FIRMIANO, R. S.; MESQUITA, G. M.; RIOS, A. D.; BUSO, W. H. D. Yield traits of soybean cultivated under Brachiaria and millet straw and potassium doses. **Revista de Agricultura Neotropical**, Cassilândia-MS, v. 9, n. 1, e6547, jan./mar. 2022. ISSN 2358-6303. DOI: https://doi.org/10.32404/rean.v9i1.6547.

Yield traits of soybean cultivated under Brachiaria and millet straw and potassium doses

Raquel Silva Firmiano[1], Glaucia Machado Mesquita[2], Anderli Divina Rios, Wilian[3] Henrique Diniz Buso[1]

[1] Instituto Federal Goiano, Campus Ceres, Ceres, Goiás, Brasil. E-mail: raquels.firmiano@gmail.com, wilian.buso@ifgoiano.edu.br

[2] Universidade Federal de Goiás, Goiânia, Goiás, Brasil. E-mail agroglaucia@gmail.com

[3] Faculdade UniEvangélica de Goianésia, Goianésia, Goiás, Brasil. E-mail: anderlidf@hotmail.com,

Received: 06/08/2021; Accepted: 18/02/2022.

ABSTRACT

There are many doubts about which straw-supplying species should be cultivated in a no-tillage system and which potassium doses are adequate for the Cerrado soils. Therefore, the current study aimed to evaluate the agronomic traits (plant height, first pod insertion height, and stem diameter); yield traits (number of pods per plant, number of grains per pod, and 100-grain weight), grain yield (kg ha^{-1}) and potassium content in the leaves, in the production of soybean cultivated in different straws and potassium doses in two crop seasons under Cerrado conditions in the region of Ceres, Goiás, Brazil. Two types of straw (Brachiaria and millet) and four potassium doses were evaluated. A randomized complete block design arranged in a 2x2x4 factorial scheme with four repetitions was used. Two crop seasons (2011/2012 and 2012/2013), two types of straw (Millet and Brachiaria), and four potassium doses (0, 30, 60, and 90 kg ha^{-1} of K_2O using KCl as source) were evaluated. Phosphate fertilization was performed using 400 kg ha^{-1} of simple superphosphate, and the cultivar used was P98Y12. The largest plant height values were obtained by applying 90 kg ha^{-1} of K_2O. The Brachiaria straw promoted a grain yield increase associated with the potassium doses increment. The highest grain yield was 4,353.90 kg ha^{-1}, achieved by applying 65 kg ha^{-1} of K_2O using millet straw. The highest grain yield reached was at the rate of 90 kg ha^{-1} of K_2O, resulting in 5,208 kg ha^{-1}. The greatest K accumulation in the leaf is provided by Brachiaria straw.

Keywords: Fertilization, Glycine max., Coverage Plant, Grain yield.

Características produtivas da soja cultivada sob palhada de braquiária e milheto e doses de potássio

RESUMO

Existe muitas dúvidas acerca de qual espécie fornecedora de palhada a ser cultivada em Sistema de Plantio Direto e qual as doses de potássio correta para ser utilizada em solos de Cerrado. Desde modo, com a presente pesquisa objetivou avaliar as características agronômicas (altura de planta, altura da inserção da primeira vagem e diâmetro do caule); características produtivas (número de vagens por planta, número de grãos por vagens e massa de 100 grãos), produtividade (kg ha^{-1}) e o teor de potássio nas folhas, na produção da soja cultivada em diferentes palhadas e doses de potássio em duas safras em condições de Cerrado na região de Ceres-Goiás. Foram usados dois tipos de palhada (braquiária e milheto), e quatro doses de potássio. Foi utilizado o delineamento de blocos completos casualizados, em esquema fatorial 2x2x4 duas safras (2011/2012 e 2012/2013), dois tipos de palhada (milheto e braquiária) e quatro doses de potássio (0, 30, 60 e 90 kg ha^{-1} na forma de KCl) com quatro repetições. A adubação fosfatada foi realizada utilizando 400 kg ha^{-1} de superfosfato simples e a cultivar utilizada foi P98Y12. A maior altura de planta foi obtida com a aplicação de 90 kg ha^{-1} e K_2O. A palhada de braquiária promoveu aumento de produtividade associada com o incremento de doses de potássio. A maior produtividade obtida foi 4.353,90 kg ha^{-1} com aplicação de 65 kg ha^{-1} de K_2O sob o uso de palhada de milheto. A maior produtividade alcançada foi na dose de 90 kg ha^{-1} de K_2O, resultando em 5.208 kg ha^{-1}. O maior acúmulo de K na folha é proporcionado pela palhada de braquiária.

Palavras-chave: Adubação, *Glycine max*., Planta de Cobertura, Produtividade.

1. Introduction

Soybean [*Glycine max* (L.) Merrill] is one of the leading agricultural commodities cultivated and traded globally, with Brazil as one of the main producers. According to CONAB data (2021), Brazil produced 124,844.8 and 134,451.1 thousand tons in the 2019/2020 and 2020/2021 crop seasons, respectively. Soybeans are widely used to produce vegetable oil, milk, fruit juice drinks, cookies, flour, food supplements, ice cream, animal feed, biofuel, and other products (Brasil et al., 2018). Soybean is listed as the most representative crop in grain production and cultivated area in Brazil, producing more protein per area than any other crop.

According to Meneghette et al. (2019), who worked with cover crops (corn, sorghum, and Millet) and potassium doses (0, 35, 70, and 120 kg ha^{-1}), potassium fertilization in areas adept to the no-tillage system results in a good correlation with the phytomass production of coverings used in rotation processes with soybean. Also, the use of millet and the dose of 35 kg ha^{-1} of K_2O resulted in higher soybean yield (2,526 kg ha^{-1}). The K accumulation, both in millet straw and in soybean leaves in succession, reached higher values when using the dose of 35 kg ha^{-1} of K_2O. The contents found were 25.55 and 18.46 g kg^{-1} for millet and soybean, respectively (Meneghette et al., 2019).

In a study carried out by Cavalli and Lange (2018) with potassium doses (0, 40, 80, 160, and 320 kg ha^{-1}) in one crop season, commonly occurring precipitations favored K absorption conditions. Adequate rainfall also accelerated K availability in crop residues to the soil, which is valuable for soybean nutrition, regardless of the cover crop species (corn or Brachiaria).

Plants from the Poaceae family have a higher C/N ratio. However, millet at the beginning of decomposition tends to have a C/N ratio of around 30; however, millet straw presents high decomposition rates in Cerrado areas, mainly due to the rainy climate and high temperatures (Kogel-Knabner, 2002). Brachiaria has an average C/N ratio of 40.76 (Menezes and Leandro, 2004). Cover crops usage aims to make part of the nutrients available during periods of greatest need for the crop to increase grain yield associated with more efficient management practices (Silva and Lazarini, 2014). Among the species used in the Cerrado region, millet (*Penisetum glaucum*) and Brachiaria (*Brachiaria brizantha*) are the most used.

Soybean sowing on desiccated Brachiaria is widely used because of its interesting way of adopting the no-tillage system. It provides excellent pasture coverage, increasing soil organic matter and allowing crop rotation. Therefore, one of the modalities of using Brachiaria straw is using it as a predecessor of summer soybean sowing (Chioderoli et al., 2012).

According to Silva and Lazarini (2014), millet has been the most employed among the various cover crop alternatives for the Cerrado region. This is mainly due to its vast soil cover potential for a no-tillage system, provided by its greater dry mass volume, contributing to the chemical characteristics of the soil. According to Pacheco et al. (2011), millet in a no-tillage system accumulates a significant amount of phytomass and nutrients at the beginning of the off-season, emphasizing nitrogen and potassium accumulation. In this way, some studies are being carried out to find the best moment and the ideal dose to carry out potassium fertilization in the no-tillage system in the Cerrado region.

Potassium fertilization can be carried out entirely by casting before sowing or in the sowing furrow, the most used way. Studies have also been carried out with potassium fertilization in the cover plant preceding soybean sowing. However, when K (KCl) is applied in the sowing furrow, parceling and covering must be done due to the high saline index, so some care is recommended when using this fertilizer (Oliveira et al., 2008). Thus, the current study aimed to evaluate the yield traits of soybean cultivated under Brachiaria and millet straw and potassium doses in two crop seasons, under Cerrado conditions, in the region of Ceres, Goiás, Brazil.

2. Material and Methods

The experiment was installed in the experimental area of the Instituto Federal Goiano Campus of Ceres, in Ceres, Goiás, Brazil at 15º21'02" S, 49º35'38' W, and 564 m of altitude. According to the Koeppen classification, the climate of the region is classified as Aw-type (hot and semi-humid, with well-defined seasons). The annual average temperature is 23ºC, with a yearly minimum average of 19ºC and a maximum average of 29ºC. The average annual rainfall in the region is 1550 mm per year. The rainfall regime is well defined: the rainy season from October to April and the dry season from May to September (Figure 1).

The experiment was conducted in a Latossolo Vermelho distrófico in two consecutive crop seasons, 2011/2012 and 2012/2013. Soil tillage was carried out by conventional means with two harrowings, and soil samples were collected in the 0 to 20 cm layer for chemical characterization. Soil chemical analyzes were determined according to procedures described by EMBRAPA (2006). The analysis results were: Ca= 2.4, Mg=1.3, Al= 0, and H+Al= 3.7 cmolc dm^{-3}, K= 98, P= 5.6 mg dm^{-3}, OM = 1.5%, V= 52%, CEC= 7.67, Clay= 50% and pH= 5.1.

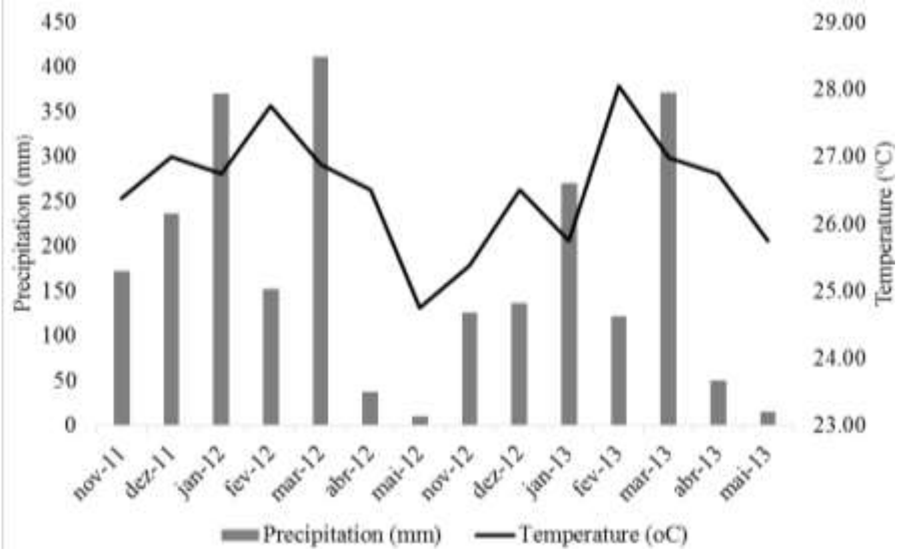

Figure 1. Temperature and precipitation during the experimental period (from Nov/11 to May/12 and from Nov/12 to May/13). Source: Meteorological station from the IF Goiano Campus of Ceres.

In October 2011 and 2012, the straw supplying crops, Millet (*Penissetum glaucum*) and Brachiaria (*Urochloa ruziziensis*), were sown by casting. The desiccation of millet and Brachiaria was carried out on 11/30/2011 and 11/26/2012, 30 days after germination, using the herbicide glyphosate at a dose of 3 L ha^{-1} with a spray volume of 200 L ha^{-1}.

A seed drill was used to cut the straw and mark the rows for manual sowing with 0.50 m of spacing and carried out on 12/01/2011 and 12/08/2012. The phosphate fertilizer used was 400 kg ha^{-1} of simple superphosphate (20% P_2O_5), distributed by the seed drill when marking the rows. The cultivar was P98Y12, and inoculation was performed on the sowing day with bacteria of the *Bradyrhizobium japonicum* genus, with a population of 240,000 plants ha^{-1}.

Weeds were controlled using the herbicide glyphosate with a dose of 2 L ha^{-1} and a spray volume of 200 L ha^{-1}. The insecticide thiamethoxan + lambda-cyhalothrin (Engeo pleno®) was used to control bed bugs at a 200 mL ha^{-1} dose. For Asian rust control, azoxystrobin + cyproconazole (priori xtra®) was used at a dose of 300 mL ha^{-1}. The insecticide triflumuron (Certero®) was used to control stink bugs caterpillars at a dose of 100 mL ha^{-1} with a spray volume of 200 L ha^{-1}.

A randomized block design with four replications arranged in a 2x2x4 factorial scheme was used. Two crop seasons (2011/2012 and 2012/2013), two types of straw (Millet and Brachiaria), and four potassium doses (0, 30, 60, and 90 kg ha^{-1} of K_2O using KCl as source) were evaluated. The plots consisted of four rows, with five linear meters spaced at 0.50 m, totaling 7.5 m^2 per plot. The evaluations were carried out in the two central rows, disregarding 0.50 m at the ends as a border. The topdressing fertilization with potassium was carried out 15 days after emergence (DAE), always next to the continuous row in a single application. The K doses were applied when the plants were at the V3 phenological stage by casting five centimeters from the row of plants.

The analyzed variables are described as agronomic traits: plant height, the first pod insertion height (for these variables, five plants were used per subplot, measured with a graduated ruler), stem diameter, measured with the aid of a caliper; yield traits: number of pods per plant, number of grains per pod, the 100-grain weight, grain yield (kg ha^{-1}) and potassium content in leaves, in the grain yield of soybean cultivated in different straws and potassium doses in two crop seasons.

Leaf potassium was obtained through foliar analysis of the fourth leaf on the main stem at the crop flowering time, and the analyses were performed according to Malavolta et al. (1997). The 100-grain weight (g) obtained from five sub-samples per subplot and the crop grain yield (kg ha^{-1}) were also evaluated. The harvest was carried out on 25/04/2012 and 30/04/2013, the plants were threshed, and the humidity corrected to 13% to determine grain yield. Statistical analysis was performed using analysis of variance, followed by the Tukey test at 5% of significance to compare the means. For the potassium doses, regression equations were fitted. These analyzes were performed using the R software (R Core Team, 2010).

3. Results and Discussion

The summary of the analysis of variance with the values, significance, and mean square of the variables evaluated and the linear and quadratic regression analysis according to the K doses applied are shown in Tables 1 and 2.

Table 1. Mean squares of the sources of variation crop season (Y), cover crop (C), dose (D), and interactions for plant height (PH), first pod insertion height (FPIH), stem diameter (SD), and the number of pods per plant (NPP) of soybean plants.

Source of variation	Variables			
	PH	FPIH	SD	NPP
Y	46.1000*	729.4051*	97.7132*	5589.4314*
C	134.5600*	31.1643 ^{ns}	4.7742*	50.2327 ^{ns}
D	74.8838*	4.4369 ^{ns}	0.4493 ^{ns}	223.2381 ^{ns}
Y x C	2.7225 ^{ns}	1.0868 ^{ns}	0.4096 ^{ns}	146.1077 ^{ns}
Y x D	12.8129 ^{ns}	10.2536 ^{ns}	0.7190 ^{ns}	175.9631 ^{ns}
Y x C	54.5613 ^{ns}	13.6181 ^{ns}	0.0780 ^{ns}	20.8110 ^{ns}
Y x C x D	88.0154 ^{ns}	12.2727 ^{ns}	0.8235 ^{ns}	474.7143 ^{ns}
Linear	ns	ns	ns	ns
Quadratic	ns	ns	ns	ns

** significant at 5%. ns - not significant

Table 2. Mean squares of the sources of variation crop season (Y), cover crop (C), dose (D), and interactions for the number of grains per pod (NGP), the 100-grain weight (W100), grain yield (GRY), and content of potassium in the leaf (CPL) of soybean plants.

Source of variation	Variables			
	NGP	W100	GRY[1]	CPL[1]
Y	4.2849*	21.1441*	10880102.2*	0.0689 ^{ns}
C	0.3192 ^{ns}	0.6480 ^{ns}	1802306.2*	21.2752*
D	0.2669 ^{ns}	7.9163 ^{ns}	9614698.2*	13.2014*
Y x C	0.0256 ^{ns}	1.9044 ^{ns}	726756.2 ^{ns}	0.2889 ^{ns}
Y x D	0.1072 ^{ns}	3.4265 ^{ns}	484594.9 ^{ns}	0.0147 ^{ns}
Y x C	0.0913 ^{ns}	2.6669 ^{ns}	1304582.9 *	13.9702*
Y x C x D	0.0707 ^{ns}	10.7407 ^{ns}	141667.6 ^{ns}	0.1814 ^{ns}
Linear	ns	ns	B*	B*
Quadratic	ns	ns	M*	M*

* significant at 5%. ^{ns} not significant. [1]B* significant for Brachiaria, M* significant for millet.

The analysis of variance showed differences between cover crops, crop season, and K doses for plant height. When millet straw was used, the soybean plants had a height of 60.87 cm. This result may be due to the faster decomposition of millet straw, as it has a lower C/N ratio, contributing to the release of nutrients. According to Rossi et al. (2013), grasses are relevant as options for straw formation in the Brazilian Cerrado since straw provides physical protection and moisture and increases organic carbon levels in the soil. Then, as mineralization occurs, nutrients are released into the soil solution, becoming available to plants. The plants were taller in the first crop season, with 67.90 cm, as shown in Table 3.

For the K doses, the zero dose was different from the others, and when the dose of 90 kg ha^{-1} of K_2O was used, the plants had a height of 61.45 cm, being equal to the other doses used. Similar results were found by Lana et al. (2002); Petter et al. (2012), in which the application of 90 kg ha^{-1} of K_2O for soybean cultivation promoted greater plant height. Plant height increased linearly with increasing potassium dose. Contrary results were observed by Venturoso et al. (2009), who working with potassium doses (0, 55, 110, and 165 kg ha^{-1}), found that in the treatment with the zero dose, the soybean crop had an average height of 79.3 cm, higher than that found for the 110 and 165 kg ha^{-1} doses of K_2O, corresponding to 68.5 and 68.6 cm, respectively (Table 3).

According to Boer et al. (2007), potassium is the nutrient accumulated in the highest amount by cover crops, rapidly released, and presents different behavior among species. Their study also showed that millet gathered the highest amounts of nutrients in the biomass. The type of straw and K doses did not affect the first pod insertion height. There was a difference between the crop seasons; in the first crop season, the first pod insertion height was 15.79 cm, as shown in Table 3. This parameter is essential since insertions very close to the ground represent losses in the harvest since the harvester platform can cut the plants above the first pods. Thus, the closest insertion to the soil occurred in the 12/13 crop season, with 9.04 cm. Buso et al. (2016) worked with plant population variation (120, 160, 200, and 240 thousand plant ha^{-1}) and found an average value of the first pod insertion height of 13.33 cm, as reported by the authors. This value allows for better action of the cutting platform, thus reducing losses during the plant cutting.

There were differences in the stem diameter parameter ($P<0.05$) between straw and crop season, while there was no difference for K doses. In the first crop season, the plants had a larger stem diameter (9.12 mm). Also, when the Brachiaria straw was used, a larger diameter of 8.15 mm, as shown in Table 3. The yield traits of the soybean crop (number of pods per plant, number of grains per pod, and 100-grain weight) were influenced only by crop season (Table 4). These differences may have occurred due to problems with Asian rust in the second crop season because there was a greater severity in this disease attack.

Moreover, fungicide application was delayed due to the higher rain incidence and may have provided lower values of these variables in the 12/13 crop season. The studied straws did not interfere with the yield traits, so using these cover crops does not promote losses for these traits (Table 4). For K doses, there were no adjustments to the linear and quadratic regression models.

Venturoso et al. (2009) observed that the number of pods per plant presented directly proportional results, increasing the number of pods occurring as potassium doses were increased. These authors also observed that for the 100-grain weight, there is a positive response according to the potassium doses, with a marked increase up to the dose of 110 kg ha^{-1} of K_2O, which differs from those found in this study.

Table 5 shows the unfolding of the interaction between K doses and straw supplying plants for grain yield. It is verified that for the 90 kg ha^{-1}, Brachiaria straw promotes superior grain yield (5208 kg ha^{-1}), statistically higher than the area with millet. This finding may be due to the higher C/N ratio of Brachiaria, promoting better soil protection and humidity maintenance, leading to increased microbial activity, resulting in nutrient release, according to the crop demand. For the other two, there is no difference between the cover crops. Amorim et al. (2020), which evaluated Brachiaria straw, observed increases in microbial activity in this type of straw that releases nutrients gradually to the soil solution.

Table 3. Agronomic traits of soybean in two crop seasons on different cover crops (Millet and Brachiaria) in Ceres, G.

Cover crops	Plant Height[1] (cm)	First pod insertion height[2] (cm)	Stem Diameter[3] (mm)
Millet	60.87 a	13.11 a	7.61 b
Braquiaria	57.97 b	11.72 a	8.15 a
Crop season			
11/12	67.90 a	15.79 a	9.12 a
12/13	50.93 b	9.04 b	6.65 b
K_2O (kg ha^{-1})			
0	56.36	12.53	7.65
30	59.80	12.69	7.87
60	60.05	11.65	7.95
90	61.45	12.81	8.05
CV (%)	7.9	23.30	11.50

*Means followed by the same letter in the column do not differ by Tukey's test at 5%.

Table 4. Soybean yield traits, number of pods per plant (NPP), number of grains per pod (NGP), and 100-grain weight (W100) in two crop seasons on different cover crops (Millet and Brachiaria) in Ceres, Goiás, Brazil.

Cover crops	NPP	NGP	W100 (g)
Millet	67.16 a	2.13 a	18.23 a
Brachiaria	68.93 a	2.27 a	18.03 a
Crop season			
11/12	77.39 a	2.46 a	18.78 a
12/13	58.70 b	1.95 b	17.48 b
K_2O (kg ha^{-1})			
0	62.95 a	2.06 a	17.29 a
30	67.56 a	2.17 a	18.40 a
60	71.06 a	2.37 a	18.94 a
90	70.60 a	2.22 a	17.90 a
CV (%)	27.93	16.73	11.97

*Means followed by the same letter in the column do not differ by the Tukey test at 5%.

Table 5. Grain yield (kg ha^{-1}) of soybean according to cover crops and different doses of potassium.

Straw	K_2O doses (kg ha^{-1})			
	0	30	60	90
Brachiaria	2983 aB	3795 aB	4888 aA	5208 aA
Millet	3117 aB	3857 aAB	4455 aA	4103 bA
CV (%)	15.73			

*Means followed by the same lowercase letter in the columns and uppercase letter in the lines do not differ by the Tukey test at 5%.

Petter et al. (2012) evaluated doses of K (0, 30, 60, 90, 120, and 150 kg ha^{-1}) for the production of soybean seeds, obtaining similar results to those found in the study in which a dose of 90 kg ha^{-1}, resulted in higher grain yield of 3,967 kg ha^{-1}. Lane et al. (2002) verified higher soybean grain yield in Cerrados soil employing 90 kg ha^{-1} of K_2O. Werner et al. (2020), confirmed it releases from 60 to 80 kg ha^{-1} of K_2O, indicating it can provide this nutrient to obtain grain yield of approximately 3000 kg ha^{-1}, agreeing with the values shown in this study for the control crop, according to Table 5.

Figure 2 represents the soybean grain yield based on the potassium doses. The maximum grain yield was 4353.90 kg ha^{-1} reached when a dose of 65 kg ha^{-1} of K_2O was applied using a millet straw, presenting quadratic behavior. With the Brachiaria straw, the behavior was linear, increasing with the K doses. Foloni and Rosolem (2008) observed the maximum grain yield of soybean grains in the first and second crop seasons with doses ranging from 85 to 90 kg ha^{-1} of K_2O applied in the millet-soybean succession in the Direct Sowing System.

In Table 6, it is observed that a significant K accumulation of 13.70 g kg-1 resulted from a K dose of 90 kg ha-1 with the Brachiaria straw. For the millet straw, 60 kg ha-1 provided the highest K accumulation in the leaf. In soybeans grown on millet straw, the K content in the leaves presented a quadratic behavior. The dose of 57.14 kg ha^{-1} of K_2O provided the highest K accumulation in the leaves due to the second-grade equation solution. For soybeans on Brachiaria straw, the K content in the leaves grew linearly with the K doses, increasing as it promoted K doses growth (Figure 3).

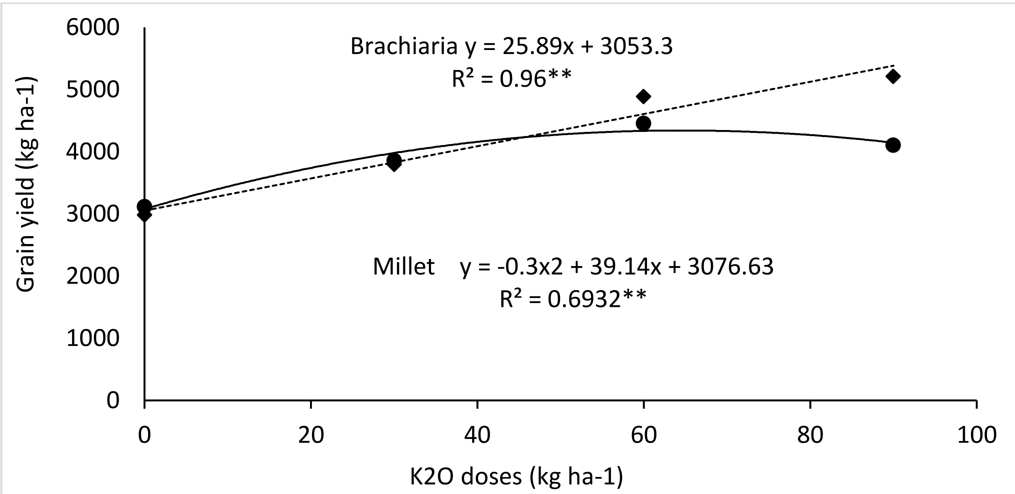

Figure 2. Grain yield (kg ha^{-1}) of soybean on Brachiaria and millet straw according to the K_2O doses.

Table 6. Influence of the interaction between cover crops and doses of potassium on the potassium content in the leaf at the flowering stage (g kg^{-1}).

Cover crops	K_2O doses (kg ha^{-1})			
	0	30	60	90
Brachiaria	10.23 aC	11.84 aB	11.01 aBC	13.70 aA
Millet	9.52 aB	10.28 bB	12.08 bA	10.27 bB
CV (%)	7.04			

*Means followed by the same lowercase letter in the columns and uppercase letter in the lines do not differ by the Tukey test at 5%.

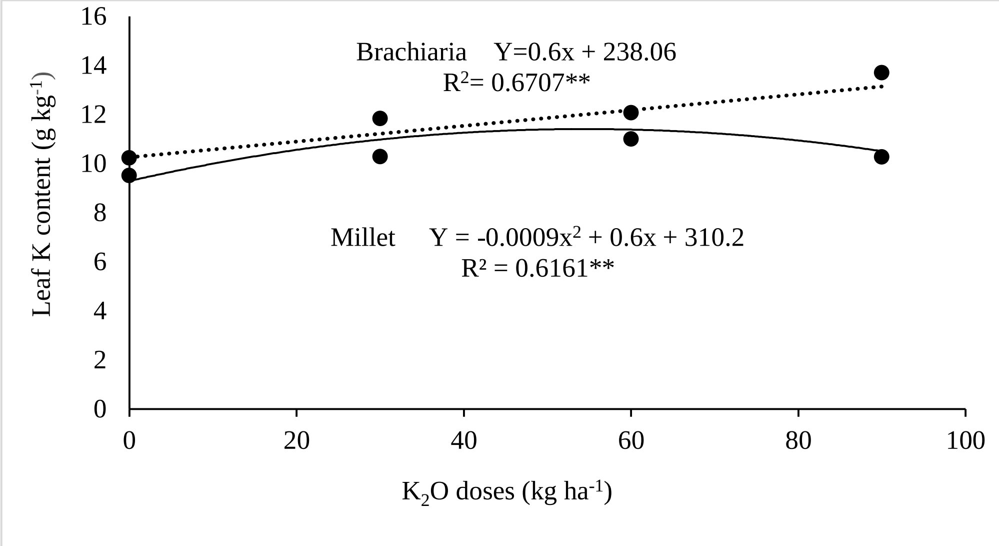

Figure 3. Potassium content in the soybean leaf on Brachiaria and millet straw according to the K_2O doses.

4. Conclusions

Applying 65 kg ha^{-1} of K_2O with millet straw promotes a higher grain yield. For Brachiaria straw, using 90 kg ha^{-1} of K_2O presented a higher grain yield.

The more significant K accumulation in the soybean leaf is provided by the Brachiaria straw, applying 90 kg ha^{-1} of K_2O.

Authors' Contribution

Raquel Silva Firmiano contributed to the installation of the experiment, data collection, and manuscript writing. Glaucia Machado Mesquita performed the corrections of data and manuscript writing and checked the manuscript guidelines. Anderli Divina Rios performed the data tabulation, writing, and manuscript corrections. Wilian Henrique Diniz Buso assisted in the installation of the experiment, carried out the data analysis and graph preparation, and guided the first author of the manuscript.

Bibliographic References

Amorim, S.P.N., Boechat, C.L., Duarte, L.S., Oliveira, D.F., Medeiros, J.C., Arauco, A.M.S. 2020. Microbial responses to doses of cover plant straw in Cerrado Piauiense Oxisol. Bioscience Journal, Uberlândia-MG, 36 (4), 1146-1155. DOI: http://dx.doi.org/10.14393/BJ-v36n4a2020-47963

Brasil, S.O.S., Marques, L.D.L., Silva, R.F.B., Freitas, D.C.L., Soari, K. 2018.Resistência de plantas no controle de oídio: um levantamento de cultivares de soja no Brasil. Revista Científica Rural, Bagé-RS, 1(2), 188-202. DOI: https://doi.org/10.30945/rcr-v20i2.324

Boer, C.A., Assis, R.L., Silva, G.P., Braz, A.J.B.P., Barroso, A.L.L., Cargnelutti Filho, A., Pires, F.R. 2007. Ciclagem de nutrientes por plantas de cobertura na entressafra em um solo de cerrado. Pesquisa Agropecuária Brasileira, Brasília, 42(9), 1269-1276. DOI: https://doi.org/10.30945/rcr-v20i2.324

Buso, W.H.D., Silva, L.B., Rios, A.D.F., Firmiano, R.S. 2016. Cultivo de soja sob dois sistemas de semeadura e diferentes densidades populacionais. Tecnologia e Ciência Agropecuária, João Pessoa, 10(1), 18-23.

Cavalli, E., Lange, A. 2018. Efeito residual do potássio no sistema de cultivo soja-milho safrinha no cerrado mato-grossense. Cultura Agronômica, Ilha Solteira, 27(2), 310-326. https://ojs.unesp.br/index.php/rculturaagronomica/article/view/2446-8355.2018v27n2p310-326/1899. (acessado 20 de outubro de 2021)

Chioderoli, C.A., Mello, L.M.M., Grigolli, P.J., Furlani, C.E.A., Silva, J.O.R., Cesarin, A.L. 2012. Atributos físicos do solo e produtividade de soja em sistema de consórcio milho e braquiária. Revista Brasileira de Engenharia Agrícola e Ambiental, Campina Grande, 16 (1), 37-43. DOI: https://doi.org/10.1590/S1415-43662012000100005

CONAB COMPANHIA NACIONAL DE ABASTECIMENTO. 2021. Acompanhamento da Safra Brasileira de Grãos, Brasília, DF, v. 8, safra 2020/21, n. 9, nono levantamento, junho.

EMBRAPA. EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA. 2006. Centro Nacional de Pesquisa de Solos. Sistema Brasileiro de Classificação de Solos. Rio de Janeiro: Embrapa Solos, 306p.

Foloni, J.S.S., Rosolem, C.A. 2008. Produtividade e acúmulo de potássio na soja em função da antecipação da adubação potássica no sistema plantio direto. Revista Brasileira Ciência do Solo, Viçosa, 32 (4),1549-1561. DOI: https://doi.org/10.1590/S0100-06832008000400019

Kogel-Knabner, I. 2002. The macromolecular organic composition of plant and microbial residues as inputs to soil organic matter. Soil Biology and Biochemistry, 34(2), 139-162.

Lana, R.M.Q., Hamawaki, O.T., Lima, L.M.L., Zanão Júnior, L.A. 2002. Resposta da soja a doses e modos de aplicação de potássio em solo de cerrado. Bioscience Journal, Uberlândia, 8, 17-23. https://seer.ufu.br/index.php/biosciencejournal/article/view/6415/4150 (acessado 12 de abril de 2021)

Malavolta, E., Vitti, G.C., Oliveira, S.A. 1997. Avaliação do estado nutricional das plantas: princípios e aplicações. 2. ed. Potafos, Piracicaba

Meneghette, H.H.A., Lazarini, E., Bossolani, J.W., Santos, F.L., Sanches, I.R., Biazi, N.Q. 2019. Adubação potássica em plantas de cobertura no sistema de plantio direto e efeitos na cultura da soja em sucessão. Colloquium Agrariae, Presidente Prudente, 15(3), 1-12. DOI: https://doi.org/10.5747/ca.2019.v15.n3.a294

Menezes, L.A.S., Leandro, W.M. 2004. Avaliação de espécies de coberturas do solo com potencial de uso em sistema de plantio direto. Pesquisa Agropecuária Tropical, Goiânia, 34(3), 173-180. https://www.revistas.ufg.br/pat/article/view/2311. (acessado 9 de março de 2021)

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, Brasília, 46(1), 17-25. https://www.scielo.br/j/pab/a/BPVHKxxjn8KJ4qJBFxB7tzC/?format=pdf&lang=pt. (acessado 18 de dezembro de 2021)

Petter, F.A., Silva, J.A., Pacheco, L.P., Almeida, F.A., Alcântara Neto, F., Zuffo, A.M., Lima, L.B. 2012. Desempenho agronômico da soja a doses e épocas de aplicação de potássio no cerrado piauiense. Revista de Ciências Agrárias, Manaus, 55(3), 190-196. DOI: https://doi.org/10.4322/rca.2012.057

Oliveira, F.A., Castro, C., Sfredo, G.J., Klepker, D., Oliveira Junior, A. 2008. Fertilidade do solo e nutrição mineral da soja. Londrina: Embrapa Soja, (Circular técnica, 62).

R Development Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Rossi, C.Q., Pereira, M.G., Giácomo, S.G., Betta, M., Polidoro, J.C. 2013. Decomposição e liberação de nutrientes da palhada de braquiária, sorgo e soja em áreas de plantio direto no cerrado goiano. Semina: Ciências Agrárias, Londrina, 34(4), 1523-1534. DOI: https://doi.org/10.5433/1679-0359.2013v34n4p1523

Silva, A.F., Lazarini, E. 2014. Doses e épocas de aplicação de potássio na cultura da soja em sucessão a plantas de cobertura. Semina: Ciências Agrárias, Londrina, 35 (1), 179-192. DOI: https://doi.org/ 10.5433/1679-0359.2014v35n1p179

Venturoso, L.R., Bergamim, A.C., Valadão Júnior, D.D., Lima, W.A., Oliveira, W.B., Schlindwein, J.A., Caron, B.O., Schimidt, D. 2009. Avaliação de duas cultivares de soja sob diferentes doses de potássio, no município de Rolim de Moura, RO. Agrarian, Dourados, 2 (4), 17-29. https://ojs.ufgd.edu.br/index.php/agrarian/article/view/543. (acessado 23 de novembro de 2021).

Werner, F., Ferreira, A.S., Balbinot Junior, A.A., Oliveira Junior, A., Franchini, J.C., Debiasi, H., Silva, M.A.A. 2020. Nitrogen, phosphorus, and potassium released by composition of palisade grass to soybean in succession. Pesquisa Agropecuária Brasileira, Brasília, 55, e01853. DOI: https://doi.org/10.1590/S1678-3921.pab2020.v55.0185