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Organomineral fertilizer in coffee plant (*Coffea arabica* L.): Fertilizer levels and application times

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ABSTRACT

Coffee (*Coffea arábica* L.) is a fundamental agricultural commodity in the Brazilian economy, demanding a high amount of nutrients for good vegetative development and productivity. The tested hypothesis was that the use of the organomineral fertilizer promotes coffee production and development due to the greater availability of N, P, and K in the soil. The objective of this study was: (i) to monitor the use efficiency of the organomineral fertilizer rates; (ii) to determine the coffee production and development with the organomineral application. A study was developed with applications of four organomineral rates (75%, 100%, 125%, and 150% of the recommended P_2O_5 rate), three forms of parceling (one, two, and three applications of the organomineral fertilizer), and one control (100% mineral). Yield, soil, leaves, and plant development were monitored. Results showed that organomineral presented a win-win scenario with adequate disposal of residues and sources of nutrients in agriculture promoting the coffee yield from 49.5 (mineral fertilizers) to 53.5 sc ha^{-1} (100% of P_2O_5 in organomineral). The plant height, the diameter of the stem, and the canopy presented a quadratic response to organomineral rates with optimal rates fitted at 127; 140; and 140 %, respectively, but there was no direct effect on yield. The split organomineral applications promoted the contents of P and K in the soil, mainly when associated with higher organomineral rates. The K efficiency use was increased with organomineral application indicating the K was used with more efficiency.

Key words: Fertilization; vegetative development; fertilizers; nutrients.

1 INTRODUCTION

Coffee (*Coffea arabica* L.) is a fundamental agricultural commodity in the economy of Brazil and the world. Brazil is the largest producer and exporter of coffee in the world with an annual production of 62.02 million bags and a total production area of 1,885 mil hectares (Companhia Nacional de Abastecimento - CONAB, 2020a). High coffee productivity depends on adequate soil nutrients available, especially in the content of nitrogen (N), phosphorus (P), and potassium (K), which are supplied mainly by mineral fertilizer application (Prezotti; Rocha, 2004).

Brazil imports about 70% nitrogen, 50% phosphorus (P_2O_5), and more than 90% of potassium (K_2O) of the total consumed (Associação Nacional para Difusão de Adubos - ANDA, 2017). Also, the use efficiency of mineral fertilizers is low due to the high losses by volatilization (i.e., urea), leaching (i.e., ammonium nitrate, and potassium chloride), and immobilization/adsorption (acid phosphate fertilizers) (Dall' Orsoletta et al., 2017; Moura et al., 2015; Mendes et al., 2016). Tasca et al. (2011) demonstrated that N lost by volatilization (ammonia, NH_3) can achieve up to 50% of superficially applied N as urea. While, in tropical soil, the P adsorbed on clay surface can achieve up to 50% P unavailable to the plants (Pereira, 2006; Zavaschi et al., 2020). The applications of mineral fertilizers in coffee plantations are made at larger rates (Silva; Coelho, 2005). On the other hand, the application of the organomineral Fertilizer has been carried out with a maximum of three installments in the coffee plant.

Organomineral fertilizers have been presented as alternatives to increase nutrient use efficiency and fertilizer demand. More recently, with the rise in the cost of fertilizers, organomineral use also demonstrated great potential in optimizing the use of by-products to replace imported synthetic fertilizers (Crusciol et al., 2020; Lopes et al., 2021), and sustainable (using national raw material) and socially alternative with a circular economy (Malaquias; Santos, 2017). Organomineral fertilizer is defined as a product resulting from the physical mixture or combination of mineral and organic fertilizers with at least: organic carbon: 8%; cation-exchange capacity: 80 $mmol_c$ kg^{-1}; maximum humidity of 30%; 10% of isolated primary macronutrients (N, P, K) or in the mixture (NK, NP, PK, NPK); 5% of secondary macronutrients (calcium, magnesium, and sulfur) and 1% of micronutrients. The organic matrices present in the organomineral fertilizer can come from different sources (i.e., animal manure, coffee straw, and filter cake), which are composed and used after the stabilization (Rossetto; Santiago, 2007).

The filter cake comes from the process of clarifying the sugarcane for sugar extraction, and the production rate varies from 18 to 40 kg for each Megagram (Mg) of crushed sugarcane (wet basis) (Nolla et al., 2015). In the 2019/2020 season, the amount of sugarcane processed in Brazil was equivalent to 642.7 Million tonnes (CONAB, 2020b) with an annual production of 19 million tons of filter cake considering the mean production rate of 30 kg ton^{-1} of filter cake. The organic matter present in residues plays a fundamental role in agricultural production, in maintaining soil fertility, as well as its effectiveness as a soil conditioner (Rosseto; Dias; Vitti, 2008). Also, the organic matter helps with soil aeration, permeability, and moisture retention promoting the slow nutrient available to the coffee tree (macro and micronutrients); increasing the soil cation exchange capacity and the use of mineral fertilizers (Matiello et al., 2016; Conceição et al., 2005). Based on the importance of organomineral fertilizers and their positive effects on crop yield, studies demonstrating the performance of organomineral fertilizer has been developed in soybean, sorghum, sugarcane, and maize crops (Mota et al., 2019; Oliveira et al., 2017; Moraes et al., 2020; Magela et al., 2019).

The tested hypothesis was that the use of the organomineral fertilizer promotes coffee production and development due to the greater availability of N, P, and K in the soil. The objective of this study was: (i) to monitor the use efficiency of the organomineral fertilizer rates; (ii) to determine the coffee production and development with the organomineral application.

2 MATERIAL AND METHODS

2.1 Study characterization

The experiment was carried out under field conditions at the Fazenda São Sebastião (18º56'08" S and 47º56'11" W), Indianópolis, Minas Gerais, Brazil, in the coffee crop (*Coffea arabica* cv. Mundo Novo) between 2019 and 2020. The region has a climate characterized as rainy tropical, classified as Aw (Tropical savanna), according to the Köppen classification, with an average altitude of 911 m (Köppen; Geiger, 1928). The soil was classified as a Latossolo Vermelho in the Brazilian Soil Classification System (Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA, 2018), with a clay texture and contents of sandy, silt, and clay of 321; 191; and 488 in the 0.0 – 0.20 m soil layer.

The experimental design was a randomized block with a 4 x 3 + 1 factorial, representing four organomineral rates (75%, 100%, 125%, and 150% of the recommended P_2O_5 rate), three forms of parceling (one, two, and three applications of the organomineral fertilizer), and one control (100% mineral), respectively, with four replications (Table 1). Organomineral rates were based on the soil P_2O_5 content in organomineral and calculated according to the "Recommendation for use of correctives and fertilizers in Minas Gerais" (Guimaraes et al., 1999): where 100% rate corresponded to 35 kg ha^{-1} of P_2O_5. Each plot consisted of twelve plants, totaling 13 treatments ($32m^2$ per plot), and a total of 52 plots.

Table 1: Organomineral Fertilizer doses in the coffee plant culture in different application plots, Indianópolis- MG.

Fertilizer	Rates P_2O_5(%)	Rates P_2O_5(Kg ha^{-1})	Split
Organomineral	75	26	1
Organomineral	100	35	
Organomineral	125	44	
Organomineral	150	53	
Organomineral	75	26	2
Organomineral	100	35	
Organomineral	125	44	
Organomineral	150	53	
Organomineral	75	26	3
Organomineral	100	35	
Organomineral	125	44	
Organomineral	150	53	
Mineral	100	35	-

The filter cake was an organic matrix in organomineral with organic carbon; nitrogen and phosphorus contents of 29.5; 2.7; and 3.3% (P_2O_5), respectively. Mineral fertilizer is a commercial product with nitrogen (urea, 16%), phosphorus (P_2O_5, 4%), and potassium (K_2O, 8%), which was added to filter cake forming the organomineral fertilizer. Fertilizers (organomineral and mineral) were applied in November 2019, with an interval of approximately 30 days between each application.

The coffee area was installed in December 2017, through conventional soil preparation with a spacing of 3.8 x 0.7 m, (3,759 plants ha^{-1}). Lime was applied using a rate of 2 Mg ha^{-1} with a subsequent application of bovine manure associated with phosphorus (source: topphos®; rate: 140 Kg ha^{-1}), with an input of 3% nitrogen; 28% phosphorus; 10% calcium; 5% sulfur; 0.12% copper; 0.12% boron; 0.3% manganese; and 0.3% zinc. Additional fertilizations were performed between October and March 2018 and 2019, with the application of nitrogen (source: ammonium nitrate; rate: 200 kg ha^{-1}), phosphorus (source: thermophosphate; rate: 35kg ha^{-1}), and potassium (source: potassium chloride; rate: 400 kg ha^{-1}). There was water supplementation with irrigation when requested during the study. Plant diseases and pests were monitored and controlled according to the recommendations of the coffee culture. The coffee tree was 28 months the period of its first harvest.

Before the fertilizer application, soil and leaves were collected for chemical characterizations according to Embrapa

(EMBRAPA, 2017). Results showed that the soil was classified as an acid with adequate contents of phosphorus, potassium, calcium, and magnesium with a respective average of 8.9 mg dm^{-3}; 0.2; 2.5; and 0.6 cmolc dm^{-3}, respectively (Table 2). Nutrients in leaves indicated that plants were with high contents of nitrogen, phosphorus, potassium, and magnesium with a respective average of 34.0; 1.9; 23.0; e 3.3 g kg^{-1}, fitting within ideal levels (Table 2).

2.2 Measurements

After 90 days of fertilization application, the soil was collected in the 0-0.2 layer to determine the phosphorus and potassium contents. Coffee leaves were collected from the third and fourth pair, at the height of the middle third, to determine the nutritional content (N, P, and K) in the leaf. Soil and leaves were monitored according to the methodology of Bataglia et al. (1983). Plant height, stem diameter, and crown diameter were monitored after eight months of fertilization application.

Coffee production was evaluated based on processed coffee bags. The harvest was carried out manually using the drop in the cloth when the percentage of green fruits was between 10% and 15%. The harvested fruits were measured in volume (L) representative of each plot. The data obtained throughout the process were used to calculate productivity (60 kg bags of processed coffee per hectare) according to the conversion methodology of Bartholo et al. (1989).

2.3 Statistical analysis

The quality of the dataset was tested using the data normality (Shapiro-Wilk test; $P < 0.05$) and homogeneity of variance (Bartlett test; $P < 0.05$). Analysis of variance (ANOVA) was used to compare the treatments (F test; $P < 0.05$), when there was a difference, the averages were tested by the Regression test (organomineral rates; $P < 0.05$), and the Least Significant Difference test, LSD (organomineral split; $P < 0.05$). The organomineral rates were tested by the models linear and quadratic; when the determination coefficient (R^2) of the models was higher than 70%, used the model more parsimonious to explain the results.

The N, P, and K use efficiencies (NUE/PUE/KUE) were calculated according to to yield (sc ha^{-1}) and nutrient content in (g Kg^{-1}) (Equation 1), to explain the conversion of nutrients in the plant into the yield of fruits.

$$Use\ eficiency = \frac{Yield\ (sc\ ha^{-1})}{Nutrient\ content\ (g\ Kg^{-1})} \quad (1)$$

3 RESULTS

3.1 Production and development parameters

The coffee yield was not influenced by organomineral rates and split with an average ranging from 53 to 58 sc ha^{-1}, and there was no significant interaction between both factors (Figure 1; Table 3). Organomineral promoted a yield 10% higher than control ranging from 49.5 to 53.5 sc ha^{-1}, but without difference between the rate of 100% mineral and 100% organomineral using the same rate of P_2O_5 (Table 3).

The plant height, the diameter of the stem, and the canopy presented quadratic responses to organomineral rates with optimal rates of substitutions fitted at 127; 140; and 140

Table 2: Soil and leaf chemical characterization before the fertilizer application.

					Soil					
Soil layer (m)		pH	K	Ca	Mg	Al	H+Al	SB	t	T
		H_2O			-------------------- **cmolc dm^{-3}** --------------------					
0.0 - 0.2		5.9	0.2	2.5	0.6	0.0	3.8	3.3	3.3	7.1
0.2 - 0.4		5.7	0.2	1.8	0.4	0.0	3.8	2.4	2.4	6.2
		P	V	m	OM	B	Cu	Fe	Mn	Zn
		mg dm^{-3}	----%----		g kg^{-1}		-------------mg dm^{-3}-------------			
0.0 - 0.2		8.9	47.0	0.0	30.0	0.5	5.1	47.0	7.8	3.6
0.2 - 0.4		7.4	39.0	0.0	29.0	0.5	4.5	43.0	3.8	2.2
					Leaves					
N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
	--------------------g Kg^{-1}--------------------						---------------mg Kg^{-1}-------------			
34	1.9	23.0	12.4	3.3	1.8	38.0	7.0	220.0	103.0	9.0

P, K= (HCL 0.05 mol L^{-1} + H2SO4 0.0125 mol L^{-1}) P disponível (extrator $Mehlich^{-1}$); Ca, Mg, Al (KCl 1 mol L^{-1}); H+Al= (Solução Tampão SMP a pH 7.5); SB= Soma de Bases; t= CTC efetiva; T= CTC a pH 7.0; V= Saturação por bases; m= Saturação por Alumínio (EMBRAPA, 1997), M.O = Método Colorimétrico. B = (BaCl2.2H20 0.0125% à quente); Cu, Fe, Mn, Zn= (DTPA 0.005 mol L^{-1} + TEA 0.1 mol L^{-1} + CaCl2 0.01 mol L^{-1} a pH 7.3). Caracterização química da folha: N: Digestão sulfúrica; P, K, Ca, Mg, S, Cu, Fe, Mn, Zn: Digestão nitro perclórico; B: Incineração.

% of organomineral (Figure 1). There was no difference in split organomineral rates on plant height, the diameter of the stem, and canopy with a general average of 215 cm; 48 mm, and 124 cm, respectively (Table 3).

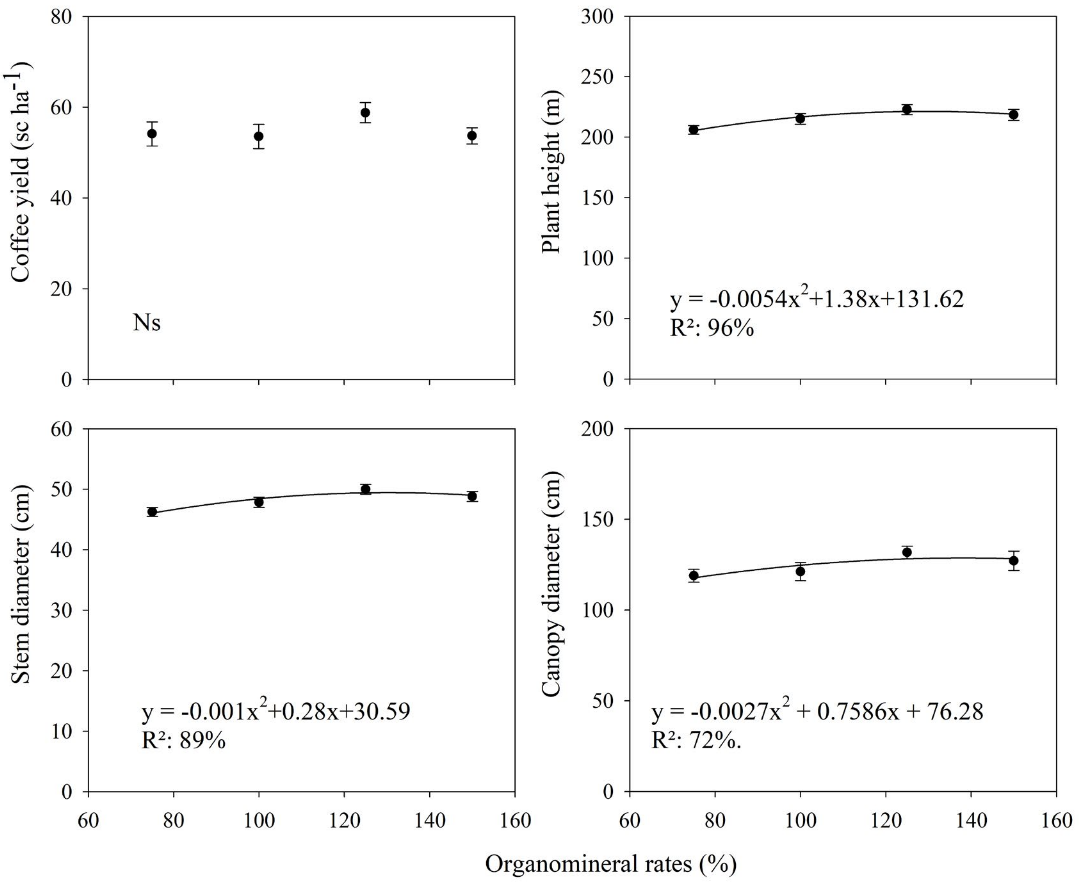

Figure 1: Coffee yield (sc ha^{-1}), plant height (cm), the diameter of the stem (mm), and canopy (cm) of coffee with the application of organomineral (75; 100; 125; and 150% of the recommended P_2O_5 rate) as P source. Rates were compared by Regression test ($P < 0.05$), and quadratically fitted; Ns: no significant difference.

Table 3: Coffee yield (sc ha^{-1}), plant height (cm), the diameter of the stem (mm), and canopy (cm) of coffee with the application of organomineral (75; 100; 125; and 150% of the recommended P_2O_5 rate) as P source split into 1, 2, and 3 times.

Organomineral split	Coffee yield ^{Ns}	plant height ^{Ns}	Stem diameters ^{Ns}	Canopy diameters^{Ns}
	sc ha^{-1}	cm	mm	cm
1	54.1±7.3	206.0±15.6	46.2±2.6	118.9±13.0
2	53.5±8.7	215.0±16.5	47.8±3.5	121.1±17.5
3	58.7±8.7	222.7±14.2	49.9±3.0	131.7±16.3
Control *vs.* Organomineral				
Organomineral (100% P_2O_5)	53.5±9.2	215.1±15.2	47.8±3.0	121.2±15.6
Control (100% P_2O_5)	49.5±5.5	221.5±13.7	49.2±2.5	129.6±13.6
ANOVA (P values)				
P_{split}	0.35	0.25	0.25	0.34
$P_{Control\_Organomineral}$	0.32	0.20	0.22	0.25
$P_{interaction}$	0.84	0.86	0.86	0.54

Split rates were compared by LSD test ($P < 0.05$). The interaction was tested with rates and split applications. In control *Vs*. organomineral, an average of organomineral represent all rates of organomineral and was compared with control by t-test ($P < 0.05$). Ns: no significant difference.

The coffee yield correlated positively with plant height (r: 0.64; $P < 0.05$), the diameter of the stem (r: 0.53; $P < 0.05$), and canopy (r: 0.37; $P < 0.05$), indicating that plant development impacted yield.

3.2 Nutrients in leaves

The P contents in leaves were not influenced by organomineral rates and split with an average ranging from 1.1 to 1.2 g kg^{-1}. Also, there was no difference in P contents in leaves between the control and organomineral (Table 4).

The interaction between organomineral rates and the split was significant on leaf N contents with a $P < 0.05$. When the organomineral rates were split into 2 and 3 times, there were quadratic responses with the optimal rates fitted at 91 and 100% with an R^2 higher than 91% (Figure 2). In contrast, there was no difference in leaf N contents without split organomineral application with a general average of 24.5 g kg^{-1} (Figure 2), and no difference between control and organomineral application (Table 4).

The K contents in leaves were linearly influenced by organomineral rates with an increase of 5 % (R^2: 84%: $P < 0.05$), representing an increment from 16.8 to 17.7 g kg^{-1} (Figure 2). The organomineral split contributed to a decrease in the leaf K content with a reduction of 5% from organomineral split 3 times to 1 time (Table 4). There was no difference between the control and organomineral application with a small difference of 0.07 g kg^{-1} (Table 4).

3.3 Nutrients in the Soil

The organomineral applications linearly increased the content of P and K in soil when there was split into 2 (phosphorus) and 3 times (potassium) with an increment from 54.1 to 77.6 mg dm^{-3}; and from 114.7 to 166.7 mg dm^{-3}, respectively (Figure 3). In general, the split organomineral applications promoted the contents of P and K in the soil, mainly when associated with higher organomineral rates (Figure 3). Using the general average, soil P and K were increased by 42% and 18% with split into 2 and 3 times.

3.4 N, P, and K use efficiencies

The NUE and PUE were not influenced by organomineral rates and split with averages ranging from 2.14 to 2.33 sc g^{-1}, and 47.68 to 51.04 sc g^{-1}, respectively (Table 4). Also, there was no difference between organomineral and control with a small difference of 0.2 and 6.1 sc g^{-1}, respectively (Table 5).

The KUE was not influenced by organomineral rates ($P>0.05$) with averages ranging from 1.14 to 1.51 sc g^{-1}. In contrast, the KUE was higher when K was not split with an average of 1.9 sc g^{-1}, considered 47 % higher than split organomineral at 2 and 3 times (Table 5).

Table 4: Leaf nitrogen, phosphorus, and potassium contents (g kg^{-1}) in coffee yield with the application of organomineral (75; 100; 125; and 150% of the recommended P_2O_5 rate) as P source split into 1, 2, and 3 times.

Organomineral	Nitrogen^{Ns}	Phosphorus^{Ns}	Potassium
Rates (%)		g kg^{-1}	
75	24.4±0.3	1.1±0.0	16.8±0.3
100	24.9±0.3	1.1±0.0	16.7±0.3
125	25.2±0.5	1.2±0.0	17.4±0.2
150	23.3±0.6	1.1±0.0	17.7±0.5
	Split		
1	24.6±0.5	1.1±0.0	17.6±0.4A
2	24.6±0.4	1.1±0.0	17.2±0.3AB
3	24.2±0.5	1.1±0.0	16.6±0.3B
	Control *vs.* Organomineral		
Organomineral (100% P_2O_5)	25.0±0.3	1.1±0.0	16.8±0.3
Control (100% P_2O_5)	23.9±0.2	1.2±0.0	17.1±0.1
	ANOVA (P values)		
P_{rates}	< 0.05	0.55	< 0.05
P_{split}	0.63	0.89	< 0.05
$P_{interaction}$	< 0.05	0.85	0.38
$P_{Control\_Organomineral}^{Ns}$	0.23	0.31	0.43

Organomineral rates were compared by Regression test ($P < 0.05$), and split rates were compared by LSD test ($P < 0.05$). The interaction was tested with rate and split organomineral. In control *vs.* organomineral, an average of organomineral represents all rates of organomineral and was compared with control by t-test ($P < 0.05$). Ns: no significant difference.

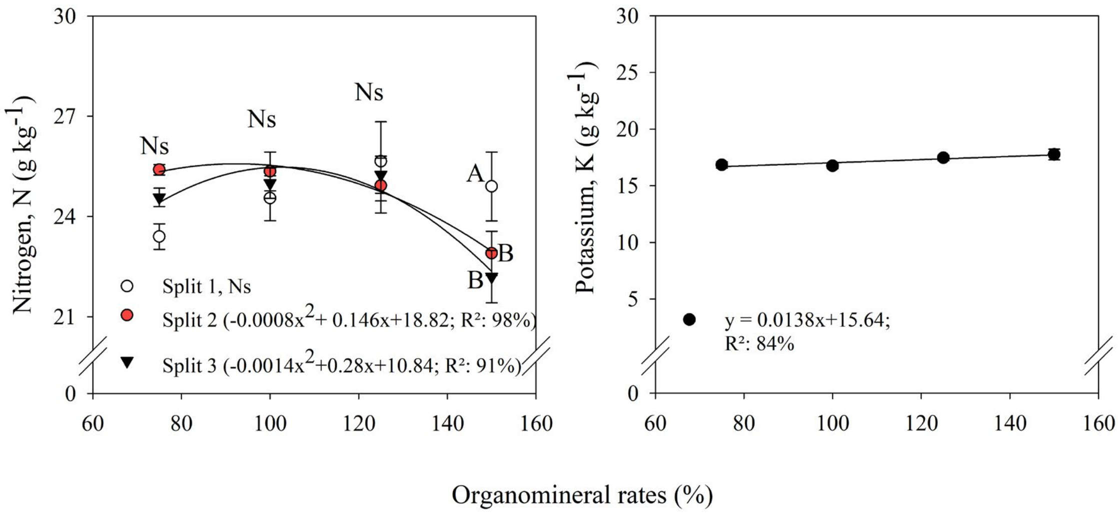

Figure 2: Leaf nitrogen and potassium contents (g kg^{-1}) in coffee with the application of organomineral (75; 100; 125; and 150% of the recommended P_2O_5 rate) as P source split into 1, 2, and 3 times. Organomineral rates were compared by Regression test ($P < 0.05$), and split rates were compared by LSD test ($P < 0.05$). The interaction was tested with organomineral rate and split. Ns: no significant effect; upper letters represent the difference on the N split.

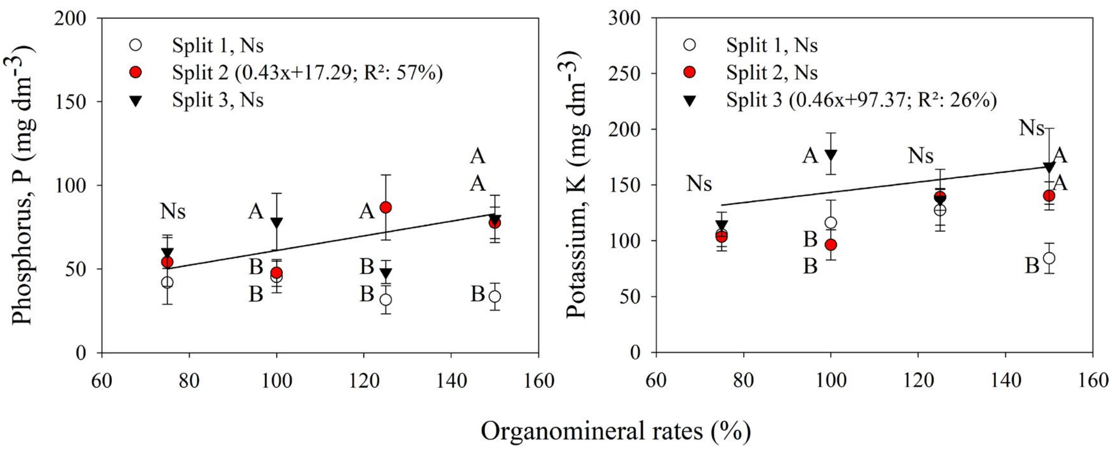

Figure 3: Soil phosphorus and potassium contents (mg dm^{-3}) in coffee yield with the application of organomineral (75; 100; 125; and 150% of the recommended P_2O_5 rate) as P source split at 1, 2, and 3 times. Organomineral rates were compared by Regression test ($P < 0.05$), and split rates were compared by LSD test ($P < 0.05$). The interaction was tested with rate and split organomineral. Ns: no significant effect; upper letters represent the difference of P split.

4 DISCUSSION

The organomineral rates did not alter the coffee productivity with averages ranging from 53 to 58 sc ha^{-1}. In 2020, the Brazilian coffee productivity was 32 sc ha^{-1} (CONAB, 2020a), considered lower than the productivity found here and indicating that the management used in our study contributed to increasing the coffee production. The absence of the organomineral effect is explained by the coffee long-cycle crop with a physiological biennial: one year of the low crop (highest rate of vegetation) followed by a year of high yield (highest rate of fruiting) (Baitelle et al., 2019). Bernardi et al. (2017) and Toro-Herrera et al. (2021) also showed the impact of biennial physiology on coffee yield with a reduction in the year of the vegetative cycle. Another point is that the organomineral requests more time to release nutrients for plants, known by the slow release mechanism that provides nutrients according to the plant's nutritional demand (Trinchera et al., 2011). Thus, if we consider the long cycle of the coffee plant and the nutritional levels before the application of the organomineral Fertilizer at appropriate levels, it is necessary to evaluate the response of this fertilizer based on more than one year of applications and results. Fernandes et al. (2007), studying fertigation in coffee with different sources

Table 5: Nitrogen (NUE), phosphorus (PUE), and potassium (KUE) use efficiencies (sc g^{-1}) in coffee with the application of organomineral (75; 100; 125; and 150% of the recommended P_2O_5 rate) as P source split into 1, 2, and 3 times.

Organomineral	NUE^{Ns}	PUE^{Ns}	KUE^{Ns}
Rates (%)		sc g^{-1}	
75	2.2±0.1	48.6±2.4	1.4±0.3
100	2.1±0.1	47.6±2.3	1.1±0.2
125	2.3±0.1	51.0±2.7	1.5±0.3
150	2.3±0.1	49.0±1.8	1.1±0.2
		Split	
1	2.3±0.1	49.7±1.9	1.9±0.3A
2	2.1±0.1	47.9±2.7	1.0±0.2B
3	2.3±0.1	49.6±2.3	0.9±0.1B
		Control *vs.* Organomineral	
Organomineral (100% P_2O_5)	2.1±0.1	47.7±1.3	1.1±0.1
Control (100% P_2O_5)	2.0±0.0	43.0±2.2	1.0±0.1
		ANOVA (P values)	
P_{rates}	0.44	0.67	0.27
P_{split}	0.31	0.71	< 0.00
$P_{interaction}$	0.77	0.98	0.38
$P_{Control\_Organomineral}$	0.12	0.24	0.26

Organomineral rates were compared by Regression test (P < 0.05), and split rates were compared by LSD test (P < 0.05). The interaction was tested with rate and split organomineral. In control *vs*. organomineral, an average of organomineral represents all rates of organomineral and was compared with control by t-test (P < 0.05). Ns: no significant difference.

of fertilizers (conventional solid fertilizer, soluble fertilizer, organomineral, and liquid organomineral) also did not present significant differences in coffee productivity. On the other hand, significant results of organomineral on the productivity of soybean, potato, and beans were found by Machado et al. (2018), Cardoso, Luz and Lana (2015), Kominko et al. (2017), and Nakayama, Pinheiro and Zerbini (2013). The optimum doses of 127, 140, and 140% promoted the plant height, stem diameter, and crown diameter, respectively, demonstrating that the requested organomineral rates were higher than 100% of the P_2O_5 recommendation. This result is possibly due to the need for higher rates to achieve representative results on plant growth in a short time. Souza et al. (2014), also demonstrated the quadratic effect of P rates on plant height in the initial development of coffee plants in clayey soil. While, Nazareno et al. (2003) did not find a positive effect of N, P, and K rates on the initial growth of the coffee tree.

Organomineral presented a better performance (up to 10%) on coffee yield compared to mineral fertilization. This result is explained by the positive effect of organic matter on the nutrient available (Almeida et al., 2019). Pereira, Diniz and Rezende (2020) showed that organomineral promoted lower nutrient losses when compared with mineral fertilizers. Also, the organomineral increased the nutrients available close to the root system with slow-release turning more efficiently than mineral fertilizers. This happens, because the organic matter has a high specific surface, allowing greater contact area with these mineral nutrients, which will be released to the plants gradually, that is, as the process of decomposition of organic matter occurs (Dick et al., 2000). Accordingly, Junek et al. (2014) state that the presence of organic material in fertilization increases the retention of nutrients in the soil, since, this organic fraction increases the capacity of cationic exchange thus providing less loss of nutrients by leaching and consequently greater utilization of these nutrients by the plants. There was no increment in NUE and PUE with organomineral application as demonstrated by Mota et al. (2019), Kominko, Gorazda and Wzorek (2017b), and Lopes et al. (2021). Crusciol et al. (2020) demonstrated that organomineral can be used as a P source P due to the greater P use by plants since the organomineral protects the P adsorption in tropical soils. This is due to the competition of interaction between the carboxylic grouping that can bind to both the P in the soil and organic matter, thus reducing the adsorption capacity of P in soils with the presence of this organic matrix, in isolation or as a component of a fertilizer (Fink et al., 2016). On the other hand, Morais and Gatiboni (2015), studying the P availability and microbial immobilization in Nitisol, demonstrated that there was also no difference between organomineral and mineral fertilizers (soluble phosphates). However, organomineral rates increased the K in leaves with a linear response and positive effect of split on K content in the soil. This result is explained by the higher use efficiency of K which promotes better utilization due to the reductions of K leaching (Duarte et al., 2013). Rosolem and Steiner, (2017) studying the effects of soil texture and K rates showed that split K applications from mineral sources constitute an important management strategy to minimize losses and improve the KUE in tropical soils. Recommendations regarding the parceling of fertilizer applications in the coffee plantation will depend on different factors, considering mainly the source of fertilizer to be used and the most appropriate season. Thus, different studies are carried out to determine the best time of application and the number of installments (Malavolta et al., 2002; Silva; Coelho, 2005; Sobreira et al., 2011). Parente et al. (2016) showed the residual K effect depends on plant absorption, crops, soil, and fertilizers (rates and sources). The higher efficiency of fertilizer contributes to increasing the profit margin through high yields obtained through the application of optimal nutrient rates, promoting greater profitability in the field (Oliveira et al., 2016). Since (i) N and K are important during the formation phase of the coffee crop to a constant nutrient available; (ii) the organomineral demonstrated to be an important alternative to increase the KUE (Magiero et al., 2017; Dubberstein et al., 2016); the use of organomineral demonstrate to be an important alternative of fertilizer with a win-win scenario with adequate disposal of residues and source of nutrients in agriculture.

5 CONCLUSIONS

The use of organomineral proved to be a win-win scenario with adequate disposal of residues and sources of nutrients in agriculture promoting the coffee yield but without difference between the P_2O_5 rate of 100% mineral and 100% of organomineral. The split organomineral application is an alternative to increase the contents of K in the soil mainly at higher organomineral rates. Based on the results conclude that organomineral is a great alternative as a substitute for mineral fertilizers using the same rate. Long-term studies are requested to monitor the organomineral performance on residual release in soil and coffee yield.

6 AUTHORS' CONTRIBUTION

RPM, RF-A, RC, MHRF, JCD, e RMGL wrote the manuscript and performed the experiment, RC supervised the experiment and co-work the manuscript, and RPM, RF-A review and approved the final version of the work, RF-A conducted all statistical analyses.

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