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Soil physical quality using an agroforestry system with an agroecological basis

Melissa Alexandre Santos
PhD Student, FEIS UNESP, Brasil.
melissa.alexandre@unesp.br

Carolina dos Santos Batista Bonini
Doctor Teacher, FCAT UNESP, Brasil.
carolina.bonini@unesp.br

Vitor Corrêa de Mattos Barretto
Doctor Teacher, FCAT UNESP, Brasil.
vitor.barreto@unesp.br

José Augusto Liberato de Souza
Master's Degree Student, FEIS UNESP, Brasil.
jose.augusto-liberato-souza@unesp.br

Aline Marchetti Silva Matos
PhD Student, FEIS UNESP, Brasil.
aline.marchetti@unesp.br

SUMMARY

Agriculture based on practices aimed at preserving biodiversity and ecological practices in food production has become increasingly important and viable as an alternative to replacing conventional systems. Agroecological systems are more effective in terms of food and nutritional security demands, strengthening changes in traditional systems in the agricultural sector. Physical attributes can be directly influenced through handling and use, and should be studied. With this, the objective of this work was to evaluate the quality of the soil, through the físicos dosoil attributes in an area managed with an agroforestry system. A completely randomized experimental design was used, with 4 treatments and 4 replications, namely: T1 – area managed with an agroforestry system since 2014; T2 - area managed with an agroforestry system since 2018; T3 - native forest area on the banks of the Paraná River and T4 - fallow pasture area since 2017. The current condition of the native forest system was considered as a reference in terms of soil quality, as it represents the natural condition of land use. The following soil attributes were evaluated: aggregate stability, soil porosity and density, soil texture, degree of flocculation and clay dispersed in water. The results were analyzed using analysis of variance, simple correlation and Tukey's test at 5% probability to compare means. It is concluded that the agroforestry systems positively influenced the physical attributes of the soil, mainly in the pore size distribution, aggregation and soil flocculation.

KEYWORDS: Family farming; soil management; sustainable development.

INTRODUCTION

Among the activities that most cause environmental impacts worldwide is agriculture, which uses approximately 80% of the fresh water available and also directly impacts natural processes, and when not carried out properly, causes erosion and environmental contamination on a large scale (FAO, 2006).

The current conventional agriculture system associates monoculture with the use of machines for soil preparation, such a system performed improperly results in a soil with negative changes in terms of its quality. Deforestation and the implantation of monocultures in large areas, without the adoption of conservationist practices such as the use of organic matter and, in addition, the excessive use of synthetic inputs for fertilization, pH correction, herbicides, among others, result in the annihilation of most of the microorganisms present in the soil, leaving few species that help in the balance of nutrients (PRIMAVESI, 2016).

The study of agriculture in its most diverse spectrums, social and global issues is essential for understanding that development is the result of a set of factors and that through this new information and perceptions it will be possible to aim for true sustainable agriculture. For this, agroecology has been used as a basis to achieve a unidimensional view of agroecosystems, not focusing only on this niche, but on human, environmental, social, political, cultural and economic interrelations. (ALTIERI, 2012).

Soil is one of the essential natural resources for survival, since it is fundamental for the ecosystem as a whole. However, according to FAO (2015) it is estimated that of all global soil, 33% is compromised due to degradation processes, thus issues related to soil quality are increasingly present in discussions on ways to mitigate and slow down these processes.

As a living and complex organism, the soil has several components to carry out its functions, such as fertility. Therefore, soil management and use can directly influence its attributes, whether physical, chemical or biological. That is why it is extremely important to frequently evaluate the effect that the management or absence of it can have on its structure. These effects can be evaluated through quantitative and/or qualitative indicators to determine the quality of the soil and thus diagnose the level of sustainability of the systems, whether managed or natural (KARLEN *et al.* , 1997).

Among the most important indicators for assessing soil health and productivity on a sustainable basis are the physical soil attributes that play a fundamental role (RABOT *et al.* , 2018; REGELINK *et al.* , 2015).

With the advancement of studies on more sustainable systems, discussions on conventional agriculture models have raised questions and criticisms from different groups of society in different areas. While discussions about conventional models are taking place, the increase in the search for healthy and sustainably produced food has been significant, aiming not only at not using pesticides, but also at protecting the environment and at affordable and socially fair prices (NASCIMENTO, 2012).

Faced with discussions about methods of cultivation and food production, one of the strategies agroforestry systems (SAF's) have stood out as an alternative against conventional agriculture. As a production alternative, these systems have also been shown to be possible mitigators of the consequences caused by conventional agriculture carried out improperly, in addition to promoting positive results in terms of soil and environmental quality, ecological stability and approximation to its natural condition (LU *et al* . *al.* , 2015; TORRALBA *et al.* , 2016; PAUL *et al.* , 2017).

Thus, the objective of this destework was to evaluate soil quality through the physical properties of an Oxisol, using an agroforestry system based on agroecology.

MATERIAL AND METHODS

The experiment was carried out on private property, called Rancho Luciana, in the city of Panorama/SP, located in the extreme west region of the State of São Paulo, at 286 meters of altitude, latitude 21º21'23" and longitude 51º51'35", on the banks of the Paraná River, on the border with the State of Mato Grosso do Sul, comone area de1.95 hectares .The climate, according to the Köpen -Geiger classification , is Aw (tropical with dry season), with a hot and rainy summer from October to March and a dry and mild winter with low rainfall from April to September. Annual averages: temperature 26.5°C. The local soil is classified as Oxisol, according to Santos *et al.* (2018), sandy texture (table 1).

Table 1. Area particle size distribution analysis. Panorama - SP, 2022.

TREATMENT	Clay	Sand	Silt
		(g/kg -1)	
	0.00 - 0.05 m		
NATIVE FOREST	38.28	905.51	56.21
SAF 2014	27.02	925.21	47.77
SAF 2018	39.75	918.43	41.82
FALLOW AREA	30.03	926.92	43.04
	0.05 - 0.10 m		
NATIVE FOREST	42.74	920.96	36.30
SAF 2014	35.11	905.46	59.43
SAF 2018	34.55	918.06	47.39
FALLOW AREA	42.73	919.84	37.44
	0.10 - 0.20 m		
NATIVE FOREST	42.01	913.91	44.09
SAF 2014	40.71	916.56	42.73
SAF 2018	33.41	914.59	52.00
FALLOW AREA	35.25	927.44	37.32
	0.20 - 0.40 m		
NATIVE FOREST	38.82	918.81	42.37
SAF 2014	42.62	919.92	37.45
SAF 2018	47.69	909.69	42.62
FALLOW AREA	34.10	923.17	42.73

Source: Santos; 2022.

The property has belonged to the Teruel Aires family for over 40 years, on which different species have been cultivated for commercial purposes, such as coffee and animal production of poultry and cattle; in addition to commercial use, there was a small-scale production of vegetables for personal consumption. For many years, the area of the property was mainly based on pasture and coffee production, where minimal management was carried out with low technology. Due to this phase, in which there was no management aimed at conservation, there was a stoppage of commercial activities, definitively ending the management of the coffee plantation and the beginning of the damming of the Paraná River, intensifying the process of degradation of the area.

In mid-2014, the process of transforming the property, which previously used the conventional system, begins, in a smaller area, to employ a model of sustainable agriculture, through the agroforestry system (SAF). For the implementation of the system, a diversity of native fruit species were initially inserted, prioritizing species from the region, being gradually expanded with medicinal plants and traditional crops, such as corn, cassava, sweet potatoes, etc. The implantation of the cited species was deliberate in order to resgatar a cultura regional and little produced species , with risk of extinction. The main purpose of this transformation was to sustainably conserve soil and water.

As of January 2018, the property originated the Rancho Y-Îara project, which seeks to create a reality different from the region, introducing agroecology, art and conservation and maintenance of natural resources. Through the protection and recovery of the ecosystem and biodiversity, the mission of preserving the environment by integrating it with social development and rescuing regional culture through food has been developing ever since, integrating nature and man.

There were no research works or previous studies in the area to analyze the changes that occurred due to the transformation of the management system.

Below are data on some soil chemical attributes, in a fertility analysis carried out in 2018 (Table 2).

Table 2. Mean values of soil chemical attributes in the SAF 20 14 area, collected in August 2018, in the 0-0.20 m and 0.20-0.40 m layer.

Depth (m)	P- resin (mg/dm³)	MO (g/dm³)	pH	K (mmol/dm³)	Ca (mmol/dm³)	Mg (mmol/dm³)	H+Al (mmol/dm³)
0-0.20	12	13	5.4	two	17	6	6
0.20-0.40	6	12	5.3	1	13	5	13
	Al (mmol/dm³)	**SB (mmol/dm³)**	**CEC (mmol/dm³)**	**V (%)**	**Ca/CTC (%)**	**Mg/CTC (%)**	**m (%)**
0-0.20	0	25	36	69	47	17	0
0.20-0.40	0	19	32	59	41	16	0

Source: SANTOS, 2022

Four areas of the property were selected, characterized by different uses and/or periods of implementation of systems and soil management. The experimental design was completely randomized, with 4 treatments and 4 repetitions for the analyzed variables.

The treatments were as follows: T1 - area managed with an agroforestry system **since 2014** - cultivated with production tree species: fruit trees, timber trees, in addition to some species used for the production of organic matter that is pruned and used to fertilize the system; T2 - area managed with an agroforestry system **since 2018** - cultivated with production tree species: fruit trees, timber trees, in addition to some species used for the production of organic matter that is pruned and used to fertilize the system; T3 - area of native forest às margens of the Paraná River and T4 - area previously used for pasture, but which has been fallow **since 2017** .

The current condition of the native forest system (natural fragment in the process of regeneration) was considered as a reference in terms física of soil quality, as it is an area where, however, there has been no study or evaluation of soil quality (physical, chemical and/or biological).) so that there is a comparison with conventional large-scale systems.

Samples were collected from December to January 2021. Sampling sites were pre-defined and marked for better monitoring of the area during the course of the experiment.

The collection of deformed soil samples for the physical analysis (granulometria, floculação e argila dispersa em água), the volumetric rings (undeformed samples) for the evaluation of soil density and soil porosity and the clods for the aggregate stability index were carried out concomitantly for the following layers: 0.00 -0.05; 0.05-0.10; 0.10-0.20 and 0.20-0.40 m, in order to verify the effect of the roots of the plants used in the studied area.

Physical analyze of the soil were carried out, described below: distribution and stability of aggregates in water, average weighted diameter of aggregates was determined by the method of Angers & Mehuys (2000); soil porosity and density: total porosity by soil saturation (volume of total pores occupied by water), amcroporosity by the tension mass method with a water column of 0.060 kPa, and microporosity was calculated by the difference between total porosity and m acropporosity, according to Teixeira *et al.* (2017). Soil density by the volumetric ring method according to Teixeira *et al.* (2017); Soil texture, degree of flocculation and clay dispersed in water: the degree of flocculation, which is the ratio between naturally dispersed clay and total clay, obtained after dispersion, thus indicating the fraction of clay that is flocculated, thus as the degree of stability of the aggregates in the soil, following the methodology by Teixeira *et al.* (2017), in the Manual of Soil Analysis Methods.

Data were tested for normality of errors and homogeneity of variance. The data were submitted to analysis of variance (ANOVA) by the F test and the averages compared in simple correlation and Tukey test at 5% probability of error, with the aid of the statistical program SISVAR ® (FERREIRA, 2011).

RESULTS AND DISCUSSION

After the period of conducting the experiment, it was possible to verify that there was a difference between the treatments for the analyzed variables, in the different layers studied. As noted in the significant effects of treatments on soil physical attributes in the tables below taking into account the textural characteristics of the soil (Table 1).

Soil porosity and bulk density

Table 1 presents data on macroporosity, microporosity, total porosity and soil density. Regarding macroporosity, admitting $m^3.m^{-3}$, there was a significant difference in the layers of 0.05-0.10m and 0.20-0.40m and the Mata Nativa treatment showed a higher average followed by the AFS 2018 and 2014; and Pousio followed by Mata Nativa, respectively. However, in all studied layers it was possible to observe the proximity of macroporosity values, mainly in the superficial layers, presenting the highest averages.

The presence of plant material and litter on the surface layer of the soil, directly influence the biological activity, providing an increase in macroporosity, and also the content of organic matter present, which together with the increase in biological activity, help in the formation of aggregates and greater pore diameter, consequently (MANHÃES *et al.* , 2009; RITA *et al.,* 2013).

For the fallow area, the macroporosity value was higher in the 0.20-0.40 m layer than in the other layers.

According to studies carried out in different soil classifications, the macroporosity results were closer to those obtained in this study, demonstrating that this attribute is higher in conservation areas, mainly in forests, and when compared to other systems, such as , pasture areas in a situation of soil degradation, or under conventional management, with intense soil use being applied for annual or perennial cultivation, show the opposite (MELLONI *et al.* , 2008; CALGARO *et al.* , 2015; KLEIN E LIBARDI, 2002; ARAUJO *et al.* , 2004; ARGENTON *et al.* , 2005; NUNES *et al.* , 2010; GUIMARÃES *et al.* , 2014).

The surface layers, from 0.00 to 0.10 m, showed higher macroporosity values when present in conservation systems (Mata, SAF 2014 and SAF 2018), with the exception of the layer from 0.05 to 0.10 m where the treatment fallow presented a higher average than the SAF 2014, however without significant difference between both.

In the deeper layers, from 0.10 to 0.20m, the fallow treatment, despite having a lower average, was very close to the other treatments. While in the layer from 0.20 to 0.40 m, this same treatment obtained the highest average, with a significant difference from the other treatments and the value close to that presented by the native forest, SAF 2014 and SAF 2018 in the superficial layers (0.00 - 0. 10m).

In work carried out by Calgaro *et al.* (2015), similar results were presented, where the macroporosity in forest systems was higher in the surface layer (0.00-0.10m) and lower in the subsurface, inversely to what was demonstrated in the grazing area, being higher in the subsurface layers and smaller in the superficial ones, the results of the deeper layers were attributed to animal trampling, a management characteristic similar to this work.

In layers from 0.00 to 0.20 m, the Mata Nativa treatment showed higher averages for macroporosity, being accompanied by treatments with APS's, showing the ability of these systems to positively influence this attribute, such similarity can be attributed to the presence of a high content root biomass of the different tree and herbaceous species implanted. According to Jackson *et al.* (1996), tree species have a biomass of 2 to 5 kg/m² compared to agricultural production and forage species, which have values lower than 1.5 kg/m².

For all treatments and layers, macroporosity showed values greater than 0.10 $m^3.m^{-3}$, the critical limit suggested by Xu ; Nieber and Gupta (1992) for good plant development.

Table 3. F test values, CV (%) and mean values of macroporosity (Ma), microporosity (Mi); total soil porosity (PT) and soil bulk density (DS) of the treatments studied in the soil layers (0-0.05; 0-05.10; 0.10-0.20; 0.20-0.40m) , Panorama -SP, December 2021.

Treatments	Bad	Mi	PT	Ds (kg.dm $^{-3}$)
		(m ^{3}.m $^{-3}$)		
		0.00-0.05m		
NATIVE FOREST	0.3272	0.1563 to	0.4835 to	1.37
SAF 2014	0.3002	0.1312 to	0.4313 ab	1.32
SAF 2018	0.3061	0.1286 to	0.4347 ab	1.36
FALLOW AREA	0.2911	0.0727b	0.3638 b	1.55
F treat	0.659 ^{NS}	20,820*	6,538*	3,362 ^{NS}
CV (%)	12.31	12.66	8.98	8.04
		0.05-0.10m		
NATIVE FOREST	0.3035 to	0.1165 to	0.3918	1.46
SAF 2014	0.2689b	0.1128 to	0.3954	1.48
SAF 2018	0.2961 ab	0.1108 to	0.3752	1.52
FALLOW AREA	0.2696 b	0.0841 b	0.3391	1.61
F treat	5.807*	24,651*	1,992 ^{NS}	1,909 ^{NS}
CV (%)	5.22	5.62	9.72	6.31
		0.10-0.20m		
NATIVE FOREST	0.3007	0.0859 to	0.3776	1.52
SAF 2014	0.3178	0.0977 to	0.3939	1.48
SAF 2018	0.3005	0.0534b	0.3539	1.59
FALLOW AREA	0.2985	0.0816 ab	0.3410	1.60
F treat	0.334 ^{NS}	8.034*	2,031 ^{NS}	1,339 ^{NS}
CV (%)	10.25	16.64	9.07	6.53
		0.20-0.40m		
NATIVE FOREST	0.2883 to	0.1177 ab	0.3613	1.57
SAF 2014	0.2106b	0.1565 to	0.3505	1.55
SAF 2018	0.2360 ab	0.951b	0.3283	1.62
FALLOW AREA	0.3098 to	0.0384c	0.3483	1.60
F treat	7.033*	15.144*	1.107 ^{NS}	0.965 ^{NS}
CV (%)	13.23	24.88	7.55	3.99

*significant at 5% probability and NS not significant. Means followed by equal letters in the column do not differ from each other by the Tukey test at 5% probability.

When evaluating the microporosity of the soil, there was a significant difference between the treatments in all layers analyzed, with higher averages in the superficial layers.

In the layers of 0.00-0.05 and 0.05-0.10m, the Mata native treatment presented higher averages compared to the other treatments, already in the layers of 0.10-0.20 and 0.20-0.40m the treatment that stood out was SAF 2014.

For all the analyzed layers, the fallow treatment presented the lowest averages of microporosity, with the exception of the 0.10 to 0.20 m layer that presented lower values in the SAF 2018 treatment.

High values of microporosity represent a stage of soil degradation, and the adequate distribution of micro and macropores, according to Kiehl (1979), is $^{2}/_{3}$ of microporosity (approximately 33.5%) and $^{1}/_{3}$ of macroporosity (approximately 16 .5%) of the 50% occupied by soil pore space.

According to Alves (2001), the modification of the macroporosity alters both the microporosity and the total porosity. Once the process of soil degradation and disruption has begun, the result is immediate, causing an increase in soil density and a decrease in macroporosity.

As verified by Kitamura *et al.* (2008) when there is a decrease in macroporosity, degraded soils respond with an increase in compaction, and this result is indicated by an increase in soil density.

It was possible to verify in this study that the systems that prioritized conservation actions and the implantation of arboreal species positively influenced the microporosity.

The sum of macro and microporosity correspond to the total porosity of the soil, however, when presented in high values, the total porosity does not represent whether the soil is in adequate condition. Thus, the pore size distribution is extremely important information to carry out the evaluation of the structural quality of the soil.

For total porosity, there was statistically significant difference only in the 0.00-0.05m layer; with higher values presented in the native forest treatment, these values being close to the AFS 2014 and 2018.

In the following layers, there was no statistical difference between treatments, maintaining the values of 0.33 to 0.39 $m^3.m^{-3}$; highlighting the SAF 2014 treatment for layers from 0.05 to 0.20m and native forest for layers from 0.20 to 0.40m.

The SAF 2014 treatment showed lower soil density for all layers, with the exception of the 0.05 to 0.10m layer, with a lower value for the Mata native treatment. It was possible to observe that there was a reduction of Ds in areas with the presence of tree species, this can be attributed to the insertion of organic material and consequently proximity to the natural condition of the soil.

In areas of natural vegetation there is a great diversity of plant and animal species, due to this also occurs the diversity of organisms present in the soil, directly contributing to the adequate development of porosity and reduction of soil bulk density (ROSSETTI; CENTURION, 2018).

Stability of aggregates in water

For aggregates with a diameter of 4 mm, there was a statistical difference in the layers of 0.00-0.05m and 0.20-0.40m, showing higher means in the Fallow and SAF 2018 treatments, respectively.

For aggregates with a diameter of 2 mm, there was a statistical difference only in the 0.00-0.05m layer, higher averages were presented in the SAF 2018 treatment, which presented a higher average compared to the other treatments. For the other layers, the treatments with the presence of trees showed better results than the fallow treatment.

The average of aggregates with a diameter smaller than 2 mm was predominant in the Fallow treatment, which presented the highest value in all layers.

According to Cavalcante *et al.* (2019), when the cover present on the soil surface is present, it is effective in reducing, and can even avoid the impact of raindrops, providing hydraulic roughness and reducing surface runoff of water (HUI *et al.* , 2010; ZHAO *et al.* , 2016; CANTALICE *et al.* , 2017), the presence of cover, as well as the tree canopy help to conserve soil moisture, providing a favorable environment for aggregation desse(COSTA *et al.* , 2015).

Primary particles are greatly influenced by organic matter and other cementing agents that are favored by Fe and Al oxyhydroxides and by the strong interaction with kaolinite in tropical climate soils (SILVA; MENDONÇA, 2007). The stabilization and formation of microaggregates is carried out through physical-chemical interactions together with clay -metal-humic bonds (TISDALL; OADES, 1982; OADES, 1989; BASTOS et al., 2005; SILVA; MENDONÇA, 2007). The deceleration of water entry into the aggregates helps to reduce disaggregation, consequently increasing the resistance of the aggregates when in contact with water, this can be attributed to the action of humified SOM (SILVA; MENDONÇA, 2007).

Table 3. F test values, CV (%) and mean values of weighted average diameter (WAD) and diameter of 4 sieves; two; 1; 0.5; 0.25 and < 0.25 mm, of the treatments studied in the soil layers (0-0.05; 0-05.10; 0.10-0.20; 0.20-0.40m), Panorama -SP , December 2021.

Treatments	WAD (mm)	4mm	2mm	1 mm	0.5mm	0.25 mm	< 0.25 mm
				0.00-0.05 m			
NATIVE FOREST	3,562	46,620 ab	41.107 ab	1.775b	1.292b	1,587	7.617 b
SAF 2014	3,590	36.667b	46.207 to	1,960b	0.747b	0.947	5.862b
SAF 2018	3,410	36,550 b	51.225 to	1.537b	1.227b	1,490	8.132b
FALLOW AREA	3,232	50.045 a	20.870b	2.802 to	2.222 to	2.312	20.987 to
F treat.	3,348 ^{NS}	5,992*	6.885*	8.661*	9.961*	3,119 ^{NS}	15,049 ^{NS}
CV (%)	5.21	13.30	25.47	18.53	18.74	20.11	23.69
				0.05-0.10 m			
NATIVE FOREST	3.370 b	48.525	38,682	1.382b	0.832	1.765	8.807b
SAF 2014	3.925 a	48.775	35.042	0.917 c	1.047	1,277	5.520b
SAF 2018	3,447 ab	45,870	38,952	1.327 bc	1972	2,617	9.262b
FALLOW AREA	3.035b	40.070	35.042	2,742 a	2,087	2,340	17.717 to
F treat.	9.361*	1,592 ^{NS}	0.757 ^{NS}	61,460*	4,131 ^{NS}	3,711 ^{NS}	32,519*
CV (%)	6.97	14.00	13.58	12.72	22.22	21.06	17.67
				0.10-0.20 m			
NATIVE FOREST	3,447 a	38.875	36,927	1,772	2.132	1,412	8.677b
SAF 2014	3.637 a	43,527	40.010	1,352	1945	3,450	9.712b
SAF 2018	3.182 b	39.097	38,600	1,602	2,722	3.515	22,950 b
FALLOW AREA	2,930 c	39,190	31.157	1,780	2,160	2,770	22,950 a
F treat.	50,420*	0.517 ^{NS}	2,892 ^{NS}	0.941 ^{NS}	0.430 ^{NS}	2,892 ^{NS}	19.413*
CV (%)	2.64	15.51	12.47	25.41	25.70	27.65	21.17
				0.20-0.40 m			
NATIVE FOREST	3.327 a	40.377 a	41.512	1,720 a	1,722 ab	2,402 ab	12.262 b
SAF 2014	3.152 a	39.817 ab	38,777	1,227 ab	1,942 ab	4.412 a	13.825 b
SAF 2018	3,180 a	41,837 a	34,160	1,700 a	2,642 a	4.130 a	15.530 b
FALLOW AREA	2.710 b	35.557 b	34,300	0.500 b	1,100 b	1.617 b	26,922 a
F treat.	10,388*	0.124*	2,886 ^{NS}	4,978*	4,797*	5.821*	51.225*
CV (%)	5.34	5.37	11.38	19.83	21.38	25.61	10.86

*significant at 5% probability and NS not significant. Means followed by equal letters in the column do not differ from each other by the Tukey test at 5% probability.

Flocculation grade and clay dispersed in water

With regard to the Flocculation Degree (FD), the value of the SAF 2018 treatment was higher in the 0.00-0.05 and 0.10-0.20m layer, showing a significant non-significant difference, respectively. While for the 0.05-0.10m layer, the highest average was for the Mata native treatment, not differing from the SAF 2018 treatment.

In the 0.20-0.40 m layer, the fallow treatment had the highest mean, not significantly different from the other treatments.

Only for AFS 2018, there was a gradual reduction in GF between the layers as the depth increased, which did not happen in the other treatments such as native forest and fallow where there was the opposite, an increase in GF as the layers deepened.

As for Clay Dispersed in Water (ADA) there was a significant difference only in the first layers (0.00-0.05 and 0.05-0.10m), the fallow treatment showed higher averages. However, for the 2014 and 2018 SAF treatments, there was an increase in ADA as the soil depth increased.

Table 4. Mean values of the degree of flocculation (%) and clay dispersed in water (%), CV (%) and F-test at 5% probability. Panorama - SP. December 2021.

Treatment	**Degree of flocculation (%)**			
	(0.00-0.05 m)	**(0.05-0.10 m)**	**(0.10-0.20 m)**	**(0.20-0.40 m)**
NATIVE FOREST	60.115 b	86.637 a	80,330	60.622
SAF 2014	44.735 b	55.067 b	55,870	42,197
SAF 2018	88.150 a	83,290 a	82.145	55,502
FALLOW AREA	48.130 b	60.297 b	69,922	71,150
F TRAT	10,776*	13.027*	4,024 NS	1,617 NS
CV (%)	19.93	12.39	16.69	22.98
Treatment	**Clay dispersed in water (%)**			
	(0.00-0.05 m)	**(0.05-0.10 m)**	**(0.10-0.20 m)**	**(0.20-0.40 m)**
NATIVE FOREST	14,390 ab	8,660 bc	11,670	25,730
SAF 2014	13.032 b	15,410 ab	23,732	25.305
SAF 2018	4,967 c	6,540 c	11,527	21,217
FALLOW AREA	21,830 a	16,587 a	14,840	20.915
F TRAT	14,642*	9.721*	2,979 NS	0.258 NS
CV (%)	26.64	26.91	23.03	23.59

*significant by Tukey's method (5%). Means followed by the same letters do not differ from each other.

According to Alleoni and Camargo (1994), values of the degree of flocculation approaching 100% and the dispersed clay of 0 observed in the B horizon of oxidic Oxisols , which have strengthened microstructures, correspond to the data of this study.

The high level of flocculation and the low level of dispersed clay are indicative of good structural stability, directly influencing the susceptibility of the soil to the occurrence of compaction processes.

CONCLUSIONS

With this, we verify some physical indicators of the soil:

- For macroporosity, the fallow treatment obtained lower values, while the density presented higher values, compared to the other treatments, in the layers of 0.00-

0.05; 0.05-0.10 and 0.10-0.20m. Being higher for macroporosity and lower than the SAF 2018 for density, only in the 0.20-0.40m layer. Showing the influence of agroforestry systems on these attributes.

- The observed microporosity was greater in all layers in agroforestry systems or native forest, evidencing the positive performance of the root system of the species inserted in the system, highlighting the tree species.
- The WAD was higher in all soil layers in treatments with inserted tree species and presence of diversified organic material, which resulted in a higher degree of soil structuring.
- Soil flocculation indicates the importance of organic matter in soil structuring and structure maintenance in agroforestry systems.

- Thus, it was observed that the agroforestry systems started in 2014 and 2018, respectively, showed the proximity to the native forest in relation to the physical attributes of the soil. With the generation and dissemination of this work, it is intended to prove the sustainability of the system and the preservation of soil quality and generate technology for the Nova Alta Paulista region, strengthening and expanding the income of family producers and transferring technologies for a better and efficient use of the soil.

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