3 stage in experiment 2, pots with less soil volume (1 dm^3) resulted in shorter plants compared to pots with 2 and 3 dm^3 of soil (Table 8). The best arrangement of plants is one that provides a more even distribution of plants in the sowed row, providing better use of water, light and nutrients (Rocha et al., 2018).

Table 8. Plants height (PH) means, in cm, of soybean cultivars evaluated in regards to soil volume (SV), in dm^3, in experiment 2, at the V2 and V3 development stages, and to plant density (number) per pot, analyzed in experiment 1, at the V2 development stage, in a greenhouse, Rio Paranaíba, MG.

| SV | Plant height (PH, in cm) | | PD | Plant height (PH, in cm) |
	V2 Stage	V3 Stage		V2 Stage
1	132.28a[1]	172.71b	1	127.53b
2	147.30a	206.27a	2	139.84ab
3	148.40a	210.03a	3	144.58a

[1]Means in each development stage followed by the same lowercase letters in the column do not differ among them by the Tukey test at 5% of significance.

For the V2 and V3 stages of development in experiment 3, the Vencedora cultivar tended to show a higher mean and the BRS 7980 the lowest mean (Table 9). Results from the Cultivars x Depths interaction (Table 10) showed a significant effect for depth only for cultivar BRS 8381, i.e., at 2 cm, plant height was greater than when seeds were disposed a1 1 centimeter. The analysis of a cultivar at each one of the depths tended to show a result like that obtained at V2 and V3 stages in experiment 3. This greater growth can be explained by the fact that soybean plants submitted to longer photoperiods can result in higher plants, once experiment 3 was submitted to more time under the light. These results are corroborated with those found by Câmara et al. (1997).

Seeding density increase (number of plants per pot), provides an increase in intraspecific competition for water, nutrients and mainly light, resulting in plants etiolation (Tancredi et al., 2006). Similarly, Almeida et al. (2014) reported that pot size, and consequently soil volume, whenever small, can limit plant development. There is a tendency to increment soybean plant height as a way to maximize the uptake by radiation when they are under radiation (Almeida et al., 2015).

Results showed correlation values over 0.65 (p<0.05 t test) for the HL-V2 x HL-V3, EH-V2 x EH-V3, PH-V2 x PH-V3 and EH-V3 X PH-V3 pairs (Table 11). These pairs correlated satisfactorily, since, according to Lopes et al. (2002) plant breeders tend to value the signal (positive or negative) and values magnitude during the applied interpretation of the correlations, valuing estimates below 0.5 and above 0.5. Based on correlation estimates, it is possible to practice indirect relation for a key trait characterized by low heritability and/or difficult evaluation with faster genetic gains in relation to the use of direct selection (Cruz et al., 2004).

Table 9. Plant height (PH) means, in mm, evaluated at the V2 and V3 development stages, in experiment 3, in function of soybean cultivars, in a greenhouse, Rio Paranaíba, MG.

| Cultivars | Plant Height (AP, in mm) | |
	V2 Stage	V3 Stage
Vencedora	99.45a[1]	131.24a
TMG 4185	88.82ab	121.83ab
BRS 8381	95.37ab	112.07b
BRS 7980	79.18b	96.47c

[1]Means in each development stage, followed by the same lowercase letters in the column do not differ among them by the Tukey test at 5% of significance.

These same authors reported that correlation coefficients equal to zero do not imply lack of relationship, they only express absence of linear association among traits.

Table 10. Results from the Depth *vs* Cultivars interaction for plant height, in mm, measured in soybean plants at the V3 development stage, in experiment 4, in a greenhouse, Rio Paranaíba – MG.

Cultivars	Depths		
	1 cm	2 cm	3 cm
Vencedora	147.56Aa[1]	119.46Aab	134.98Aa
TMG 4185	128.29Aab	117.41Aab	115.34Aab
BRS 8381	104.54Bb	137.72Aa	131.01ABa
BRS 7980	101.21Ab	95.24Ab	93.44Ab

[1]Means followed by the same lowercase letters in the column and uppercase in the line do not differ significantly by the Tukey test at the 5% level.

Table 11. Phenotypical correlation coefficients between characters obtained separately for each one of the four experiments.

Pairs of characters	EXP 1	EXP2	EXP3	EXP4
HL-V2 X HL-V2	0.24	0.27	0.75**	0.30
HL-V2 X PH-V2	0.29	-0.22	0.58*	0.16
HL-V2 X HL-V3	0.71*	0.11	0.67*	0.81**
HL-V2 X EL-V3	0.40	0.28	0.68*	0.27
HL-V2 X PH-V3	0.48	-0.22	0.52	0.35
EL-V2 X PH-V2	0.37	-0.27	0.82**	-0.20
EL-V2 X HL-V3	0.33	0.39	0.47	0.17
EL-V2 X EL-V3	0.83**	0.65	0.93**	0.82**
EL-V2 X PH-V3	0.37	-0.25	0.77**	0.60*
PH-V2 X HL-V3	-0.15	0.06	0.43	0.03
PH-V2 X EL-V3	0.51	0.14	0.81**	0.01
PH-V2 X PH-V3	0.75*	0.97**	0.76**	-0.02
HL-V3 X EL-V3	0.53	0.52	0.44	0.14
HL-V3 X PH-V3	0.26	0.24	0.37	0.34
EL-V3 X PH-V3	0.71*	0.14	0.86**	0.65*

** and * significant at the 1% and 5% probability level by the t test; HL: Hypocotyl length; CE: Epicotyl length; PH: Plant height; V2: Development stage V2 and V3: Development stage V3 (Ferh and Caviness. 1977).

CONCLUSIONS

Hypocotyl length, evaluated at the V2 stage, was not affected by soil volume, plant density and sowing depth; epicotyl length was not affected by sowing depth; plant height was affected by soil volume variations, plant density, sowing depth and cultivars; and soybean cultivars sowed distinguishability for hypocotyl and epicotyl length at the V2 and V3 stages, being considered potential soybean descriptors.

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