Iron rods in support of the use of ground penetrating radar with 450 MHz monostatic antenna for imaging argillic horizon

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Abstract

This work aimed to use a GPR equipped with a 450 MHz antenna to identify the depth of the clayey horizon marked with iron rods in Planosols. This study was carried out in an agroecological farm (Fazendinha Agroecológica do km 47), located in Seropédica municipality, Rio de Janeiro state, Brazil. First, three Planosols were described, and iron rods with dimensions of 80 cm in length and 0.8 cm in diameter were inserted in the transitions among soil horizons. Next, radargrams from the soil profiles and from one transect with those profiles were acquired using a GPR porting a shielded monostatic antenna of 450 MHz. Then, a depth model was adjusted to the transect radargram using the arithmetic average from the pulse velocities measured among the individual radargrams from the soil profiles. As the result, the average velocity created a depth model for the transect radargram that produced similar depths to those transitions viewed in the field for the argillic horizon.

Keywords: soil survey; shallow geophysics; Planosols.

Introduction

The ground penetrating radar (GPR) has been shown potential to identify and map soil features (Ucha et al., 2002). One of those features can be the bottom of the E horizon in Planosols, that is, the depth to the argillic horizon. Its estimation is essential in order to study the soil water storage volume, the depth of the sandy horizons for soil tillage purposes, and other uses. In addition, this feature could also be used to locate the boundaries among soil types in the field, possibly expediting soil survey (Ucha et al., 2002). Then, this work aimed to analyze the feasibility of iron rods in support of a GPR porting a monostatic antenna of 450 MHz to determine the depth of the argillic horizon in an area with Planosols.

Methodology

This work was carried out in an agroecological farm (Fazendinha Agroecológica do km 47), located in Seropédica municipality, Rio de Janeiro state, southeastern Brazil. Three trenches were opened, where soil profiles were described according to Santos et al. (2015) and classified according to the World Reference Base (IUSS Working Group WRB, 2015) as Planosols, named of P2 (with six horizons), P5 (with seven horizons) and P6 (with six horizons). Disturbed soil samples were collected at each horizon and analyzed in the laboratory to measure the particle size fractions (PSF) and the gravimetric water content, according to Teixeira et al. (2017).

Iron rods with dimensions of 80 cm in length and 0.8 cm in diameter were inserted in the transitions among soil horizons. Then, the three soil profiles (2-m long by 1.5-m wide by 1.20 to 1.72-m deep) and one transect (220-m long) with those profiles were imaged using the GPR MALÅ GroundExplorer (Guideline Geo AB, Sundbyberg, Sweden), creating radargrams using a monostatic shielded antenna of 450 MHz. The radargrams obtained in the field were processed using the ReflexW software (Sandmeier, 2009), and two pre-processing procedures were done in sequence: static correction and dewow. After pre-processing, the hyperbolas from the iron rods were identified in the radargrams, and the pulse velocity estimations were obtained in ReflexW, followed by the conversion of the Y-axis of the radargram from time (ns) to depth units (m).

Results and discussion

The main results of the physical attributes from the horizons are shown in Table 1, which identify the abrupt transitions (the top of the argillic horizon). Each soil profile has a higher clay content in the B horizon concerning the E horizon, leading to a higher K (dieletric constant) contrast between these horizons (De Benedetto et al., 2010), which may help see the argillic horizon in the 450 MHz radargram.

Table 1. Physical attributes of the P2, P5, and P6 soil profiles.

Profile	Horizon	Horizon number	Depth (cm)	PSF (g kg^{-1}) Sand	Clay	Gravimetric water (%)	Horizon transition
P2	E	3	22-69	831	92	2.1	3
	Bt1	4	69-92	564	388	5.9	
P5	E5	6	145-158	717	20	6.1	6
	Bt	7	158-172^{+}	621	267	4.2	
P6	E	3	32-44	878	45	4.1	3
	Btg1	4	44-66	703	216	12.3	

Then, the GPR was used on the soil profiles and the pulse velocities were measured in the radargrams using the ReflexW (Table 2). From those velocities was calculated an average to apply to the depth model in the transect radargram (Figure 1).

Table 2. Pulse velocities acquired at the horizon transitions in the radargrams.

Profile	Horizon transition	Pulse velocities
P2	1, 2, 3	0.11 m ns^{-1}
P5	1, 2, 3	0.11 m ns^{-1}
P6	1, 3, 4	0.10 m ns^{-1}

The iron rod at the abrupt change in P5 (Table 1) was not possible to observe (Figure 1b). It may be caused by its higher depth (at 1.58 m) in relation to P2 (at 69 cm) and P6 (at 44 cm) (Porsani, 1999), even with the upper horizons with low water content and composed by sandy texture (Doolittle and Collins, 1995).
The arithmetic average from those velocities is 0.107 m ns^{-1} for that specific day of soil survey. It means that according to the environmental conditions of the day, those velocities may change, for instance, due to the water content in the soil (Doolittle and Collins, 1995). Then, considering that average to the transect radargram, the depths of the argillic horizons were very similar to those viewed in the field description (in P2 and P6) (Table 1) and for the last rod seen in the P5 (at 38 cm, third transition). This means that the iron rods can be feasible to map the argillic horizon in large areas where Planosols appear, using the frequency of 450 MHz for shallower argillic horizons. However, since antennas with lower frequencies can map deeper regions in the soil (Porsani, 1999), iron rods can also help map greater depths.

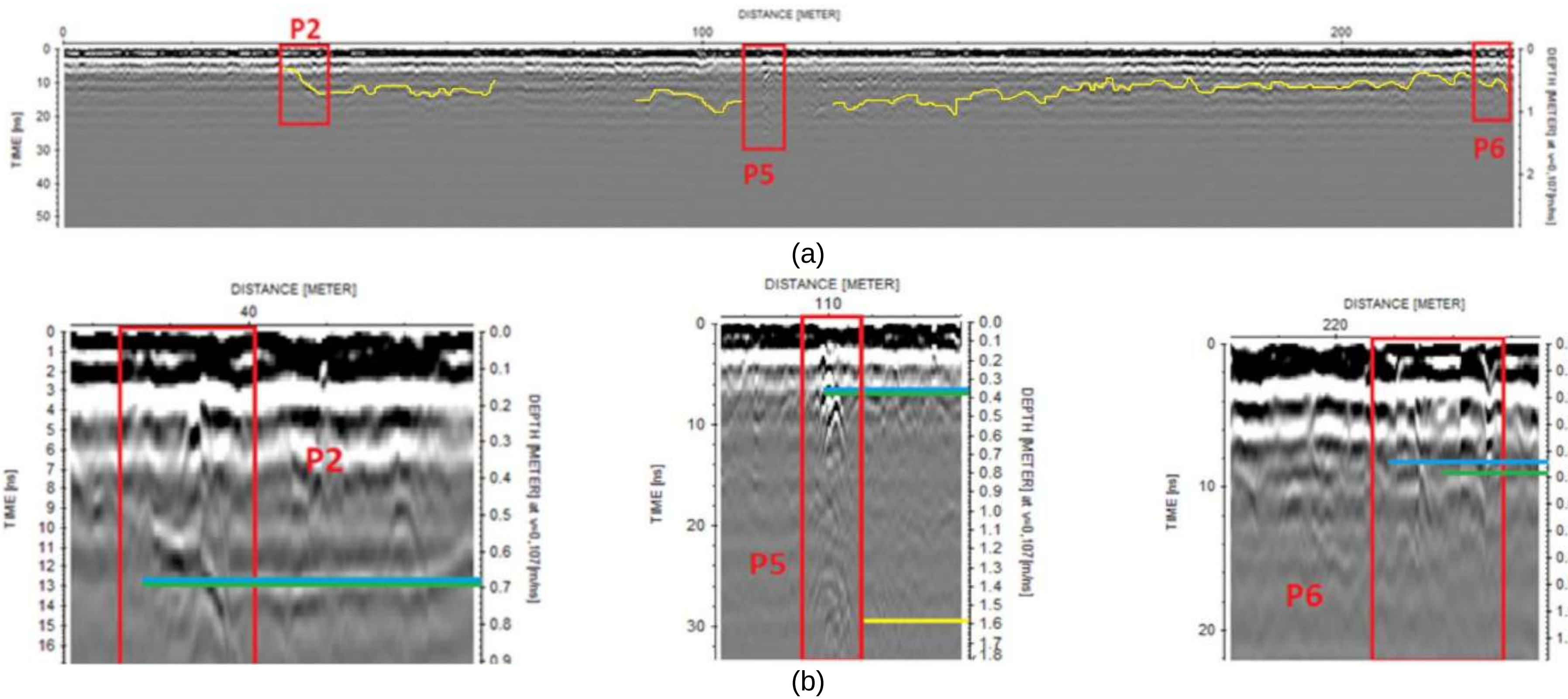

Figure 1. In (a), the transect radargram with the P2, P5, and P6 profiles (in red) and the top of the argillic horizon marked in yellow, when it is possible to be seen in the radargram. In (b) is represented the detail of each profile from the transect radargram. The blue bar in each radargram demarcates the hyperbola of the deepest iron rod in each profile, while the green bar represents the real depth seen in the field. In P2 and P6, the green bars are close to the actual depth of the base of the E horizon (69 and 44 cm depth, simultaneously). In P5, the yellow bar represents the base depth of the E5-to-Bt transition (at 1.58 m).

Conclusions

The iron rods supporting the 450 MHz antenna showed a good potential to identify argillic horizon where Planosols dominate in significant areas, especially when the E-to-B transitions are placed in shallower depths.

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