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Characterization and spatial georeferencing of the physical properties of Eutric Fluvisols soils for agricultural use in the "La María" Experimental Farm in the Mocache Canton.

Characterization and spatial georeferencing of the physical properties of Eutric Fluvisols soils for agricultural use in the "La María" Experimental Farm in the Mocache Canton

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Luis Fernando Salazar Carranza
Agricultural Engineer Universidad Técnica Estatal de Quevedo, Postgraduate Unit, Master's Degree in Agronomy, Mention in Sustainable Agricultural Production, Quevedo, Los Ríos, Ecuador. luis.salazar2013@uteq.edu.ec
https://orcid.org/0000-0001-5046-8507

Diana Verónica Véliz Zamora
Master's Degree in Plant Sciences, mention in plant production, Universidad Técnica Estatal de Quevedo, Faculty of Livestock Sciences, Quevedo, Ecuador. dvveliz@uteq.edu.ec
https://orcid.org/0000-0003-2039-8741

Gregorio Humberto Vásconez Montúfar
Master in Plant Production, PhD in Agricultural Sciences, Universidad Técnica Estatal de Quevedo, Facultad de Ciencias Pecuarias, Quevedo, Ecuador. gvasconez@uteq.edu.ec
https://orcid.org/0000-0003-1260-8075

Camilo Alexander Mestanza Uquillas
Master in Sciences, mention in Genetics. D. in Agricultural Sciences Universidad Técnica Estatal de Quevedo, Facultad de Ciencias Pecuarias, Quevedo, Ecuador. cmestanza@uteq.edu.ec
https://orcid.org/0000-0001-9299-170X

John Jairo Pinargote Alava
Master in Digital Transformation in the Agri-Food and Forestry Sector, Graduate of the University of Cordoba-(UCO), Cordoba, Spain.
john.pinargote2013@uteq.edu.ec
https://orcid.org/0000-0002-8065-5124

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ABSTRACT

This work was carried out in the Experimental Farm "La María" of the State Technical University of Quevedo (UTEQ) with the objective of characterizing and georeferencing the physical properties of the Eutric Fluvisols soils for agricultural use in the farm "La María". Where there is a lack of knowledge of the physical characteristics, inadequate management and use of soils being necessary the use of technologies such as geographic information systems (GIS) that allow storing, analyzing and managing activities of the different sites of agricultural interest. This research was conducted from June to October 2018, using a completely randomized design (CRD) with 20 treatments considered by horizons and surfaces in 3 replications. The data were analyzed in the statistical program InfoStat free version (VL), and subjected to Tukey's test at 95% probability. These results were plotted on a georeferenced map in a GIS (ARGIS) (VL), WGS 1984 UTM Zone 17S coordinate system. The soils of the "La María" farm had an average bulk density of 1.18 g/cm3 and real density of 2.24 g/cm3. There was a pore space percentage of 46%, average moisture percentage of 41%, and soil aggregate size of 4.28 mm. In the texture analysis, 85% of the soils of the farm have a loamy soil texture.

Keywords: Calicata, munsell, coordinates, GPS, georeferenced.

RESUMEN

Este trabajo se realizó en la Finca Experimental “La María” de la Universidad Técnica Estatal de Quevedo (UTEQ) con, el objetivo es caracterizar y georreferenciar las propiedades físicas de los suelos Eutric Fluvisols de uso agropecuario en la finca “La María”. Donde existe el desconocimiento de las características físicas, inadecuado manejo y uso de los suelos siendo necesario el uso de tecnologías como los sistemas de información geográfica (SIG) que permita almacenar, analizar y gestionar actividades de los diferentes sitios de interés agropecuario. Esta investigación se realizó entre junio a octubre del 2018, empleando un diseño completamente al azar (DCA) con 20 tratamientos considerados por horizontes y superficies en 3 repeticiones. Los datos fueron analizados en el programa estadístico InfoStat versión libre (VL), y sometidos a la prueba de Tukey al 95% de probabilidad. Estos resultados se graficaron en un mapa georreferenciado en un SIG (ARGIS) (VL), Sistema de coordenadas WGS 1984 UTM Zona 17S. Los suelos de la finca “La María” presentaron una densidad aparente promedio de 1.18 g/cm3 y densidad real 2.24 g/cm3. Existiendo un porcentaje de espacio poroso del 46%, porcentaje humedad promedio de 41%, tamaño de agregados del suelo de 4.28 mm. En el análisis de textura un 85% de los suelos de la finca poseen una textura de suelo de tipo franca.

Palabras clave: Calicata, munsell, coordenadas, GPS, georreferenciado.

1. Introduction

Ecuador is characterized by the abundant diversity of its natural resources, where the different types of soils and climatic floors with great agricultural potential of the different Regions such as Coast, Highlands, East and Galapagos stand out, according to INEC Ecuador as of 2017 has a total area of 25'558,691 hectares where 12'355,146 hectares destined for agriculture (Rodriguez, 2016).

The importance of the determination of the physical characteristics is that it allows us to know the properties of the soil such as the texture allows us to know the composition of the soil according to the size of its particles, the apparent density and real density that allow us to know the relationship between a unit of weight over volume g/cm3, the percentage of moisture present in the soil and the pore space that will serve for water relations, We also analyzed the size of the aggregates that are the product of the grouping of soil particles forming a larger structure called clod capable of retaining more water, nutrients, organic matter, air and air circulation through pores and micropores between mass, favoring the structure of the soil itself and the crops as well.

At the "La María" Experimental Farm, there is a lack of knowledge and information on the physical characteristics of the soil, making it necessary to create a support system to make informed decisions on the use of agricultural and livestock land.

The soils of the "La María" farm are inadequately managed for agricultural and livestock activities, causing deterioration of the soil structure and with it the modification of other soil properties. Where it is necessary to have physical-digital maps at present is not enough being necessary the use of Geographic Information Systems (GIS) that allow us to store, describe, categorize, manage, analyze spatial information of sites of interest.

With this background, it is necessary to create, determine and provide information on the soils of the "La María" farm in order to know the particularities of the different treatments under study. This will allow an adequate and rational use of the soil based on the results obtained. This collected information requires the use of technologies such as GIS and Global Geo-positioning Systems (GPS).

The objective is to characterize and georeference the physical properties of the Eutric Fluvisols soils for agricultural use at the UTEQ "La María" farm through the study of soil density (apparent and real), porosity, moisture content, textural classes, soil aggregate size and horizon depth. The experimental sites were also georeferenced on the farm map.

Materials and methods

Investigation procedure.

In the development of this work we started with the distribution of sites to perform the pits in the Experimental Farm "La María" and their respective geographical coordinates with the help of a GPS, then, we made the opening of the pits with the following dimensions of 1m wide, 1 meter long and a depth of 1.5 meters. Each test pit was considered a treatment, where the samples were collected and labeled on the surface (S) and from the different Horizon A (HA), Horizon B (HB) and Horizon C (HC).

The samples were dried at room temperature for 7 days and sieved with a <2mm sieve. Then the determination of the soil physical properties was carried out at the Soil and Water Laboratory of the UTEQ.

Table 1 *Shows detailed information on the treatments, established crops, geographic coordinates in X and Y, as well as meters above sea level.*

Treatments	Cultivation	Geographical coordinates WGS 1984 UTM Zone 17S.		M.S.N.M
		EAST(X)	NORTH (Y)	
1	Banana	0666665	9880325	
	Corn	0666796	9880330	
	African Palm	0666782	9880306	
	Teak	0666889	9880323	
5	Quinoa	0666855	9880182	
	Short Cycle 1	0666796	9880186	
	Citrus	0666632	9880067	
	Banana 1	0666724	9879945	
	Fruit trees	0666614	9879992	
	Soursop	0666599	9879935	
	Cocoa CCN-51	0667087	9880109	
	National Cocoa	0667058	9879998	
	Banana 2	0667082	9879935	
	Short cycle 2	0667161	9879888	
	Brachiaria	0666940	9879762	
	Savoy Pasture	0666626	9879489	
	Savoy Pasture	0666514	9879283	
	Savoy Pasture	0666444	9878938	
	Savoy Pasture	0666621	9878683	
	Savoy Pasture	0666494	0978583	

M.S.N.M: meters above sea level.

Experimental Design.

A completely randomized design (CRD) was used, with 20 treatments analyzing the surface layer and the horizons of each test pit, with 3 replications. Qualitative and quantitative variables were studied in this research.

Statistical analysis.

It was performed by analysis of variance (ANDEVA) and the averages were compared by Tukey's test (P≤0.05), with the use of InfoStat software free version (VL). Data, Tables and figures were made in EXCEL spreadsheets (VL) of the Microsoft Office package. The graphics of the maps and data processing were performed in the ArcGIS (VL) program.

Geographic coordinate system.

The distribution and collection of geographic coordinates was carried out by means of a GPS, with the WGS 1984 UTM Zone 17S system.

Methodologies used.

For the determination of bulk density (Da), the cylinder method was used for the samples of horizons A, B and C. Methodology proposed by Dörner et al.(2011).

The pycnometer method was used to determine the true density (Dr) in the samples of horizons A, B and C. Methodology proposed by CandoandCollantes(2014).

The pore space (Ep) was calculated by the difference between (Dr/Da) expressed in (%) in the A, B and C horizons. Methodology proposed by Dörner et al.(2011).

To determine the percentage of moisture expressed as a percentage (%), the oven method was used at 105 ºC for 24 hours in the samples of horizons A, B, C and S. The methodology proposed by Dörner et al.(2009).

The aggregate size (AT) was determined by measuring the soil clods expressed in mm in the surface samples. Methodology proposed by Dörner et al.(2011).

The Bouyoucos method was used to determine the texture, in the samples of horizons A, B, C and S. And the classification to which type of soil corresponds according to the textural triangle The methodology proposed by, "The United States Department of Agriculture (USDA)" (Fernandez Dörner et al., 2011).

3. Results

Analysis of bulk density and true density.

Table 2 shows the average bulk and actual densities of the treatments evaluated in horizons A, B and C, which show statistical differences at 95% probability, according to the Tukey test. The bulk density (DA) in Horizon A (HA) showed a statistical difference (P<0.05) with an overall average of 1.10 g/cm3. Where T16 presented the highest DA of 1.35 g/cm3 while T14 had the lowest value of 0.85 g/cm3 presenting a cv of 9.53%. While in Horizon B (HB) showed statistical difference (P<0.05), presenting a general average DA of 1.20 g/cm3 where T9 reached the highest value of 1.55 g/cm3 while T2 reflected the lowest DA of 0.98 g/cm3 with a cv of 7.03%. Consequently, Horizon C (HC) showed statistical difference (P<0.05), with overall average DA of 1.26 g/cm3 where T14 with 1.41

g/cm3 higher than all treatments and T18 with 1.03 g/cm3 lower than all, with a cv of 8.09%.

The results obtained in this research are similar to those obtained by Novillo et al.(2018), entitled "Soil physical properties in different agricultural systems in the Province of Los Ríos, Ecuador in 2017 where they investigated soil physical variables in 5 different monocultures of the area in the Province of Los Ríos, studying different soil depths for the bulk density variable using the waxed clod method, obtaining value of 0.83g/cm3 in corn (*Zea mays* L.) and bulk densities of 1.50 g/cm3 in African Palm (*Elaeis guineensis*) under similar agroclimatic conditions. Adding that the bulk density is linked to the type of crop present and its root system and the agricultural activities developed in it.

The averages of real density RD in the HA showed statistical difference at 95% probability according to the Tukey test, with an overall average of 2.29 g/cm3 where T17 presented the highest RD of 2.68 g/cm3 higher than all the treatments and T2 with 1.95 g/cm3 was lower, presenting a cv 7.42%. While the RD in HB and HC showed no statistical difference (P<0.05), presenting an overall average of 2.25 g/cm3 and 2.19 g/cm3 respectively. Table 2.

In the analysis of the data in real density are similar to those obtained by Novillo et al.(2018), employing the pycnometer method in fluid displacement, registering an overall average of 2.20 g/cm3 in 5 different monocultures of the area in the Province of Los Ríos.

Table 2. *Averages of bulk and real density in the A, B and C horizons in different sites of the soils of the "La María" farm, July 2018.*

	Bulk density g/cm3			**Actual density g/cm3**		
Treat.	**Horizon A**	**Horizon B**	**Horizon C**	**Horizon A**	**Horizon B**	**Horizon C**
1	1.11 abcd	1.10 bc	1.05 b	2.31 abc	1.85 a	1.79 a
	0.85 f	0.98 c	1.33 ab	1.95 c	2.27 a	2.34 a
	1.29 ab	1.14 bc	1.12 ab	2.34 abc	2.15 a	1.91 a
	1.34 a	1.24 b	1.25 ab	2.19 abc	2.06 a	2.41 a
5	0.99 bcd	1.33 ab	1.34 ab	2.16 abc	2.29 a	2.11 a
	0.89 cd	1.24 b	1.15 ab	2.21 abc	2.13 a	2.18 a
	1.08 abcd	1.15 bc	1.28 ab	2.30 abc	2.27 a	2.21 a
	1.11 abcd	1.24 bc	1.18 ab	2.39 abc	2.12 a	2.25 a
	1.07 abcd	1.55 a	1.34 ab	2.25 abc	2.29 a	2.30 a
	1.21 abc	1..08 bc	1.25 ab	2.23 abc	2.13 a	2.09 a

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	1.24 ab	1.25 b	1.29 ab	2.13 bc	2.56 a	1.86 a
	0.89 cd	1.18 bc	1.38 a	2.18 abc	2.32 a	2.25 a
	1.13 abcd	1.17 bc	1.41 a	2.28 abc	2.19 a	2.28 a
	0.90 cd	1.20 bc	1.41 a	2.24 abc	2.56 a	2.25 a
	1.22 abc	1.15 bc	1.34 ab	2.39 abc	2.33 a	2.05 a
	1.35 a	1.26 b	1.17 ab	2.62 ab	2.21 a	2.40 a
	1.16 abcd	1.25 b	1.28 ab	2.68 a	2.54 a	2.30 a
	1.00 bcd	1.09 bc	1.03 b	2.18 abc	2.21 a	2.16 a
	1.22 abc	1.30 ab	1.33 ab	2.26 abc	2.40 a	2.41 a
	0.97 bcd	1.17 bc	1.24 ab	2.54 ab	2.21 a	2.24 a
x	1.10	1.20	1.25	2.29	2.25	2.19
P<(0.05)	0.0001**	0.0001**	0.0003**	0.0001**	0.1381ns	0.0265ns
CV	9.53%	7.03%	8.09%	7.42%	10.91%	9.73%

Treatments; x: Mean; P<(0.05): Probability value; CV: Coefficient of variation; ns: not significant; *: significant; **: highly significant. Similar letter in vertical direction does not present a difference.

Analysis of pore space, pore number and aggregate sizes.

Table 3 shows the averages of pore space (PS) and aggregate size (AS) of the treatments evaluated in the A, B, C and surface (S) horizons, reflecting statistical differences at 95% probability, according to the Tukey test. The EP in the HA showed statistical difference (P<0.05) with an overall average of 51.40% where T20 was superior with 61.81% and the lowest was T4 with 38.77% presenting a cv of 12.08%. While the EP of HB showed statistical difference (P<0.05), with overall average of 46.04% where T2 achieved the highest value of 56.72% and the lowest was T9 with 32.11% with a cv of 14.92%. Consequently, the EP in the HC showed statistical difference (P<0.05), in the HC existing an overall average of 42.09% being T18 who presented the highest value with 52.04% and T11 obtained the lowest value of 31.49% a cv of 15.15%. Table 3.

According to the results of González et al.(2011) in the research entitled "Characterization of soil porosity as an indicator of soil physical quality in 2011 in the analysis of pore space" by means of the difference between (Dr/Da) expressed in percentage, presented pore space values of 32% in semi-naked areas, resulting in a lower value than the present research, obtaining values of 46.51% (EP). The pore space is related to water retention, infiltration, water runoff, water-air flow ratio, root penetration and displacement, and the physical, chemical and biological exchange of the soil, as also stated by González et al.(2011).

In the "Guide for the description of soils according to FAO(2009), in 2009, it states different ranges of porosity, expressing them as follows: low 2-5%, medium between 5-15%, high 15-40% and very high when it is >40%, concluding that the soils of the "La María" farm have high and very high porosity.

The aggregate size of the topsoil at the different sites evaluated showed statistical differences at 95% probability, according to the Tukey test. The aggregate size in S showed a statistical difference ($P<0.05$) with an overall average of 4.28 mm. T19 had the highest aggregate size value of 5.60 mm. Where T4 had the lowest value with 2.80 mm presenting a cv of 14.49%. Table 3.

Aggregate size according to the research of Gabioud et al.(2011) is the work of "Analysis of aggregate stability by the method of le bissonnais in three orders of soils" where they presented average values of 2.77mm, noting that this value is lower than the research developed in T19 a value of 5.60mm. On the other hand, the International Center for Tropical Agriculture (CIAT, 2013), in the Agropastoral Systems Manual, points out that the size of the aggregates is related to the intensity of use of tillage, machinery or activities developed in the soil.

Table 3. *Averages of pore space A, B, C and aggregate size in Surface (S) in different sites of the soils of "La María" farm, July 2018.*

Treat.	Percentage of pore space (%)			Aggregate size (mm)
	Horizon A	Horizon B	Horizon C	Surface
1	52.00 abc	39.95 ab	40.88 ab	4.67 abcde
	56.32 abc	56.71 a	43.22ab	4.40 abcde
	44.68 abc	46.67 ab	40.82 ab	3.40 cd
	38.77 c	39.65 ab	48.17 ab	5.07 abcd
5	53.61 abc	41.88 ab	35.81 ab	4.80 abcd
	59.16 ab	41.31 ab	47.34 ab	2.80 e
	52.55 abc	48.05 ab	41.77 ab	5.20 abc
	53.45 abc	41.62 ab	47.39 ab	3.67 bcd
	52.17 abc	32.11 b	41.16 ab	3.27 of
	45.70 abc	48.99 ab	39.87 ab	4.47 abcde
	41.41 bc	51.32 ab	31.49 b	4.73 abcd
	58.70 ab	49.07 ab	38.05 ab	4.87 abcd
	50.34 abc	46.20 ab	38.26 ab	4.33 abcde
	59.97 ab	52.75 ab	37.46 ab	3.47 cd
	48.39 abc	50.38 ab	34.62 ab	3.20 of
	48.32 abc	42.27 ab	50.99 ab	3.40 cd

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John Jairo Pinargote Alava

	56.69 abc	48.94 ab	43.98 ab	3.47 cd
	53.91 abc	50.81 ab	52.04 a	5.27 abc
	45.51 abc	45.91 ab	44.47 ab	5.60 a
	61.81 a	46.26 ab	44.09 ab	5.47 ab
	51.40	46.04	42.09	4.28
P<(0.05)	0.0014**	0.0303*	0.0206*	0.0001**
c.v.	12.08	14.92	15.15	14.49

Treatment: Treatment; x: Mean; P<(0.05): Probability value; CV: Coefficient of variation; ns: not significant; *: significant; **: highly significant. Similar letter in vertical direction does not present a difference.

Moisture percentage analysis

Table 4 shows the soil moisture averages in the treatments evaluated in the A, B, C and surface horizons, reflecting statistical differences at 95% probability, according to the Tukey test. The percentage of moisture in the HA showed statistical difference (P<0.05) with an overall average of 35.40% being the highest in T12 with a value of 64.00% being superior to T17 with 18% presenting a cv of 12.00. While the percentage of moisture in the HB showed statistical significance (P<0.05), it presented a general average of 43.27% where T12 presented the highest value of 63.33% being superior to T18 with 16.67% with a cv of 7.82. Consequently, the percentage of moisture in HC showed statistical significance (P<0.05), with an overall average of 44.80%, where T3 with 70% was superior to T14 with 12% and a cv of 7.82 (Table 3). The percentage of moisture in S showed statistical difference (P<0.05) with a general average of 31.10%, the highest being T6 with a value of 44.67% being superior to T20 with 15.33% presenting a cv of 26.81.

According to GarciaandSchlatter(2012), in the analysis of soil moisture percentage in the research entitled "Characterization of soils along an altitudinal gradient in Ecuador, in their analysis of moisture percentage where presenting volumetric moisture values of 41.2mm being similar to those obtained in this research.

Table 4. *Averages of the percentage of moisture in the A, B, C horizons and surface layer in different sites of the soils of the "La María" farm, July 2018.*

Treat.	Moisture content (%)			
	Horizon A	**Horizon B**	**Horizon C**	**Surface**
1	24.00 gh	50.67 bcde	58.67 bcd	32.67 ab
	33.33 efg	33.33 ghi	33.33 fgh	26.00 ab
	40.00 cde	49.33 bcdef	70.00 a	40.67 ab
	36.67 def	60.00 ab	60.00 abcd	36.00 ab
5	51.33 b	50.00 bcdef	58.00 cd	39.33 ab
	40.00 cde	33.33 ghi	60.00 abcd	44.67 a
	32.00 efg	46.00 cdef	53.33 cd	23.33 ab
	31.33 efg	52.67 abcd	69.33 ab	38.67 ab
	49.33 bc	40.00 efgh	60.67 abcd	28.67 ab
	34.67 defg	56.00 abc	64.00 abc	36.00 ab
	16.67 h	24.00 ij	30.00 gh	20.00 ab
	64.00 a	63.33 a	42.00 ef	26.67 ab
	31.33 efg	38.67 fgh	25.33 h	40.67 ab
	44.67 bcd	43.33 defgh	12.00 i	40.67 ab
	26.00 fgh	58.67 ab	30.00 gh	42.00 a
	26.00 fgh	54.00 abcd	31.33 fgh	22.67 ab
	18.00 h	32.00 hi	28.00 gh	31.33 ab
	34.67 defg	16.67 j	50.67 of	16.00 b
	38.67 cde	44.00 defg	36.67 fg	20.67 ab
	35.33 def	19.33 j	22.67 hi	15.33 b
	35.40	43.27	44.80	31.10
P<(0.05)	0.0001**	0.0001**	0.0001**	0.0002**
CV	12.00	8.87	7.82	26.81

x: Mean; P<(0.05): Probability Value; CV: Coefficient of Variation; ns: not significant; *: significant; **: highly significant. Similar letter in vertical direction does not present a difference.

Texture analysis in the different arable sites and soil depth of the "La María" farm 2018.

According to the percentages of sand, silt and clay presented in Table 5, the types of texture that belong to the soils of the "La María" farm are highlighted. Eighty-five percent of the sites evaluated in their surface layer belong to a loam texture. The HA textures of the treatments have a 55% loam type and 40% correspond to a clay loam texture. In the analysis of the texture in the HB, there is great

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variability in the texture, with loam, clay loam, clayey loam, sandy clay loam textures. The texture in HC is 70% clayey texture type.

GarciaandSchlatter(2012) in their work entitled "Characterization of soils along an altitudinal gradient in Ecuador, in the "Quevedo" area, coincides with the research with types of loam, clay loam and clayey loam soils, these results coincide because it is an alluvial area. Table 5 shows the different textures and depths (cm) of the superficial layer and horizons A, B and C.

Table 5. *Texture type and depth (cm) of the different treatments of the soils of the "La María" farm in the soil surface and its horizons.*

Treat.	Cultivation	Texture S	Texture HA	Prof. HA (cm)	Texture HB	Prof. HB (cm)	Texture HC	Prof. HC (cm)
1	Banana	Franca	Franco Arc.		Arc.		Arc.	
	Corn	Franca	Franca		Franca		Arc.	
	African Palm	Franca	Franca		Franco Arc.		Franco Arc.	
	Teak	Franco Arc. Are.	Franco Arc.		Arc.		Arc.	
5	Quinoa	Franca	Franca		Franco Arc.		Arc.	
	Short Cycle 1	Franca	Franco Arc.		Franco Arc.		Arc.	
	Citrus	Franca	Franco Arc.		Arc.	45	Arc.	
	Banana 1	Franca	Arc.		Clayey		Arc.	
	Fruit trees	Franca	Franca		Franco Arc. Sandy		Arc.	
	Soursop	Franca	Franco Arc.		Clayey		Arc.	
	Cocoa CCN-51	Franca	Franco Arc.		Franco Arc.		Franco Arc	
	National Cocoa	Franca	Franca		Franca		Arc.	
	Banana 2	Franca	Franca		Franco Arc.	45	Franco Arc.	
	Short cycle 2	Franca	Franca		Franca		Franco Arc.	
	Brachiaria	Franca	Franca		Arc.		Arc.	

Savoy Pasture	Clay loam	Franca	Arc.		Arc.
Savoy Pasture	Clay loam	Franco Arc.	Arc.		Arc.
Savoy Pasture	Franca	Franco Arc.	Franco Arc.		Franca
Savoy Pasture	Franca	Franca	Franco Arc.	58	Arc.
Savoy Pasture	Franca	Franca	Arc.		Arc.

Trat: treatment; S: surface; HA: A horizon; HB: B horizon; HC: C horizon; Dep: depth; Arc: clayey; Are: sandy.

Georeferenced map of the physical properties of Eutric Fluvisols soils for agricultural use in the "La María" experimental farm in Mocache canton.

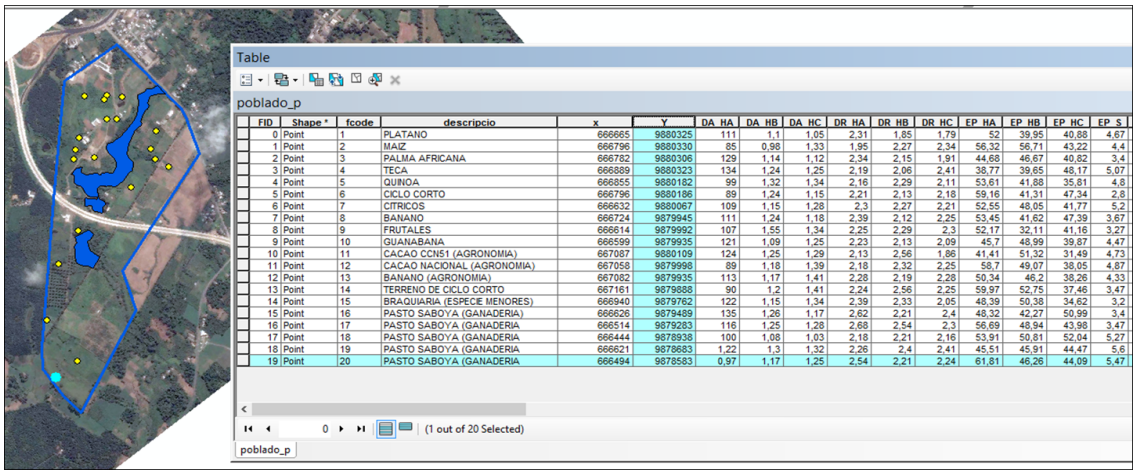

Figure 1 shows the georeferenced base map with the physical properties of the soils of the experimental farm "La María" with the variables of bulk density (DA), real density (DR), pore space (EP), aggregate size (TA), moisture content (CH), texture and depth of the different horizons.

5. Conclusions

The soils of the "La María" farm had a bulk density of 1.18 g/cm3 and a true density of 2.24 g/cm3, this being the average of the three horizons in the sites evaluated. The percentage of pore space was 46%, reflecting an average moisture content of 41%. According to the texture triangle, the soils of the "La María" farm

had a loam textural class of 70% in the first 50 cm and a clay loam of 10% from 50 cm of the soil profile of the treatments.

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