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Organomineral fertilization in eucalypt plantations

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***Abstract*— Organomineral fertilization is a sustainable alternative to the use of mineral fertilizers in forest plantations, promoting stands establishment of high volumetric productivity. This work aimed to evaluate volumetric production of eucalypt under different organomineral fertilization regimes. Four fertilization regimes were tested: three treatments with use of organomineral fertilizers and one with mineral fertilizers. Continuous forest inventory was conducted from 12 to 72 months. Three permanent plots were established for each fertilization regime, totaling 12 sample units. Growth in height, basal area and volume differed between fertilization regimens over age. Treatment that provided the best development in first years of cultivation was not necessarily the one with higher volume production. Biometric estimates were higher with application of organomineral fertilizers. Volumes at 72 months of these treatments ranged from 180 to 192 m^3 ha^{-1}. Organomineral fertilization of plantation and cover is an efficient sustainable alternative to obtain high yields in eucalypt crops. Application of only one organomineral cover fertilization favors volumetric production of the clone and reduces interventions in cultivation area.*

I. INTRODUCTION

Eucalypt culture has a large share and influence in the Brazilian and world economy, with wood being one of the most important commodities in international market. Companies have been looking for sustainable technologies of management, implantation, and management of forests. Organomineral fertilizers produced from waste, often environmental liabilities, represent an alternative to reduce dependence on mineral fertilizers (Kominko et al. 2017).

Due to the nutrition role in the growth and eucalypt production, it is not difficult to find stands with excessive application of mineral fertilizers, regardless of the associated costs of acquisition and application (Carvalho et al. 2014, Stape et al. 2010, Santos et al. 2019). Mineral fertilizers have inorganic salts in the chemical composition that come from extractions or industrial processes. In general, these are fertilizers derived from non-renewable sources and that have no carbon in their chemical structure (Carvalho et al. 2014).

On the other hand, the agricultural, industrial, and urban waste destination is a major environmental challenge faced by society (Ibrahim et al. 2019, Crusciol et al. 2020, Hafez et al. 2021). Brazilian imports were approximately 10.9 million tons of nitrogen fertilizers in 2019, volume 18% higher than that observed in 2019 (Globalfert, 2021). Appropriate waste treatment is essential for soil conservation and water quality. Conversion of waste for fertilizers production is a sustainable strategy for reforestation and disposal of potential environmental polluters (Borges et al. 2019, Nascimento et al. 2020, Rodrigues et al. 2021).

Organomineral fertilizer is a product of the mineral and organic fertilizers combination. Normative Instruction of the Secretariat for Agricultural Defense No. 25, of July 2009 establishes minimum specifications and guarantees for this product in Brazil, with maximum humidity of 30%, minimum organic carbon content of 8% and minimum cation exchange capacity (CEC) of 80 mmolc kg^{-1}. Such normative instruction groups in Class A all fertilizers that have raw material of plant, animal, or agribusiness processing, free from toxic heavy metals, potentially toxic synthetic organic elements or compounds (Brasil, 2009).

Organomineral fertilizers provide biological, chemical, and physical benefits to the soil; increasing microbiological activity, CEC, nutrients availability, water retention during drought and drainage in rainy periods (Novais et al. 2007, Chassapis et al. 2009, Frazão et al. 2019, Namazov et al. 2019). These characteristics promote nutrients absorption and growth plants.

Fertilizers with different sources are frequently analyzed for the nutrition of various crops, particularly swine, cattle and poultry manure. Organomineral fertilization has been used successfully in cultivations of: *Zea mays* L. (Ayeni et al. 2012, Aderibigbe et al. 2017, Hafez et al. 2021), *Solanum tuberosum* L. (Cardoso et al. 2017), *Helianthus annuus* L. (Santos et al. 2013), Saccharum sp. (Olivério et al. 2011, Borges et al. 2019, Moraes et al. 2020), *Olea europaea* L. (Carvalho et al. 2014), *Citrullus lanatus* (Thumb.) Matsum. (Ojo et al. 2014), *Abelmoschus esculentus* L. (Olawuyi et al. 2012) and *Glycine max* L. (Mota et al. 2018, Silva et al. 2020).

Although mineral fertilizers are used extensively in agriculture, research that evaluates organomineral fertilization in the eucalypt plantations is still incipient or practically nonexistent. Part of this lack of information is justified by the traditional use of mineral fertilization, less commercial availability of organomineral fertilizers and / or lack of research that demonstrates organominerals efficiency in forests cultivations, and difficulty in providing products on a large scale with same guarantee of nutrients concentration.

Within this context, this work aimed to evaluate volumetric production of eucalypt under different organomineral fertilization regimes.

II. MATERIALS AND METHODS

2.1. Characterization of the experimental area

The work was carried out in Três Marias municipality, Minas Gerais State, Brazil. The native vegetation is the Cerrado, situated on typical Yellow Oxisol with medium sandy texture. Region climate is Cwa type, with hot and humid summers and dry winters (Alvares et al. 2013). The annual averages of temperature and precipitation are 23.7 ºC and 1041 mm, respectively (INMET, 2021).

This research was conducted in different eucalypt forest management units, located at 18°14’29” S and 45°04’32” O - Datum WGS84, at an altitude of 710 m. Forest implantation was in January 2014 under a 3.0 x 3.0 m spatial arrangement (usable area of 9 m²). Genetic material used was a clone of Eucalyptus urophylla S.T. Blake, known commercially as “GG 1923”, with basic wood density of 529 kg m^{-3}.

2.2. Description of treatments

Four fertilization regimes were tested, one in each handling unit, described in detail in Table 1. In treatments T1, T2 and T3, organomineral fertilizers with organic base formed by composting of chicken manure and sawdust were used. Physical structure of these fertilizers is granular and has 50.0% humic substances and total organic carbon equal to or greater than 9%. For planting, inputs “Organomineral 1” (OM1) were used, whose formulation is 2.8% N; 15.4% P2O5; 6% K2O and 14.56% CaO and “Organomineral 2” (OM2), whose formulation is 12.5% N; 3.0% P2O5; 10% K2O e; 11.9% CaO.

T4 treatment received mineral fertilizer (M) that has two phosphorus sources, reactive and soluble, composed of: 3.0% N; 26.0% P2O5; 5.0% K2O; 22% CaO; 3.0% S; 0.3% B; 0.2% Cu; 0.2% Zn and 0.5% humic substances. Planting fertilization was done in the planting furrow.

At 7 months, 1000 kg ha-1 of calcined limestone were applied, a fertilizer composed of calcium oxide (48.0% CaO), magnesium oxide (30.0% MgO) and sulfur (5.4% S), whose Relative Power of Total Neutralization is 130%. Application of this product was in soil (below the crown projection), without incorporation, with standardized amount for all treatments.

“Organomineral 3” (OM3) application was in continuous fillet, also below the crown projection, for T1, T2 and T3 treatments. OM3 has guarantees of 4.9% of N; 2.9% P2O5; 18.0% K2O e; 11.76% CaO. T4 treatment received KCl fertilizer in coverage, with 54.0% K2O and 1.0% B and NK 20:00:20 + 1% B.

Table 1: Fertilization regimes evaluated for eucalypt clonal cultivation.

Phases	Date	Treatments			
		T1	T2	T3	T4
Planting fertilization	01/14	400 kg ha^{-1} (OM1)	400 kg ha^{-1} (OM1) + 150 kg ha^{-1} (OM2)	400 kg ha^{-1} (OM1) + 150 kg ha^{-1} (OM2)	400 kg ha^{-1} (M)
Source of Ca, Mg and S	07/14	1000 kg ha^{-1} Calcined limestone			
Cover fertilization	05/14	150 kg ha^{-1} (OM2)	200 kg ha^{-1} (OM2)	-	200 kg ha^{-1} 20:00:20
	11/14	200 kg ha^{-1} (OM2)	150 kg ha^{-1} (OM3)	150 kg ha^{-1} (OM3)	200 kg ha^{-1} 20:00:20
	04/15	150 kg ha^{-1} (OM3)	-	-	200 kg ha^{-1} 20:00:20
	04/16	-	-	-	150 kg ha^{-1} KCl

M = commercial mineral fertilizer; OM1 = commercial organomineral fertilizer 1; OM2 = commercial organomineral fertilizer 2; OM3 = commercial organomineral fertilizer 3.

Details of macronutrients amount applied in each treatment are in the Table 2.

2.3. Database and statistical analysis

Database for growth and production analysis came from continuous forest inventories conducted annually of 12-to 72-month-old. Three permanent plots were established for each fertilization regime, totaling 12 sample units. Plot area was 324 m^2 (18 x 18 m), comprising 6 planting rows with 6 holes. Information was provided on the diameter at 1.30 m in height from the ground (Diameter at breast Height, DBH, cm), total height (H, m) and commercial volume with bark (V, m^3) of all stems. Average height ($\overline{H}$), basal area (B, m^2 ha^{-1}) and volume (m^3 ha^{-1}) of the plots were calculated.

Plot-level data were subjected to non-linear regression analysis using the Levenberg-Marquardt iterative method. Three-parameter logistic model was adjusted to estimate each biometric attribute as a function of age, in months. The logistic model was chosen due to the biological basis and the easy interpretation of its parameters.

$$Y=\alpha/(1+\beta\, e^{\wedge}(-\gamma I))+\varepsilon$$

Where: Y = biometric attribute (H, B and V); I = age; α, β and γ = logistic model parameters; e = Neperian constant; and ε = random error.

Adjustments quality was assessed according to the parameters significance by t test, Mean of Absolute Error (MAE), Root-Mean-Square-Error (RMSE), Pearson's correlation coefficient (r) and Akaike Information Criterion (AIC). Lower values of MAE, RMSE and AIC imply higher predictive quality. Through the derivation, ages and volume corresponding to the bottom tangent of curve (passing through origin, P1), inflection point (P2), technique age of cutting (TAC, P3) and asymptote (P4, "α" parameter of the logistic model). Age ranges corresponding to the origin up to P1 and from P3 to P4 represent phases of slow plant growth. Age range of intense growth is between P1 and P3, reaching the maximum current increase in P2.

Statistical analyzes were performed using R version 3.5.2 software (R Core Team, 2018), Metrics (Hamner & Frasco 2018) and minpack.lm (Elzhov et al. 2016) statistical packages, at a significance level of 5 %.

Table 2: Macronutrients amount applied per fertilization regimes, in kg ha^{-1}.

Treatments	**N**	**P_2O_5**	**K_2O**	**CaO**	**MgO**	**S**
			---------------------- Planting (01/14) ----------------------			
T1	11,2	26,9	16,0	41,6	-	-
T2	30,0	28,8	26,8	54,4	-	-
T3	30,0	28,8	26,8	54,4	-	-
T4	12,0	45,4	16,6	45,7	-	12,0
			--------------- Calcium fertilization (07/14) ---------------			
Standard	-	-	-	480,0	300,0	54,0
			----------------- Cover fertilization (05/14) ----------------			
T1	18,8	2,0	10,8	12,8	-	-
T2	25,0	2,6	14,4	17,0	-	-
T4	40,0	-	33,2	-	-	-
			----------------- Cover fertilization (11/14) ----------------			
T1	25,0	2,6	14,4	17,0	-	-
T2	7,4	1,9	27,0	12,6	-	-
T3	7,4	1,9	27,0	12,6	-	-
T4	40,0	-	33,2	-	-	-
			----------------- Cover fertilization (04/15) ----------------			
T1	7,4	1,9	27,0	12,6	-	-
T4	40,0	-	33,2	-	-	-
			----------------- Cover fertilization (04/16) ----------------			
T4	-	-	81	-	-	-
			----------------------------- Total -----------------------------			
T1	62,3	33,4	68,2	564,0	300,0	54,0
T2	62,3	33,4	68,2	564,0	300,0	54,0
T3	37,3	30,7	53,8	547,0	300,0	54,0
T4	132,0	45,4	197,2	525,7	300,0	66,0

Table 1 contains a detailed description of treatments T1 to T4. - = absence of nutrient.

III. RESULTS

Equations generated for the fertilization regime are in Tab. 3. All equations presented significant coefficients by the t test ($p \leq 0.05$) and few deviations, with low values of MAE, RMSE and IAC. Correlation coefficients were high and significant ($r \geq 0.98$, $p \leq 0.05$). Asymptotes values oscillated relatively little, with a variation coefficient of 2, 2 and 3 % for height, basal area and volume estimates, respectively. In general, T2 treatment equations exhibited lower MAE and RMSE values than those pertinent to the other treatments (T1, T3 and T4).

The curves visually showed small differences in sigmoidal behavior for height, basal area and volume between fertilization regimes up to 72 months (Fig. 1 and 2). Although the age estimate for P1 to P3 positions fluctuated relatively little between studied regimes (maximum of 2 months), it was noted that T3 treatment expressed approximately 7 % more volume than the others (T1, T2 and T4), including up to the P4 position (Tab. 4).

Table 3: Coefficients and adjustment quality of logistic model to estimates of height (m), basal area (m^2 ha^{-1}) and volume (m^3 ha^{-1}) of eucalypt as a function of age (months), for different regimes of fertilization.

Treatments	α	β	γ	MAE	RMSE	r	AIC
			------------------------------- Height -------------------------------				
T1	21,868675	5,209340	0,073657	0,3044	0,3708	0,9973	23,3673
T2	21,551981	5,552248	0,080568	0,2345	0,3397	0,9977	20,2176
T3	22,313647	5,790057	0,077222	0,4002	0,6250	0,9931	42,1645
T4	21,602612	5,683219	0,077529	0,2810	0,3354	0,9979	19,7509
			----------------------------- Basal area -----------------------------				
T1	18,608807	14,432416	0,084809	0,7657	0,8765	0,9880	54,3363
T2	18,926446	12,882718	0,081307	0,5780	0,6659	0,9930	44,4463
T3	19,281329	13,354475	0,082423	0,7462	0,8717	0,9887	54,1388
T4	19,420532	12,136547	0,078321	0,6251	0,7341	0,9918	47,9520
			------------------------------ Volume ------------------------------				
T1	191,379693	36,726699	0,089292	7,3067	8,6245	0,9910	136,6476
T2	190,656323	34,874338	0,090649	4,4809	5,6795	0,9962	121,6090
T3	203,375729	36,217262	0,088992	6,5200	7,5254	0,9940	131,7398
T4	190,829118	31,971055	0,086922	6,6650	7,9719	0,9923	133,8150

α, β and γ refer to the logistic model parameters; MAE = mean of the absolute error; RMSE = root-mean-square error; r = correlation coefficient e; AIC = Akaike information criterion. Detailed description of treatments T1 to T4 are in Table 1.

Average age estimates for P1, P2 and P3 positions of the production curves were 25 (CV = 2 %), 40 (CV = 1 %) and 55 (CV = 1 %) months. Average volume estimate for T3 treatment differed from the others as the inventoried age increased (Tab. 4).

In average terms at 72 months, height estimate ranged from 21.15 m (T4) to 21.82 m (T3), from a basal area of 18.02 m^2 ha^{-1} (T1) to 18.62 m^2 ha^{-1} (T3) and volume, 180 m^3 ha^{-1} (T4) to 192 m^3 ha^{-1} (T3). At this age and in the same sequence of biometric attributes, coefficients of variation were 1 %, 2 % and 3 %. Technique ages of cutting decreased in the following order: T3 (55.13 months and 160 m^3 ha^{-1}), T1 (55.11 months and m^3 ha^{-1}), T4 (55.01 months and 151 m^3 ha^{-1}) and T2 (53.71 months and 150 m^3 ha^{-1}). All these ages occurred before the last inventory was taken, at 72 months.

The treatment that provided the best development in the first years of cultivation was not necessarily the one with the highest volumetric production. Greater variability of biometric estimates was observed between treatments at the age of 12 months, with coefficients of variation of 2 % for height, 5 % for basal area and 4 % for volume.

Table 4: Age and volume estimates for different eucalypt fertilization regimes.

Treatments	**Age (month)**				**Volume (m^3 ha^{-1})**			
	P1	**P2**	**P3**	**P4**	**P1**	**P2**	**P3**	**P4**
T1	25,61	40,36	55,11	182,63	40,44	95,69	150,94	191,38
T2	24,65	39,18	53,71	179,63	40,29	95,33	150,37	190,66
T3	25,54	40,34	55,13	183,08	42,98	101,69	160,40	203,38
T4	24,71	39,86	55,01	185,99	40,33	95,41	150,50	190,83

P1 = bottom tangent of curve; P2 = curve inflection point; P3 = technical age of cutting and; P4 = asymptote.

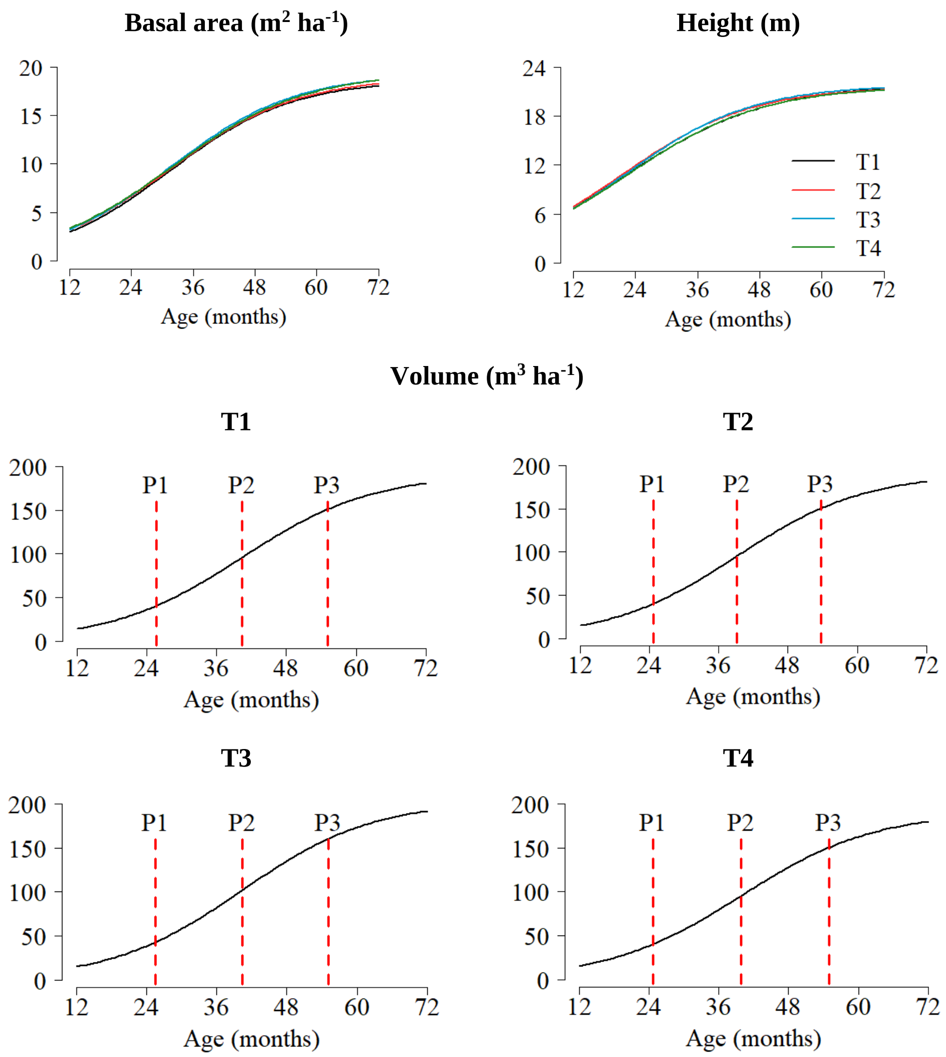

Fig.1: Eucalypt height, basal area and volume curves under different fertilization regimes. The detailed description of treatments T1 to T4 can be found in Table 1. P1 = bottom tangent of curve; P2 = inflection point of curve e; P3 = technical age.

Regarding the treatment of better vegetative development, average height estimate was the attribute that oscillated the most over the years; average height estimate of T1 treatment was the highest at 12 months, T2 at 24 and 36 months The T4 treatment presented the most accentuated deceleration rate of volumetric growth, with the highest average volume estimate at 12 months and the lowest at 84 months. and T3, the rest of the time (Tab. 5).

IV. DISCUSSION

The amount of biometric information at the parcel level made it possible to use logistic model accurately, adequately representing operational reality. Because of the wide phenotypic plasticity that genus Eucalyptus can assume in scenarios with different fertilization regimes (Araujo et al. 2019), height, basal area and volume were estimated satisfactorily by the equations obtained (Tab. 3). It is emphasized that the logistic model for estimating production is in current use in the Brazilian forestry sector. It is not objective this study to prove efficiency of the model itself, but tendency of response variables in operational realities.

Functional relations of simple entry were defined for estimation of height, basal area and volume of the clone, using age as a predictor variable (Fig. 1). Basal area correlated more with age than height, relevant statistical aspect for volumetric calculations in forest stands. Correlation coefficients between volume and basal area was 0.98 ($p \leq 0.01$) and between volume and height, 0.95 ($p \leq 0.01$). Fertilization regimes did not exert a strong influence on the ages referring to the P1, P2 and P3 positions of production curves analyzed of the clone (Tab. 4).

Table 5: Percentage variations of the biometric attributes of different eucalypt fertilization regimes, using the best vegetative development treatment for each age.

Treatments	Age (months)						
	12	24	36	48	60	72	84
	------------------------------- Height (m) -------------------------------						
T1	100,00	96,83	96,86	97,19	97,41	97,66	97,82
T2	99,85	100,00	100,00	98,84	97,71	97,11	96,82
T3	97,70	97,87	99,43	100,00	100,00	100,00	100,00
T4	96,07	95,92	97,01	97,21	97,00	96,90	96,85
	------------------------ Basal area (m^2 ha^{-1}) ------------------------						
T1	88,50	94,73	96,84	97,23	97,05	96,81	96,32
T2	95,55	98,22	97,99	97,81	97,89	98,01	97,74
T3	95,54	99,47	100,00	100,00	100,00	100,00	99,65
T4	100,00	100,00	98,58	98,58	99,32	99,97	100,00
	-------------------------- Volume (m^3 ha^{-1}) --------------------------						
T1	90,59	93,59	93,93	94,12	94,16	94,14	94,12
T2	96,10	99,78	99,23	97,37	95,56	94,52	94,05
T3	97,20	100,00	100,00	100,00	100,00	100,00	100,00
T4	100,00	99,67	96,65	94,63	93,84	93,70	93,74

Biometric averages between treatments at 12 and 24 months (phase comprised up to P1) were 6.83 (CV = 2 %) and 11.67 m (CV = 2 %) for height, 3.21 (CV = 5 %) and 6.68 m2 (CV = 2 %) for basal area and, 14.93 (CV = 4 %) and 37.85 m^3 ha^{-1} (CV = 3 %) for volume, respectively. This low biometric variability is an indication that all treatments nutritionally supplied the clone in a similar way during its establishment in the experimental environment.

Initial growth of seedlings (start) was more prominent in the t4 treatment, with the highest yields until 22 months after planting. However, its maximum volumetric difference in contrast to the second most productive treatment (T3) was estimated at 11 months. This age exactly coincided with application date of the only organomineral cover fertilization of T3, which stood out by reducing the volumetric difference and became the most productive permanently after 23 months.

Planting phase of the T4 treatment was marked by the greater application of P, and maintenance phase was marked by greater fertilization in coverage for N and K (Tab. 2). The applied amounts of N at 11 and 28 months in T4 were 2.5 and 3.5 times greater than all fertilization intrinsic to T3 rotation, respectively.

A hypothesis raised is that the highest levels of N stimulated mineralization of organic matter in the soil and anticipated nutrients cycling in the forest ecosystem; higher values of C: N ratio stimulate immobilization of organic matter and reverse, its mineralization (Cookson et al 2005, Khalil et al. 2005, Flavel & Murphy 2006, Novais et al. 2007).

Average estimate of basal area of the T4 treatment remained high during all the inventoried ages, representing more than 99 % of the maximum basal area between fertilization regimes (Fig. 1 and Tab. 5). However, its shafts tended to be smaller in height, reflecting negatively on the volumetric estimates at 72 months.

Another hypothesis considered is that the exacerbated application of N may also have stimulated the increase in leaf area, and consequently increased evapotranspiration in the canopy of trees (Taiz & Zeiger 2010), characteristics that made the plant more vulnerable to occasions of water deficit and with limited productivity.

Periods without water surplus were noted in Três Marias municipality during experiment, being the most accentuated between 26 and 33 months (2016). Monthly reference evapotranspiration peaks above 200 mm were seen at 9 months (211 mm), 22 months (242 mm), 33 months (201 mm), 46 months (233 mm) and 69 months (214 mm) in 2014, 2015, 2016, 2017 and 2019, respectively (INMET, 2021). The stomatal control mechanism, which controls water losses through transpiration, is limited in periods of water deficit.

At the other extreme, T1 treatment received the least nutrients amount in planting phase and was the least productive in the first months of cultivation. It should be noted that the growth resumption with cover fertilizations occurred in this treatment, with an average volumetric estimate higher than that T4 treatment after 54 months; 39 months after the last organomineral fertilization in cover (April 2014). Probably, nutrients release by organomineral fertilizers OM2 and OM3 took place gradually and was soon taken advantage by eucalypt. According to Carvalho et al. (2014) and Santos et al. (2013), due to the organic component, organomineral fertilizers provide nutrients with gradual solubilization, reducing eventual ion losses, leaching, volatization and/or fixation by the soil.

The moment of productive intensification (P1) started at 25 months of age. This moment is often neglected in the management of forest stands, but essential for silvicultural planning and for achieving high productivity. It is recommended that all nutrients are properly balanced and that there is full control of pests/diseases before of the phase start of significant plant growth, whose peak (P2) was estimated at 40 months.

According to Santos et at. (2019), the effect of fertilization decreases over the cultivation cycle, especially after 24 months; age similar to that found in P1 by the present study, from 24.65 to 25.61 months. Care with late installments requires the manager's attention, as the gain in growth does not always result in economic viability.

Coverage fertilization of treatments was performed between 5 to 28 months of age, close to the interval from P1. The first application of organomineral coverage at the age of 5 months in T2 treatment was not accompanied by an increase in productivity compared to T3. It was found that the amount of fertilizer applied at planting was sufficient to supply nutritional demand for both treatments until 10 months.

The recommendation of organomineral fertilizers should also be viewed with caution, because, although gradual, it is assumed that nutrients release is faster on occasions when the mineral fraction is made up of more nitrogen. Organominerals formulation requires supplementation with mineral fertilizers; different inorganic bases, formulations and granulations can result in different solubilities (Olivério et al. 2011, Sakurada et al. 2019). It is common to combine urea, with high levels of N (> 40 % of N), and compost products for making organic mineral fertilizers.

OM2 and OM3 fertilizers proved to be an efficient source of nitrogen, potassium and calcium in cover fertilizations. According to the manufacturer, minimum guarantee of N for OM2 is 2.6 times greater than OM3. This in turn has 2.5 times more K than that. In this perspective, it is suggested that cover fertilization be carried out only with OM3. However, it is pointed out that the influence of nitrogen fertilization on the volumetric production of eucalypt tends to reduce with age, with N being supplied mainly by matter organic (Pulito et al. 2015).

In T3 treatment, the lowest total amount of N, P and S applied (Tab. 2) did not limit its production. This treatment showed the highest average volumetric estimate at 72 months of 192 m^3 ha^{-1}, being 7 % more productive than the others. It should be noted that fertilization carried out in T2 was different from that of T3 in two nutrients, receiving a total of 67 % and 27 % more of N and K. For the region under study, there was no need to apply large amounts of N, corroborating what was observed in other sites (Stape et al. 2010, Pulito et al. 2015, Santos et al. 2019).

There was no increase in productivity as the amount of nutrients and cover fertilizations increased. The accomplishment of organomineral fertilizations for planting and only one application (T3), with OM3, was enough to meet the demand of the clone. This fact has great practical and economic relevance, since the use of only a cover fertilization reduced the number of interventions and made execution of nutritional planning less laborious and costly.

It is expected that the combination of organic mineral fertilizers, OM1 and OM2, for planting can be carried out without incompatibility problems. This statement was based on the premise that the organic component conditions the decomposing minerals, avoiding physical and chemical incompatibilities between the elements that make up its inorganic fraction (Cardoso et al. 2017). Even though cover fertilization is an alternative for possible corrections and nutritional supplements, it is indicated that the recommendation of organominerals contemplates their chemical composition and their particularities regarding the gradual release of nutrients.

Fertilizers recommendation based on the nutritional balance promotes an increase in forest productivity, avoiding waste of fertilizers and / or identifying possible nutritional deficiencies that limit plant development (Deeks et al. 2013, Namazov et al. 2019). Excessive and inadequate application of fertilizers impairs growth, economic return and environmental quality, due to the possibility of soil, subsoil and groundwater contaminations (Carvalho et al. 2014, Lima et al. 2017).

Forest fertilization must be combined with conservationist forms of soil management, which reduce nutrient losses and increase sustainability; information on the assimilation capacity of nutrients is necessary for better definition of recommendations. It is pertinent to assume that the non-removal of cultural residues in stands after forest harvest, such as husking in field, contributes to the composition of organic matter in litter and reduces number of fertilizers applied in the next crop.

The modeling of growth and volumetric production is a management tool that supports silvicultural decisions. Experimentation on an operational scale emerges as an option for better realism and reliability of information. The results obtained provide subsidies for development of future research on organomineral fertilization in eucalypt stands both in planting and in cover. Organomineral fertilization has shown promise for obtaining high volumetric yields. However, there is a need to evaluate the cost/benefit ratio of using different fertilization regimes.

In addition to productivity, it is sensible that the choice of fertilizer source also follows criteria such as commercial availability and transportation, storage, and application costs (Mumbach et al. 2019). Organic base from chicken manure and sawdust showed good quality for the cultivation of the clone. The organomineral fertilizations evaluated are a sustainable alternative to the use of mineral fertilizers.

V. CONCLUSION

Organomineral fertilization, used in an equivalent amount of nutrients, has the same efficiency in growth and eucalypt production as mineral fertilizer. The application of fertilizer quantities higher than the recommended ones does not necessarily result in productivity gains.

Organomineral fertilization for planting and covering is a sustainable, efficient and promising alternative for obtaining high productivity in eucalypt crop.

Splitting organomineral fertilization influences the productivity of eucalypt plantations. Accomplishment of only an organomineral fertilization of cover (maintenance) favors volumetric production of the eucalypt clone and reduces interventions in the cultivation area.

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