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INCREASED EFFICIENCY FERTILIZERS IN ARABICA COFFEE GROWTH IN VALE DO RIBEIRA, SP

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Abstract

Controlled-release fertilizers have been increasingly used. This study aimed to evaluate and adapt new technologies applied via soil for sustainable coffee production, in order to generate information that contribute to the technical innovation of the crop for the Vale do Ribeira region. The experiment was set at UNESP, in Registro – SP. The experimental design was in randomized blocks. The experiment consisted of eight treatments with four replications, with plots of six plants. Four doses (200, 300, 400 and 500 kg ha^{-1}) of a mixed fertilizer 20-05-20 were used, with controlled release in six months, intended for coffee trees in formation and production, compared to the dose of 500 kg ha^{-1} of the conventional mixed fertilizer 20-05-20, ammonium sulfate and calcium nitrate with boron, in addition to a control treatment, which did not receive NPK fertilization. The cultivar used was 'Obatã IAC 1669' in 3.0 x 0.6 m spacing. The following characteristics were evaluated: number of plagiotropic branches, number of nodes of plagiotropic branches, stem diameter, plant height and yield, in two harvest periods, besides the surface chemical characteristic of the soil. Increasing the dose of the slow-release fertilizer leads to greater plant growth; the coffee plant presents a highly responsive behavior to the increase in fertilizer doses in relation to nitrogen, and the use of the slow-release fertilizer Agroblen (20-05-20) 100% and ammonium sulfate + SS + KCl allows greater yield.

Keywords: Controlled-Release Fertilizers. Nutritional Analysis. Plant Growth. Yield.

1. Introduction

Coffee production is one of the most important activities for the Brazilian economy, and Brazil holds the title of the world's largest producer, with a total coffee production reaching 169.3 million 60 kg bags in 2019/2020, 95.8 million of Arabica coffee (*Coffea arabica* L.) and 73.6 million of Robusta coffee (*Coffea canephora* Pierre) (MAPA 2020). According to a FAO estimate (2018a), total coffee production could reach 273.6 million bags in 2050.

In the Vale do Ribeira region, seedlings of species native to the Atlantic Forest are currently sold, and it i salso possible to observe the management of the native juçara palm heart using only the fruits of the trees, large-scale planting of bananas, açaí, pupunha, rice, Indian tea, various types of flowers, foliage and fruits with the planting of passion fruit, guava, cupuaçu, etc. The region has great agricultural potential, including for coffee, although most producers are mainly dedicated to subsistence agriculture (Eidt et al. 2019).

As it is a region close to the capital of São Paulo and Curitiba-PR, other agricultural options should be researched for Vale do Ribeira. In this case, coffee cultivation should be better investigated in order to provide a new profitable agricultural option, encouraging the socio-economic development of the region.

However, to be successful in the coffee sector, it is necessary to adopt appropriate agricultural techniques for a correct crop management. Thus, emphasis should be given to the rational and efficient use of soil fertilizers due to their prices, application cost and lower losses through leaching and evaporation.

Controlled-release fertilizers have been increasingly used and are defined as those that, after application, are capable of delaying the availability of absorption and use of the nutrient by plants, or that manage to extend its availability to the plant for longer than conventional fertilizers (Almeida et al. 2019). Fertilizer prices increase in the following order: conventional < stabilized < blends < slow release < controlled-release, as a function of production technology (Guelfi, 2017).

However, the benefits they can bring to the crop, such as increasing yield, due to the greater use of the fertilizer according to the needs of the plants, can provide a better cost/benefit ratio. Thus, care must be taken in choosing the appropriate fertilizers to obtain efficiency and, in the long term, guarantee the yield and profitability of coffee production (Pinto et al. 2017).

In recent years, several companies have entered the segment of fertilizers with increased efficiency for coffee plantations. However, the coffee grower has been increasingly in doubt about the use of these new Technologies; thus, the participation of public research entities plays a fundamental role in the validation and recommendation of these new products. In view of the above, the objective of this study was to evaluate and adapt new technologies applied via soil, in the management of fertilization for sustainable coffee production.

2. Material and Methods

The experiment was set in March 2019, in the southern region of São Paulo, in the municipality of Registro-SP. The climate in the region is Cfa, according to the Köppen classification (1948), with a predominance of hot and humid climate without drought, with an average temperature below 18°C in the coldest month and above 22°C in the hottest month. As for rainfall, the region is characterized by a period of high rainfall rates, with an annual average of 1415 mm. The soil of the experimental area was classified as Red-Yellow Dystrophic Argisol with sandy loam texture (240, 166 and 594 g kg^{-1} of clay, silt and sand, respectively) and presented the following chemical characteristics, in the layers from 0 to 0.2 and from 0.21 to 0.4 m depth, respectively: pH ($CaCl_2$) of 4.6 and 4.2; organic matter of 19 and 18 g dm^{-3}, 4 and 3 mg dm^{-3} P (resin); 0.3 and 0.1 $mmol_c$ dm^{-3} K; 14 and 7 $mmol_c$ dm^{-3} Ca; 10 and 6 $mmol_c$ dm^{-3} Mg; CTC of 71 and 82 $mmol_c$ dm^{-3} and base saturation of 34 and 17%.

The layer from 0 to 20 cm was removed by plowing and harrowing, followed by the application of dolomitic limestone, at 2 ton ha^{-1}, in addition to incorporation. 'Obatã IAC 1669' seedlings were used, implanted in February 2018, at a spacing of 3.0 x 0.6 m, in holes (30 x 30 x 30 cm), applying organic compost and simple superphosphate in amounts of 1.5 kg and 200 g $hole^{-1}$, respectively.

The experimental design was in randomized blocks. The experiment consisted of eight treatments, four replications, with plots of six plants, with only the four central plants being considered as a useful plot.

In the first cycle, four doses (200, 300, 400 and 500 kg ha^{-1}) of a mixed fertilizer 20-05-20, of controlled release, intended for coffee plants in formation and production (100, 25 and 100 kg ha^{-1} of N, P_2O_5 and K_2O, respectively) were used, compared with the dose of 500 kg ha^{-1} of the conventional mixed fertilizer 20-05-20, and the combination of ammonium sulfate or calcium nitrate coated with boron, with simple superphosphate and potassium chloride, maintaining an NPK ratio of 20-05-20, in addition to a control treatment, which did not receive NPK fertilization, set to verify the contribution of soil fertility (Table 1). In the second cycle, the doses were doubled (200, 50 and 200 kg ha^{-1} of N, P_2O_5 and K_2O, respectively). The mixed fertilizer 20-05-20, of controlled release (Agroblen Max – ICL® - 20-05-20 + 4.2 S +

1.7 Ca + 0.5 Mg) has a controlled release by a reference temperature of 21ºC, in approximately six months. This release is controlled by a layer of organic resin coating the granule.

Table 1. Treatments with controlled-release fertilizer on coffee: Control 1 (20-05-20) Conventional fertilizer; Control 2 (No fertilizer); Agroblen (20-05-20) 40%; Agroblen (20-05-20) 60%; Agroblen (20-05-20) 80%; Agroblen (20-05-20) 100%; Nitrabor + SS + KCl and Sulfato de amônio + SS + KCl were applied in two installments, the first in March/2019 and the second in September/2019. The treatment considered conventional, on the other hand, was applied in three installments in the first cycle and again three installments in the second cycle in Registro-SP.

Treatments used in the first cycle						
			N	P_2O_5	K_2O	S
Treatments	Kg ha^{-1}	g plant^{-1}		Kg ha^{-1}		
1-Control 1 (20-05-20)*	500	105	100	25	100	0
2-Control 2 (No fertilizer)	0	0	0	0	0	0
3- Agroblen (20-05-20) - 40% **	200	42	40	10	40	8
4-Agroblen (20-05-20) - 60% **	300	63	60	15	60	13
5-Agroblen (20-05-20) - 80% **	400	84	80	20	80	17
6-Agroblen (20-05-20) - 100% **	500	105	100	25	100	21
7- Nitrabor + SS + KCl	646/146/161	45/10/11	100	25	100	18
8- Sulfato de amônio + SS + KCl	500/146/161	35/10/11	100	25	100	138
Treatments used in the second cycle						
			N	P_2O_5	K_2O	S
Treatments	Kg ha^{-1}	g plant^{-1}		Kg ha^{-1}		
1-Control 1 (20-05-20)*	1000	210	200	50	200	0
2-Control 2 (Sem adubo)	0	0	0	0	0	0
3- Agroblen (20-05-20) - 40% **	400	84	80	20	80	16
4-Agroblen (20-05-20) - 60% **	600	126	120	30	120	26
5-Agroblen (20-05-20) - 80% **	800	168	160	40	160	34
6-Agroblen (20-05-20) - 100% **	1000	210	200	50	200	42
7- Nitrabor + SS + KCl	1292/292/322	90/20/22	200	50	200	36
8- Sulfato de amônio + SS + KCl	1000/292/322	70/20/22	200	50	200	276

The conventional fertilizer was applied in three plots. SS: Simple super phosphate. KCl: Potassium chloride **Agroblen Max 20-05-20 + 4.2 S + 1.7 Ca + 0.5 Mg; Nitrabor: calcium nitrate plus boron

The treatments with the controlled-release fertilizer were applied in two batches, the first in March/2019 and the second in September/2019. The conventional treatment was applied in three batches in the first cycle and again three batches in the second cycle. Fertilizers were weighed separately per plant, according to each treatment. Fertilizers were applied manually according to the pre-established dose for each treatment.

The experiments were implemented and conducted in accordance with the technical recommendations for the coffee crop, according to Bulletin 200 of Instituto Agronômico de Campinas (Aguiar et al. 2014). All the management practices commonly used in the coffee crop were adopted.

Plant growth characteristics were evaluated every three months. Therefore, four plant growth evaluations were carried out over a year of conduction, between 03/01/2019 to 12/14/2019. The characteristics analyzed were: number of plagiotropic branches, number of nodes of plagiotropic branches, stem diameter and plant height.

For coffee yield, the harvest of the year 2020 and 2021 was evaluated, from the total detachment of fruits per plot, evaluating the 4 central plants of each plot. Subsequently, the fruits harvested from the six plants were mixed and 4L per experimental plot were sampled. Such collections were exposed to the sun until they reached the appropriate water level to proceed with their processing (between 11 and 12%) with constant inversion, so that the drying process occurred homogeneously. After coffee processing, the sample was weighed; yield conversion was then calculated (bags ha^{-1}).

The results were submitted to analysis of variance, using the Sisvar software (Ferreira 2011). Mean values were compared using the Scott-Knott test at 5% significance.

The productivity results related to Agroblen doses were adjusted to linear or quadratic models through regression analysis (t test), adopting that significant highest regression coefficient.

3. Results

According to Table 2, the increase in stem diameter (SD) as a function of fertilization was quite significant, reaching almost double in the treatment with the conventional fertilizer 20-05-20 compared to the treatment without fertilization. Even using only 40% of the conventional dose, the use of the controlled-release fertilizer provided the same stem diameter as the other fertilizers, which were used at 100%. This treatment provided approximately 18% more plagiotropic branches (NPB), in relation to the treatment without fertilization, and did not differ from the other treatments. As for the number of nodes in the plagiotropic branches, the same effect was observed, with emphasis on treatments with 100% of the dose, using the controlled-release fertilizer, or ammonium sulfate, simple superphosphate and potassium chloride, which showed, respectively,10 and 9% more nodes in relation to the absence of fertilization.

Table 2. Means of stem diameter variables (SD); number of plagiotropic branches (NPB); Number of nodes in the plagiotropic branches (NNPB); plant height (PH) of the coffee tree. Submitted to fertilizer doses: Control 1 (20-05-20) Conventional fertilizer; Control 2 (No fertilizer); Agroblen (20-05-20) 40%; Agroblen (20-05-20) 60%; Agroblen (20-05-20) 80%; Agroblen (20-05-20) 100%; Nitrabor + SS + KCl and Sulfato de amônio + SS + KCl in Registro-SP.

Treatments	Increment			
	SD	NPB	NNRP	PH
	cm			cm
1- Control 1 (20-05-20) **	15.51[a]	18.83[a]	697.50[a]	79.45[a]
2- Control 2 (No fertilizer)	8.09[b]	16.83[b]	512.08[b]	46.37[b]
3- Agroblen (20-05-20)- 40% **	11.03[a]	22.16[a]	679.91[a]	76.52[a]
4- Agroblen (20-05-20) - 60% **	11.82[a]	19.66[a]	643.08[a]	70.44[a]
5- Agroblen (20-05-20) - 80% **	11.11[a]	18.50[a]	704.08[a]	71.50[a]
6- Agroblen (20-05-20) - 100% **	11.21[a]	21.66[a]	764.16[a]	76.03[a]
7 – Nitrabor + SS + KCl	13.64[a]	19.33[a]	711.50[a]	72.27[a]
8 – Sulfato de amônio + SS + KCl	14.70[a]	19.16[a]	758.83[a]	79.60[a]
C.V. (%)	26.96	13.68	27.83	13.80
Means	12.13	19.52	683.89	71.52

Means followed by distinct letters in the column differ from each other by the Scott-Knott test, at 5% probability. **Agroblen Max 20-05-20 + 4.2 S + 1.7 Ca + 0.5 Mg *C.V.: Coefficient de variation.

In relation to Table 3, in the first year, the dose of 100% of Agroblen 20-05-20 and the application of ammonium sulfate, together with SS and KCl, provided the highest yields, significantly different from the other treatments. The dose of 60% of Agroblen resulted in a yield equivalent to that obtained in the treatment with the formulated 20-05-20, commonly used by producers. Calcium nitrate coated with boron (Nitrabor) may have showed lower yield due to the nitric form of N, which requires a lot of energy for assimilation by the plant, or leaching losses, or even excess boron (since fertilizers contain 0.3% B).

Regarding regression productivity (Figure 1) data were adjusted to the linear model in the two years evaluated. In 2020, according to the modified engineering, an increase of 6.6 bags per hectare was achieved every 100 kg ha^{-1} from Agroblen (20-05-20), while in 2021, this increase was slightly higher (6.8 bags per hectare for every 100 kg ha^{-1}). Due to the trend shown, in the two years, without the provide the maximum productivity point depending on the Agroblen doses, higher doses must be tested.

For the second year, 100% Agroblen was similar to all other fertilizers (20-05-20, Nitrabor + SS + KCl and Ammonium sulfate + SS + KCl), demonstrating the efficiency of the controlled-release fertilizer equal to the sources commonly used. The highest yield was obtained in the treatment with ammonium sulfate, although it is an acidifying fertilizer. The form of ammoniacal N, which requires less energy to be assimilated by the plant, and the presence of S may have contributed to this result. The treatments with 100% of Agroblen and Nitrabor provided higher yields than the treatment with 20-05-20.

As for the chemical characteristics (Table 4 and 5) of the surface layer of the soil (0 to 0.2 m depth), after the fertilization of the first cycle, only the levels of K, S, B and the CEC of the soil were influenced by the treatments. The K content in the treatment with the controlled-release fertilizer, at a dose of 100%, allowed maintaining the same K content in the soil as the treatments with periodic K applications, and higher than the control treatment, which did not receive fertilization. Regarding sulfur, the content of this element in the soil, in the form of sulfate, was higher in treatments in which simple superphosphate was used as a P source, which has 12% S, in addition to the treatment in which ammonium sulfate was used, with 24% S. Despite the controlled-release fertilizer having sulfur covering the granules (4.2% S), the dose and release time were not sufficient to differentiate from the control treatment (without fertilization). The boron content in the soil was higher in the treatment with calcium nitrate in relation to the other treatments, once the granules of this fertilizer were covered with boron (0.3% B).

Table 3. Initial productivity (sacks. ha-1) of the coffee tree, submitted to fertilizer doses: Control 1 (20-05-20) Conventional fertilizer; Control 2 (No fertilizer); Agroblen (20-05-20) 40%; Agroblen (20-05-20) 60%; Agroblen (20-05-20) 80%; Agroblen (20-05-20) 100%; Calcium nitrate plus boron + SS + KCl and Ammonium sulphate + SS + KCl in Registro-SP.

Treatments	Fruits Yield (sacks ha^{-1})		
	2020	2021	Average
1- Control 1 (20-05-20) **	51.1^{a}	20.36^{c}	35.73^{b}
2- Control 2 (No fertilizer)	13.0^{c}	2.89^{d}	7.95^{c}
3- Agroblen (20-05-20)- 40% **	22.51^{c}	4.82^{d}	13.66^{c}
4- Agroblen (20-05-20) - 60% **	25.72^{c}	8.20^{d}	16.96^{c}
5- Agroblen (20-05-20)- 80% **	37.6^{b}	22.18^{c}	29.89^{b}
6- Agroblen (20-05-20) - 100% **	45.97^{a}	38.25^{b}	42.11^{a}
7 – Nitrabor + SS + KCl	33.75^{b}	40.51^{b}	37.13^{b}
8 – Sulfato de amônio + SS + KCl	48.22^{a}	52.72^{a}	50.47^{a}
C.V. (%) *	21.07	18.96	16.85
Means	34.73	23.74	29.23

Means followed by distinct letters in the column differ from each other by the Scott-Knott test, a 5% probability. **Agroblen Max 20-05-20 + 4.2 S+ 1.7 Ca + 0.5 Mg *C.V.: Coefficient de variation.

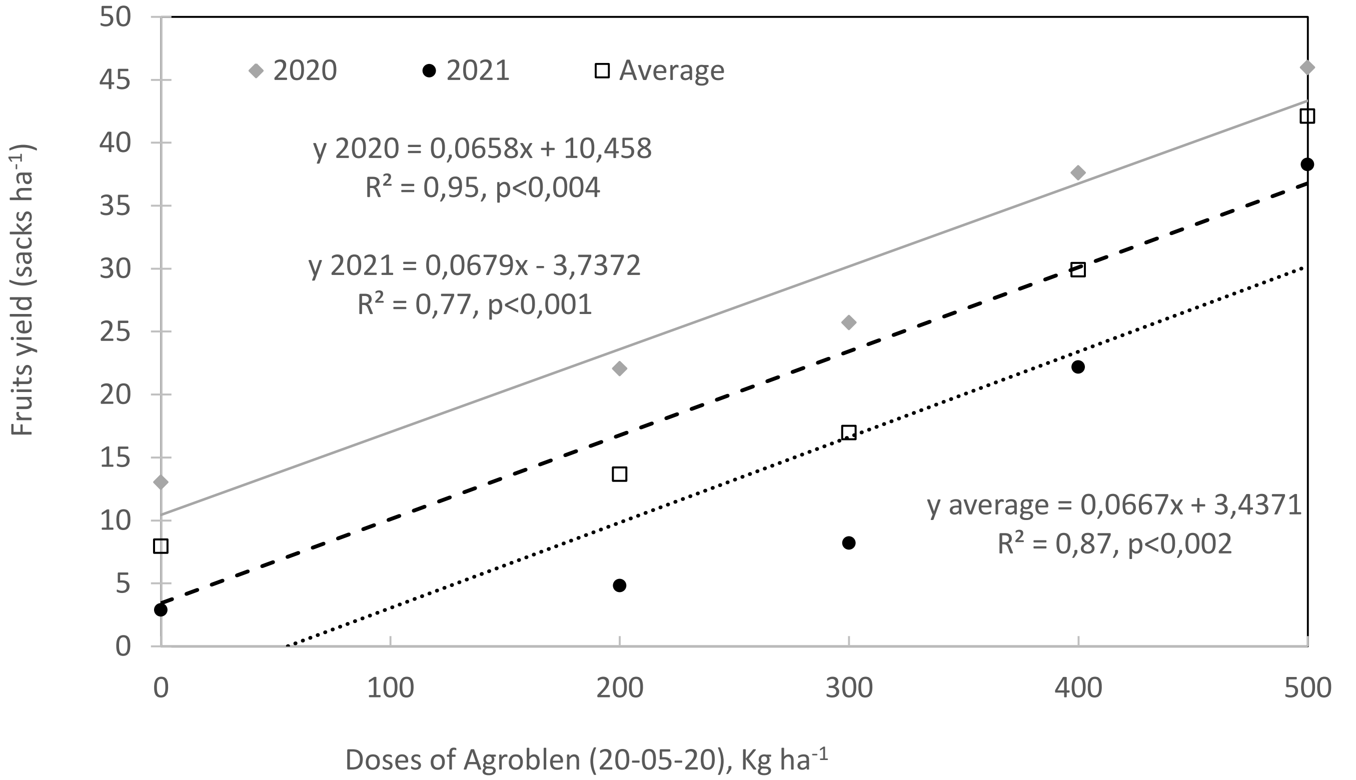

Figure 1. Initial productivity (bags. ha-1) of the coffee tree, subjected to fertilizer doses: Agroblen (20-05-20) 40%; Agroblen (20-05-20) 60%; Agroblen (20-05-20) 80%; Agroblen (20-05-20) 100% in the years 2020 and 2021 in Registro-SP.

Table 4. Chemical characteristics of pH, MO, P, K, Ca, Mg, CTC and V% of the soil surface layer of the soil (0 a 0,2 m of depth), after the fertilizantion of the first cycle. Submitted to fertilizer doses: Control 1 (20-05-20) Conventional fertilizer; Control 2 (No fertilizer); Agroblen (20-05-20) 40%; Agroblen (20-05-20) 60%; Agroblen (20-05-20) 80%; Agroblen (20-05-20) 100%; Nitrabor + SS + KCl and Sulfato de amônio + SS + KCl in Registro-SP.

Tratamento	pH	MO	P	K	Ca	Mg	CTC	V%
1- Controle 1 (20-05-20) **	4.2	17.0	146	6.3ᵃ	29	2.4	112.1ᵃ	30.4
2-Controle 2 (No fertilizer)	4.1	22.0	64	0.23ᵇ	15	4.4	87.2ᵇ	22.0
3- Agroblen (20-05-20) -40% **	4.4	18.3	52	1.3ᵇ	16	7.2	75.2ᵇ	32.6
4- Agroblen (20-05-20) -60% **	4.1	19.7	104	2.6ᵇ	14	5.6	97.8ᵃ	24.3
5- Agroblen (20-05-20) -80% **	4.3	19.7	97	2.2ᵇ	14	5.8	83.2ᵇ	27.0
6-Agroblen (20-05-20) -100% **	4.3	18.7	113	4.3ᵃ	19	6.6	86.0ᵇ	34.3
7 – Nitrabor + SS + KCl	4.6	17.7	159	4.7ᵃ	37	2.3	97.0ᵇ	48.5
8 – Sulfato de amônio + SS + KCl	3.9	20.0	132	4.2ᵃ	20	3.4	106.3ᵃ	25.7
C.V. (%)*	6.7	14.9	43.8	48.9	64.5	55.2	11.8	47.5
p-valor*	0.341	0.531	0.151	0.006	0.377	0.223	0.015	0.476

Means followed by distinct letters in the column differ from each other by the Scott-Knott test, a 5% probability. **Agroblen Max 20-05-20 + 4.2 S+ 1.7 Ca + 0.5 Mg *C.V.: Coefficient de variation *p-valor < 0,05: significant.

Table 5. Chemical characteristics of S, B, Cu, Fe, Mn and Zn of the soil surface layer of the soil (0 a 0,2 m of depth), after the fertilizantion of the first cycle. Submitted to fertilizer doses: Control 1 (20-05-20) Conventional fertilizer; Control 2 (No fertilizer); Agroblen (20-05-20) 40%; Agroblen (20-05-20) 60%; Agroblen (20-05-20) 80%; Agroblen (20-05-20) 100%; Nitrabor + SS + KCl and Sulfato de amônio + SS + KCl in Registro-SP.

Tratamento	S	B	Cu	Fe	Mn	Zn
1- Controle 1 (20-05-20)	79 ᵇ	0.78 ᵇ	0.4	185	1.9	2.1
2- Controle 2 (No fertilizer)	44 ᵇ	0.64 ᵇ	0.3	193	2.2	1.7
3- Agroblen (20-05-20) 40%	33 ᵇ	0.74 ᵇ	0.3	154	2.1	2.4
4- Agroblen (20-05-20) 60%	66 ᵇ	0.80 ᵇ	0.4	205	2.1	2.2
5- Agroblen (20-05-20) 80%	81 ᵇ	0.83 ᵇ	0.4	188	2.0	2.2
6- Agroblen (20-05-20) 100%	92 ᵇ	1.22 ᵇ	0.7	177	2.1	1.8
7 – Nitrabor + SS + KCl	146 ᵃ	3.27 ᵃ	0.4	138	2.0	3.4
8 – Sulfato de amônio + SS + KCl	233 ᵃ	0.72 ᵇ	0.3	201	2.2	3.1
C.V. (%)	43.4	27.9	18.8	19.9	15.8	54.0
p-valor	0.001	0.001	0.001	0.343	0.925	0.694

Means followed by distinct letters in the column differ from each other by the Scott-Knott test, a 5% probability. **Agroblen Max 20-05-20 + 4.2 S+ 1.7 Ca + 0.5 Mg *C.V.: Coefficient de variation *p-valor < 0,05: significant.

4. Discussion

The increase in the number of plagiotropic branches is a good indication of an increase in yield, since they are fruit generators. Abranches et al. (2018) also observed an increase in the number of plagiotropic branches in coffee plants when evaluated in controlled-release fertilizers compared to those conventional.

Regarding the number of nodes in the plagiotropic branches, Jaeggi et al. (2020), corroborating this study, state that the increase in the number of plagiotropic branches can be considered as an increase in productive potential, once there is an increase in the number of nodes, where the lateral buds with productive capacity develop. The same authors state that one of the most important production components is the number of nodes, as well as the number of fruits present in each node of the plagiotropic branches, directly influencing production.

Silva et al. (2016), confirm that better responses to plant development, such as diameter and height, are an indicative of the efficiency in nutrient uptake by the plant.

Results confirm that controlled-release fertilizers induce height superiority (Dutra et al. 2016). Menegatti et al. (2017), working with slow-release fertilizers in the early development of *Aspidosperma parvifolim*, obtained positive responses in diameter and height with increasing doses. Souza et al. (2018)

also state that diameter and height are some of the most important morphological characteristics to estimate growth after permanent planting in the field.

Regarding plant development parameters, there was a significant difference from the control (Treatment 2), and the smallest increase was observed in relation to the other treatments, that is, a superiority in the increments in the morphological characteristics of 48%, 24%, 33% and 42%, respectively. Thus, it is possible to positively evidence the use of fertilizers, whether controlled or conventional. Such results corroborate with Navroski et al. (2016), who showed that controlled-release fertilizers positively influence plant development and present efficiency in use compared to conventional fertilizers.

For yield, the control treatment without fertilizer application and the treatments using controlled-release fertilizers, with up to 60% of the total dose of N, P and K, of the conventional fertilizer, showed the lowest yield values in the two harvests (2020 and 2021), as plants need nutrients for their growth and reproductive development (Table 3).

Lima et al. (2016), working with the coffee plant and nitrogen fertilizer, observed that the treatments were superior to the control without fertilization, leading to yield increases of up to 151% in relation to the control. The lowest yields in treatments with the controlled-release fertilizer (20-05-20) at doses of 40 or 60% reveal that these doses were not sufficient to increase yield in relation to the control, although the controlled-release fertilizer presented characteristics that could increase its efficiency with lower losses by leaching and/or volatilization.

The doses of conventional nitrogen fertilizers can be reduced by 15 to 20%, due to the increase in nutrient use efficiency by plants, when using controlled-release fertilizers (Brito et al. 2018). However, in this experiment, the dose was reduced by up to 60%. In fact, in treatments with a 20% reduction in the dose of the controlled-release fertilizer, yield was superior to that of the control treatment in both cycles and equivalent to the treatment with 100% of the dose using the conventional fertilizer, in the second harvest and in the sum of the two harvests. The use of calcium nitrate with boron also provided greater yield than the control treatment, showing the same yield as the conventional fertilizer and the controlled-release fertilizer, at a dose of 80%, in the sum of the two harvests. In the first cycle, the yield of the treatment with calcium nitrate was lower than that of the treatment with 20-05-20 (conventional) and, in the 2021 crop, yield was higher.

The use of the controlled-release fertilizer at a dose of 100%, in the sum of the two harvests, provided greater yield than the other treatments, with the exception of the treatment with ammonium sulfate, which showed greater yield, due to the second cycle. In the first cycle, the yield obtained with a single application of the controlled-release fertilizer, at a dose of 100%, was equivalent to the yield obtained with three applications of ammonium sulfate + simple superphosphate + potassium chloride, or the yield obtained with the conventional fertilizer. 20-05-20. In the second cycle, the use of controlled-release fertilizer (100%) provided higher yield than in the treatment with the conventional 20-05-20 fertilizer, commonly used by coffee growers, and was equivalent to the yield of the treatment with calcium nitrate plus boron (+simple superphosphate and potassium chloride), only inferior in relation to the treatment with ammonium sulfate.

This result allows to infer the advantage of using controlled-release fertilizers since, compared to conventional fertilizers, there is greater practicality in application and rationing in the application cost being, therefore, an important technology for the management of fertilization for coffee growers of the Vale do Ribeira. As stated by Alves et al. (2018), the use of slow-release fertilizers makes it possible to reduce the doses to be used, as well as the application of a blend formed by the mixture of fertilizers makes it possible to reduce losses, especially for nitrogen (Chagas et al. 2016).

5. Conclusions

The use of controlled-release fertilizers provides greater efficiency in the use of labor and inputs, allowing only one application at the beginning of the rainy season.

The use of the slow-release fertilizer Agroblen (20-05-20) 100% or Ammonium Sulfate + SS + KCl allows higher yields than the use of other nitrogen sources such as urea and calcium nitrate.

Among the nitrogen sources, ammonium sulfate provided the highest yields.

The use of controlled-release fertilizers can provide higher yields than urea (conventional) fertilization, with less labor.

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