Congresso Plantações Florestais
23 a 25 de maio de 2023
Piracicaba - SP

Série Técnica IPEF v. 26, n. 48, maio de 2023
https://doi.org/10.18671/sertec.v26n48.002

Litterfall and nutrient cycling in different restoration models

Fernando Santos Bogiani[1]
Lucas Florêncio Mariano[2]
Glória Fabiani Leão da Costa[1]
Francisca Alcivânia de Melo Silva[2]
José Mauro Santana da Silva[1]
Fátima C. Márquez Piña-Rodrigues[1]

[1]Universidade Federal de São Carlos (UFSCar) (fsboggiani@estudante.ufscar.br)
[2]Universidade Paulista, campus Registro- UNESP (lucas.mariano@unesp.br)

ABSTRACT: *Restoration models need to promote a short-term rehabilitation of ecological functionalities, such as litterfall and nutrient contents in degraded areas. The present study aims to evaluate litter decomposition and production of litter and nutrient in restoration models combining different planting spaces (1 m x 0.3 m; 2 m x 1.0 m; 1 m x 1 m; 2 m x 1 m) and pioneer (P) and non-pioneer (NP) proportions (40P-60NP; 60P-40NP; 20P-80NP). Litterfall collection took place in the seventh year of planting, the leaf fraction was used for chemical analysis. The annual litterfall was 7953 kg ha^{-1}. It differed significantly only for plant spacing, the highest production occurred in the 1 x 0.3 m. There was only a significant increase for calcium content. The order of nutrient production was N>Ca>K>Mg>S>P. Plant spacing showed high production of litter in the system. The treatments by successional group did not influence the results, except for the calcium content. The smallest spacing was more efficient in promoting the fast return of nutrient cycling functionalities at the beginning of the restoration process.*

Key-words: Forest nutrition, Planting Space, Seasonal Semideciduous Forests

Introduction

The use of indicators of ecological functionality showed that many models of restoration based on functional groups such as filling and diversity (Rodrigues et al., 2009) presented problems in the above soil litter cover (Altivo e Piña-Rodrigues, 2017). The litterfall is an environmental indicator to evaluate and quantify decomposition rate and nutrient cycling, which are fundamental for the formulation of new restoration proposals and decision-making guidance (Silva et al., 2018).

Based on the above, we aimed to analyze the litterfall and the contribution of nutrients in different restoration models.

Material and methods

The study was carried out in the region of Itu, São Paulo. The regional vegetation physiognomy is predominantly from the Atlantic Seasonal Semideciduous Forest (IBGE, 2012) transitioning to Cerrado. The climate is classified as Cwa - dry winter and hot summer, with an average annual precipitation of 1,299.6 mm and an average annual temperature of 21.3ºC (Alvares et

al., 2013). The experiment was installed in March 2012, using a partial factorial experimental design with three randomized blocks and 10 treatments (Table 1), with 70 seedlings distributed in different plant spacing and successional groups proportions.

Table 1. Description of restoration models for degraded areas and treatments implemented in the study area located in Itu, São Paulo, Brazil.

Models	Plant spacing	Proportion by successional group	Treatments
Dense	1 m x 1 m (1 m²/plant)	40% of non-pioneer species and 60% of pioneers	T1
		60% of non-pioneer species and 40% of pioneers	T2
		80% of non-pioneer species and 20% of pioneers	T3
Semi-densified	2 m x 1 m (2 m²/plant)	40% of non-pioneer species and 60% of pioneers	T4
		60% of non-pioneer species and 40% of pioneers	T5
		80% of non-pioneer species and 20% of pioneers	T6
High Dense	1 m x 0.3 m (0,3 m²/plant)	40% of non-pioneer species and 60% of pioneers	T7
		60% of non-pioneer species and 40% of pioneers	T8
		80% of non-pioneer species and 20% of pioneers	T9
Conventional	3 m x 2 m (6 m²/plant)	40% of non-pioneer species and 60% of pioneers	T10

The litterfall was sampled bimonthly in 2019. We used conic collectors arranged transversally and equidistantly at a height of 1.20 m above soil, with an area equivalent to 0.33 m². The sampled material was classified into leaves, branches and reproductive material fractions. The plant material was placed in an oven at 65ºC for 24 hours (Scoriza et al., 2012) and then weighted. The total litterfall production was estimated from the equation adapted from Lopes et al. (2002):

Equation 1: $PAS = (\frac{\sum_{PS} \quad X10.000}{AC})$

Where: PAS is the average annual litterfall (kg ha^{-1} year); PS is the average monthly litterfall production (kg ha^{-1} month); and AC is the area of the collector (m²).

The leaf fraction of the litterfall was used for nutrient analysis. The nutrient contents were determined by the Kjeldahl method for nitrogen (N), colorimetry for phosphorus (P), barium sulfate turbidimetry for sulfur (S) and atomic absorption spectrophotometer, after nitric-perchloric digestion as proposed by Malavolta et al. (1989) for potassium (K), calcium (Ca), magnesium (Mg). The amount of nutrient contained in the litter was calculated according to the equation described by Scoriza et al. (2012):

Equation 2. $Ce = T_e \frac{T_s}{1000}$

Where: Ce is the content of element "e" (kg); te is the content of element "e" in the litter (g kg^{-1}) and Ts corresponds to the amount of litterfall (kg ha^{-1}).

Results and discussions

The annual litterfall production was 7953 kg ha^{-1}, it differed significantly only for plant spacing. The proportion of successional groups and its interaction with plant spacing were not significant (Table 2).

Table 2. Average annual litterfall (kg ha^{-1} $year^{-1}$), and nutrients production (kg/ha^{-1}) in the different restoration models in the experimental area, in Itu-SP, 2019. Means followed by the same letter, in the column, do not differ from each other, by the Tukey test ($p < 0.05$).

	Litterfall	**N**	**P**	**K**	**Ca**	**Mg**	**S**
Proportion by successional groups							
60NP40P	8145 A	132 A	10 A	33 A	90.9 A	21 A	12.4 A
60P40NP	7407 A	118 A	9.3 A	32 A	85.9 A	20 A	10.6 A
80NP20P	8452 A	135 A	10.1 A	36 A	93.6 A	21 A	16.6 A
Plant spacing							
1 x 0.3 m	9131 A	140.3 A	10.9 A	44.5 A	103.7 A	24.5 A	13.5 A
2 x 1 m	7732 AB	132.5 AB	10.0 A	29.1 B	88.6 AB	19. AB	11.6 AB
1 x 1 m	7758 AB	122.3 AB	9.5 A	28.6 B	85.6 AB	19.1 AB	11.4 AB
3 x 2 m	5761 B	86.4 B	6.8 A	26.2 B	63.4 B	14.2 B	7.9 B

The plant spacing 1 m x 0.3 m had the greatest canopy closure, a condition that favors natural pruning and leaf fall (Villa et al., 2016). In general, the highest production obtained for leaves, followed by branches and reproductive material, was similar to other studies in Seasonal Semideciduous Forests (Villa et al., 2016; Dick and Schumacher, 2020). The results for spacing and successional groups proportions confirm the hypothesis that plant spacing, and consequently the density, influenced the production but do not confirm the influence of different proportions of successional groups.

The highest nutrient production in the experimental area occurred for spacing 1 m x 0.3 m (337.4 kg ha^{-1}), followed by 1 m x 1 m (290.8 kg ha^{-1}), 2 m x 1 m (276 .5 kg ha^{-1}) and finally 3 m x 2 m (204.9 kg ha^{-1}). There were significant differences for the nutrient content (Table 3).

Table 3. Nutrient content (g/kg^{-1}) in different restoration models in the experimental area, in Itu-SP, 2019. Means followed by the same letter, in the column, do not differ from each other, by the Tukey test ($p < 0.05$).

Identification	N		P		K		Ca		Mg		S	
Proportion by successional groups												
60NP40P	16.1	A	1.2	A	3.9	A	11.0	A	2.5	A	1.4	A
60P40NP	16.0	A	1.3	A	4.3	A	11.5	B	2.6	A	1.5	A
80NP20P	16.0	A	1.2	A	4.1	A	11.0	A	2.5	A	1.5	A
Plant spacing												
1 m x 0.3 m	15.6	B	1.2	A	4.3	A	11.6	A	2.8	A	1.5	A
1 m x 1 m	17.0	A	1.3	A	3.8	A	11.1	AB	2.4	B	1.4	A
2 m x 1 m	15.8	B	1.2	A	4.0	A	10.9	B	2.4	B	1.5	A
3 m x 2 m	15.3	B	1.2	A	4.8	A	11.1	AB	2.5	AB	1.4	A

The variations of the different content of nutrients in the litterfall are related to their mobility within the plant (Caldeira et al., 2019). The significant calcium content for the 60P40NP treatment can be explained by the fact that the element has low mobility in the plant tissue (Godinho et al., 2014; Caldeira et al., 2019).

In the 1 m x 1 m, the nitrogen presented higher content due its high mobility in plants and may be associated with the dominance of some Fabaceae species, family with symbiotic associations with atmospheric N2-fixing bacteria (Schumacher et al., 2018). Magnesium showed reduced content in the 2 m x 1 m spacing, which can be attributed to the oxidation of chlorophyll. Phosphorus was the nutrient with the lowest content in litter, this fact may be related to the low fertility of the soil.

Conclusion

The treatments by successional group did not influence the results, except for the calcium content, and there is a need for a phytosociological survey to verify the effect of the dominance of the species.

Spacing was the most significant treatment and showed greater evidence of the contribution of litterfall and nutrients content to the system, showing that they were more efficient in promoting the rapid recovery of these functionalities at the beginning of the forest succession process, regardless of the proportion of the successional groups.

References

ALTIVO, F. S.; PIÑA-RODRIGUES, F. C. M. Funcionalidade ecológica da restauração de áreas degradadas no Bioma Mata Atlântica, Rio de Janeiro. Revista Brasileira de Ciências Ambientais, n.43, p. 17-31, 2017. https://doi.org/10.5327/Z2176-947820170175

ALVARES, C. A.; STAPE, J. L.; SENTELHAS, P. C.; GONÇALVES, J. D. M.; SPAROVEK, G. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift, vol. 22, n. 6, p. 711–728, 2013. https://doi.org/10.1127/0941-2948/2013/0507

CALDEIRA, M. V. W.; GODINHO, T. D. O.; MOREIRA, F. L.; CAMPANHARO, Í. F.; CASTRO, K. C.; MENDONÇA, A. R. D.; TRAZZI, P. A. Litter as an ecological indicator of forest restoration processes in a dense ombrophylous lowland forest. Floresta e Ambiente, v. 26, n. 1, 2019. https://doi.org/10.1590/2179-8087.041118

DICK, G; SCHUMACHER, M. V. Litterfall in the Semideciduous Seasonal Forest in Southern Brazil. Floresta e Ambiente, v. 27, n. 2, p. 1-7, 2020. https://doi.org/10.1590/2179-8087.029818

GODINHO, T. O.; CALDEIRA, M. V. W.; ROCHA, J. H. T.; CALIMAN, J. P.; TRAZZI, P. A. Quantificação de biomassa e nutrientes na serapilheira acumulada em trecho de Floresta Estacional Semidecidual Submontana, ES. Cerne, v. 20, n. 1, p. 11-20, 2014. https://doi.org/10.1590/S0104-77602014000100002

IBGE. Manual técnico da vegetação brasileira. Rio de Janeiro: Fundação Instituto Brasileiro de Geografia e Estatística, 2012. p. 271.

LOPES, M.I.M.; DOMINGOS, M.; VUONO, Y.S. Ciclagem de nutrientes minerais. In: SYLVESTRE, L. S. e ROSA, M. M. T. (Org.); Manual metodológico para estudos botânicos na Mata Atlântica. Seropédica/EDUR, 2002. p.72-103.

MALAVOLTA, E.; VITTI, G.C.; OLIVEIRA, S.A., 1997. Avaliação do estado nutricional das plantas: princípios e aplicações. POTAFOS, 1997. 319p.

RODRIGUES, R. R.; LIMA, R. A. F.; GANDOLFI, S.; NAVE A. G. On the restoration of high diversity forests: 30 years of experience in the Brazilian Atlantic Forest. Biological Conservation, v. 142 p. 1242–1251, 2009. https://doi.org/10.1016/j.biocon.2008.12.008

SCHUMACHER, M. V.; SZYMCZAK, D. A.; TRÜBY, P.; LONDERO, E. K.; MARAFIGA, J. Aporte de serapilheira e nutrientes em uma floresta Estacional na região central do Rio Grande do Sul. Ciência Florestal, v. 28, n. 2, p. 532-541, 2018. https://doi.org/10.5902/1980509832036

SCORIZA, R.N.; PEREIRA, M. G.; PEREIRA, G. H. A.; MACHADO, D. L.; SILVA, E. M. R. Métodos para coleta e análise de serapilheira aplicados à ciclagem de nutrientes. Floresta e Ambiente, v. 2, n. 2, p. 01 – 18, 2012.

VILLA, E. B.; PEREIRA, M. G.; ALONSO, J. M.; BEUTLER, S. J.; LELES, P. S. D. S. Aporte de serapilheira e nutrientes em área de restauração florestal com diferentes espaçamentos de plantio. Floresta e Ambiente, v. 23, n. 1, p. 90-99, 2016. https://doi.org/10.1590/2179-8087.067513