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INFLUENCE OF EDAPHIC CHARACTERISTICS OF THE EDGE AND INSIDE THE REFORESTED AREA AT THE SPATIAL DISTRIBUTION OF *Oeceoclades maculata* (LINDL.) LINDL. (ORCHIDACEAE)[1]

INFLUÊNCIA DAS CARACTERÍSTICAS EDÁFICAS DA BORDA E DO INTERIOR DE UMA ÁREA REFLORESTADA NA DISTRIBUIÇÃO ESPACIAL DE *Oeceoclades maculata* (LINDL.) LINDL. (ORCHIDACEAE)

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ABSTRACT - Factors such as soil properties, altitude and topography are conditional aspects on the spatial distribution of species around the forest. The present work carried out edaphic analyzes on the edge and inside the Arboretum of Native Essences at the Hermínio Ometto University Center - Uniararas and in vegetative organs of *Oeceoclades maculata***,** to demonstrate the influence of soil attributes on its spatial distribution. For this purpose, 20 cm deep soil samples and 10 individuals from *O. maculata* were collected, inside of each fragment, on its edge and interior. At the end of the investigation, the results demonstrated that *Oeceoclades maculata* has an aggregate distribution pattern in the studied microhabitats, considering that OM and P were present at a moderate and high positive correlation at the edge, respectively, and V% with median positive correlation for the interior, showing among all analyzed attributes distributive spatial influence.

Keywords: Soil properties; exotic species; orchid.

RESUMO - As propriedades do solo, a altitude e a topografia são alguns aspectos condicionantes da distribuição espacial de espécies em florestas. O presente trabalho realizou análises edáficas na borda e no interior do Arboreto de Essências do Centro Universitário Hermínio Ometto – Uniararas e em órgãos vegetativos de *Oeceoclades maculata*, com o objetivo de demonstrar a influência dos atributos do solo em sua distribuição espacial. Para esse propósito, amostras de solo de 20 cm de profundidade e 10 indivíduos de *Oeceoclades maculata* foram coletados dentro do fragmento, tanto na borda quanto no interior. Ao final da investigação, os resultados demonstraram que *Oeceoclades maculata* tem padrão de distribuição agregado nos micro-habitats estudados, considerando que MO e P apresentaram moderada e alta correlação positiva para a borda, respectivamente, e V% com mediana correlação positiva para o interior, mostrando, entre todos os atributos analisados, influência espacial distributiva.

Palavras-chave: propriedades do solo; espécies exóticas; orquídeas.

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1 INTRODUCTION

Chemical analysis of soil is done to estimate the nutritional elements available to plants (Raij et al., 2001). This analysis may reveal nutritional sources under different edaphic conditions, for agricultural purposes and/or environment quality preservation. Spatial distribution of species in different vegetation formations has often been associated with not only soil properties but also altitude and topography (Rodrigues, 1991; Schiavini, 1992; Oliveira Filho et al., 1994; Cruz Ruggiero et al., 2002).

The forest fragmentation is a process, as a landscape, which includes the loss of the habitat and its disruption in its permanence (Fahrig, 2003). Habitat fragmentation increases the point of contact between anthropogenic effects and natural vegetation, which causes local physical, chemical and biological changes. This is known as the edge effect (Murcia, 1995), which may result in a decrease in habitat quality for native species while facilitating the invasion of exotic species (Morgan, 1998; Honnay et al., 2002*).*

Orchids are not always considered aliens, but some are, such as the widespread *Oeceoclades maculata* (Lindl.) Lindl., a terrestrial orchid usually rooted in humus (Dubbern et al., 2013). The species shows substantial ecological amplitude, often including habitats modified by anthropogenic actions (Cohen and Ackerman, 2009). In Brazil, it may be found growing under different climate conditions such as: Semideciduous Seasonal Forest (Mesophytic forest) (Ivanauskas and Rodrigues, 2000; Menini Neto et al., 2004a; Menini Neto et al., 2004b; Kinoshita et al., 2006; Pansarin and Pansarin, 2008), the Cerrado (Brazilian Savanna) (Batista and Bianchetti, 2003; Batista et al., 2005) and Caatinga (Semi-Arid Brazilian Savanna) (Araújo et al., 2005), growing mostly on banks in riverside woods, which (Menini Neto et al., 2004b; Araújo et al., 2005). In a survey of the central region of São Paulo, populations of *O. maculata* were found in severely human-impacted areas as well as undisturbed, natural areas (Ferreira et al., 2010; Pedroso-de-Moraes et al., 2010; Schuster et al., 2010; Dubbern et al., 2013).

So, the doing of the soil physical-chemical analyses, the chemical composition of the vegetative organs, the understanding of their possible connections and spatial distribution are important for this kind of orchid to adapt itself, as they indicate ecological conditions linked to the acquisition of nutrients, which may help the monitoring and further treatment of the species. This work has as a goal edaphic analysis on edges and interior of Arboretum of Native Essences of the Hermínio Ometto University Center – Uniararas and in *O. maculata*, single vegetative organs, to emphasize the influence of the soil traits in the spatial distribution of the species.

2 MATERIAL AND METHODS

2.1 Characterization of the study area

The work was developed from August to December 2013 in the Arboretum and the Laboratory of Botany and Environmental Analysis at the Hermínio Ometto University Center, Uniararas, Municipality of Araras, SP. The arboretum is characterized as a forested area in 1996, implanted with native essences originating from Semideciduous Seasonal Forest within the university campus, being under the coordinates 22º22’31.00 “S and 47º22’04.29” W, 652 m elevation and covering an area approximately 0.93 hectare.

The Araras region is under a tropical, seasonal climate with rainy summer and dry winter, described as Cwa in the climatic classification of Köppen. Rainfall does not exceed 30 mm during the driest month and the temperature of the hottest month varies between 19° C and 29° C (CEPAGRI, 2007). In this region, there is predominance of Red-Yellow Latosol, with more fertile spots of Dark Red Latosol (Pivello-Pompéia, 1985). Specifically in relation to the microclimate of the study area, for the edge, concerning light intensity, relative humidity and temperature, the following data were previously obtained: 1420 $\mu mol.m^{-2}.s^{-1}$, 37.5% and 38,6°C and into the 540 $\mu mol.m^{-2}.s^{-1}$ fragment, 82.3% and 21.3°C, respectively.

2.2 Spatial distribution

The population census of *O. maculata* occurred from August to September 2013. Data collection was done by demarcating 20 contiguous plots of the same size and shape (Greig-Smith, 1964) on the edge and inside the fragment, which plots were 10 x 20 m (Clements, 1929) with the largest length parallel to the edge of the fragment, totaling 4000 m^2 of study area, for each area.

The use of the Morisita Index (MI) and the variance-to-mean Ratio (VMR) (Budke et al., 2004) was done to identify the spatial distribution pattern before collecting material for analysis. Values of MI and VMR equal to 1 indicate regular distribution. Values less than 1 indicate the absence of clustering and values greater than 1 indicate clustering (Lima-Ribeiro and Prado, 2006). The statistical significance of the distribution of individuals was inferred by the χ^2 test for a given number of degrees of freedom (df), and at the level of significance, desired (Budke et al., 2004). For df (n-1 = 20-1), the critical reference value is 43.82 with $\alpha = 0.05$ (Ayres et al., 2007). The Spearman correlation coefficient (rs) (Zar, 1996) was used to verify the existence of correlation between the edge and inland distributions with the edaphic variables.

2.3 Collection of soil and plants

For the analysis, a soil sample and 10 *Oeceoclades maculata* individuals were collected at physiological maturity (reproducing), within each pre-established plot, both at the edge (distance up to 20 m inland) and within the fragment (more than 50 m from the edge) (Williams-Linera, 1990).

To establish a history of chemical fertility and to generate uniform procedures, a depth of 20 cm was used for soil sampling, which allows comparisons with results from different locations (EMBRAPA, 2005). In relation to the botanical material, it is found in literature recommendation only regarding the collection of leaves in orchids (Malavolta et al., 1997). However, due to the presence of pseudobulbs and roots that were inconspicuously tuberized in the species, a sample of the stem and radicals was also collected, which went through the same methods of foliar analysis.

2.4 Soil analysis

After drying and ground, the samples were analyzed as follows: grain size by pipetting method, pH by potentiometry $CaCl_2$, H + Al by SMP, exchangeable aluminum extracted with KCl at 1 mol L^{-1} and determination by titration with NaOH at 0.01 mol L^{-1}, sulfur by turbidimetry determined by spectrophotometry, boron extracted by the hot water method and determined by spectrophotometry, organic matter content oxidized by sodium dichromate and quantified by colorimetry, sodium extracted with dilute hydrochloric acid solution and determined by photometer, silicon by colorimetry, copper (Cu), zinc (Zn), iron (Fe) and manganese (Mn) by DTPA and determined in atomic absorption spectrometry; phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) contents by the ion exchange resin method, being determined: phosphorus by spectrophotometry of blue, potassium by flame photometer, calcium and magnesium by atomic absorption spectrometry, the moisture content determined with analytical balance after oven drying at 105°C for 48h (Vitti, 1989; Raij et al., 2001; EMBRAPA, 2005).

2.5 Plant analysis

The washed, dried and ground vegetable samples were weighed for wet digestion for the following analyzes: nitrogen (N) determined by Kjeldhal semi-micro technique in steam distillation and titration for quantification of ammoniacal nitrogen; phosphorus (P) determined by vanadate yellow; sodium (Na) and potassium (K) determined by flame photometer; calcium (Ca) and magnesium (Mg) determined by atomic absorption spectrometry; sulfur determined by turbidimetry with barium chloride in spectrophotometry; silicon (Si), after autoclaving, determined by spectrophotometer colorimetry; copper (Cu), zinc (Zn), iron (Fe) and manganese (Mn) determined by atomic absorption spectrometry; Boron (B) by dry digestion, determined by staining with azomethine-H reagent in spectrophotometry. To determine the dry matter (DM) and mineral matter (MM), the sample after milling was weighed, carried to the oven 105°C and then to the muffle oven at 550°C (Malavolta et al., 1997; EMBRAPA, 2005).

2.6 Statistical analyze

The data obtained for the number of individuals and physical-chemical attributes of the soil on the edge and inside the fragment were analyzed by performing the F-test and Tukey averages at 5% significance with the aid of the SAS-Statistical Analysis System (SAS, 2008). The Spearman correlation coefficient (rs) (Zar, 1996) was used to verify the existence of correlation between the edge and inland distributions with the edaphic variables.

3 RESULTS

In the plots, 304 individuals were found on the edge and 261 in the interior, totaling a sample population of 565 individuals (Table 1). For both the edge and the interior, the variation in the number of plants among the plots was large, and the number at the edge ranged from 1 to 96 and the interior from 1 to 54 individuals. Such abundance and variance resulted in aggregate distribution pattern for both sample units.

The edge plants obtained MI = 20.06 and VMR = 6.31. The interior plants presented MI = 20.07 and VMR = 4.13. These values are statistically significant according to the χ^2 test (Ayres et al., 2007).

Table 1. Number of individuals and chemical characteristics of the soil for each plot installed on the edge and inside of the Arboretum at the Hermínio Ometto University Center - Uniararas, Araras, SP, Brazil.

Tabela 1. Número de indivíduos e características químicas do solo para parcela instalada na borda e no interior do Arboreto do Centro Universitário Hermínio Ometto – Uniararas, Araras, SP, Brasil.

Plots	Nº. individuals	pH	O.M.	P	S	K	Ca	Mg	H+Al	Al	Na	CEC	BS	V	M	B	Cu	Fe	Mn	Zn	Si
Edge																					
1	23	5.4	25	7	3	0.8	26	7	23	-	-	57	34	60	-	0.59	0.4	59	4.9	0.7	8.14
2	2	5.3	22	8	4	0.8	17	5	19	-	-	42	23	55	-	0.27	0.7	59	3.7	1.5	8.22
3	96	5.2	29	56	3	0.9	13	5	18	-	-	37	19	51	-	0.14	0.5	40	2.3	0.3	7.90
4	38	5.4	28	14	5	0.9	20	6	19	-	-	46	27	59	-	0.25	0.5	58	5.0	2.3	8.54
5	45	4.9	36	19	5	1.2	9	4	23	1	-	37	14	38	7	0.51	0.2	84	5.4	1.6	7.90
6	41	5.2	32	18	3	1.0	15	6	22	-	-	44	22	50	-	0.36	1.2	99	62.0	3.1	8.86
7	36	5.2	25	10	5	1.1	18	6	21	-	-	46	25	54	-	0.20	0.6	92	7.8	2.2	8.94
8	21	5	23	7	3	1.0	14	6	24	5	-	45	21	47	19	0.40	0.5	103	7.5	1.3	7.82
9	1	5.2	20	8	3	0.9	13	6	20	2	-	40	20	50	9	0.21	0.6	111	3.4	0.5	8.30
10	1	5.2	31	8	3	0.8	18	4	18	3	-	41	23	56	12	0.23	0.5	86	2.6	0.3	7.82
Interior																					
1	54	4.9	30	25	4	1.1	22	6	42	4	-	71	29	41	12	0.54	0.9	216	12.7	2.1	7.10
2	1	5.2	29	8	3	1.1	24	5	30	-	-	60	30	50	-	0.39	0.6	88	10.5	0.6	6.86
3	34	5.0	28	10	4	1.2	20	5	25	4	-	51	26	51	14	0.74	0.6	100	8.9	0.8	7.26
4	20	5.5	19	7	3	1.1	34	7	25	-	-	67	42	63	-	0.37	0.6	85	6.1	0.6	7.34
5	23	5.5	24	7	4	1.4	32	5	23	-	-	61	38	63	-	0.59	0.7	98	2.4	0.3	6.22
6	28	5.7	25	9	3	1.9	55	7	22	-	-	86	64	74	-	0.58	0.6	106	4.8	0.6	6.94
7	32	5.5	27	9	3	1.5	33	7	23	-	-	65	42	64	-	0.02	0.8	121	5.1	1.0	8.22
8	30	5.0	24	10	3	2.5	12	4	23	1	-	41	18	45	5	0.25	0.6	101	5.5	1.2	8.30
9	20	4.8	21	8	4	0.8	11	6	25	3	-	43	18	42	14	0.30	0.7	80	5.1	0.5	7.90
10	19	5.1	26	8	3	1.1	16	5	24	4	-	46	22	48	15	0.39	0.8	63	6.9	0.6	8.14

The linear correlations to verify the influence of the soil edaphic characteristics on the spatial distribution of the species showed the very low physical-chemical properties of the soil and the distribution pattern found, because for *Oeceoclades maculata*, only O.M. (Organic Matter) and P with moderate (0.6402) and high (0.8025) positive correlation for the edge respectively, and V% with a median positive correlation (0.0461) in the interior were statistically significant ($p < 0.05$) (Table 2).

Table 2. Spearman's Correlations (r_s) among the physical and chemical attributes of the soil and the spatial distribution of *Oeceoclades maculata* on the edge and interior of the Uniararas arboretum.

Tabela 2. Correlações de Spearman (rs) entre os atributos físicos e químicos do solo e a distribuição espacial de *Oeceoclades maculata* na borda e no interior do arboreto da Uniararas.

Edge	r_s	p	Interior	r_s	p
pH	-0.162	n/s	pH	0.487	n/s
O.M	0.640	0.046	O.M.	0.012	n/s
P	0.802	0,005	P	0.068	n/s
S	0.299	n/s	S	0.249	n/s
K	0.537	n/s	K	0.498	n/s
Ca	-0.263	n/s	Ca	0.589	n/s
Mg	-0.075	n/s	Mg	0.191	n/s
H+Al	0.101	n/s	H+Al	-0.292	n/s
Al	-0.513	n/s	Al	-0.269	n/s
Na	0	n/s	Na	0	n/s
CEC	-0.146	n/s	CEC	0.498	n/s
BS	-0.277	n/s	BS	0.571	n/s
V	-0.247	n/s	V	0.640	0.046
M	-0.513	n/s	M	-0.413	n/s
B	0.024	n/s	B	0.594	n/s
Cu	-0.239	n/s	Cu	-0.32	n/s
Fe	-0.481	n/s	Fe	0.437	n/s
Mn	0.279	n/s	Mn	-0.265	n/s
Zn	0.381	n/s	Zn	0.015	n/s
Si	0.168	n/s	Si	-0.425	n/s
Sand g Kg^{-1}	-0.133	n/s	Sand g Kg^{-1}	-0.389	n/s
Clay g Kg^{-1}	-0.060	n/s	Clay g Kg^{-1}	0.596	n/s
Silt g Kg^{-1}	0.206	n/s	Silt g Kg^{-1}	-0304	n/s
Moisture %	-0.285	n/s	Moisture %	-0.280	n/s

In relation to the physical characteristics of the soil, the amount of sand and silt was larger for the edge of the fragment, while the clay amount was larger in the interior (Table 3).

Table 3. Soil physical characteristics expressed in g/kg for each plot installed on the edge and interior of the Arboretum at the Hermínio Ometto University Center - Uniararas, Araras, SP, Brazil.

Tabela 3. Características físicas do solo expressas em g/kg para cada parcela instalada na borda e no interior do Arboreto do Centro Universitário Hermínio Ometto – Uniararas, Araras, SP, Brasil.

Plots	Sand		Clay		Silt	
	Edge	Interior	Edge	Interior	Edge	Interior
1	856.4	730.3	94	166	49.6	103.7
2	849.32	834.62	85	109	65.68	56.38
3	773.76	787.52	92	171	134.24	41.48
4	820.39	831.64	124	120	55.61	48.36
5	822.28	787.99	115	152	62.72	60.01
6	821.11	854.19	106	101	72.89	44.81
7	833.66	813.23	77	124	89.34	62.77
8	851.86	870.58	88	80	60.14	49.42
9	817.6	822.82	114	90	68.4	87.18
10	805.53	842.52	128	115	66.47	42.48
Average	825.19	817.54	102.3	122.8	72.51	59.66

The relationship between edge and interior plants in the number of individuals and chemical attributes of the soil was not statistically significant even though there were significant differences among soil chemical attributes between the two habitat types for Ca, H+Al, CEC, BS and K, for which ones the highest averages were obtained from the forest interior. Only the Si attribute was shown larger for the edge (Tables 4 and 5).

Table 4. F statistics for the number of individuals and for chemical attributes of the soil according to the collection sites in the Arboretum at the Hermínio Ometto University Center - Uniararas, Araras, SP, Brazil.

Tabela 4. Estatística F para o número de indivíduos e atributos químicos do solo de acordo com a os locais de coleta no Arboreto do Centro Universitário Hermínio Ometto – Uniararas, Araras, SP, Brasil.

SOILS					
Nº of indviduals	pH	O.M.	P	S	K
P-value					
0.6607ns	0.6607ns	0.6981ns	0.7235ns	0.4850ns	0.4471ns
Ca	Mg	H+Al	CEC	BS	V%
0.0234*	0.2170ns	0.0208*	0.0012*	0.0212*	0.4413ns
B	Cu	Fe	Mn	Zn	Si
0.1505ns	0.2141ns	0.1884ns	0.0619ns	0.1238ns	0.0011*

ns: non-significant *: significant at 5% (0.05) of probability according to F-test.

ns: não significativo *: significativo a 5% (0,05) de probabilidade de acordo com teste F.

Table 5. Average number of individuals and soil chemical attributes of the collection sites in the Arboretum at the Hermínio Ometto University Center - Uniararas, Araras, SP, Brazil.

Tabela 5. Número médio de indivíduos e atributos químicos do solo dos locais de coleta do Arboreto do Centro Universitário Hermínio Ometto – Uniararas, Araras, SP, Brasil.

SOILS						
Treatments	Nº. of individuals	pH	O.M.	P	S	V
			g/kg	mg . dm^{-3} (ppm)		%
Edge	30.00 A	5.20 A	27.22 A	11.00 A	3.70 A	52.00 A
Interior	26.00 A	5.22 A	25.36 A	10.11 A	3.40 A	54.11 A
MSD	3	0.22	4.07	4.92	0.71	8.54
CV (%)	79	4.69	16.48	48.27	21.51	17.14
Treatments	Ca	Mg	H+Al	CEC	BS	K
	mmolc . dm^{-3}					
Edge	16.30 B	5.50 A	20.70 B	43.50 B	22.80 B	0.94 B
Interior	22.66 A	5.7 A	26.20 A	59.10 A	32.90 A	1.37 A
MSD	4.92	0.95	4.23	9.78	10.01	0.34
CV (%)	36	18.15	19.22	21.51	38.26	31.51
Treatments	B	Cu	Fe	Mn	Zn	Si
	mg . dm^{-3}(ppm)					
Edge	0.31 A	0.57 A	70.10 A	4.73 A	1.37 A	8.23 A
Interior	0.42 A	0.69 A	93.55 A	6.80 A	0.83 A	7.42 B
MSD	0.16	0.18	20.2	2.52	0.71	0.53
CV (%)	48.55	31.52	24.02	44.71	69.1	7.26

MSD: Minimum significant difference. Mean values in the column followed by the same letter do not differ at the 5% probability level according to Tukey's test.

DSM: diferença mínima significativa. Os valores médios na coluna, seguidos pela mesma letra, não diferem ao nível de 5% de probabilidade de acordo com o teste de Tukey.

The F-test indicated that There were statistical differences for the interior and edge plants differed significantly in N, P, Cu, Fe, Si and DM (Dry Matter) in the leaves; K, B, Cu, Fe and Mn in the pseudobulbs; and for P in the roots. The P value found for the roots and leaves was larger in the interior than in the edge of the fragment; however, for the pseudobulbs no statistical difference was found with respect to the plants of the two areas of the studied fragment (Table 6 and 7).

Table 6. Chemical analyzes performed for roots, stems (pseudobulbs) and leaves of *Oeceoclades maculata* collected in the edge and interior plots of Arboretum at the Hermínio Ometto University Center - Uniararas, Araras, SP, Brazil.

Tabela 6. Análises químicas realizadas nas raízes, caules (pseudobulbos) e folhas de *Oeceoclades maculata* coletadas nas parcelas da borda e interior do Arboreto do Centro Universitário Hermínio Ometto – Uniararas, Araras, SP, Brasil.

	Plot	N	P	K	S	Ca	Mg	Na	B	Cu	Fe	Mn	Zn	Si	DM	MM
					g/kg						mg/kg			mg/L	%	
									Edge							
Leaf	1	24.56	4.02	38.47	2.56	14.08	6.17	-	17.96	6.20	291.80	96.10	74.45	8308.46	91.75	25.94
	2	26.49	6.80	51.47	2.02	9.22	7.05	-	20.41	7.80	216.10	65.60	87.46	8059.70	92.53	16.27
	3	20.55	2.21	32.47	1.77	10.52	8.29	-	22.60	7.70	173.50	417.30	51.04	7810.95	92.34	14.45
	4	22.51	1.76	30.47	2.19	14.78	3.03	-	20.24	8.60	147.10	178.30	63.73	8308.46	92.77	21.30
	5	21.76	1.29	36.47	2.61	16.55	3.19	-	20.59	11.20	115.40	204.10	54.06	8805.97	93.20	16.43
	6	20.19	1.94	35.47	1.81	13.20	3.98	-	21.90	10.40	169.00	212.80	34.55	10298.51	91.95	13.09
	7	21.56	2.34	39.47	1.60	12.88	4.72	-	20.94	10.60	140.50	315.10	55.92	8805.97	91.65	14.86
	8	22.51	2.43	33.47	1.68	12.92	3.69	-	21.55	9.60	175.30	394.10	59.83	8059.70	92.65	14.70
Pseudobulb	1	17.14	9.33	39.47	3.03	10.25	3.17	-	19.45	8.00	180.80	33.80	73.13	14029.85	95.76	11.68
	2	25.73	10.90	31.47	3.24	10.04	4.50	-	19.36	6.40	103.90	19.30	429.97	20248.76	90.88	13.28
	3	21.45	9.20	31.47	2.23	6.41	4.20	-	19.27	5.50	117.60	42.90	75.82	16268.66	93.87	10.81
	4	22.37	11.26	19.47	2.69	11.56	2.88	-	19.89	3.20	194.20	38.50	137.89	13283.58	91.24	11.56
	5	15.06	11.66	28.47	2.14	13.41	2.89	-	19.27	3.00	175.20	22.20	37.80	16019.90	90.78	11.90
	6	16.04	7.60	28.47	2.56	13.52	2.53	-	20.67	5.20	131.60	26.60	31.43	23731.34	92.16	11.04
	7	17.02	6.93	32.47	2.23	8.94	3.70	-	21.29	7.10	117.30	23.70	65.94	24228.86	92.97	12.94
	8	16.49	7.55	21.47	1.72	5.71	2.96	-	18.92	5.60	147.90	35.80	74.99	14776.12	91.48	9.04
Root	1	18.23	6.55	22.47	3.95	6.12	9.53	-	18.31	25.70	9743.30	39.80	195.80	21741.29	95.20	16.35
	2	20.13	12.52	24.47	2.98	3.16	4.23	-	16.29	38.30	2013.20	11.00	84.25	17263.68	93.65	13.07
	3	12.96	6.24	26.47	4.20	3.05	15.46	-	17.78	24.30	4638.30	44.80	77.96	18507.46	94.07	14.70
	4	16.10	4.96	17.47	2.77	3.64	8.37	-	17.96	17.40	2804.40	129.90	169.84	17512.44	91.64	13.45
	5	14.34	4.16	23.47	28.56	5.81	9.36	-	16.65	18.70	2453.60	117.40	36.47	29203.98	92.41	18.61
	6	14.17	3.87	15.47	2.02	1.94	10.47	-	17.08	15.90	3107.00	27.70	25.77	22736.32	92.41	13.10
	7	13.69	4.47	19.47	2.52	2.88	21.47	-	17.43	16.80	2550.30	34.40	32.08	22238.81	91.56	13.39
	8	16.55	4.33	20.47	1.51	0.87	2.83	-	20.41	15.30	2918.10	39.00	36.14	15273.63	93.29	11.91
Leaf	1	31.33	10.70	21.47	2.27	15.42	4.40	-	19.19	5.20	291.30	202.70	165.42	12288.56	93.97	15.73
	2	24.53	4.74	24.47	2.27	15.18	5.97	-	21.81	5.10	333.50	232.10	48.33	17761.19	94.93	16.22
	3	25.68	5.58	44.47	2.35	13.46	5.56	-	20.41	9.40	252.20	289.40	82.10	7810.95	93.84	15.95
	4	21.84	3.40	39.47	2.14	13.84	6.12	-	20.85	5.70	390.30	188.20	49.97	9801.00	94.45	16.29
	5	27.78	8.53	27.47	2.61	9.45	7.73	-	19.89	4.50	416.20	207.70	49.37	15024.88	93.53	14.78
Pseudobulb	1	29.82	11.70	17.47	3.28	9.75	3.76	-	17.96	9.80	217.40	65.20	142.46	18258.71	93.03	13.41
	2	21.56	12.03	23.47	2.69	6.46	3.75	-	19.80	8.80	146.30	63.90	86.69	16517.41	92.83	12.75
	3	20.41	10.79	17.47	2.40	14.22	4.48	-	18.84	9.00	136.80	60.30	77.57	15024.88	94.49	10.34
	4	13.13	6.62	23.47	2.61	8.10	4.18	-	17.61	6.40	372.80	37.90	67.69	16268.66	91.74	9.74
	5	16.10	7.58	23.47	2.48	9.32	3.71	-	17.96	6,.40	328.20	30.30	68.81	15024.88	95.29	9.07
Root	1	21.67	9.42	15.47	3.15	5.32	2.93	-	15.16	37.70	3882.50	38.20	154.18	19751.24	95.16	15.56
	2	19.60	7.42	22.47	3.99	5.64	13.22	-	17.26	26.60	5931.50	42.00	188.90	19502.49	94.08	14.61
	3	18.45	12.70	24.47	3.53	9.15	4.66	-	16.29	23.00	9089.40	48.50	164.73	19751.24	92.96	14.19
	4	12.43	12.06	15.47	3.03	2.98	9.96	-	16.38	17.10	6817.80	37.20	62.46	26965.17	94.33	16.17
	5	25.31	11.84	18.47	2.98	3.16	4.29	-	17.70	50.10	5011.00	23.90	227.73	16517.41	93.13	13.25

Table 7. Value of the F-statistic performed for the root, stem and leaf chemical analyzes of *Oeceoclades maculata* collected on the edge and interior of the Arboretum at the Hermínio Ometto University Center - Uniararas, Araras, SP, Brazil.

Tabela 7. Valores da Estatística F encontrados nas análises química das raízes, caules e folhas de *Oeceoclades maculata* coletadas na borda e no interior do Arboreto do Centro Universitário Hermínio Ometto – Uniararas, Araras, SP, Brasil.

			Leaves			
N	P	K	S	Ca	Mg	B
			P-value			
0.0371*	0.0152*	0.2302 ns	0.1380 ns	0.7322 ns	0.3505 ns	0.6493 ns
Cu	Fe	Mn	Zn	DM	MM	Si
0.0136*	0.0007*	0.8539 ns	0.3349 ns	0.0001*	0.5107 ns	0.0142*
			PSEUDOBULB			
N	P	K	S	Ca	Mg	B
			P-value			
0.6514 ns	0.7190 ns	0.0252 *	0.4265 ns	0.8087 ns	0.0947 ns	0.0180*
Cu	Fe	Mn	Zn	DM	MM	Si
0.0212*	0.0369*	0.009*	0.6034 ns	0.2658 ns	0.6082 ns	0.4471 ns
			ROOTS			
N	P	K	S	Ca	Mg	B
			P-value			
0.0848 ns	0.0085*	0.3923 ns	0.3110 ns	0.1478 ns	0.3252 ns	0.1115 ns
Cu	Fe	Mn	Zn	DM	MM	Si
0.1309 ns	0.1040 ns	0.3990 ns	0.0587 ns	0.1878 ns	0.6682 ns	0.9422 ns

ns: non-significant *: significant at 5% (0,05) of probability according to F-test.

ns: não significativo *: significativo a 5% (0,05) de probabilidade de acordo com teste F.

The Cu and Fe values found in the leaves and pseudobulbs were larger within the fragment than at the edge. For the roots, the analysis of these elements did not reveal significance in any of the environments studied (Table 6 and 7).

The DM had significant values in the analysis of variance and presented higher value in the leaves of the interior of the fragment when compared with those of the edge (Table 6 and 7).

The value of Si in the leaves in the interior was higher than in the edge, however, for pseudobulbs and roots were not significant. In relation to K, Mn and B the values found in leaves and roots were not significant, however, the values found in the pseudobulbs for K are larger at the edge than inside the fragment, for the Mn, larger inside than the edge (Table 6 and 7), and significant for B only for the F-test ($p < 0.05$) (Table 6). For DM, statistical significance was only found for the leaves, and the plants present at the edge of the fragment had the highest average value for the analyzed variable (Table 6 and 7).

4 DISCUSSION

The statistical non-significance observed among the average number of individuals occurring at the edge and inside the fragment and the occurrence of few variables that correlate between the physical and chemical attributes of the soil and the geospatial pattern of the population analyzed demonstrate that there is no direct influence of the edaphic characteristics on the spatial distribution of *Oeceoclades maculata*. This detection corroborates the claim that pioneer/alien species are low demanding in relation to nutrition, developing well in soils characterized by their low availability of nutrients (Larcher, 2004). In addition, for invasive orchids such as *O. maculata* and *Sacoila lanceolata* (Aubl.) Garay, climatic conditions are the main limiting factor for their expansion (Dubbern et al., 2013; Piccoli et al., 2014), independent from the edaphic characteristics of the invaded area, mainly in physiognomies that present a history of intense anthropic disturbance. In this aspect, it is observed that native orchids can be affected as much as other vascular species by an invasive orchid (Vilà et al., 2011). Such an assertion is because *O. maculata* threatens the diversity of terrestrial orchids from invaded areas in Puerto Rico, where the abundance of *Wullschlaegelia calcarata* Benth and *Prescottia stachyodes* (Sw.) Lindl. was reduced in several coexistence sites (Cohen and Ackerman, 2009).

Aggregate spatial distribution patterns, such as those found for *O. maculata*, are the most common among plants of different sinusiae (Hay et al., 2000; Lima-Ribeiro and Prado, 2006). The verification of such distributive pattern for the species was also observed in the Restinga vegetation area located in the city of Vila Velha, ES (Krahl et al., 2009) and in a fragment of Semideciduous Seasonal Forest of Cordeirópolis, SP (Dubbern et al., 2013).

Other species of Brazilian terrestrial orchids are also shown with aggregate distribution, such as: *Mesadenella cuspidata* (Lindl.) Garay in Mata Ribeirinha de Santa Maria, RS (Budke et al., 2004), *Eltroplectris triloba* (Lindl.) Pabst in Restinga de Vila Velha, ES (Krahl et al., 2010) and *S. lanceolata* in a Semideciduous Seasonal Fragment of Pirassununga, SP (Piccoli et al., 2014). For Orchidaceae, it is known that in several phytophysiognomies investigated in Brazil, such a pattern of distribution is commonly found, which is mainly determined by the seminal characteristics of the family (Budke et al., 2004; Piccoli et al., 2014).

In general, the spatial pattern of species is defined by the way their seeds are dispersed, and for orchids, which are anemochoric plants; a random distribution pattern would be expected (Nathan and Muller-Landau, 2000; Chung et al., 2004). However, seed allocation at favorable sites has been shown to be the most influential factor in the distribution to the detriment of the dispersion syndrome (Jacquemyn et al., 2007; Phillips et al., 2011). Thus, for such plants, the establishment of new seedlings through germination is crucial for the maintenance of specimens at different stages of development and, consequently, for the survival of the species (Jersáková and Malinová, 2007). However, in this family, germination depends on the presence of mycorrhizal fungi responsible for embryo nutrition in the early stages of development (Rasmussen, 2002). Due to this relationship, mycorrhizal fungi also show aggregate distribution along the orchid *habitats* (Dubbern et al., 2013; Piccoli et al., 2014). Thus, the greatest abundance of fungi is usually found near mature plants (Batty et al., 2001; Otero et al., 2004; Diez, 2007), although under normal circumstances such fungi are susceptible to the independent distribution of orchids (Feuerherdt et al., 2005).

Sites endowed with favorable soil conditions are predominant in the density and growth of mycorrhizal fungi (Ettema and Wardle, 2002) and, consequently, in the germination of orchid seeds (Batty et al., 2001; Diez, 2007; Phillips et al., 2011), leading to the creation of sites with favorable environmental conditions for the development of both. However, there is no information on the mineral nutrition of orchid species in natural and/or reforested areas and their influence by mycorrhizal fungi (Pedroso-de-Moraes, 2000).

The statistical non-significance found for the average number of *O. maculata* occurring on the edge and inside the fragment is one more indicative of the adaptive capacity of the species. However, numerically, it has been found that a greater number of individuals occurring on the edge than inside the fragment. This density is possibly directly related to the predilection of the species by natural areas characterized as heliophytes (Dubbern et al., 2013) and well drained soils (Pedroso-de-Moraes, 2000) differently from the interior of the fragment characterized as a more clayey area compared to the edge, and therefore more humid (Stencel et al., 2016). Concerning its habit, *O. maculata* is also described as a humiculous terrestrial orchid (Menini Neto et al., 2004a), and is frequently found in the middle of the soil litter (Pedroso-de-Moraes, 2000), a fact corroborated by the correlation between OM, the edge of the fragment and the spatial distribution of the species. In addition to the physical characteristics of the soil, there is a tendency of the species to occupy sandy soils, as it can be observed in restingas (Krahl et al., 2009), Cerrado (Brazilian Savanna) (Batista et al., 2005) and Caatinga (Semi-Arid Brazilian Savanna) (Araújo et al., 2005), a fact that can be related to the African origin of the species, a continent with sandy soils (ISRIC, 2014).

In the meantime, in relation to soil chemical attributes and root, stalk and leaf tissue analyzes, it was observed that for *O. maculata* the P for the edge of the fragment and V% for the interior influenced the spatial distribution of the species.

With respect to P, it is known that orchids need in abundance such element to carry out the germinative phenomenon (Pedroso-de-Moraes, 2000). Once again, as previously mentioned, the importance of mycorrhizal fungi for seed germination of the species is noticed, since one of the benefits received by orchids in association with such organisms is the increase in the availability of N and P and consequently the increase of DM values for the aerial part (Bressan et al., 2001), as found for the leaves of *O. maculata* on the edge of the fragment. Furthermore, the effect of P on the efficiency of mycorrhizal fungi in dry matter production has been described in different works, in different situations (Paula and Siqueira, 1987; Saggin Júnior et al., 1995). These studies demonstrated that low P rates increase the mycorrhization and mycorrhizal fungi efficiency in promoting increase in dry matter; however, high doses of this nutrient negatively affect mycorrhization and dry matter production, especially in soybean cultivation (Bressan et al., 2001). For orchids in general, the rate of incorporation of phosphate ions depends on the genotype and is proportional to the growth rate of the culture in seedlings grown *in vitro* (Cunha et al., 2011).

Furthermore, as previously explained, a greater amount of clay was found inside the fragment, which is directly related to the correlation found for V% for this area studied. Clay colloids are small-sized soil particles that have surface charges which can retain nutrients (ions) in an exchangeable way. Thus, the clays have a specific exchange surface and are the main colloids responsible for the cation exchange capacity (CEC) of the soils under tropical conditions. The adsorption of cations occurs mainly due to the greater number of negative charges of these colloids (Ronquim, 2010) and it's an important feature when it relates to the nutrition of orchids, which have slow metabolism (crassulacean acid metabolism) (Galdiano Júnior et al., 2013), and therefore require higher amounts of macro and micronutrients for their full development (Pedroso-de-Moraes, 2000), not necessarily showing, as observed in this work, a direct relationship between these elements and the species distribution.

The total amount of cations retained in clayable colloids capable of being exchanged ($Ca^{2+} + Mg^{2+} + K^{+} + H^{+} + Al^{3+}$) corresponds to the cation exchange capacity (CEC) of a soil. The essential cations are Ca^{2+}, Mg^{2+} and K^{+} and if a soil is occupied by them then it can be considered a well nourished soil for the plants. In the case of the fragment studied, the interior is more fertile than the edge. In other forest systems this is due to the greater nutrient cycling that occurs inside the forest when compared to its edge (Redding et al., 2003).

The sum of exchangeable bases ($BS = Ca^{2+} + Mg^{2+} + K^{+}$) of a soil represents the sum of the interchangeable cations contents, except H^{+} and Al^{3+}. Basal saturation (V%) is represented by the sum of exchangeable bases expressed as percentage of cation exchange capacity ($V\% = 100 * BS/ CEC$) (Ronquim, 2010). The contents found in the work indicate that the studied soil is dystrophic (not very fertile), since the contents previously mentioned are in low values.

For orchids, N fixation, which is one of the main essential nutrients for plants, depends on the associations with mycorrhizal fungi, on the environment conditions and on some mineral elements that are closely involved: Mo, Fe, Co, Mg, P, S and Cu (Gebauer and Dietrich, 1993; Schulze et al., 1994). The essentiality of N and P is conditioned in the structures of compounds that form amino acids and proteins, nucleic acids, coenzymes, carbohydrate esters and phospholipids, and also in processes that develop as ionic absorption, photosynthesis, respiration, cellular multiplication and differentiation, inheritance, storage and transfer of energy (Malavolta et al., 1997). Thus they are in constant movement and are the most readily redistributed elements, which corroborate the N and P contents that show predominantly normal to high values for *O. maculata* in both microhabitats of the studied fragment.

Standing out as the second most absorbed nutrient by plants (Vilela et al., 2004), potassium was found in the present work at normal levels for the leaves and normal to low levels for the pseudobulbs and roots of both microenvironments of the fragment, implying an increase in DM and indicating higher productivity at high levels.

Micronutrients also have their essentiality in plant life. Cu and Fe are found in the structures of proteins and glycoproteins, in the processes of photosynthesis, respiration, hormonal regulation, metabolism of secondary compounds and in the fixation of N (Malavolta et al., 1997). Fe exerts its functions through enzymes and in its acquisition processes this is mobilized in the root apical zones for different physiological strategies (Römheld, 1987; Marschner, 1995); in this sense the results obtained for this nutrient in the roots of the fragments corroborate the assertion, since the values are very high compared to normality.

In turn, manganese is an important micronutrient for photosynthesis (its deficiency can alter the structure of chloroplasts), important in ionic absorption, respiration, hormonal control, protein synthesis and increase in resistance to pests, as it participates in the synthesis of lignin, constituting a physical barrier to the entry of pathogens (Malavolta et al., 1997). The association with mycorrhizal fungi in corn crops results in lower Mn acquisition, and this was verified because of a lower activity in the reduction of Mn by the rhizosphere (Kothari et al., 1990; Posta et al., 1994). The present work shows similar results for *O. maculata*, where the contents of this nutrient are found in low levels of concentration in the roots and pseudobulbs, mainly on the edge of the fragment.

The benefits conferred by silicon to plants are due to their contribution in structuring the cell wall of roots and leaves where it is accumulated, and then solidified, becoming immobile, which helps limit water loss by transpiration, to promote its growth and protection (Epstein, 1999). Therefore, this element does not have a defined metabolic role in the plants and its action causes indirect effects, which together contribute to a higher productivity (Malavolta et al., 1997). The present study agrees with this assertion, since the contents of Si corroborate with the increase of DM at the edge of the fragment. This finding is also supported by the notable increase in leaf size of *Phalaenopsis* Blume in *in vitro* cultures with different concentrations of calcium silicate (Zhou, 1995), because Si is involved in the structure of the cell walls and its capacity to expand allows the increase of cell width (Gunes et al., 2007).

According to Malavolta (2006), boron is known to present deficiency in several crops being absorbed by the plants as undissociated boric acid (H_3BO_3). However, it is unclear how this happens, whether actively or passively. Nevertheless, such acid competes with Zn for transport. The B has important function in the meristematic growth, in the metabolism of carbohydrates, phenols and callose, in cell membranes and in the synthesis of hormones (Malavolta et al., 1997). The content of this nutrient for the work corroborates the previously mentioned assertion, where the values of B present low levels in all plant tissues for both fragments and in contrast Zn presents with normal to high levels in the tissues in both microhabitats.

5 CONCLUSION

Oeceoclades maculata has an aggregated distribution pattern in our study area. Considering that O.M. and P with moderate and high positive correlation for the edge, respectively, and V% with a median positive correlation to the interior have shown, among all attributes analyzed, spatial distributive influence.

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REFERENCES

ARAÚJO, L.E. et al. Diversidade de herbáceas em micro habitats rochoso, plano e ciliar em uma área de caatinga, Caruaru, PE, Brasil. **Acta Botanica Brasílica**, v. 19, n. 2, p. 285-294, 2005. http://dx.doi.org/10.1590/S0102-33062005000200011.

AYRES, M. et al. **Bioestat:** Aplicações estatísticas nas áreas das ciências biomédicas. Belém: Instituto Mamirauá, 2007. 380 p.

BATISTA, J.A.N.; BIANCHETTI, L.B. Lista atualizada das Orchidaceae do Distrito Federal. **Acta Botanica Brasílica**, v. 17, n. 2, p. 183-201, 2003. http://dx.doi.org/10.1590/S0102-33062003000200003.

BATISTA, J.A.N.; BIANCHETTI, L.B.; PELLIZZARO, K.F. Orchidaceae da Reserva Ecológica do Guará. **Acta Botanica Brasílica**, v. 19, n. 2, p. 221-232, 2005. http://dx.doi.org/10.1590/S0102-33062005000200004.

BATTY, A.L. et al. Constraints to symbiotic germination of terrestrial orchid seed in a mediterranean bushland. **The New Phytologist**, v. 152, n. 1, p. 511-520, 2001. http://dx.doi.org/10.1046/j.0028-646X.2001.00277.x.

BRESSAN, W. et al. Fungos micorrízicos e fósforo, no crescimento, nos teores de nutrientes e na produção do sorgo e soja consorciados. **Pesquisa Agropecuária Brasileira**, v. 36, n. 2, p. 315-323, 2001. http://dx.doi.org/10.1590/S0100-204X2001000200015.

BUDKE, J.C. et al. Distribuição especial de *Mesadenella cuspidata* (Lindl.) Garay (Orchidaceae) em uma floresta ribeirinha em Santa Maria, RS, Brasil. **Acta Botanica Brasílica**, v. 8, n. 1, p. 31-35, 2004. http://dx.doi.org/10.1590/S0102-33062004000100004.

CENTRO DE PESQUISAS METEOROLÓGICAS E CLIMÁTICAS APLICADAS À AGRICULTURA – CEPAGRI. **Clima dos municípios paulistas**. 2007. Disponível em: <https://www.cpa.unicamp.br/>. Acesso em: 10 Nov. 2012.

CHUNG, M.Y.; NASON, J.D.; CHUNG, M.G. Spatial genetic structure in populations of the terrestrial orchid *Cephalanthera longibracteata* (Orchidaceae). **American Journal of Botany**, v. 91, n. 1, p. 52-57, 2004. http://dx.doi.org/10.3732/ajb.91.1.52. PMid:21653362.

CLEMENTS, F.E. Experimental Methods in Adaptation and Morphogeny. **Journal of Ecology**, v. 17, n. 2, p. 356-379, 1929. http://dx.doi.org/10.2307/2256048.

COHEN, I.M.; ACKERMAN, J.D. *Oeceoclades maculata*, an alien tropical orchid in a Caribbean rainforest. **Annals of Botany**, v. 104, n. 3, p. 557-563, 2009. http://dx.doi.org/10.1093/aob/mcn191. PMid:18840872.

CRUZ RUGGIERO, P.G. et al. Soil-vegetation relantioships in cerrado (Brasilian savanna) and semideciuous Forest, southeastern Brazil. **Plant Ecology**, v. 160, n. 1, p. 1-16, 2002. http://dx.doi.org/10.1023/A:1015819219386.

CUNHA, T. et al. Desenvolvimento *in vitro* de *Laeliocattleya schilleriana* Rolfe utilizando meios de cultivo simplificados. **Scientia Plena**, v. 7, n. 8, p. 1-5, 2011.

DIEZ, J.M. Hierarchical patterns of symbiotic orchid germination linked to adult proximity and environmental gradients. **Journal of Ecology**, v. 95, n. 1, p. 159-170, 2007. http://dx.doi.org/10.1111/j.1365-2745.2006.01194.x.

DUBBERN, C.A.; SOUZA-LEAL, T.; PEDROSO-DE-MORAES, C. Distribuição espacial de *Oeceoclades maculata* Lindl. (Orchidaceae) em fragmento florestal Estacional Semidecidual da fazenda Santa Tereza, Cordeirópolis, SP, Brasil. **Natureza *on line*,** v. 11, n. 1, p. 29-32, 2013.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA – EMBRAPA. **Manual de laboratório:** solo, água, nutrição vegetal, nutrição animal e alimentos. São Carlos: Embrapa Pecuária Sudeste, 2005. 334 p.

EPSTEIN, E. Silicon. **Annual Review of Plant Physiology and Plant Molecular Biology**, v. 50, n. 4, p. 641-664, 1999. http://dx.doi.org/10.1146/annurev.arplant.50.1.641. PMid:15012222.

ETTEMA, C.H.; WARDLE, D.A. Spatial soil ecology. **Trends in Ecology & Evolution**, v. 17, n. 2, p. 77-183, 2002.

FAHRIG, L. Effects of habitats fragmentation on biodiverdity. **Annual Review of Ecology Evolution and Systematics**, v. 34, n. 1, p. 487-515, 2003. http://dx.doi.org/10.1146/annurev.ecolsys.34.011802.132419.

FERREIRA, A.W.C.; LIMA, M.I.S.; PANSARIN, E.R. Orchidaceae na região central de São Paulo, Brasil. **Rodriguésia**, v. 61, n. 2, p. 243-259, 2010. http://dx.doi.org/10.1590/2175-7860201061208.

FEUERHERDT, L.; PETIT, S.; JUSAITIS, M. Distribution of mycorrhizal fungus associated with the endangered pink-lipped spider orchid (*Arachnorchis* (syn. *Caladenia*) *behrii*) at Warren Conservation Park in South Australia. **New Zealand Journal of Botany**, v. 43, n. 2, p. 367-371, 2005. http://dx.doi.org/10.1080/0028825X.2005.9512961.

GALDIANO JÚNIOR, R.F. et al. Desenvolvimento inicial e crescimento *in vitro* de *Cattleya violacea* (Kunth) Rolfe em diferentes concentrações de sacarose. **Acta Amazonica**, v. 43, n. 2, p. 127-134, 2013. http://dx.doi.org/10.1590/S0044-59672013000200001.

GEBAUER, G.; DIETRICH, P. Nitrogen isotope ratios in different compartments of a mixed stand of spruce, larch and beech trees and of understorey vegetation including fungi. **Isotopenpraxis Isotopes in Environmental and Health Studies**, v. 29, n. 1-2, p. 35-44, 1993. http://dx.doi.org/10.1080/10256019308046133.

GREIG-SMITH, P. **Quantitative plant ecology**. London: Butterworths, 1964. 256 p.

GUNES, A. et al. Silicon-mediated changes on some physiological and enzymatic parameters symptomatic of oxidative stress in barley grown in sodic-B toxic soil. **Journal of Plant Physiology**, v. 164, n. 6, p. 807-811, 2007. http://dx.doi.org/10.1016/j.jplph.2006.07.011. PMid:17070965.

HAY, J.D. et al. Comparação do padrão da distribuição espacial em escalas diferentes de espécies nativas do cerrado, em Brasília, DF. **Revista Brasileira de Botanica**, v. 23, n. 3, p. 341-347, 2000. http://dx.doi.org/10.1590/S0100-84042000000300008.

HONNAY, O.; VERHEYEN, K.; HERMY, M. Permeability of ancient Forest edges for weedy plant species invasion. **Forest Ecology and Management**, v. 161, n. 1, p. 109-222, 2002. http://dx.doi.org/10.1016/S0378-1127(01)00490-X.

INTERNATIONAL SOIL REFERENCE AND INFORMATION CENTRE – ISRIC. **A new generation soil property maps of Africa**. Disponível em: <https://www.isric.org/projects/africa-soil-profiles-database-afsp/newgeneration>. Acesso em: 08 ago. 2014.

IVANAUSKAS, N.M.; RODRIGUES, R.R. Florística e fitossociologia de remanescente de floresta estacional decidual em Piracicaba, São Paulo, Brasil. **Revista Brasileira de Botanica**, v. 23, n. 3, p. 291-304, 2000. http://dx.doi.org/10.1590/S0100-84042000000300005.

JACQUEMYN, H. et al. A spatially explicit analysis of seedling recruitment in the terrestral orchid *Orchis purpurea.* **The New Phytologist**, v. 176, n. 2, p. 448-459, 2007. http://dx.doi.org/10.1111/j.1469-8137.2007.02179.x. PMid:17888122.

JERSÁKOVÁ, J.; MALINOVÁ, T. Spatial aspects of seed dispersal and seedling recruitment in orchids. **The New Phytologist**, v. 176, n. 2, p. 237-241, 2007. PMid:17888110.

KINOSHITA, L.S. et al. Composição florística e síndromes de polinização e de dispersão da mata do Sítio São Francisco, Campinas, SP, Brasil. **Acta Botanica Brasílica**, v. 20, n. 2, p. 313-327, 2006. http://dx.doi.org/10.1590/S0102-33062006000200007.

KOTHARI, S.K.; MARSCHNER, H.; RÖMHELD, V. Direct and indirect effects of VA mycorrhizal fungi and rhizosphere microorganisms on acquisition of mineral nutrients by maize (*Zea mays* L.) in a calcareous soil. **The New Phytologist**, v. 116, n. 1, p. 637-645, 1990. http://dx.doi.org/10.1111/j.1469-8137.1990.tb00549.x.

KRAHL, A.H. et al. Distribuição espacial de *Oeceoclades maculata* Lindl. em uma floresta arenosa litorânea no sudeste do Brasil. In: CONGRESSO DE ECOLOGIA DO BRASIL, 9., 2009, São Lourenço. **Anais...** São Lourenço: SEB, 2009. p. 1-2. Disponível em:<http://www.seb-ecologia.org.br/2009/resumos_ixceb/1696.pdf>. Acesso em: 08 ago. 2014.

______. et al. Padrão espacial de *Eltroplectris triloba* (Lindl.) Pabst (Orchidaceae, Spiranthinae) em uma formação florestal de restinga no Sudeste do Brasil. **Orquidário**, v. 4, n. 2, p. 117-123, 2010.

LARCHER, W. **Ecofisiologia vegetal**. São Carlos: RiMa, 2004. 531p.

LIMA-RIBEIRO, M.S.; PRADO, E.C. Métodos estatísticos e estrutura espacial de populações: uma análise comparativa. **Acta Scientiarum. Technology**, v. 28, n. 2, p. 219-224, 2006. http://dx.doi.org/10.4025/actascitechnol.v28i2.1197.

MALAVOLTA, E.; VITTI, G.C.; OLIVEIRA, S.A. **Avaliação do estado nutricional das plantas:** *princípios e aplicações*. 2. ed. Piracicaba: POTAFÓS, 1997. 319 p.

______. **Manual de nutrição de plantas**. São Paulo: Ed. Agronômica Ceres, 2006. 638 p.

MARSCHNER, H. **Mineral nutrition of higher plants**. 2. ed. New York: Academic Press, 1995. 889 p.

MENINI NETO, L.; ASSIS, L.C.S.; FORZZA, R.C. A família Orchidaceae em um fragmento de floresta estacional semidecidual, no município de Barroso, Minas Gerais, Brasil. **Lundiana**, v. 4, n. 1, p. 9-24, 2004a.

______.; ALMEIDA, V.; FORZZA, R.C. A família Orchidaceae na Reserva Biológica da Represa do Grama – Descoberto, Minas Gerais, Brasil. **Rodriguésia**, v. 55, n. 2, p. 137-156, 2004b.

MORGAN, J.W. Patterns of invasion of an urban remnant of a species-rich grassland in southeastern Australia by non-native plant species. **Journal of Vegetation Science**, v. 9, n. 2, p. 181-190, 1998. http://dx.doi.org/10.2307/3237117.

MURCIA, C. Edge effect in fragmented Forest: implications for conservation. **Trends in Ecology & Evolution**, v. 10, n. 2, p. 58-62, 1995. http://dx.doi.org/10.1016/S0169-5347(00)88977-6. PMid:21236953.

NATHAN, R.; MULLER-LANDAU, H.C. Spatial patterns of seed dispersal, their determinants and consequences for recruitment. **Trends in Ecology & Evolution**, v. 15, n. 7, p. 278-285, 2000. http://dx.doi.org/10.1016/S0169-5347(00)01874-7. PMid:10856948.

OLIVEIRA FILHO, A.T. et al. Estrutura fitossociológica e variáveis ambientais em um trecho de mata ciliar do córrego das Vilas Boas, Reserva Biológica do Poço Bonito, Lavras (MG). **Revista Brasileira de Botanica**, v. 17, n. 1, p. 67-85, 1994.

OTERO, J.T.; ACKERMAN, J.D.; BAYMAN, P. Differences in mycorrhizal preferences between two tropical orchids. **Molecular Ecology**, v. 13, n. 8, p. 2393-2404, 2004. http://dx.doi.org/10.1111/j.1365-294X.2004.02223.x. PMid:15245412.

PANSARIN, E.R.; PANSARIN, L.M. A família Orchidaceae na Serra do Japi, São Paulo, Brasil. **Rodriguésia**, v. 59, n. 1, p. 99-111, 2008. http://dx.doi.org/10.1590/2175-7860200859105.

PAULA, M.A.; SIQUEIRA, J.O. Efeito de micorrizas vesicular arbusculares no crescimento, nodulação e acúmulo de N na soja. **Pesquisa Agropecuária Brasileira**, v. 22, n. 2, p. 71-178, 1987.

PEDROSO-DE-MORAES, C. **Cultivo de Orquídeas**. Araras: Biblioteca Duse Rüegger Ometto, 2000. 135 p.

______. et al. Florística e fitossociologia da família Orchidaceae no Centro de Educação Ambiental "Francisco Mendes", município de Mogi Guaçu, SP, Brasil. **Scientia Plena**, v. 6, n. 3, p. 1-5, 2010.

PHILLIPS, R.D. et al. Orchid biogeography and factors associated with rarity in a biodiversity hotspot, the Southwest Australian Floristic Region. **Journal of Biogeography**, v. 38, n. 3, p. 487-501, 2011. http://dx.doi.org/10.1111/j.1365-2699.2010.02413.x.

PICCOLI, M.C.A. et al. Distribuição espacial de *Sacoila lanceolata* (Aubl.) Garay (Orchidaceae) em fragmento mesófito de Pirassununga, São Paulo, Brasil. **Nucleus (Ituverava. Online)**, v. 11, n. 3, p. 115-129, 2014.

PIVELLO-POMPÉIA, V.R. **Exportação de macronutrientes para a atmosfera durante queimadas realizadas no campo-cerrado de Emas (Pirassununga, SP)**. 1985. 95 f. Dissertação (Mestrado em Ecologia) - Departamento de Ecologia Geral, Instituto de Biociências, Universidade de São Paulo, São Paulo.

POSTA, K.; MARSCHNER, H.; RÖMHELD, V. Manganese reduction in the rhizosphere of mycorrhizal and non-mycorrhizal maize. **Mycorrhiza**, v. 5, n. 2, p. 119-124, 1994. http://dx.doi.org/10.1007/BF00202343.

RAIJ, B. Van et al. (Eds.). **Análise química para avaliação da fertilidade de solos tropicais.** Campinas: Instituto Agronômico, 2001. 285 p.

RASMUSSEN, H.N. Recent developments in the study of orchid mycorrhiza. **Plant and Soil**, v. 244, n. 1/2, p. 149-163, 2002. http://dx.doi.org/10.1023/A:1020246715436.

REDDING, T.E. et al. Spatial patterns of soil temperature and moisture across subalpine forest-clearcut edges in the southern interior of British Columbia. **Canadian Journal of Soil Science**, v. 83, n. 1, p. 121-130, 2003. http://dx.doi.org/10.4141/S02-010.

RODRIGUES, R.R. **Análise de um remanescente de vegetação natural às margens do rio Passa Cinco, Ipeúna, SP**. 1991. 325 f. Tese (Doutorado em Biologia Vegetal) - Instituto de Biologia, Universidade Estadual de Campinas, Campinas.

RÖMHELD, V. Different strategies for iron acquisition in higher plants. What's new in plant physiology. **Physiologia Plantarum**, v. 70, n. 2, p. 231-234, 1987. http://dx.doi.org/10.1111/j.1399-3054.1987.tb06137.x.

RONQUIM, C.C. **Conceitos de fertilidade do solo e manejo adequado para as regiões tropicais**. Campinas: Embrapa Monitoramento por Satélite, 2010. 26 p. (Embrapa Monitoramento por Satélite. Boletim de Pesquisa e Desenvolvimento, n. 8).

SAGGIN JÚNIOR, O.J. et al. Colonização do cafeeiro por diferentes fungos micorrízicos: efeitos na formação das mudas e crescimento em solo fumigado. **Revista Brasileira de Ciência do Solo**, v. 19, n. 2, p. 213-220, 1995.

SCHIAVINI, I. **Estrutura das comunidades arbóreas de mata de galeria da Estação Ecológica do Panga (Uberlândia, MG).** 1992. 139 f. Tese (Doutorado em Ecologia) - Instituto de Biologia, Universidade Estadual de Campinas, Campinas.

SCHULZE, E.D.; CHAPIN 3rd, F.S.; GEBAUER, G. Nitrogen nutrition and isotope differences among life forms at the northern treeline of Alaska. **Oecologia**, v. 100, n. 4, p. 406-412, 1994. http://dx.doi.org/10.1007/BF00317862. PMid:28306929.

SCHUSTER, H. et al. Diversidade de Orchidaceae da fazenda Cantagalo, município de Mogi-Mirim, São Paulo. **Revista Brasileira de Biociências**, v. 8, n. 3, p. 242-245, 2010.

STATISTICAL ANALYSES SYSTEM – SAS. **Statistical Analysis System user's guide.** *Version 9.2.* Cary: Statistical Analyses System Institute, 2008.

STENCEL, M.A. et al. Plasticidade fenotípico-vegetativa de *Oeceoclades maculata* (Lindl.) Lindl. (Orchidaceae) em dois ambientes de área florestada. **Revista em Agronegócio e Meio Ambiente,** v. 9, n. 3, p. 635-655, 2016.

VILÀ, M. et al. Ecological impacts of invasive alien plants: a meta-analysis of their effects on species, communities and ecosystems. **Ecology Letters**, v. 14, n. 7, p. 702-708, 2011. http://dx.doi.org/10.1111/j.1461-0248.2011.01628.x. PMid:21592274.

VILELA, L.; SOUSA, D.M.G.; SILVA, J.E. Adubação potássica. In: Sousa, D.M.G.; Lobato, E. (Eds.). **Cerrado:** correção do solo e adubação. Planaltina: Embrapa Cerrados, 2004. p.169-183.

VITTI, G.C. **Avaliação e interpretação do enxofre no solo e na planta**. Jaboticabal: FUNEP, 1989. 37 p.

WILLIAMS-LINERA, G. Vegetation structure and environmental conditions of forest edges in Panama. **Journal of Ecology**, v. 78, n. 2, p. 356-373, 1990. http://dx.doi.org/10.2307/2261117.

ZAR, J.H. **Biostatistical analysis**. Prentice-Hall, New Jersey, 1996. 662 p.

ZHUO, T. The detection of the accumulation of silicon in *Phalaenopsis* (Orchidaceae). **Annals of Botany**, v. 75, n. 3, p. 605-607, 1995. http://dx.doi.org/10.1006/anbo.1995.1065.