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SOIL FERTILITY OF TWO HUNDRED PROPERTIES IN THE SOUTHWEST PARANÁ WITH THE PRESENCE OF NATIVE FRUIT TREES

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ABSTRACT - The native fruit trees are of great importance to the Southwest Region of Paraná biome, but little is known about them, especially as the soil fertility in which they are found. Such information is necessary when domestication is intended for orchards usage. The objective of this work was to collect information on the distribution of the native fruit trees in relation to the chemical characteristics of the soil in which they are found, in four municipalities of the Phytophysiognomy Forest and Araucária (DoisVizinhos, Itapejara do Oeste, Verê and São Jorge d'Oeste). The chemical soil characterization for the native fruit trees were applied in the species of jaboticaba tree (*Plinia* sp.), Surinam cherry tree (*Eugenia uniflora* L.), sete-capote tree [*Campomanesia guazumifolia* (Cambess.) O. Berg], cereja-do-mato tree (*Eugenia involucrata* DC.), guabiroba tree (*Campomanesia xanthocarpa* Berg), guabiju tree *(Myrcianthes pungens)*, feijoa tree [*Acca selowiana* (O. Berg) Burret], uvaia tree (*E. pyriformis* Cambess), yellow and red araça trees (*Psidium cattleyanum* Sabine). The soil was collected in two hundred properties with the presence of at least some native fruit of natural occurrence, in order to obtain information about the chemical soil characteristics with native fruit presence. In general, only where the native fruits are present, they present weakly acid reaction and high organic matter, calcium, magnesium, phosphorus and potassium, as high CTC.
Keywords: Myrtaceae, edaphic characteristic, genetic resources, preservation.

FERTILIDADE DO SOLO DE DUZENTAS PROPRIEDADES DO SUDOESTE DO PARANÁ NA PRESENÇA DE FRUTEIRAS NATIVAS

RESUMO - As fruteiras nativas são de grande importância para o bioma da Região Sudoeste do Paraná, porém pouco se conhece sobre elas, principalmente quanto a fertilidade do solo em que se desenvolvem. Tais informações são necessárias quando se pensa em domesticá-las para uso em pomares. Este trabalho teve por objetivo coletar informações da distribuição das fruteiras nativas em relação as características químicas do solo em que elas se encontram, em quatro municípios da Fitofisionomia Floresta com Araucária (Dois Vizinhos, Itapejara do Oeste, Verê e São Jorge d'Oeste). A caracterização química dos solos para as fruteiras nativas foi aplicada nas espécies de jabuticabeira (*Plinia* sp.), pitangueira (*Eugenia uniflora* L.), sete capoteiro [*Campomanesia guazumifolia* (Cambess.) O. Berg], cerejeira-do-mato (*Eugenia involucrata* DC.), guabirobeira (*Campomanesia xanthocarpa* Berg), guabijuzeiro (*Myrcianthes pungens*), goiabeira serrana [*Acca selowiana* (O. Berg) Burret], uvaieira (*E. pyriformis* Cambess), araçazeiro amarelo e vermelho (*Psidium cattleyanum* Sabine), realizando-se a coleta de solo em 200 propriedades com presença de pelo menos alguma fruteira nativa de ocorrência natural. De forma geral, os solos onde as fruteiras nativas estão presentes apresentam reação fracamente ácida e elevados teores de matéria orgânica, cálcio, magnésio, fósforo e potássio, bem como alta CTC.
Palavras-chave: Myrtaceae, característica edáfica, recursos genéticos, preservação.

INTRODUCTION

The Southwest region of Paraná has an area of 1,163,842.64 ha, located in the Third Plateau of Paraná corresponding to approximately 6% of the Paraná state territory (IPARDES, 2004). The vegetative characteristic of this region is due to the occurrence of the Mixed Ombrophylous Forest or Forest with Araucaria, with the presence of araucaria [*Araucaria angustifolia* (Benth.) O. Ktze], which makes the landscape unique (MEDEIROS et al., 2005). In this forest formation, the presence of native fruit trees of the Myrtaceae family is also common (OLIVEIRA FILHO; FONTES, 2000; GUILHERME et al., 2004), especially jabuticaba tree (*Plinia sp.*), Surinam cherry tree (*Eugenia uniflora* L.), sete-capote tree (*Campomanesia guazumifolia*), cereja-do-mato tree (*Eugenia involucrata* DC.), guabiroba tree (*Campomanesia xanthocarpa Berg*), guabiju tree (*Myrcianthes pungens*), yellow and red araça tree (*Psidium cattleyanum*).

Although those fruit trees are present in the region, and even in other forests, they are still not commonly used in commercial orchards, they are used for specific purposes such as urban ornamentation in squares and streets projects, as well as in urban backyards. However, all those fruit trees produce fruits that are widely accepted by the consumer,

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with characteristics that make them attractive to the food segments (REIS; SCHMIELE, 2019), pharmaceuticals and cosmetics (PAZ et al., 2015; DENARDIN et al., 2015; INFANTE et al., 2016; ROMÃO et al., 2019; SANTOS et al., 2019), this creates demand for commercial native fruit orchards. But there is a historical gap regarding the lack of detailed and important information for the cultivation of native fruit trees. One of the factors that limit the growth of these fruit trees is the nutritional issues of the environment where they are found. To this extent, one should go to the place of origin to collect information which may be useful as parameters for orchard use, regarding plant management, mainly linked to existing fertility conditions.

Given the above, the objective of the present work was to collect information on the distribution of native fruit trees in relation to the chemical characteristics of the soil, in the forest phytophysiognomy with araucaria in four municipalities (Dois Vizinhos, Itapejara do Oeste, Verê and São Jorge d'Oeste).

MATERIAL AND METHODS

The present work was carried out during visits to rural properties, in the Dois Vizinhos, Itapejara D'Oeste, Verê and São Jorge D'Oeste (Paraná) municipalities, during the years 2014 and 2015. Two hundred agricultural properties that had native fruit trees of the Myrtaceae family such as surinam cherry, jaboticaba tree, uvaia tree, cereja-do-mato tree, guabiroba tree, guabiju tree, sete-capote tree, feijoa tree, yellow and red araça tree were selected. The location of each rural property was identified by means of a specific number, mapping it with the coordinate obtained through GPS [(Global Positioning System), brand Garmim, Etrex Vista H 2.8]. The average altitudes of each municipality visited were 482, 509, 459 and 501 m above sea level, for Dois Vizinhos, Itapejara D'Oeste, São Jorge D'Oeste and Verê, respectively. The lowest altitude was 307 m in a property located in São Jorge D'Oeste and the highest was 627 m in Dois Vizinhos.

Soil collections were carried out in the 200 properties, with the presence of at least native fruit species, in order to determine the soil fertility condition in which each one was inserted. These collections were distributed in numbers of 21, 17, 27, 3, 22, 31, 24, 31 and 24 properties, which contained yellow and red araça tree, cereja-do-mato tree, feijoa tree, guabiju tree, guabiroba tree, Surinam cherry tree, sete-capote tree and uvaia tree, respectively. These collections were carried out first by means of simple sampling, with the aid of an auger, at a depth of 0-20 cm, considering at least five points close to the plants of each fruit tree. The samples were mixed homogeneously, thus constituting a composite sample, from which a part was removed to be sent to the Soil Laboratory of the Federal Technological University of Paraná (UTFPR) *Campus* Pato Branco, for chemical characterization. After drying and milling (sieve with 2 mm mesh opening), the samples were characterized in terms of pH-$CaCl_2$, organic matter by wet digestion (Walkley Black), P and K (Mehlich^{-1}), Ca, Mg and Al (KCl mol L^{-1}) and H+Al (SMP buffer solution), according to the methodology described by Pavan et al. (1992). From these results, the sum of bases, potential CTC and base saturation were calculated.

The results were classified in absolute terms and randomly organized into interpretation classes. For organic matter, three classes of values were organized: ≤25 g dm^{-3}, 25.01 to 50 g dm^{-3} and >50 g dm^{-3}. Regarding soil pH-$CaCl_2$, five ranges of interpretation were determined: ≤4.0, 4.01 to 4.50, 4.51 to 5.00, 5.01 to 5.50 and >5.50. Soil CTC was separated into two classes (10 to 20 and >20 cmolc dm^{-3}). As for the characterization of calcium in the soil, five classes were separated: ≤4 cmolc dm^{-3}, 4.01 to 8 cmolc dm^{-3}, 8.01 to 12 cmolc dm^{-3}, 12.01 to 16 cmolc dm^{-3} and 16.01 to 20 cmolc dm^{-3}. Aluminum was organized into six classes: ≤0.50 cmolc dm^{-3}, 0.51 to 1.00 cmolc dm^{-3}, 1.01 to 1.50 cmolc dm^{-3}, 1.51 to 2.00 cmolc dm^{-3}, 2.01 to 2.5 cmolc dm^{-3} and 2.51 to 3.00 cmolc dm^{-3}. For potential acidity, characterized by H+Al, it was separated into five classes: ≤4 cmolc dm^{-3}, 4.01 to 8.0 cmolc dm^{-3}, 8.01 to 12.0 cmolc dm^{-3}, 12 .01 to 16.0 g dm^{-3} and 16.01 to 20.00 cmolc dm^{-3}.

According to the presence of magnesium in the soil, the separation of this element was in three classes, according to the value presented. The first class was composed by the presence of magnesium in the soil, with values ≤5.0 cmolc dm^{-3}, 5.01 to 10 cmolc dm^{-3} and 10.01 to 15 cmolc dm^{-3}. The base saturation of the analyzed soils was divided into two classes, below or above 50%. As for the phosphorus content present in it, the native fruit trees were distributed into five classes, designated according to the amount presented (≤10 mg dm^{-3}, 10.01 to 20 mg dm^{-3}, 20.01 to 30 mg dm^{-3}, 30.01 to 40 mg dm^{-3} and >40 mg dm^{-3}). The potassium contents present in the soil were divided into four classes, whose values were: ≤0.5 cmolc dm^{-3}, 0.51 to 1.0 cmolc dm^{-3}, 1.01 to 1.5 cmolc dm^{-3} and >1.5 cmolc dm^{-3}. Data were analyzed descriptively, according to the classes described above.

RESULTS AND DISCUSSION

It is observed that 63% of native fruit trees are found in areas within the class between 25 and 50 g dm^{-3} of organic matter (O.M.) and 26% in areas with more than 50 g dm^{-3} of O.M. The remaining 11% were within first class, with the least amount of O.M. in soils (Table 1). This fact was already expected, as the fruit trees are in the forest, a place with full litter formation which allows the decomposition of plant and animal remains, thus increasing the amount of organic matter (GODINHO et al., 2015).

If the O.M. average presented by property to each native fruit tree, all were allocated in soils, in the range between 34.17 and 69.02 g dm^{-3} (Table 2). And as for the median, it represents the value that divides a set of ordered values into equal parts, the same range was between 8.3 and that was between 8.3 and 44.9 g dm-3, in soils with feijoa tree and uvaia tree, 36,2; 37,5; 37,5; 8,3; 36,9; 42,9; 38,9; 44,2 e 44,9 g dm^{-3}, in soils with yellow and red araça tree, cereja-do-mato tree, feijoa tree, guabiju tree, guabiroba tree, Surinam cherry tree, sete-capote tree and uvaia tree, respectively.

TABLE 1 - Number of native fruit trees, according to the range of organic matter (g dm^{-3}) present in the soil, in each property visited, within the four municipalities visited in the Southwest of Paraná.

Native fruit tree	Organic matter soil (g dm^{-3})		
	≤25.00	25.01 a 50.00	>50.00
	Fruit native number		
Uvaia tree	4	8	12
Sete capote tree	4	16	11
Surinam cherry tree	2	16	6
Guabiroba tree	1	18	11
Guabiju tree	2	20	1
Feijoa tree	0	3	0
Cereja-do-mato tree	4	20	3
Red araça tree	1	12	4
Yellow araça tree	4	13	4
Total	22	126	52
Total (%)	11	63	26

TABLE 2 - Number of collections (NC), average, maximum and minimum values, standard deviation, error, variance and median of soil organic matter content (g dm^{-3}), soil pH ($CaCl_2$), CTC (cmolc dm^{-3}), soil Soil aluminum content (cmolc dm^{-3}), soil magnesium content (cmolc dm^{-3}) base saturation (V%), Phosphorus content (mg dm^{-3}) and soil potassium content (cmolc dm^{-3}) in relation to the native fruit trees present in the collected properties.

	ARA	ARV	CM	GSE	GUJ	GUB	PIT	SET	UVA
	Organic matter soil (g dm^{-3})								
NC	21	17	27	3	22	31	24	31	24
Average	69.02	53.60	46.23	40.88	34.17	52.94	42.21	52.94	52.94
Minimum	4.02	21.44	8.04	32.17	2.68	12.06	2.68	10.72	14.74
Maximum	134.02	85.77	84.43	49.59	65.67	93.82	81.75	95.16	91.14
D.S.	2.65	1.73	1.49	8.31	1.24	1.82	1.93	2.02	2.00
Error	5.78	4.19	2.87	5.26	2.64	3.27	3.94	3.63	4.08
Variance	7.02	2.99	2.23	8.31	1.54	3.32	3.73	4.10	4.00
Median	36.19	37.53	37.53	8.33	36.86	42.89	38.87	44.23	44.90
	Soil pH ($CaCl_2$)								
NC	21	17	27	3	22	31	24	31	24
Average	4.70	4.85	5.40	4.35	4.90	4.95	5.65	4.85	4.95
Minimum	3.70	4.10	3.90	3.50	3.70	4.10	4.30	3.60	4.20
Maximum	5.70	5.60	6.90	5.20	6.10	5.80	7.00	6.10	5.70
D.S.	0.50	0.44	0.65	0.86	0.55	0.40	0.58	0.63	0.40
Error	0.11	0.11	0.12	0.50	0.12	0.07	0.12	0.11	0.08
Variance	0.25	0.19	0.42	0.74	0.30	0.16	0.34	0.40	0.16
Median	4.80	4.80	4.80	4.60	4.65	4.80	4.70	4.70	4.75
	CTC ($cmol_c$ dm^{-3})								
NC	21	17	27	3	22	31	24	31	24
Average	20.01	20.69	19.16	20.43	22.27	19.78	20.38	19.66	18.03
Minimum	12.58	13.06	12.00	20.01	11.89	12.14	10.83	12.19	10.58
Maximum	27.43	28.31	26.32	20.85	32.65	27.42	29.93	27.12	25.47
D.S.	50.93	38.99	32.86	42.01	52.21	37.37	44.42	32.54	35.76
Error	1.11	0.95	0.63	0.24	1.11	0.67	0.91	0.58	0.73
Variance	2.59	1.52	1.08	0.17	2.72	1.39	1.97	1.05	1.27
Median	20.51	17.7	15.49	20.50	16.00	17.41	17.47	17.94	17.80
	Aluminum soil ($cmol_c$ dm^{-3})								
NC	21	17	27	3	22	31	24	31	24
Average	0.78	0.16	0.42	0.82	1.09	0.29	0.23	1.30	0.28
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	1.55	0.31	0.83	1.63	2.18	0.58	0.45	2.59	0.55
D.S.	0.33	0.09	0.18	0.92	0.53	0.14	0.13	0.90	0.11
Error	0.07	0.02	0.03	0.53	0.11	0.03	0.03	0.16	0.02
Variance	0.11	0.01	0.03	0.85	0.28	0.02	0.02	0.81	0.01
Median	0.12	0.10	0.06	0.06	0.09	0.11	0.08	0.11	0.08

Continuation of Table 1: Number of native fruit trees…

Magnesium soil (cmol$_c$ dm^{-3})									
NC	21	17	27	3	22	31	24	31	24
Average	5.50	5.75	3.80	3.10	7.20	5.00	6.25	3.85	5.25
Minimum	1.00	0.90	1.10	1.60	0.90	1.30	0.50	1.20	1.40
Maximum	10.00	10.60	6.50	4.60	13.50	8.70	12.00	6.50	9.10
D.S.	2.66	2.79	1.47	1.60	3.37	2.08	2.73	1.41	2.00
Error	0.58	0.68	0.28	0.93	0.72	0.38	0.56	0.26	0.41
Variance	7.07	7.83	2.18	2.58	1.13	4.36	7.48	2.01	4.03
Median	4.40	2.40	3.30	2.10	2.65	3.00	4.05	3.90	4.05
Base saturation (V%)									
NC	21	17	27	3	22	31	24	31	24
Average	57.82	58.88	61.03	46.14	47.21	60.42	59.74	49.77	60.07
Minimum	31.52	34.05	33.44	18.32	11.00	32.66	33.51	11.41	34.01
Maximum	84.12	83.71	88.61	73.97	83.41	88.21	85.97	88.13	86.12
D.S.	1.29	1.25	1.28	2.84	1.76	1.33	9.66	2.09	1.26
Error	2.83	3.03	2.46	1.62	3.76	2.40	1.97	3.62	2.57
Variance	1.68	1.56	1.64	8.08	3.11	1.79	9.33	4.79	1.59
Median	67.69	64.96	64.53	56.82	64.17	62.88	65.51	61.31	64.62
Phosphorus content (mg dm^{-3})									
NC	21	17	27	3	22	31	24	31	24
Average	48.16	89.61	95.63	25.23	88.29	42.64	52.08	41.68	44.51
Minimum	2.62	4.62	5.3	18.17	1.97	1.97	1.32	0.05	3.28
Maximum	93.7	174.6	186.0	32.28	174.6	83.3	102.83	83.3	85.74
D.S.	2.55	3.95	4.63	7.86	3.54	2.43	2.55	2.22	2.14
Error	5.57	9.60	8.91	4.53	7.55	4.37	5.21	3.98	4.37
Variance	6.52	1.57	2.14	6.17	1.25	5.93	6.53	4.92	4.58
Median	15.7	24.36	20.75	31.23	14.50	14.90	20.32	15.70	14.51
Soil potassium content (cmol$_c$ dm^{-3})									
NC	21	17	27	3	22	31	24	31	24
Average	1.17	0.68	0.63	1.07	0.95	1.18	0.68	1.09	0.68
Minimum	0.10	0.13	0.18	0.58	0.05	0.15	0.23	0.08	0.05
Maximum	2.23	1.23	1.08	1.55	1.85	2.20	1.13	2.10	1.30
D.S.	0.43	0.32	0.23	0.50	0.35	0.45	0.21	0.52	0.33
Error	0.09	0.08	0.04	0.29	0.07	0.08	0.04	0.09	0.07
Variance	0.19	0.11	0.05	0.25	0.12	0.20	0.05	0.27	0.11
Median	0.45	0.38	0.53	0.85	0.46	0.55	0.54	0.53	0.63

*NC = Number of collections. ARA = yellow araça tree, ARV = red araça tree, CMM = cereja do mato tree, GSE = feijoa tree, GUJ = guabiju tree, GUB = guariroba tree, PIT = Surinam cherry, SET = sete capote tree, UVA = uvaia tree. D. S. = standard deviation.

In tropical and subtropical soils, O.M. has a close relationship with the other physical properties (aeration, water retention, compaction, structuring), chemical (soil reaction, nutrient availability, CTC) and biological (respiration, carbon biomass, nitrogen biomass, colonization rate and species of microorganisms) from the soil (PETRERE; CUNHA, 2010). Therefore, the sustainable management of soil organic matter is essential for the maintenance of long-term productive capacity, where the effect of this management on O.M. is dependent on the type of soil. As the collections were in places with the presence of native fruit trees, mostly in forest areas, this high amount of organic matter becomes important for these relationships to occur in the environment, and specially, the nutrient cycling, which allows the plants to grow and develop in such places (CIOTTA et al., 2003).

Despite the averages framing the properties as places with a large amount of O.M., there were situations where the values were below 5 g dm^{-3}, in the places where the yellow araça tree, guabiju tree and Surinam cherry tree were found (Table 2). On the other hand, in other properties with soils whose extreme values were greater than 90 g dm^{-3}, the presence of uvaia tree, sete-capote tree, guabiroba tree and yellow araça tree, where, in general, the O.M of soil was between 2.7 to 134.0 g dm^{-3}. Thus, it can be inferred that native fruit trees adapt to different O.M. conditions, with low to high content, demonstrating versatility and preferentially occurring in places with high levels, typical of the conditions of their origins: the forests.

Danner et al. (2010), analyzing the soil in 14 sites of occurrence of jaboticaba tree (*Plinia cauliflora*), observed that one of the main characteristics found was the high content of O.M. (6.56% ± 1.0), recording 4,036 adult plants belonging to the species, in 201.9 ha of forest in the Araucaria Forest Ecosystem.

Regarding soil pH, a higher concentration of native fruit trees (54.51%) was observed in the places, whose values were between 4.51 and 5.00 ($CaCl_2$) (Table 3), which indicates the preference of these species for slightly acidic soils, characteristic of the Southwest region of Paraná. However, there were extreme cases in which the range presented maximum values of 7.0 ($CaCl_2$), with the presence of Surinam cherry tree and minimum values of 3.5 ($CaCl_2$), with the presence of feijoa tree (Table 4). Probably, in places where the pH range presented maximum values above 5.00 ($CaCl_2$), it was due to the use of liming or incorporation of poultry litter below the projection of the canopy of the plants, since the latter contains lime, used for sterilization of poultry in the region. It is noteworthy, however, that this is a hypothesis, because in the conversation with the farmers, most of them do not manage the fruit trees, except for the jaboticaba tree. Associated with this, the soils in the region are characterized as acidic, with a pH close to 4.5-5.0, as verified in most properties.

On average, the soil pH values per native fruit tree were 4.70; 4.85; 5.40; 4.35; 4.90; 4.95; 5.65, 4.85 and 4.95 ($CaCl_2$) with the presence of yellow and red araça trees, cereja-do-mato tree, feijoa tree, guabiju tree, guabiroba tree, Surinam cherry tree, sete-capote tree and uvaia tree, respectively (Table 2). Danner et al. (2010) mentioned that, in areas with occurrence of jabuticaba tree, the soils were considered strongly acidic (pH close to 4.0), studying the guabiroba tree, it was found that the species tolerates low fertility, however, the possibility of fertilization cannot be eliminated.

TABLE 3 - Number of native fruit trees, according to the pH range ($CaCl_2$) present in the soil, in each visited property, within the four municipalities of Southwest Paraná.

Native fruit tree	pH ranges soil ($CaCl_2$)				
	≤4.00	4.01 a 4.50	4.51 a 5.00	5.01 a 5.50	>5.50
Uvaia tree	0	3	14	4	3
Sete capote tree	6	1	18	4	2
Surinam cherry tree	0	5	13	5	1
Guabiroba tree	0	5	19	4	2
Guabiju tree	1	3	12	4	3
Feijoa tree	1	1	0	1	0
Cereja-do-mato tree	1	1	15	3	7
Red araça tree	0	3	8	5	1
Yellow araça tree	1	5	10	4	1
Total	10	27	109	34	20

As for the municipalities, pH values below 4.0 were found in São Jorge D'Oeste and Verê, and above 5.5 in Itapejara D'Oeste. In Dois Vizinhos, the pH values were between 4.51 and 5.5. Gasperini et al. (2012) carried out 394 soil collections in 38 communities in Dois Vizinhos (PR), checking the pH levels in pasture areas, in which values between 4.6 and 5.5 were found, close to those found in the present work, for most native fruit trees (Table 2). Regarding soil CTC, 70% of native fruit trees were found in areas with values above 20 cmolc dm^{-3} and no sampled area presented values below 10 cmolc dm^{-3} (Table 4).

TABLE 4 - Number of native fruit trees, according to the range of CTC present in the soil, in each property visited, within the four municipalities of Southwest Paraná.

Native fruit tree	Soil CTC ($cmol_c\ dm^{-3}$)	
	10.01 a 20.00	>20.00
Uvaia tree	18	6
Sete capote tree	22	9
Surinam cherry tree	17	7
Guabiroba tree	21	9
Guabiju tree	18	5
Feijoa tree	0	3
Cereja-do-mato tree	24	3
Red araça tree	12	6
Yellow araça tree	9	12
Total	140	60

The averages obtained for CTC in the soil of each property, according to each native fruit tree present, were 20.0; 20.7; 19.2; 20.4; 22.3; 19.8; 20.4; 19.7 and 18.0 cmolc dm^{-3}, in an area cultivated with yellow and red araça tree, cereja-do-mato tree, feijoa tree, guabiju tree, guabiroba tree, Surinam cherry tree, sete-capote tree and uvaia tree, respectively (Table 2).

About the properties analyzed, those that presented soils with the highest CTC values ranged from 20.9 cmolc dm^{-3}, in an area cultivated with feijoa tree to 32.7 cmolc dm^{-3} with guabiju tree. The lowest CTC occurred in soils with uvaia tree (10.58 cmolc dm^{-3}), and these minimum values were up to 13.1 cmolc dm^{-3}, in an area with red araça tree. The standard deviation for this case was high, indicating that the data are spread over a range of values, and the error and variance values are low (Table 2).

In Dois Vizinhos and Itapejara D'Oeste, soils with CTC below 20 cmolc dm^{-3} and above 20 cmolc dm^{-3} stand out in Verê, with São Jorge D'Oeste, showing a certain division between the areas. As for the medians for CTC, the values were between 15.5 cmolc dm^{-3} for cereja-do-mato tree and 20.5 cmolc dm^{-3} for yellow araça, although all medians had values of 20.5; 17.7; 15.5; 20.5; 16.0; 17.4; 17.5; 18.0 and 17.8 cmolc dm^{-3} for yellow and red araça trees, cereja-do-mato tree, feijoa tree, guabiju tree, guabiroba tree, Surinam cherry tree, sete-capote tree and uvaia tree, respectively.

The CTC values observed were between 12 and 24 cmolc dm^{-3}, being considered high for soils that present kaolinitic and oxidic mineralogy, which is the case of the region studied. In this situation, the O.M. of the soil is largely responsible for the generation of these electrical charges, characterized by CTC, favoring a greater retention of cations, thus reducing losses by leaching. The analyzed soils showed greater representation of CTC (60.86%) of the elements K, Mg and Ca, qualifying them as fertile, in relation to H+Al. This allows us to visualize that, despite being present in forests, most fruit species are found in soil that allows for survival and production conditions, but they do not have genetic capacity expressing their maximum potential but favoring the conditions they are in (Table 5).

TABLE 5 - Average percentage of macronutrients (K, Mg and Ca) and potential acidity (H+Al) levels present in the soil of the rural properties that make up the CTC, in each property visited, within the four municipalities in the Southwest of Paraná.

Fruit native tree	Macronutrient contents (%)			Potential acidity
	K	Mg	Ca	H+Al
Uvaia tree	3.52	21.68	39.43	35.37
Sete capote tree	3.46	20.77	34.00	41.77
Surinam cherry tree	3.11	21.84	39.43	35.62
Guabiroba tree	3.93	19.00	39.75	37.32
Guabiju tree	2.95	20.43	35.26	41.36
Feijoa tree	4.82	13.45	31.44	50.29
Cereja-do-mato tree	2.96	20.05	38.53	38.46
Red araça tree	2.75	20.08	41.73	35.44
Yellow araça tree	2.50	22.32	38.57	36.61
Average	3.33	19.96	37.57	39.14

It can be observed that 93.5% of the native fruit trees were found in areas with low aluminum contents (≤ 0.5 cmolc dm^{-3}) (Table 6), characterizing the preference for slightly acidic soils. In this class there were representatives of all native species, while in the others the same did not occur. In the aluminum (Al) range between 0.51-1.00 cmolc dm^{-3} there was the presence of guabiroba tree, cereja-do-mato tree and yellow araça tree.

Between 1.01-1.50 cmolc dm^{-3}, sete-capote tree and guabiju tree appeared; between 1.51-2.00 and 2.0- 2.50 cmolc dm^{-3} of Al, which characterizes soils with a high level of acidity (NEPAR-SBCS, 2019), the feijoa tree and sete-capote tree appeared, respectively. In the range of Al between 2.51-3.00 cmolc dm^{-3}, considered very high (NEPAR-SBCS, 2019), only sete-capote trees were found, possibly due to the adaptation of this fruit tree to very acidic soil conditions. In this sense, the preference of the native fruit trees studied in the present study for soils with low presence of aluminum was notorious.

TABLE 6 - Number of native fruit trees, according to the aluminum strip (cmolc dm^{-3}) present in the soil, in each property visited, within the four municipalities of Southwest Paraná.

Fruit native tree	Soil aluminum (cmol$_c$ dm^{-3})					
	≤0.50	0.51-1.00	1.01-1.50	1.51-2.00	2.01-2.50	2.51-3.00
Uvaia tree	24	0	0	0	0	0
Sete capote tree	26	0	1	0	2	2
Surinam cherry tree	24	0	0	0	0	0
Guabiroba tree	29	2	0	0	0	0
Guabiju tree	20	0	1	0	1	0
Feijoa tree	2	0	0	1	0	0
Cereja-do-mato tree	25	2	0	0	0	0
Red araça tree	17	0	0	0	0	0
Yellow araça tree	20	1	0	0	0	0
Total	187	5	2	1	3	2

Al is considered one of the most important metal toxicity problems in acidic soils, with pH-H_2O ≤5.0 (BENNET and BREEN, 1991), limiting plant growth (FOY and FLEMING, 1976). Al toxicity represents a serious problem for agricultural production (MOUSTAKAS et al., 1993), however, there are species that adapt to such conditions, mainly those of acidic soils, as is the case of native fruit trees.

When considering the average soil Al content per property, according to each native fruit tree, the values were between 0.16 and 1.30 cmolc dm^{-3}. The averages in each property regarding this element were 0.8; 0.2; 0.4; 0.8; 1.1; 0.3; 0.2; 1.3 and 0.3 cmolc dm^{-3}, with the presence of yellow and red araça tree, cereja-do-mato tree, feijoa tree, guabiju tree, guabiroba tree, Surinam cherry tree, sete-capote tree and uvaia tree, respectively. The standard deviation, error and variance showed low numbers and the medians, 0.12; 0.1; 0.06; 0.06; 0.09; 0.11; 0.08, 0.11 and 0.08 cmolc dm^{-3}, being the extreme values of 0.06 and 0.12 cmolc dm^{-3}, for cereja-do-mato tree, feijoa tree and yellow araça tree, respectively. The maximum Al value verified in the soil was 2.60 cmolc dm^{-3} in an area with sete-capote tree (Table 2).

As for the magnesium (Mg) content in the soil, 74.5% of the native fruit trees were found in areas smaller than 5 cmolc dm^{-3}. The other species were divided between 23 and 2.50%, within the second and third classes (Table 7). The range of Mg contents per property was between 3.1 and 7.2 cmolc dm^{-3}. The averages presented for this macronutrient in the soils, according to each native fruit tree present in the area, were 5.5; 5.8; 3.8; 3.1; 7.2; 5.0; 6.3; 3.9 and 5.3 cmolc dm^{-3}, for yellow and red araça trees, cereja-do-mato tree, feijoa tree, guabiju tree, guabiroba tree, Surinam cherry tree, sete-capote tree and uvaia tree, respectively. The medians of this nutrient for the same sequence of fruit trees were 4.4; 2.4; 3.3; 2.1; 2.7; 3.0; 4.1; 3.9 and 4.1 cmolc dm^{-3}, with minimum values of 2.1 cmolc dm^{-3} in the soil for feijoa tree and 4.4 cmolc dm^{-3} for yellow araça. Also, there were minimum values of 0.50 g cmolc dm^{-3} for Surinam cherry tree and maximum values of 13.50 g cmolc dm^{-3} for guabiju tree (Table 2).

The maximum value found for the standard deviation was 2.8, for red araça and the minimum, 1.4, for sete-capote tree. For the error, the values did not exceed 1.0, being between 0.3 for sete-capote tree and 0.9 for feijoa tree. As for the variance values, they were between 1.1 and 7.8, represented by guabiju tree and red araça tree, respectively (Table 2). The Mg content obtained per sample presented values between 1.0 and 5.0 cmolc dm^{-3}, with few plants in soils outside this range, being possible to observe more frequent values up to 8.00 cmolc dm^{-3}, with few peaks above this value (Table 7).

TABLE 7 - Number of native fruit trees, according to the range of magnesium (cmolc dm^{-3}) present in the soil, in each property visited, within the four municipalities of Southwest Paraná.

Fruit native tree	Soil Magnesium (cmol$_c$ dm^{-3})		
	≤5.00	5.01-10.00	10.01-15.00
Uvaia tree	19	5	0
Sete capote tree	24	7	0
Surinam cherry tree	15	8	1
Guabiroba tree	23	8	0
Guabiju tree	17	2	3
Feijoa tree	3	0	0
Cereja-do-mato tree	23	4	0
Red araça tree	12	4	1
Yellow araça tree	13	8	0
Total	149	46	5

The highest occurrence of native fruit trees occurred in the highest range of base saturation (82%), whose areas presented values above 50% (Table 8), in the four municipalities visited, especially in Dois Vizinhos, whose coverage involved almost the entirety. Verê presented an almost equal distribution between areas with values above and below 50%. In general, what was observed was the highest concentration of areas in values of base saturation between 30 and 70%, with 143 properties, with nine with lower values and 48 above.

Although the first class had a smaller number of fruit trees (18%) in the areas, which range was below 50% of the base saturation, all those described in the present work were found, even if with a single plant. It was two for uvaia tree, sete-capote tree with six, Surinam cherry tree with one, guabiroba tree with four, guabiju tree with eight, feijoa tree with one, cereja-do-mato tree with ten, and red and yellow araça trees with one and three plants, respectively (Table 2).

Regarding the standard deviation, the indexes were between 9.66 and 1.25, represented in soils with Surinam cherry tree and red araça tree, respectively. Base saturation remained between 30 and 90% overall, with few peaks outside this range.

TABLE 8 - Number of native fruit trees according to the range of base saturation (V%) present in the soil, in each property visited, within the four municipalities of southwestern Paraná.

Fruit native tree	Soil base saturation (V%)	
	≤50	50.01-60.00
Uvaia tree	2	22
Sete capote tree	6	25
Surinam cherry tree	1	23
Guabiroba tree	4	26
Guabiju tree	8	15
Feijoa tree	1	2
Cereja-do-mato tree	10	17
Red araça tree	1	16
Yellow araça tree	3	18
Total	36	164

The fruit trees feijoa tree and cereja-do-mato tree were not present in areas whose phosphorus content was lower than 10 mg dm^{-3}, emphasizing that for feijoa tree there was also occurrence in places between 20.01 to 30.00 and higher than 40 mg dm^{-3}. Also, for cereja-do-mato tree, together with yellow araça tree, no specimens were obtained in soils with phosphorus values between 30.01 and 40 mg dm^{-3} (Table 9).

TABLE 9 - Number of native fruit trees according to the range of the amount of phosphorus (mg dm^{-3}) present in the soil, in each property visited, within the four municipalities of southwestern Paraná

Fruit native tree	Soil phosphorus (mg dm^{-3})				
	≤10	10.01-20.00	20.01-30.00	30.01-40.00	>40
Uvaia tree	3	12	2	3	4
Sete capote tree	13	4	8	1	5
Surinam cherry tree	5	7	5	4	3
Guabiroba tree	8	8	4	3	7
Guabiju tree	7	10	4	1	1
Feijoa tree	0	1	0	2	0
Cereja-do-mato tree	0	9	10	0	8
Red araça tree	1	6	3	3	4
Yellow araça tree	5	8	4	0	4
Total	42	65	40	17	36

It is believed that such behavior may have been a coincidence and not a preference of such fruit trees, as it was noticed that all are widely distributed in such ranges described for this nutrient. This distribution showed the presence of 21% of native fruit trees in the lower class of contents, whose phosphorus values were lower than 10 mg dm^{-3}. In the others, 32.50%, 20%, 8.5% and 18% of the fruit trees followed, within classes 2, 3, 4, and 5 (>40 mg dm^{-3}), respectively (Table 9).

The municipality of Verê was the only one in which the properties had soils with values below 10 mg dm^{-3}, with the presence of yellow and red araça trees, cereja-do-mato tree, guabiju tree, guabiroba tree, Surinam cherry tree and sete-capote tree. In Dois Vizinhos, São Jorge d'Oeste and Itapejara d'Oeste most properties are classified as places with amounts greater than 20.01 mg dm^{-3} of phosphorus.

Although the total phosphorus content of soils is generally between 200 and 3000 mg kg^{-1}, less than 0.1% of this total is found in the soil solution, available to plants (NOVAIS et al., 2007), especially in soils with kaolinitic and oxidic mineralogy, such as those in this study, where the specific adsorption of phosphorus is very high.

Litter formation, associated with high rates of decomposition of organic matter, can meet part of the phosphorus demand by plants, through the cycling of organic residues, allowing the accumulation of organic phosphorus in the soil, which is less susceptible to adsorption reactions of phosphorus. Normally, cultivated soils present higher levels of phosphorus than natural soils, due to the fertilization process. The high values obtained in the present study may be related to the considerable amount of organic matter, which competes with phosphorus for the same adsorption sites, favoring the appearance of more labile forms of phosphorus. Phosphorus values between 2.14 and 7.86 mg dm^{-3} were obtained for standard deviation, being represented in the presence of uvaia tree and feijoa tree, respectively. Except for the feijoa tree, the other native fruit trees were found in soils with an average phosphorus level considered good for agricultural cultivation (RAIJ et al., 2001).

However, the minimum and maximum range found for phosphorus in the properties ranged from 2.61 to 93.7 mg dm^{-3} (yellow araça tree); 4.62 to 174.60 mg dm^{-3} (red araça tree); 5.3 to 185.96 mg dm^{-3} (cereja-do-mato tree); 18.17 to 32.28 mg dm^{-3} (feijoa tree); 1.97 to 174.60 mg dm^{-3} (guabiju tree); 1.97 to 83.30 mg dm^{-3} (guabiroba tree); 1.32 to 102.83 mg dm^{-3} (Surinam cherry tree); 0.05 to 83.30 mg dm^{-3} (sete-capote tree) and 3.28 to

85.74 mg dm^{-3} (uvaia tree), respectively.

What can be highlighted is the minimum value of 0.05 mg dm^{-3} of phosphorus found with the presence of sete-capote tree, that is, it is practically inexistent the presence of this macronutrient in such soil. However, the plant showed no symptoms of deficiency, but the entire area close to it had no vegetation.

As a maximum value, the content of 185.96 mg dm^{-3} of phosphorus appeared, with the presence of cereja-do-mato tree. This fact may have been due to the plant being close to a pasture area and having been favored by the cycling that occurs with animal manure. Phosphorus, in general, was between the range of 0 to 80 (mg dm^{-3}), with few variations above this.

Based on the classes into which the potassium contents were divided, 44.5% of the samples were in the first, 44% in the second and 9% of the native fruit trees fell into potassium values between 1.01 and 1.5 cmolc dm^{-3} and 2.5% in the fourth class. What was observed was the absence of guabiju tree in areas with potassium between 1.01 and 1.5 cmolc dm^{-3} and of uvaia tree, Surinam cherry tree, feijoa tree, cereja-do-mato tree and yellow and red araça trees in the range above 1.51 cmolc dm^{-3} (Table 10).

The potassium values obtained by property were in the minimum range of 0.05 to maximum of 2.23 cmolc dm^{-3}. Most properties in the municipalities visited showed a range of potassium with values from 0.05 to 1.5 cmolc dm^{-3}, with some small areas with levels above 1.51 cmolc dm^{-3} in São Jorge d'Oeste and Verê, and the latter municipality presented most of its area with potassium between 0.51 and 1.0 cmolc dm^{-3}.

Such values are in the range considered great for this macronutrient in soil analyzes (NEPAR-SBCS, 2019). However, in such potassium analyzes it was possible to find minimum and maximum values for each fruit plant from 0.10 to 2.23 cmolc dm^{-3} with yellow araça tree, 0.13 to 1.23 cmolc dm^{-3} for red araça tree, 0. 18 to 1.08 cmolc dm^{-3} in cereja-do-mato tree, 0.58 to 1.55 cmolc dm^{-3} for feijoa tree, 0.05 to 1.85 cmolc dm^{-3} with guabiju tree, 0.15 to 2.2 cmolc dm^{-3} in guabiroba tree, 0.23 to 1.13 cmolc dm^{-3} in the presence of Surinam cherry tree, 0.08 to 2.1 cmolc dm^{-3} for sete-capote tree and 0.05 to 1.3 cmolc dm^{-3} with uvaia tree.

TABLE 10 - Number of native fruit trees according to the range of the amount of potassium (cmol$_c$ dm^{-3}) present in the soil, in each property visited, within the four municipalities of southwestern Paraná.

	Soil Potassium (cmol$_c$ dm^{-3})			
Fruit native tree	≤0.5	0.51-1.00	1.01-1.50	>1.50
Uvaia tree	9	13	2	0
Sete capote tree	11	14	4	2
Surinam cherry tree	10	13	1	0
Guabiroba tree	12	12	4	2
Guabiju tree	12	10	0	1
Feijoa tree	0	2	1	0
Cereja-do-mato tree	14	12	1	0
Red araça tree	9	4	4	0
Yellow araça tree	12	8	1	0
Total	89	88	18	5

Based on this characterization, it could be extended to other regions with the presence of the same native fruit trees, seeking to observe whether their occurrence is in similar edaphic conditions, which would facilitate their management in orchards.

CONCLUSIONS

In general, soils where native fruit trees are present show a weakly acidic reaction and high levels of organic matter, calcium, magnesium, phosphorus and potassium, as well as high CTC.

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REFERENCES

BENNET, R.J., BREEN, C.M. The aluminium signal: new dimensions to mechanisms of aluminium tolerance. **Plant and Soil**, v.134, n.7, p.153-166, 1991.

CARVALHO, P.E.R. **Espécies arbóreas brasileiras.** Brasília: Embrapa Informação Tecnológica; Colombo, 2010. 644p.

CIOTTA, M.N.; BAYER, C.; FONTOURA, S.M.V.; ERNANI, P.R.; ALBUQUERQUE, J.A. Matéria orgânica e aumento da capacidade de troca de cátions em solo com argila de atividade baixa sob plantio direto. **Ciência Rural**, v.33, n.6, p.1161-1164, 2003.

DANNER, M.A., CITADIN, I., SASSO, S.A.Z.; TOMAZONI, J.C. Diagnóstico ecogeográfico da ocorrência de jabuticabeiras nativas no sudoeste do Paraná. **Revista Brasileira de Fruticultura**, v.32, n.3, p746-753, 2010.

DENARDIN, C.C.; HIRSCH, G.E.; ROCHA, R.F.; VIZZOTTO, M.; HENRIQUES, A.T.; MOREIRA, J.C.F.; GUMA, F.T.C.R.; EMANUELLI, T. Antioxidant capacity and bioactive compounds of four Brazilian native fruits. **Journal of Food and Drug Analysis**, v.23, n.3, p.387-398, 2015.

FOY, C.D., FLEMING, A.L. The Physiology of Plant Tolerance to Excess Available Aluminum and Manganese in Acid Soils. In: JUNG, G.A. **Crop Tolerance to Suboptimal Land Conditions**. ASA Special Publications, 1976, v.32, p. 301-328.

GASPERINI, M.A., SARTOR, L.R., PIN, E., DETONI, M.J., MARTINELLI, A. **Mapeamento do pH, matéria orgânica e saturação por bases do solo do munícipio de Dois Vizinhos-PR.** In: CONGRESSO DE CIÊNCIA E TECNOLOGIA DA UTFPR. p.51-54. 2012.

GODINHO, T.O.; CALDEIRA, M.V.W.; BRUN, E.J. Ciclagem de nutrientes na serrapilheira em ecossistemas florestais naturais. In: FARIA, A.B.C.; BRUN, E.J.; FERRARI, F. **Ciências Florestais e Biológicas**, v.1, [s.n.], p.13-52, 2015.

GUILHERME, F.A.G.; MORELLATO, L.P.C.; ASSIS, M.A. Horizontal and vertical tree community structure in a lowland Atlantic rain forest, Southeastern Brazil. **Revista Brasileira de Botânica**, v.27, n.4, p.725-737, 2004.

INFANTE, J.; ROSALEN, P.L.; LAZARINI, J.G.; FRANCHIN, M.; ALENCAR, S.M. Antioxidant and anti-inflammatory activities of unexplored Brazilian native fruits. **Plos One**, v.11, n.4, e0152974, 2016.

IPARDES. INSTITUTO PARANAENSE DE DESENVOLVIMENTO ECONÔMICO E SOCIAL. **Leituras regionais:** mesorregião geográfica sudoeste Paranaense. Curitiba, 2004. 32p.

MEDEIROS, J.D.; SAVI, M.; BRITO, B.F.A. Seleção de áreas para criação de unidades de conservação na floresta ombrófila mista. **Biotemas**, v.18, n.2, p.33-50, 2005.

MOUSTAKAS, M., OUZOUNIDOU, G., LANNOYE, R. Rapids creening for aluminum tolerance in cereals by use the chlorophyll fluorescence test. **Plant Breeding**, v.111, n.4, p.343-346, 1993.

NEPAR-SBCS. **Manual de adubação e calagem para o Estado do Paraná.** 2ª ed. Curitiba: SBCS, 2019. 289p.

NOVAIS, R.F.; SMITH, T.J.; NUNES, F. **Fósforo.** In: NOVAIS, R.F.; ALVARES, V.H.; BARROS, N.F.; FONTES, R.B.C.; NEVES, J.C.L. (Eds.). Fertilidade do solo. 1ª ed. Sociedade Brasileira de Ciência do Solo, p.471-550. 2007.

OLIVEIRA FILHO, A.T.; FONTES, M.A. Patterns of floristic differentiation among Atlantic forests in southeastern Brazil and the influence of climate. **Biotropica**, v.32, n.4, p.793-810, 2000.

PAVAN, M.A.; BLOCH, M.F.; ZEMPULSKI, H.C., MIYAZAWA, M.; ZOCOLER, D.C. **Manual de análise química do solo e controle de qualidade.** IAPAR, 1992. 40p. (Circular Técnica, 76).

PAZ, M.; GÚLLON, P.; BARROSO, F.M.; CARVALHO, A.P.; DOMINGUES, V.F.; GOMES, A.M.; BECKER, H.; LONGHINOTTI, E.; DELEREU-MATOS, C. Brazilian fruit pulps as functional foods and additives: evaluation of bioactive compounds. **Food Chemistry**, v.172, n.1, p.462-468, 2015.

PETRERE, V.G.; CUNHA, T.J.F. **Cultivo da videira:** manejo e conservação do solo. Embrapa semiárido. Sistema de produção. 2ª ed. Brasília: Embrapa, 2010.

RAIJ, B. VAN; ANDRADE, J.C.; CANTARELLA, H.; QUAGGIO, J.A. **Análise química para avaliação da fertilidade de solos tropicais.** 4a. ed. Campinas: Fundação Cargill, 2001, 343p.

REIS, A.F.; SCHMIELE, M. Características e potencialidades dos frutos do Cerrado na indústria de alimentos. **Brazilian Journal of Food Technology**, v.22, e2017150, 2019.

ROMÃO, P.V.M.; PALOZI, R.A.C.; GUARNIER, L.P.; SILVA, A.O.; LORENÇONE, B.R.; NOCCHI, S.R.; MOURA, C.C. F.S.; LOURENÇO, E.L.B.; SILVA, D.B.; GASPAROTTO JUNIOR, A. Cardioprotective effects of *Plinia cauliflora* (Mart.) Kausel in a rabbit model of doxorubicin-induced heart failure. **Journal of Ethnopharmacology**, v.242, n.5, p.1-11, 2019.

SANTOS, D.P.; LOPES, D.P.S.; MELO CALADO, S.P.; GONÇALVES, C.V.; MUNIZ, I.P.R.; RIBEIRO, I.S.; GALANTINI, M.P.L.; DA SILVA, R.A.A. Efficacy of photoactivated *Myrciaria cauliflora* extract against *Staphylococcus aureus* infection - a pilot study. **Journal of Photochemistry and Photobiology A: Chemistry**, v.191, [s.n.], p.107-115, 2019.