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Soybean grain yield is impacted by the sowing depth and the type of soil cover

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ABSTRACT

Implementing a crop such as a soybean requires favorable sowing conditions so that uniform and healthy seedlings emerge. This study aimed to evaluate the yield of soybeans crop concerning the type of soil cover and sowing depth. The experiment was conducted at the State University of Mato Grosso do Sul - University Unit of Cassilândia. A Completely randomized design with four replications in a 3x5 factorial scheme was used. Three cropping systems (without soil cover, millet straw, and brachiaria straw) and five sowing depths (2, 4, 6, 8, and 10 cm) were evaluated. The emergence speed index, plant height, stem diameter, first pod insertion height, number of branches, number of pods per plant, number of grains per pod, and grain yield per plant were assessed. The highest yield per plant was obtained with millet straw and a sowing depth of 6 cm. It can be concluded that the sowing depth and type of straw influence the soybean grain yield.

Keywords: *Glycine max*, Soil management, Yield, Straw mulch, Development.

Profundidade de semeadura e tipo de palhada influenciam a produtividade da soja

RESUMO

A implantação de uma cultura como a soja exige que na semeadura ocorram condições propícias, para que se obtenha uma emergência de plântulas uniformes e sadias. O objetivo do trabalho foi avaliar a produtividade da cultura de soja em relação ao tipo de cobertura vegetal e profundidade de semeadura. O experimento foi realizado na Universidade Estadual de Mato Grosso do Sul – Unidade Universitária de Cassilândia. O delineamento utilizado foi inteiramente casualizado, com 4 repetições em esquema fatorial 3x5, sendo três sistemas de cultivo (convencional, com palhada de milheto e palhada de braquiária) e cinco profundidades de semeadura (2, 4, 6, 8 e 10 cm). Avaliou-se o índice de velocidade de emergência, altura de planta, diâmetro, altura de inserção primeira vagem, número de ramificações, vagens por planta, grãos por vagem e produtividade por planta. Obteve-se maior produtividade por planta no tratamento associado a palhada de milheto e profundidade de semeadura de 6 cm. Conclui-se que a profundidade de semeadura e o tipo de palhada influenciam na produtividade da cultura de soja.

Palavras-chave: *Glycine max,* Manejo do solo, Produtividade, Cobertura vegetal, Desenvolvimento.

1. Introduction

Soybeans (*Glycine max*) are a crop of global importance, producing grain for human and animal food, oil, meal, and biofuels. Brazil is the largest producer of soybeans, with 44,075.6 million hectares of cultivated area, with an average grain yield of 3,508 kg ha^{-1} and a production of 154,617.4 million tons. The Midwest region is the largest producing region in the country, with 65.9 million tons, and the state of Mato Grosso do Sul collaborates with a production of 27.810 million tons (CONAB, 2023). Proper and uniform seed depth within the optimum range increases crop germination rate, which directly affects yield (Iqbal et al., 2022). According to Rocha et al. (2018), sowing is a step that requires perfection in its execution because it can compromise the profitability of agricultural activity.

The sowing depth is linked to the decrease in the expression of seed vigor, hinders the emergence, and increases the time exposed to pathogens; however, there is a reduction of drought or heat stress effects, which can compromise the seedling formation, resulting in low size seedlings without resistance (Alves et al., 2014; Marcos Filho, 2015). Seeds buried deeply spend extra reserves of food materials in elongation of stem for their shoot apices to emerge at the soil surface than seeds sown at shallower depths (Yadav et al., 2023).

According to Pinto et al. (2021), the soil cover offers positive effects, such as soil moisture retention, increasing the nutrients in the soil surface, weed suppression, organic matter enhancement, temperature maintenance, and erosion reduction. Millet used as a soil cover is highlighted as a weed suppressant and protects against soil erosion (Kornecki et al., 2023), besides standing out for a large amount of biomass produced and high drought tolerance, also providing good nutrient cycling (Pacheco et al., 2011).

Pereira et al. (2011) observed that the millet straw helped improve soybean yields due to its larger layer of dry matter, resulting in better soil conditioning. According to Pinto et al. (2021), covering the soil with brachiaria residues provided an increase in soybean productivity due to its high biomass production and high soil surface persistence, contributing to the production environment, in addition to improving the microbiological characteristics of the soil (Simon et al., 2019), which may favor greater grain productivity.

Establishing a good vegetation cover depends on factors such as plant density and good initial development to generate an amount of phytomass favorable to the no-tillage system (Timossi et al., 2007). This study aimed to evaluate the yield of soybeans crop concerning the type of soil cover and sowing depth.

2. Material and Methods

The experiment was conducted in a protected environment at the State University of Mato Grosso do Sul - Unit of Cassilândia (UEMS/UUC), Cassilândia - MS. (19º05'29" S, 51º48'49" W, and altitude 535 m). The experimental environment is characterized by the dimensions of 18.0 x 8.0 m and a ceiling height of 3.5 m, containing black polyethylene screen on the sides and in the upper portion transparent plastic. A Completely randomized design with four replications in a 3x5 factorial scheme was used. Three cropping systems (without soil cover (WC), millet straw (M), and brachiaria straw (B)) and five sowing depths (2, 4, 6, 8, and 10 cm) were evaluated.

Pots (11-liter capacity) were filled with soil from the 0-20 cm layer. The soil used was classified as a Neossolo Quartzarênico with a sandy texture, according to the Brazilian Soil Classification System (Santos et al., 2018). The soil was chemically characterized, and according to the analysis, the necessary fertilizers were added to implement the crops according to agronomic recommendations. Then the cover crops were sown (Millet ADR 300 and Brachiaria Ruziziensis (*Urochloa ruziziensis*)) with populations in proportions that are sown in the field for each species, 25 kg ha^{-1} and 10 kg ha^{-1}, respectively, with daily superficial watering using a semi-automated irrigation system with micro sprinklers. After 39 days of emergence, the plants were cut at ground level and crushed (particles with around 3.0 cm), which was left on the surface of the pot for 30 days while the roots decomposed.

To evaluate the dry matter, we used the methodology adapted and described by Chaila (1986); the chopped material of the cover plants was collected, placed in paper bags, and taken to an air-forced circulated oven at a temperature of 65°C for 72 hours, then weighed on a precision scale. The values in grams were transformed into tons ha^{-1}. The dry matter of millet straw was 3.59 t ha^{-1}, and brachiaria was 3.93 t ha^{-1}. In the pots without soil cover, there was no straw.

After this period, three soybean seeds of the cultivar Brasmax Desafio were sown at different depths in each treatment with the help of a wooden stick with the pre-established depth markings. Irrigation was daily, and the plants were managed like in commercial crops, with manual weeding of the pots. The emergence of the first seedlings was monitored daily to determine the emergence speed index. When the first emergence was verified, the emerged seedlings were counted daily until stabilization occurred, according to the Nakagawa (1994) methodology. The emergence speed index (ESI) values were determined according to equation 1, proposed by Maguire (1962).

Equation 1

$$ESI = \left(\frac{G1}{N1}\right) + \left(\frac{G2}{N2}\right) + \cdots + \left(\frac{Gn}{Nn}\right)$$

Where:

ESI: emergence speed index (plants day^{-1});

G1, G2,...,Gn: number of seedlings emerged on each day;

N1, N2,...,Nn: number of days elapsed between sowing and the last counting day.

The total height of the plant was measured by the distance between the base of the main stem and the apex with a ruler graduated in centimeters. The stem diameter was determined on the main stem of the plant with the aid of a digital caliper. The first pod insertion height was measured from the base of the main stem of the plant to the insertion of the first pod using a ruler graduated in centimeters. To determine the number of branches, the primary branches from the main stem of the plant were counted.

The number of pods per plant was counted by removing all the pods from the plant. After counting the pods, the number of grains within the pod was determined to calculate the total per plant. Based on the previous evaluations, the grain yield per plant was determined. The results were submitted to the normality test, homogeneity test and analysis of variance, and the means were compared using the Tukey test at a 5% significance level. Minitab 16 software was used for data analysis.

3. Results and Discussion

Types of cover crops, such as millet and brachiaria, are very common because they present a similar potential for biomass production (t ha^{-1}). According to Firmiano et al. (2022), both are widely used in the Brazilian Cerrado and provide excellent soil cover. The type of soil cover did not interfere with the emergence speed index (ESI); however, sowing depths influenced this variable. The sowing depth of 2 cm differed from the others, with the highest ESI (Figure 1). This result indicates that since there is less of a physical barrier in the soil to emerge, there was a greater speed, so there is less energy expenditure by the seed, ensuring good initial development.

Da Silva Almeida (2020) proved that the emergence speed index of soybean seedlings at 2 cm deep was higher than deeper sowings. Bottega et al. (2014) observed no significant difference in the emergence speed index of corn seeds, but the highest speed was at the 5 cm sowing depth. The plant height was not influenced by the types of soil covers and sowing depths (Figure 2). On the other hand, stem diameter was influenced by the sowing depths and types of soil cover (Figure 2).

The stem diameter in the brachiaria straw had the smallest value, 8.3 mm at a depth of 10 cm, while the largest was in the millet straw, with 11.27 mm at a depth of 6 cm (Figure 2). Firmiano et al. (2022) observed higher height of soybean plants grown in millet straw concerning brachiaria straw this result may have occurred due to the lower C/N ratio of millet, which is therefore decomposed faster than the brachiaria straw. On the other hand, the authors observed a larger soybean stem diameter with the brachiaria straw.

About the first pod insertion height (FPIH) (Figure 3), the highest FPIH was found in the soil with brachiaria straw (10.82 cm), not significantly different from the millet straw (9.37 cm), but distinguishing when the soil was without coverage with 8.15 cm. The sowing depths did not influence the FPIH. However, the highest FPIH was the highest at sowing at 2 cm deep. Results show that the soil cover influences the first pod insertion height.

According to Muraishi et al. (2005), the millet, brachiaria decumbens, and brachiaria brizantha straw did not interfere with the first pod insertion height, an average of 15.2 cm; unlike the work of Dias et al. (2020), where the depths interfered significantly with FPIH. According to Lemos et al. (2011), the height of insertion of the first pod is linked exactly with the height of plants; these aspects suffer great interference from the environment or the practices imposed during the crop season, besides the genotype.

There were no influence of the types of soil cover and sowing depths on the number of branches (NR) and pods per plant (NVP) (Figure 3). The highest averages of all these variables were found in the treatment with millet cover, while the lowest averages were without soil cover. Both parameters may not have differed significantly since water availability was daily, so all plants had light and water in similar amounts; also, these characteristics are strongly linked to the genotype.

Regarding the sowing depths, the highest number of branches was 7.08 at a depth of 8 cm, and the lowest was 5.58 at a depth of 4 cm. The highest number of pods per plant was found at sowing at 4 cm deep, with 50.66 pods, while the lowest was 45.58 pods per plant at a depth of 8 cm. Plants derived from shallow sowings may have expended less energy to emerge, ensuring that the remaining energy contributed to better vegetative growth.

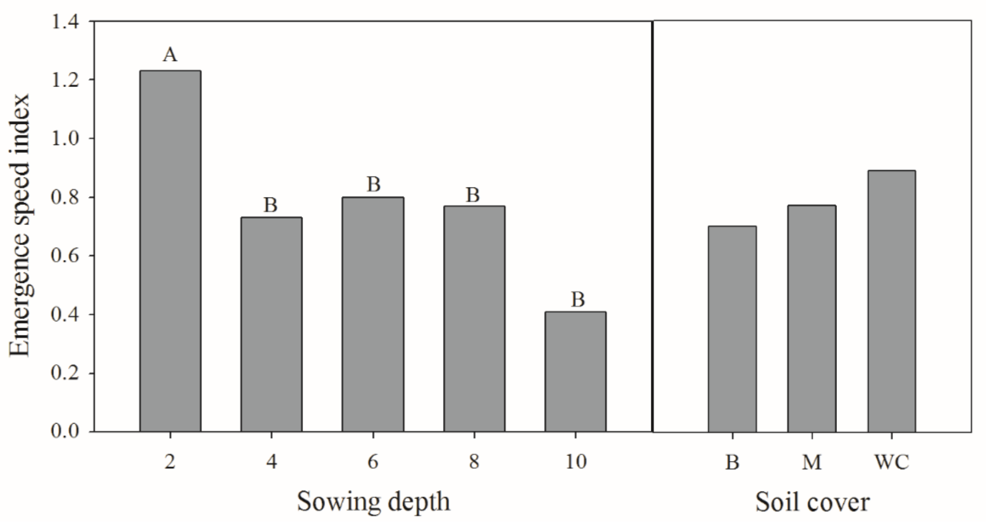

Figure 1. Emergence speed index of soybean seedlings according to the sowing depth and types of soil cover. Means followed by equal letters do not differ by the Tukey test (α=5%).

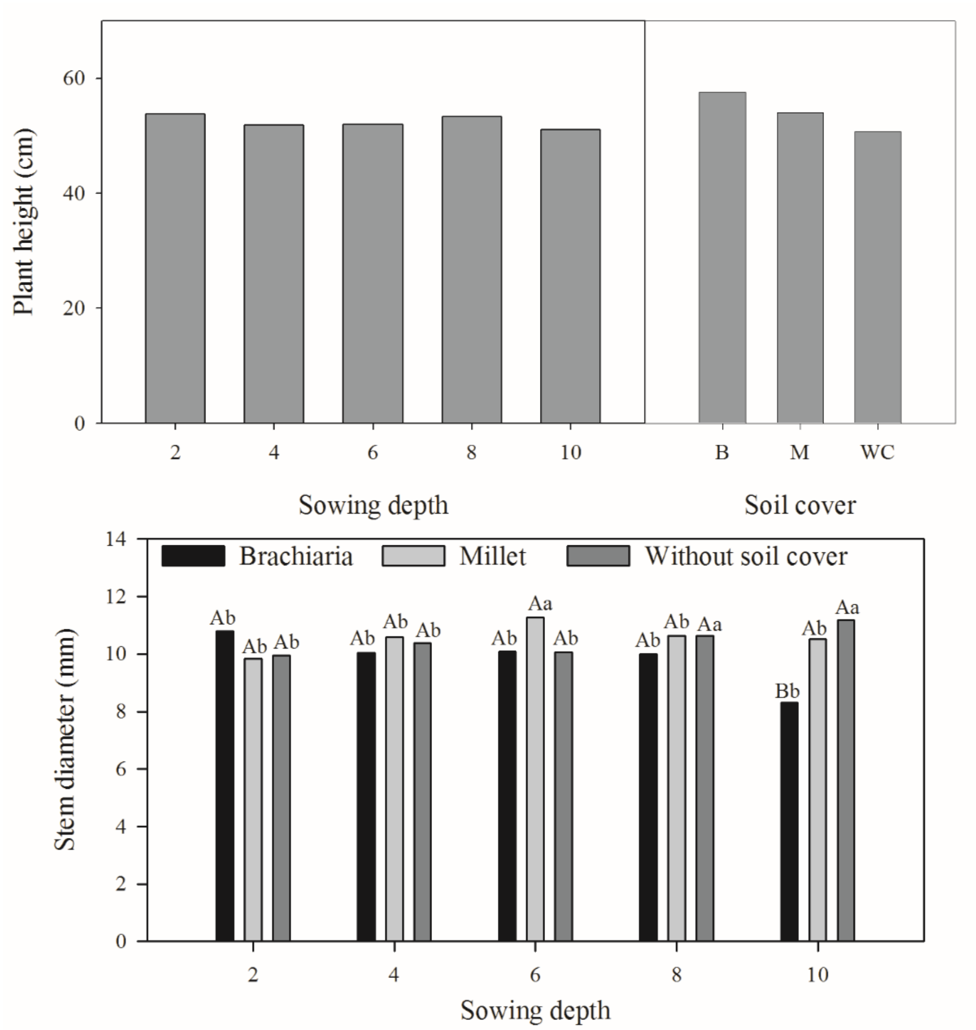

Figure 2. Plant height and stem diameter of soybean plants according to the sowing depth and types of soil cover. Means followed by the same uppercase letter for the type of soil cover and lowercase letter for sowing depth do not differ by the Tukey test at 5% probability level.

According to Lima et al. (2009), there were no significant differences between the treatments without soil cover and with millet straw concerning PH and the number of pods per plant (NPP) of soybean. Muraishi et al. (2005) observed that the NPP of soybean had no difference among the various straws, but the one that obtained the highest average was that of millet, showing it to be better than those of brachiaria decumbens and brachiaria brizantha.

For the number of grains per plant (NGP), the lowest value was obtained without a straw at 8 cm depth and the highest in millet straw at 6 cm depth, with 135 grains per plant (Figure 4). Due to the benefits that the soil cover provides, the plants can have a higher number of grains compared to those that did not have some cover, which also shows that even sowings at 6 cm deep can generate a good NGP compared to shallower sowings.

According to the results of a study on soybeans at 2, 5, and 8 cm sowing depths, there were no significant differences in the first 2015/16 crop season for NGP, unlike the second 2016/17 crop season, where the highest amount of grains per plant was at interspersed depths of 5 and 8 cm not significantly differing from that at 2 cm (Dias et al., 2020).

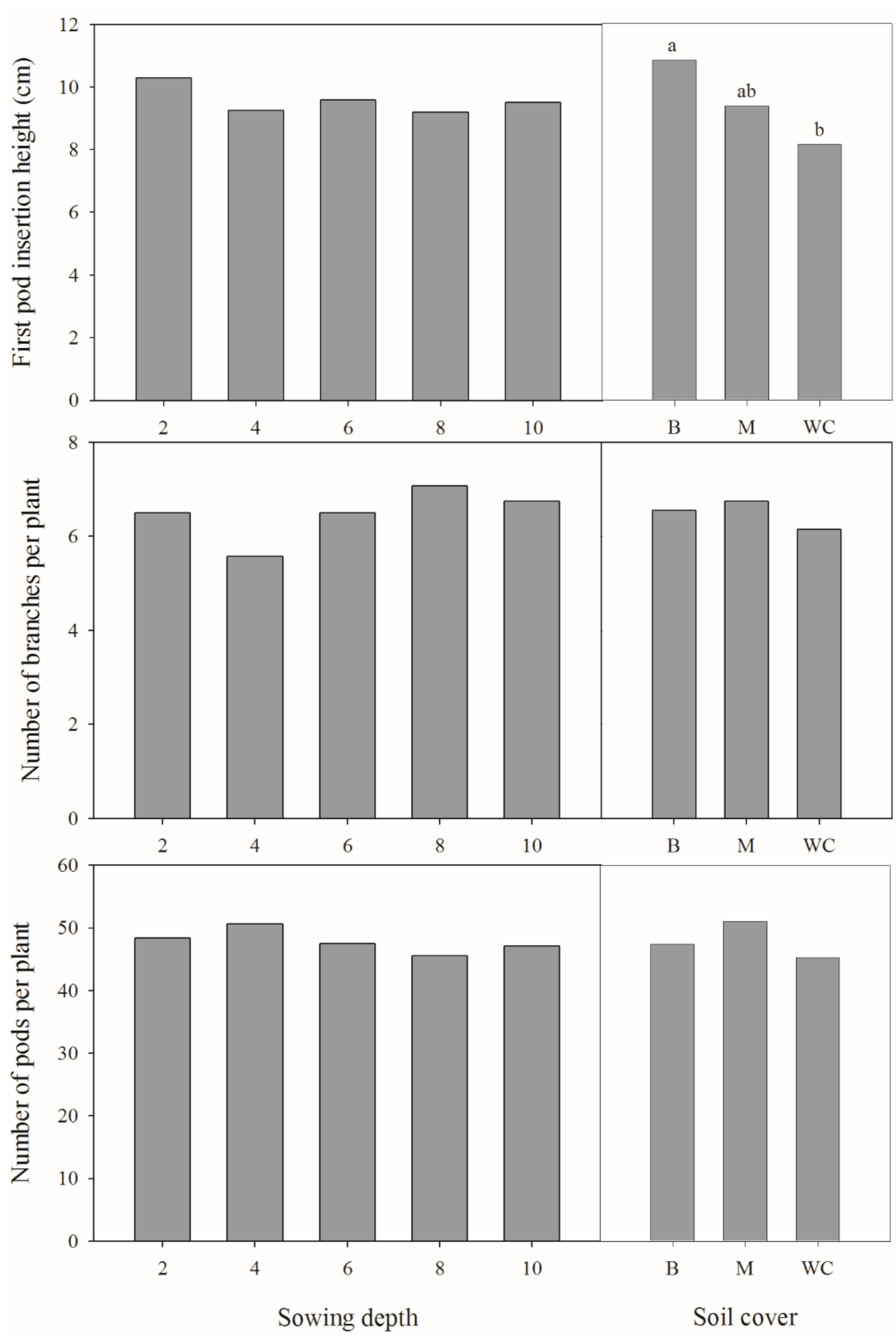

Figure 3. First pod insertion height, number of branches, and number of pods per plant according to the sowing depth and types of soil cover. Means followed by equal letters do not differ by the Tukey test (α=5%).

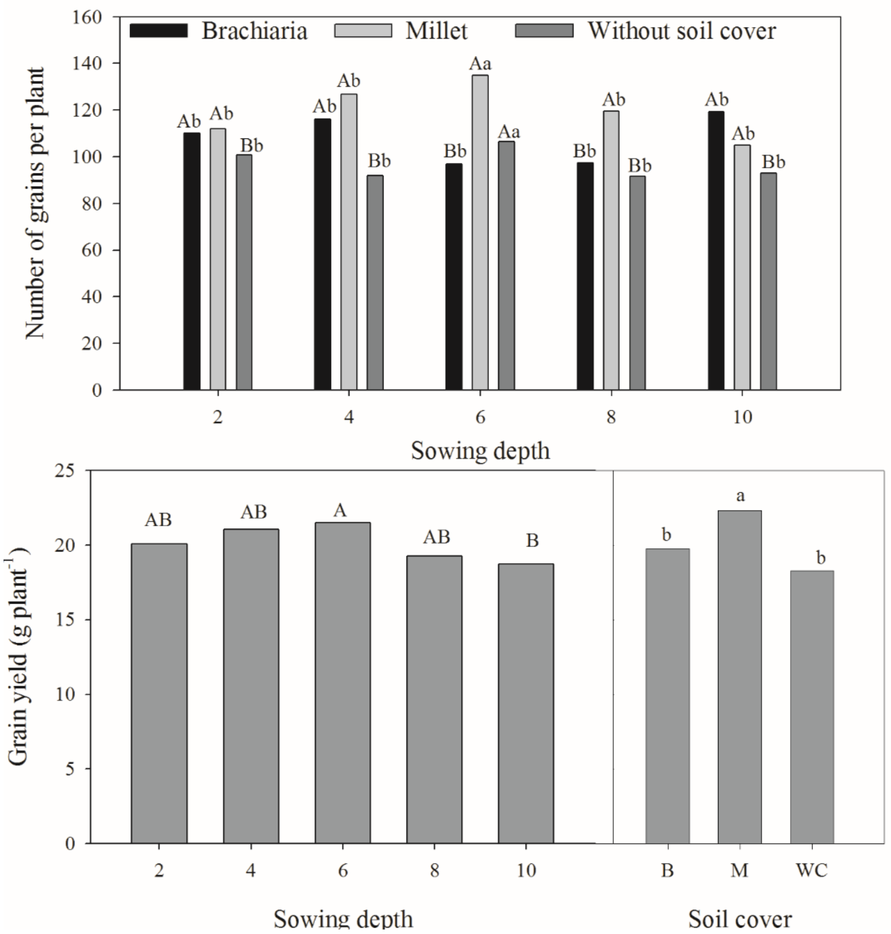

Figure 4. Number of grains per plant and grain yield per plant according to the sowing depth and types of soil cover. Means followed by equal letters do not differ by the Tukey test (α=5%).

For the grain yield per plant, the millet straw stands out for providing the highest grain yield with 22.33 grams per plant, different from the other types of soil cover, and comparing the depths, sowing at 6 cm had the highest grain yield, different from the sowing at 10 cm deep, which had lowest grain yield per plant (Figure 4). Firmiano et al. (2022) observed no significant difference in soybean yield regarding millet or brachiaria straw.

The difference in grain yield according to the type of soil cover can probably occur due to the conditions of the pot, which limited the capacity of the brachiaria roots; however, the millet root had a greater rooting capacity, providing better aeration and replacement of nutrients in the subsurface. Because it has a lower C/N ratio, millet straw decomposes faster than brachiaria straw, which has a higher C/N ratio, thus providing more nutrient availability for plant development (Firmiano et al., 2022).

The highest grain yield observed at sowing at 6 cm depth may be due to the more favorable conditions concerning water, temperature, and aeration than those in deeper sowings that gave the seedlings a greater energy expenditure to emerge, compromising part of the initial development. Dias et al. (2020) observed that grain yield at 8 cm depth stood out compared to 2 cm, corroborating with Conte et al. (2009), who say that it is due to water scarcity, demonstrating that higher sowing depths are ideal not to compromise the crop.

4. Conclusions

The type of soil cover did not influence the emergence speed index; however, the sowing depth influenced this variable. The most recommended sowing depth, at suitable climatic conditions, is 2 cm because it gives the plants a higher emergence speed to obtain an initial stand of plants. Both millet and brachiaria straws can be used as soil cover in no-tillage systems, but the most indicated is the millet for providing the highest soybean grain yield per plant.

Authors' Contribution

João Flávio Floriano Borges Gomides, Murilo Battistuzzi Martins and Fernanda Pacheco de Almeida Prado Bortolheiro: conceptualization, data curation and writing-original draft. João Flávio Borges Gomides, Cássio de Castro Seron and Jussara Souza Salles: writing-reviewand formal analysis. Murilo Battistuzzi

Martins and Eduardo Pradi Vendruscolo: writing review and editing

Bibliographic References

Alves, A.U., Cardoso, E.A., Alixandre, T.F., Cavalcante, I.H.L., Beckmann-cavalcante, M.Z. 2014. Emergência de plântulas de fava em função de posições e profundidades de semeadura. Bioscience Journal, 30(1), 33-42. https://seer.ufu.br/index.php/biosciencejournal/article/view/15023/13680.

Bottega, E.L., Braido, R., Piazzetta, H.L., Oliveira Neto, A.M., Guerra, N. 2014. Efeitos da profundidade e velocidade de semeadura na implantação da cultura do milho. Pesquisa Agropecuária Pernambucana, 19(2), 74-78. DOI: https://doi.org/10.12661/pap.2014.011.

Chaila, S. 1986. Métodos de evaluación de malezas para estudios de población y control. Malezas, 14, 1-78.

CONAB. COMPANHIA NACIONAL DE ABASTECIMENTO, 2023. Ministério da Agricultura, Pecuária e Abastecimento. Acompanhamento de Safra Brasileira Grãos, Safra 2022/2023. Brasília, Ministério da Agricultura, Pecuária e Abastecimento, 76 p. https://www.conab.gov.br/info-agro/safras/graos/boletim-da-safra-de-graos.

Conte, O., Levien, R., Trein, C.R., Xavier, A.A.P., Debiasi, H. 2009. Demanda de tração, mobilização de solo na linha de semeadura e rendimento da soja, em plantio direto. Pesquisa Agropecuária Brasileira, 44(10), 1254-1261. DOI: https://doi.org/10.1590/S0100-204X2009001000007.

Da Silva Almeida, A., Helgueira, D.B., Moura, D.S., Bohn, A., Jaques, L.B.A., Garcia, M., Moraes, N.A.B., Tunes, L.V.M. 2020. Emergência e desenvolvimento inicial de plântulas de soja em diferentes profundidades de semeadura. Brazilian Journal of Development, 6(6), 41100-41107. DOI: https://doi.org/10.34117/bjdv6n6-593.

Dias, P.P., Sousa, S.F.G., Silva, P.R.A., Correia, T.P.S., Gomes, A.R.A., 2020. Emergência e sobrevivência de plantas de soja a campo em relação às profundidades e épocas de semeadura. Energia na agricultura, 35(2), 150–157. DOI: https://doi.org/10.17224/EnergAgric.2020v35n2p150-157.

Iqbal, T., Ghaffar, A.M., Rehman, U., Saeed, Y., Aqib, M., Iqbal, F., Saleem, S.R. 2022. Development of Real Time Seed Depth Control System for Seeders. Environmental Sciences Proccedings, 23(1). DOI: https://doi.org/10.3390/environsciproc2022023007.

Firmiano, R.S., Mesquita, G.M., Rios, A.D., Buso, W.H.D., 2022. Yield traits of soybean cultivated under Brachiariaand millet straw and potassium doses. Revista de Agricultura Neotropical, 9(1), e6547. DOI: https://doi.org/10.32404/rean.v9i1.6547.

Kornecki, T.S. and Kichler, C.M., 2023. Recurring Rolling/Crimping Effects on Termination Effectiveness of Iron Clay Pea and Pearl Millet Warm-Season Cover Crops. Agriculture, 13(10), e1949. DOI: https://doi.org/10.3390/agriculture13101949.

Lemos, N.G., Braccini, A.L., Abdelnoor, R.V., Oliveira, M.C.N., Suenaga, K., Yamanaka, N., 2011. Characterization of genes Rpp2, Rpp4, and Rpp5 for resistance to soybean rust. Euphytica, 182(1), 53-64. DOI: https://doi.org/10.1007/s10681-011-0465-3.

Lima, E.V. Crusciol, C.A.C., Cavariani, C., Nakagawa, J. 2009. Características agronômicas, produtividade e qualidade fisiológica da soja" safrinha" sob semeadura direta, em função da cobertura vegetal e da calagem superficial. Revista Brasileira de Sementes, 31, 69-80. DOI: https://doi.org/10.1590/S0101-31222009000100008.

Maguire, J.D. 1962. Speed of germination-aid in relation evaluation for seedling emergence vigor. Crop Science, 2(2), 176-177.

Marcos Filho, J. 2015. Fisiologia de Sementes de Plantas Cultivadas. ABRATES, Londrina.

Muraishi, C.T., Leal, A.J.F., Lazarini, E., Rodrigues, L.R., Gomes Junior, F.G., 2005. Manejo de espécies vegetais de cobertura de solo e produtividade do milho e da soja em semeadura direta. Acta Scientiarum Agronomy, 27(2), 199-207. DOI: https://doi.org/10.4025/actasciagron.v27i2.1903.

Nakagawa, J. 1994. Testes de vigor baseados na avaliação das plântulas. In: Vieira R.D., Carvalho, N.M., (Ed.), Testes de vigor em sementes. FUNEP, Jaboticabal, p. 48-85.

Pacheco, L.P., Leandro, W.M., Machado, P.L.O.A., Assis, R.L., Cobucci, T., Madari, B.E., Petter, F.A. 2011. Produção de fitomassa e acúmulo e liberação de nutrientes por plantas de cobertura na safrinha. Pesquisa Agropecuária Brasileira, 46(1), 17-25. DOI: https://doi.org/10.1590/S0100-204X2011000100003.

Pereira, R.A., Alves, P.L.C.A., Corrêa, M.P., Dias, T.C.S. 2011. Influência da cobertura de aveia-preta e milheto sobre comunidade de plantas daninhas e produção de soja. Revista Brasileira de Ciências Agrarias, 6(1), 1-10. DOI: https://doi.org/10.5039/agraria.v6i1a545.

Pinto, P.H.G., Lima, S.F., Andrade, M.G.O., Contardi, L.M., Ávila, J., Reis, B.O., Bernardo, V.F., Vendrusculo, E.P. 2021. Weeds in soybean cultivation with different predecessor cover crops. Revista de Agricultura Neotropical, 8(2), e5890. DOI: https://doi.org/10.32404/rean.v8i2.5890.

Rocha, B.G.R., Amaro, H.T.R., Porto, E.M.V., Gonçalves, C.C.G., David, A.M.S.S., Lopes, E.B., 2018. Sistema de semeadura cruzada na cultura da soja: avanços e perspectivas. Revista de Ciências Agrárias, 41(2), 376-384. DOI: https://doi.org/10.19084/RCA17260.

Santos, H.G., Jacomine, K.T., Anjos, L.H.C., Oliveira, A., Lumbreras, J.F., Coelho, M.R., Almeida, J.A., Cunha, T.J.F., Oliveira, J.B., 2018. Sistema brasileiro de classificação de solos. 3ª.ed. Embrapa, Brasília, DF, Brasil.

Simon, C.A., Lima, S.F., Cordeiro, M.S., Secco, V.A., Nacata, G., Silva, A.M.M., Simon, C.C., Brasil, M.S. 2019. Cover crops as modying agentes of microbiological soil attribute. Australian Journal of Crop Science, 13(10), 1578-1585. DOI: https://doi.org/10.21475/ajcs.19.13.10.p17.

Timossi, P.C., Durigan, J.C., Leite, G.J., 2007. Formação de palhada por braquiárias para adoção do sistema plantio direto. Bragantia, 66, 617-622. DOI: https://doi.org/10.1590/S0006-87052007000400012.

Yadav, N., Khanduri, V.P., Singh, B., Dhanai, C.S., Riyal, M.K., Rawat, D., Ahmad, T., Kumar, M. 2023. Effect of Temperature, Seed Size, Sowing Depth, and Position on Seed Germination and Seedling Growth of *Bauhinia retusa* Roxb. and *Bauhinia variegata* L. Forests, 14(8), e1664. DOI: https://doi.org/10.3390/f14081664.