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Rekal Remineralizer as an Alternative to Potassium Fertilization in Soybean Cultivation

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Abstract

The agricultural sector seeks regional solutions to reduce environmental impact and to develop practices that consider the assumptions of the circular bioeconomy, in addition, to meeting the objectives set out in the 2030 agenda of the United Nations. In this context, Brazil leads research with soil remineralizers to contribute to regenerative agriculture and to have greater sovereignty in the use of natural inputs. This study aimed to evaluate the efficiency of the remineralizer of Rekal soils in soybean commercial areas in the State of Goiás, verifying the availability and mobility of potassium in soils compared to using soluble source (KCl). The methodology adopted was the application of doses of a Rekal remineralizer in four commercial areas in the municipalities of Santa Rita do Novo Destino/GO, Mimoso de Goiás/GO, and Niquelândia/GO, in rainfed and irrigated systems. The experimental design was the same for all experimental fields, randomized blocks made with four experimental treatments and four replications. The treatments were constituted of the farm standard using KCl (potassium chloride), as the only supplier of K_2O demand, and three different doses of a Rekal remineralizer of soils. The parameters evaluated were the determination of the residual potassium content in the soil at three depths (0 to 10 cm, 0 to 20 cm, and 20 to 40 cm); determination of potassium leaf concentrations; determination of potassium concentrations in the grains; yield and weight of one thousand grains (PMG). The remineralizer of Rekal soils did not show significant differences, compared to the use of KCl (potassium chloride), in the variables of potassium content (soil, leaf, and grain) productivity and PMG in different productive environments in a commercial study of soybean cultivation in the Cerrado Goiano.

Keywords: circular bioeconomy, soil remineralizers, regenerative agriculture, potassium, productivity, Rekal

1. Introduction

Remineralization is a practice aimed at "rejuvenating" agricultural soils through the addition of material derived from ground silicate rocks, contributing to soil fertility management. Remineralization can bring several benefits to the pedological geodiversity of Brazil, as these agricultural inputs are widely available in the country, favoring logistics and making them more affordable (Rodrigues, 2024).

In agricultural scenarios, research on inputs from "remineralizing" silicate rocks has been developed as an alternative or supplement to the use of soluble fertilizers. In addition to reducing the use of fertilizers and their environmental impact, the use of such inputs can also increase crop productivity (Almeida Júnior et al., 2022).

Martins (2023) characterized soil remineralizers as multifunctional inputs since they can act as conditioners and correctives for the soil, raise pH levels, reduce exchangeable aluminum, increase nutrient use efficiency, stimulate biological activity in the soil and plant roots, and increase the soil's water retention capacity. As fertilizers, they contribute to the availability of calcium, potassium, magnesium, silicon, and other nutrients, as well as forming new mineral phases (increasing CEC through the formation of clay minerals and low crystallinity minerals), creating a stable soil layer with superior long-term properties resulting from interactions.

They also serve as raw materials for the development of processes and other local and regional inputs, integrated with organic sources, bioinputs, and nanotechnology.

Soybean is one of the main agricultural crops in the world, being an oilseed of great socio-economic importance due to its role as a source of protein for human and animal consumption, as well as a raw material for the production of vegetable oils and various products (Zuffo et al., 2021; Queiroz et al., 2020).

In the 2022/23 harvest, the area planted with soybeans in Brazil was estimated at 77 million hectares, marking a 3.3% increase compared to the previous harvest. National production is estimated at 153.6 million tons of beans, reflecting a 20.6% increase compared to the previous cycle, indicating a recovery in productivity from the crops affected by adverse climatic conditions during the 2021/22 period. The national average productivity for this year was estimated at 3,527 kg ha^{-1} (CONAB, 2023).

According to Bossolani et al. (2018), research on fertilizer application methods and types is frequent, mainly to reduce losses and increase efficiency in agriculture. Potassium fertilization is critical in soybean cultivation, as potassium (K) is one of the key chemical elements required by soybeans. It is found in low concentrations in Brazilian tropical soils but has a direct impact on grain yield, protein content, and oil production (Lima et al., 2017). Physiologically, potassium's main functions are related to the activation of enzymatic systems involved in respiration and photosynthesis (Taiz et al., 2017). Furthermore, potassium concentration in a plant is closely tied to the opening and closing of stomata (Novais et al., 2007). Potassium fertilization is essential not only for increasing productivity but also for managing the health of various crops (Gabriel et al., 2016).

The objective of this study was to assess the efficiency of the Rekal soil remineralizer in commercial soybean areas, evaluating the increase and mobility of potassium in the soil and plant tissues, as well as productivity in different commercial cultivation areas in the state of Goiás, making a comparison with the use of KCl (potassium chloride).

2. Material and Method

The soil remineralizer (rock dust) used in the experiment is called Rekal, originating from the northern region of the state of Goiás. It is extracted and processed in the town of Vila Propício by the company Stracta Mineração Ltda. Four experimental plots were established, covering a total area of 25.92 hectares, located in commercial soybean fields in the municipalities of Santa Rita do Novo Destino/GO, Mimoso de Goiás/GO, and Niquelândia/GO, as detailed in the characteristics listed in Table 1.

Table 1. Name and Location of Experimental Fields

Name	City	Water Regime	Coordinates	Altitude (m)
Farm São Luiz II	Santa Rita do Novo Destino-GO	Irrigated	14°50′50.69″ S and 49°04′54.24″W	536
Farm São Luiz II	Santa Rita do Novo Destino-GO	Rainfed	14°51′02.38″ S and 49°05′09.62″ W	527
Farm Lago	Mimoso de Goiás-GO	Rainfed	15°01′33.39″ S and 48°20′42.65″ W	725
Farm Canadá	Niquelândia-GO	Rainfed	14°50′22.09″ S and 48°38′28.62″ W	588

The characteristic climate of the regions is of the Aw type, being hot and humid with six months of dry winter and a tropical climate, with annual precipitation exceeding 750 mm, reaching up to 1800 mm, according to the Köppen and Geiger (1928) climate classification system.

The preparation of Rekal begins with the geological reconnaissance of the deposit and the selection of the masses to be addressed. It proceeds through the drilling and blasting stage, followed by loading, transportation, and feeding the beneficiation plant. The manufacturing of Rekal follows the same traditional logic as limestone production, with the process route including the stages of primary crushing, secondary crushing, and grinding, being just a physical beneficiation process. After the grinding stage, the finished product is homogenized to ensure uniform granulometric distribution and minimal cohesion between the granules, to mitigate possible segregation during the stacking process.

Batches of the product were separated for shipment to the experimental fields. For each batch sent, samples were collected for physical-chemical analysis in the laboratory, as presented in Table 2.

Table 2. Physicochemical characterization of the soil remineralizer Rekal used in the experimental fields

Identification	**Analytical Data**						
Remineralizer Rekal	CaO	MgO	K_2O	Sum of oxides	Retained on sieves		
	%				2.00 mm	0.85 mm	0.30 mm
Farm São Luiz II-Irrigated	16.51	8.82	2.68	68.81	0.32	8.75	21.48
Farm São Luiz II-Dryland	16.93	8.76	2.65	67.24	0.41	8.52	21.41
Farm Lago	16.67	7.78	2.48	64.82	0.60	9.06	21.26
Farm Canadá	16.75	9.61	2.20	57.73	0.00	11.40	23.42

The experimental design used was the same for all the experimental fields, consisting of a randomized block design with four treatments and four repetitions. The treatments were made up of the farm standard (T1), using KCl (potassium chloride) as the sole source of K_2O, and three different doses of the Rekal soil remineralizer (T2, T3, and T4), as shown in Table 3.

Table 3. Experimental treatments used to evaluate the Rekal soil remineralizer in comparison with K_2O from a soluble source (potassium chloride), in four experimental fields

Treatments	**Doses of remineralizer as a K_2O supplier**	**Amount of K_2O supplied by soluble source (KCl)**
	kg/ha	
Farm São Luiz II-Irrigated Area		
T1	0	100.00
T2	4662.81	0
T3	8817.11	0
T4	11944.58	0
Farm São Luiz II-Dryland Area		
T1	0	100.00
T2	2068.74	0
T3	3621.90	0
T4	5463.24	0
Farm Lago		
T1	0	150.00
T2	3312.42	0
T3	5813.27	0
T4	8228.09	0
Farm Canadá		
T1	0	100.00
T2	3223.82	0
T3	4417.76	0
T4	7122.24	0

Initial soil sampling was carried out before the application of the treatments. The sampling process was outsourced to a company with experience in precision agriculture. The samples were collected using rotary augers at the depths of 0-10 cm, 0-20 cm, and 20-40 cm. After collection, the samples were transported to a commercial laboratory, air-dried, crushed, passed through a 2 mm sieve, homogenized, and sent for analysis of their physical and chemical attributes. The physical and chemical characteristics of the soils (at depths of 0-10 cm, 0-20 cm, and 20-40 cm) before the application of the treatments are presented in Table 4.

Table 4. Average results by treatment of the chemical and physical analyses of the soils used before the installation of the four experimental fields.

Exp.	Depth	Treat.	Clay	Silt	Sand	Org. Mat.	CTC	Bases Sat.	Al Sat.	K
			---------- g dm^{-3} ----------				cmolc/dm^3	------ % ------		mg dm^{-3}
Farm São Luiz -Irrigated	0-10	T1	326.67	50.00	623.33	20.33	8.80	66.87	0.00	143.33
	0-10	T2	343.33	50.00	606.67	20.33	9.03	63.30	0.47	126.00
	0-10	T3	343.33	50.00	606.67	20.00	8.97	69.07	0.00	156.67
	0-10	T4	326.67	50.00	623.33	19.67	9.00	70.43	0.00	140.00
	0-20	T1	343.33	50.00	606.67	17.93	7.90	57.80	0.67	113.33
	0-20	T2	360.00	50.00	590.00	16.80	7.80	56.80	1.33	104.33
	0-20	T3	360.00	50.00	590.00	17.33	7.83	62.33	0.00	133.67
	0-20	T4	326.67	50.00	623.33	18.27	7.80	62.43	0.00	110.00
	20-40	T1	351.67	50.00	598.33	-	5.70	42.63	2.20	77.00
	20-40	T2	360.00	50.00	590.00	-	5.50	37.57	3.40	65.33
	20-40	T3	368.33	50.00	581.67	-	5.77	45.57	2.23	81.00
	20-40	T4	368.33	50.00	581.67	-	5.53	49.30	0.73	69.33
Farm São Luiz-Rainfed	0-10	T1	376.67	50.00	573.33	20.33	10.03	76.40	0.00	92.33
	0-10	T2	376.67	50.00	573.33	20.33	10.03	76.40	0.00	92.33
	0-10	T3	360.00	50.00	590.00	20.67	10.07	76.97	0.00	91.33
	0-10	T4	360.00	50.00	590.00	20.67	10.07	76.97	0.00	91.33
	0-20	T1	401.67	50.00	548.33	16.97	9.40	69.80	0.00	89.33
	0-20	T2	401.67	50.00	548.33	15.13	8.10	63.37	0.00	72.33
	0-20	T3	385.00	50.00	565.00	16.03	8.53	69.67	0.00	84.67
	0-20	T4	385.00	50.00	565.00	16.37	9.13	68.27	0.00	87.67
	20-40	T1	426.67	58.33	515.00	-	6.03	56.40	0.00	55.33
	20-40	T2	435.00	58.33	506.67	-	5.90	60.27	0.00	61.67
	20-40	T3	418.33	58.33	523.33	-	5.63	61.10	0.00	44.00
	20-40	T4	435.00	66.67	498.33	-	5.70	56.03	0.00	51.33
Farm Lago	0-10	T1	476.67	100.00	423.33	32.00	10.43	67.70	0.00	61.67
	0-10	T2	476.67	91.67	431.67	29.00	9.93	61.40	0.00	62.00
	0-10	T3	468.33	100.00	431.67	29.00	10.00	63.17	0.00	57.00
	0-10	T4	435.00	133.33	431.67	30.00	10.13	64.17	0.00	60.33
	0-20	T1	501.67	141.67	356.67	24.10	9.20	53.20	0.00	50.67
	0-20	T2	510.00	116.67	373.33	22.83	8.83	49.87	0.00	49.67
	0-20	T3	501.67	116.67	381.67	23.47	9.10	51.90	0.00	48.33
	0-20	T4	460.00	125.00	415.00	23.30	9.13	50.37	0.00	52.00
	20-40	T1	535.00	108.33	356.67	-	7.07	37.03	3.90	40.33
	20-40	T2	535.00	91.67	373.33	-	6.40	30.63	7.93	35.33
	20-40	T3	535.00	150.00	315.00	-	6.83	31.23	7.00	37.00
	20-40	T4	526.67	116.67	356.67	-	7.20	33.43	6.57	39.33
Farm Canadá	0-10	T1	350.00	58.33	591.67	20.67	9.20	47.90	2.77	131.67
	0-10	T2	341.67	50.00	608.33	21.00	9.77	58.90	4.00	131.00
	0-10	T3	375.00	58.33	566.67	22.00	9.67	46.17	4.13	153.00
	0-10	T4	350.00	50.00	600.00	21.33	9.87	52.67	5.83	117.00
	0-20	T1	391.67	50.00	558.33	16.00	8.20	29.73	15.70	97.67
	0-20	T2	408.33	50.00	541.67	16.57	8.57	42.13	15.53	101.67
	0-20	T3	391.67	50.00	558.33	17.60	8.90	31.73	14.20	102.67
	0-20	T4	391.67	50.00	558.33	16.83	9.07	39.50	24.57	88.33
	20-40	T1	383.33	58.33	558.33	9.13	6.47	20.27	27.70	54.67
	20-40	T2	400.00	58.33	541.67	9.20	6.70	26.60	29.13	56.33
	20-40	T3	416.67	50.00	533.33	10.33	6.67	19.00	35.70	57.00
	20-40	T4	391.67	50.00	558.33	10.10	7.43	33.57	37.33	52.67

Source: Exata Laboratory, Jataí, GO.

The experimental field areas are consolidated under a no-tillage soybean system, with over five years of planting history, except for Farm Canadá, which has been under cultivation for less than three years. The soil management and cultural practices adopted in the experimental fields were different. Each farm carried out soil management, planting, pest control, disease control, weed management, and other cultural practices based on its specific needs and the level of technology employed.

To identify differences and assess the influence of the soil remineralizer Rekal as a potassium (K) source and its effectiveness in soybean cultivation, the following were evaluated: K levels (g kg^{-1}) in leaves and grains; increases in soil K levels (mg kg^{-1}) after the crop cycle (0-10 cm, 0-20 cm, and 20-40 cm depths); yield per hectare (bags/ha); and thousand-grain weight (TGW).

Leaf sampling was carried out following Embrapa's recommendations (2021), using the third or fourth leaf, with petiole, during the R1 growth stage, in accordance with the soybean vegetative and reproductive stages described by Fehr and Caviness (1977). Grain samples were collected after harvest and analyzed according to Embrapa's guidelines (2021).

Changes in potassium content (soil before planting-soil after harvest) were obtained by collecting soil samples with rotary augers at three depths (0-10 cm, 0-20 cm, and 20-40 cm). After collection, the samples were air-dried, crushed, sieved through a 2 mm mesh, homogenized, and sent to a commercial laboratory for K-content analysis. Yield data was obtained through the manual harvest of three 50-meter rows, totaling 150 meters for each experimental unit. The entire plants were harvested and threshed to separate the grains. After separation, the grains were weighed and adjusted for the plant stand in each experimental plot, with results expressed in bags/ha. For the TGW variable, 1000 undamaged grains were separated, counted, and weighed on a precision scale, with results expressed in grams.

The variables were subjected to analysis of variance (ANOVA) at a 5% significance level. For variables that showed significance in the F-test, mean comparisons were performed using Tukey's test (5%).

3. Results and Discussion

The analysis of variance showed a significant difference for foliar potassium content (K-Foliar) in soybean crops at Farm Canadá (Table 5). For other K-Foliar and grain potassium content (K-Grain) variables across the other experimental fields, no significant differences were observed among treatments. This result confirms that replacing KCl with the remineralizer Rekal did not affect the mobility and translocation of potassium to the leaves and grains.

Table 5. Summary of the analysis of variance for foliar potassium (K-Foliar) and grain potassium (K-Grain) variables as a function of Rekal remineralizer doses compared with potassium chloride (KCl) across four experimental fields (Farm São Luiz II (irrigated); Farm São Luiz II (rainfed); Farm Lago; Farm Canadá)

Source of Variation	*df*	Mean square							
		São Luiz II-Irrigated		**São Luiz II-Rainfed**		**Farm Lago**		**Farm Canadá**	
		K-Foliar	K-Grain	K-Foliar	K-Grain	K-Foliar	K-Grãos	K-Foliar	K-Grãos
		g/kg							
Treatment	3	3.533^{NS}	2.033^{NS}	0.751^{NS}	1.024^{NS}	2.415^{NS}	0.415^{NS}	9.279*	0.083^{NS}
Block	3	1.931^{NS}	1.220^{NS}	1.164^{NS}	1.727^{NS}	0.030^{NS}	4.247^{NS}	3.526^{NS}	0.056^{NS}
Error	9	1.355	3.098	3.366	0.752	1.640	2.540	1.746	0.035
CV (%)	-	5.71	12.80	9.98	6.80	8.57	11.73	8.24	1.85

Note. *, **: Significant at 5% and 1% probability levels, respectively; ^{ns}: not significant; CV: Coefficient of variation.

Source: Table created by the authors.

The significant difference observed at Farm Canadá demonstrates that the application of the Rekal remineralizer at the T3 dosage influenced the mobility and translocation of the potassium element to the crop's leaves, as shown in Figure 1.

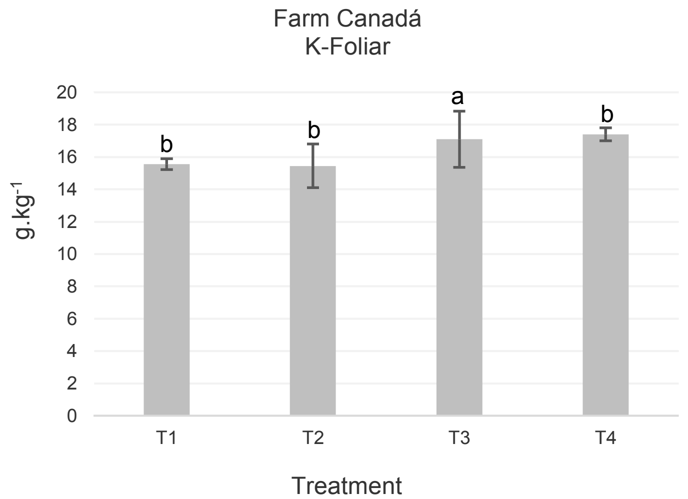

Figure 1. Average values of foliar potassium (K-Foliar) as a function of Rekal remineralizer doses compared to potassium chloride (KCl) at Farm Canadá

Note. *: Means followed by the same letter in the column do not differ significantly from each other according to Tukey's test at 5% significance.

Source: Figure created by the authors.

The maintenance of adequate potassium concentration in plants is essential, as this nutrient regulates stomatal opening and closing, which in turn is linked to the photosynthetic process. This makes potassium supply stimulate better production of photoassimilates by the plant, enhancing vegetative and reproductive development (NOVAIS et al., 2007). It is important to note that the K content in the leaves is a result of the nutrient's availability in the soil, absorption conditions by the roots, and its translocation to the aerial part, including fruits or grains (Ernani et al., 2007).

The results of the analysis of variance for the increase in potassium content in the soil, at different depths (0-10 cm, 0-20 cm, and 20-40 cm), showed no significant differences between the treatments in any of the experimental fields (Farm São Luiz II, under irrigation and rainfed cultivation; Farm Lago; and Farm Canadá), as shown in Table 6.

Table 6. Summary of the analysis of variance for the increase (initial-final) in potassium content in the soil (0-10 cm; 0-20 cm; and 20-40 cm) as a function of Rekal remineralizer doses compared to potassium chloride across four experimental fields (Farms São Luiz II-irrigated; São Luiz II-rainfed; Lago; Canadá)

Source of Variation	***df***	**Mean square**					
		São Luiz II-Irrigated			**São Luiz II-Rainfed**		
		0-10	0-20	20-40	0-10	0-20	20-40
		K	K	K	K	K	K
Treatment	3	1170.963^{NS}	385.629^{NS}	67.802^{NS}	178.66^{NS}	370.778^{NS}	177.296^{NS}
Block	3	2668.167**	25.722^{NS}	83.389^{NS}	38.166^{NS}	150.056^{NS}	36.222^{NS}
Error	9	285.870	184.981	32.204	121.28	176.722	268.148
CV (%)	-	29.66	72.22	53.20	28.24	55.58	96.80
Source of Variation	***df***	**Mean square**					
		Farm Lago			**Farm Canadá**		
		0-10	0-20	20-40	0-10	0-20	20-40
		K	K	K	K	K	K
Treatment	3	75.074^{NS}	67.962^{NS}	70.037^{NS}	129.481^{NS}	163.666^{NS}	83.555^{NS}
Block	3	131.056^{NS}	60.666^{NS}	51.644^{NS}	22.722^{NS}	974.000**	310.389*
Error	9	172.759	0.666	49600.000	206.352	115.555	53.722
CV (%)	-	-	115.76	159.46	60.7	78.18	137.43

Note. *, **: Significant at 5% and 1% probability levels, respectively; ^{ns}: not significant; CV: Coefficient of variation.

The increases in potassium (K) obtained through soil analyses before planting and after harvest at depths of 0-10 cm, 0-20 cm, and 20-40 cm were not significant compared to the soluble source (KCl). This effect was expected since all treatments used some form of K source, contributing to the increase in the availability of this nutrient in the soil. This result highlights the availability of K through sources considered insoluble in the first growing cycle.

The treatment with the lowest dose of the remineralizer (T2) showed no statistical difference from the other treatments (T1, T3, and T4) in any of the experimental fields. Therefore, it can be concluded that residual effects may occur due to the gradual release of nutrients in treatments with higher doses of the remineralizer. This reduces losses through leaching in the soil profile and ensures greater utilization by the plants, even with the use of higher doses.

The analysis of variance showed a significant difference for the thousand-grain weight (TGW) parameter in the soybean crop at Farm São Luiz II under irrigation (Table 7). The yield and TGW variables in the other experimental fields showed no significant differences between treatments. This result confirms that substituting KCl with the Rekal remineralizer is potentially viable, as this substitution did not affect the yield per hectare.

Table 7. Summary of the analysis of variance for yield (sacas ha^{-1}) and thousand-grain weight (TGW) as a function of Rekal remineralizer doses compared to potassium chloride (KCl) across four experimental fields (Farm São Luiz II (irrigated); Farm São Luiz II (rainfed); Farm Lago; and Farm Canadá)

Source of Variation	*df*	Mean square							
		São Luiz II-Irrigated		**São Luiz II-Rainfed**		**Farm Lago**		**Farm Canadá**	
		Yield (saca ha^{-1})	TGW (kg)	Yield (saca ha^{-1})	TGW (kg)	Yield (saca ha^{-1})	TGW (kg)	Yield (saca ha^{-1})	TGW (kg)
	3	5.526^{NS}	0.001*	21.691^{NS}	0.000^{NS}	1.6592^{NS}	0.000^{NS}	14.309^{NS}	14.264^{NS}
Treatment	3	6.357^{NS}	0.000^{NS}	22.858^{NS}	0.000^{NS}	16.7116^{NS}	0.000^{NS}	223.799**	18.646^{NS}
Block	9	5.408	0.000	34.077	0.000	2035.000	0.000	29.570	8.464
CV (%)	-	2.97	4.35	7.20	0.83	5.62	3.02	7.81	4.91

Note. *, **: Significant at 5% and 1% probability levels, respectively; ^{ns}: not significant; CV: Coefficient of variation.

It was observed in Figure 2 that there was a significant difference in thousand-grain weight (TGW) at Farm São Luiz II under irrigation. The use of a higher dose of the Rekal remineralizer influenced TGW, showing an increase of 9% when compared to T1 (farm standard). According to Thomas et al. (2010), there are four primary components of soybean yield, which are: the number of plants per area, the number of pods per plant, the number of grains per pod, and the grain weight. Additionally, the grain weight component represents the size of the grain, thus reflecting a characteristic value of the cultivar, although it is influenced by environmental conditions and crop management practices.

Figure 2. Average values of Thousand Grain Weight (TGW) as a function of Rekal remineralizer doses compared to potassium chloride (KCl) at Farm São Luiz II in the irrigated area

Note. *: Means followed by the same letter in the column do not differ from each other by Tukey's test at 5%. Source: Figure created by the authors.

The Rekal remineralizer, as a source of K, showed similar results to KCl in the first growing cycle for all the variables studied. This fact demonstrates that soil fertilization with the Rekal remineralizer is capable of making its nutrients available to the soil, with absorption and translocation by the plants to the vegetative tissues, not differing from a soluble source of K, such as KCl.

Additionally, it is worth noting that the use of soil remineralizers may present advantages when compared to commonly used agricultural inputs (chlorides, carbonates, sulfates, phosphates, and borates) that dissolve completely in the soil. In contrast, remineralizers undergo partial dissolution, and their use will generate new mineral phases that remain in the soil long-term, altering the physical, chemical, and biological properties of the soil, while also providing various essential chemical elements to plants (Silva et al., 2013; Theodoro et al., 2013; Souza et al., 2023).

3. Conclusion

The results demonstrate a positive response to the use of the Rekal remineralizer, with increases in leaf potassium and TGW variables in the commercial areas of the study (Farm Canadá and Farm São Luiz II-Irrigated).

Potassium fertilization, whether applied as KCl or through the Rekal remineralizer, showed no significant differences in production variables (sacas ha^{-1}) in the commercial areas studied in the Cerrado Goiano region.

There is potential for substituting soluble potassium sources (KCl) with natural sources, such as the Rekal remineralizer, with potential improvements in soil quality, offering an alternative in the pursuit of regenerative agriculture.

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