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METHODOLOGY EVALUATION OF PIN MICRORELIEF METER

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ABSTRACT: The effects of natural weathering and different managements performed in agriculture may best be understood by studying the soil roughness. The aim of this study was to evaluate the optimization of the use of pin microrelief meter, an instrument used to determine the soil surface roughness, as the number of readings collected over traditional methodology proposed in the bibliography. The study was conducted in Rio Paranaiba (MG), in a Haplustox soil. The experimental design was completely randomized in a 2x3 factorial design with four replications. There were combined two types of primary tillage: conventional tillage with disc plow (PCAD) and harrow (PCGA), and three amounts of readings (100, 200, and 300 reading points) sampled in each experimental unit. Independently of the soil tillage, disc plow and harrow, the collection of 100 readings using a pin microrelief meter of a square meter, was sufficient to determine the surface roughness before and after soil preparation, without accuracy loss compared with the traditional method.

KEYWORDS: mobilization, pin microrelief meter, roughness, soil tillage.

INTRODUCTION

Among the main agricultural equipments used by most properties in Brazil for conventional tillage stand out the disk plow and harrow. The action of the active organs of such equipments provides favorable conditions for root and consequently crop development in compacted soils (Deperon Júnior et al., 2016). However, this kind of soil tilling promotes alterations on the soil physical properties resulting in changes on the micro relief of the mobilized area (Castro et al., 2006), which can cause destabilization of the aggregate structure enhancing the erodibility of the topsoil.

The knowledge of micro relief or soil surface roughness can generate important information for interpretation of the effects caused by both human activities in function of the management adopted in the area (Panachuki et al., 2011; Panachuki et al., 2015), as by natural inclement weather as the climate, highlighting the need of studies to determine this parameter (Dalla Rosa et al., 2012; Tuo et al., 2016).

Basically, soil surface roughness could be determined by the elevation difference in relation to the ground surface over relatively short distances. Most part of the studies found in the literature that aimed evaluate this parameter are based on the methodology proposed by Allmaras et al. (1966) and described by Gamero & Benez (1990), which indicate the collection of 200 readings through a pin microrelief meter with coverage of one square meter area.

The pin microrelief meter, instrument used to roughness determination, is characterized to be simple, cheap, of easy use and acquisition, and it can even be built by the producers themselves. However, the time spent to collect the 200 recommended readings reduces the adoption practicality of this equipment on the field, characterizing it as a disadvantage.

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Information about the soil roughness are found in several studies involving different equipments that mobilize the soil; however, occurs in Brazil and in the international bibliography a lack of studies that compare methodologies in the use of pin microrelief meter.

Finally, studies that aim the improvement of the pin microrelief meter utilization in the field become necessary, given the importance of the micro relief determination, especially in periodically managed areas by soil tillage equipments. Thus, this research aims to evaluate the optimization of the pin microrelief meter use through the reduction of collected readings number over a traditional methodology.

SUBJECT DESCRIPTION

The experiment was developed in Rio Paranaiba (MG) county, in the coordinates 19° 12’ 43’’ S and 46°07’56’’ with altitude of 1128 m. The regional climate can be classified as Cwb according to the classification by the Köppen scale, which shows a humid temperate climate with two well defined seasons. The average temperature is 20.4°C and the average annual rainfall is 1570 mm. The soil was classified as Haplustox, with 31.0 g dm^{-3} of organic matter, 440 g kg^{-1} of clay and topsoil average density of 0.99 kg dm^{-3}.

The area used in the present study has been cultivated with annual crops since 2014, in conventional primary periodic tillage systems and direct tillage. On May, 2016 were evaluated the soil swelling, the mobilized area, the elevation area and the average thickness of the mobilized layer, before and after the primary conventional tillage generally adopted with disc plow (PCAD) and harrow (PCGA).

The experimental design was completely randomized with a factorial arrangement 2 x 3, with two kinds of primary soil tillage (PCAD and PCGA), combined with 3 readings quantities (100, 200 and 300 reading points) to determine the readings of the land elevation before and after the equipment utilization, with four repetitions, totaling 24 experimental units. These were composed of parcels of 100 m^2 (10 x 10 m), and between each parcel was left a maneuvering and regulation area of 10 x 10 m.

During the primary soil tillage, those equipments were used: disc plow, AF-3 model, BALDAN®, assembled and equipped with three flat concave disks (Ø 28” x 6.0 mm), with vertical angle of 20º, horizontal angle of 50º, cutting width of 900 mm, 402 kg mass, set to cut to 150 mm depth and working speed of 5.0 km h^{-1}; and a dragging intermediate harrow, GAC300 model, KÖHLER®, off set, equipped with 14 concave cut disks (Ø 30” x 6.0 mm), set to cut to 150 mm depth and working speed of 5.0 km h^{-1}. To pull the machines was used the New Holand TL85E, 4x2FWD tractor, with power of 88 cv and transmission 12 x 12 Power Shuttle. The soil moisture verified at the moment of the tillage was 14%. Thus, the periodic primary soil tillage followed the settings and procedures generally used in the rural property where the experiment was installed.

In each experimental unit, were made the surface micro relief readings using a pin microrelief meter of 1 m^2, containing 20 aluminum pins with 0.6 m length and 0.05 m equidistant. These pins were distributed along the principal bar of the reading equipment, which moves up to 10 positions parallelly of its original position, towards the planting line, which allows obtaining 200 readings in a 1m^2 area, as the methodology described by Gamero & Benez (1990) and indicated by Allmaras et al. (1966). After the acquisition of the 200 readings, the equipment was moved longitudinally, making the last reading point coincide with the first point of the new position, in order to obtain more 100 points, totalizing 300 readings in a 1.5 m^2 area.

In order that the pin microrelief meter was positioned and aligned at the same point before and after the soil tillage, two stakes were installed on the sides of the parcels to serve as a planimetric and altimetry reference to the equipment installation.

The roughness index was calculated as being the standard deviation of the heights, using the data of surface height before and after the soil tillage, without transformation and without eliminating the extreme values, by the method proposed by Kamphorst et al. (2000).

The elevation area calculation, mobilized area and average thickness of mobilized layer were obtained through the Simpson Rule (Equation 1):

$$\int_{X_0}^{Xn} f(x)dx = \frac{h}{3(f_0 + 4f_1 + 2f_2 + 4f_3 + 2f_4 + \cdots + 2f_{n-2} + 4f_{n-1} + f_n)} \tag{1}$$

with,

$$h = \frac{X_n - X_0}{n}, X_n > X_0$$

where,

n = intervals number;

f = elevation height (m);

h = distance between elevation (m), and

X = number of elevations.

After the obtainment of the mobilized area data, was determined the average thickness through the [eq. (2)]:

$$ATML = \frac{MA}{Cp} \tag{2}$$

where,

ATML = average thickness of mobilized layer (m);

MA = mobilized soil area (m^2), and

Cp = pin microrelief meter length (m).

The soil swelling (Equation 3) is the relation between the ground elevation area and mobilized area by the active organs of the equipment (Gamero & Benez 1990).

$$SS = \left(\frac{A}{MA}\right)x100 \tag{3}$$

where,

SS = soil swelling (%);

A = elevation area (m^2), and

MA = mobilized area (m^2).

To the analysis of the number of readings needed to the determination of the surface micro relief before and after soil tillage, was used as variable response the variation coefficient to each number of points in each experimental unit, calculated through [eq. (4)]:

$$VC = \frac{S}{\mu}x100 \tag{4}$$

where,

S = standard deviation, and

μ = average

The data were submitted under variance analysis (ANOVA) and, in significance presence, those were compared by the Tukey test in 5% probability.

Variability determination of the soil superficial microrelief as a function of different number of sampled points through the microrelief meter

The obtained variation coefficient results for the different numbers of sampled points showed no significant differences between them independently of the type of the soil tillage adopted in the experimental area. (Table 1). This result indicates that the usual adopted methodology for roughness index mensuration, mobilized area, elevation area, soil swelling, using as mensuration equipment the pin microrelief meter, initially indicated by Allmaras et al. (1966), and described by Gamero & Benez (1990), which recommended sampling of 200 points per meter squared, can be reduced by half of the readings numbers indicated by them (Table 1).

TABLE 1. Summary of variance analysis (ANOVA) to the variation coefficient (VC) of the soil roughness determined by different tillage (PCAD and PCGA) and number of readings (100, 200 and 300) through the microrelief meter.

Variation Factor (VF)	P-value
Number of readings (N)	0.973ns
Tillages (M)	0.111ns
Interaction (M x N)	0.906ns
VC (ANOVA)	1.17%

ns = not significant at the probability level of 1 and 5% respectively, by the F test of the variance analysis (ANOVA).

Although the pin microrelief meter is an easy acquisition and handling equipment, it shows as main limitation the data collection on field, for being laborious and slow (Turner et al., 2014). In this context, these devices have been substituted in the last years by more sophisticated devices that make the same measurements, as through laser for example (Thomsen et al., 2015) or through a pin microrelief meter with an attached high precision camera (Trudel et al., 2010). However, these new technologies, although having good precision and speed in evaluation, require a bigger financial investment, which can restrict its utilization by a small group of people of less purchasing power.

Influence of the different primary soil tillages on the initial and final roughness, mobilized area, elevation area, swelling, mobilized layer average thickness.

There was no significant difference for the mobilized area, average thickness of mobilized area, and neither for the roughness index before and after soil tillage in function of the collected points (Table 2).

TABLE 2. Initial roughness (IR), final roughness (FR), mobilized area (MA), elevated area (EA), swelling (S) and average thickness of mobilized layer (ATML) in function of soil tillages.

	Disk plow	Disk plow Harrow	Number of readings (N)	Tillage (M)	Interacion (M x N)
IR (mm)	9.080a	9.920a	7.770a	0.108ns	0.008ns
FR (mm)	25.400a	25.520a	19.840a	1.687ns	0.118ns
MA (m^2)	0.080a	0.081a	0.637ns	0.914ns	0.988ns
EA (m^2)	0.028a	0.014b	0.093ns	0.001**	0.953ns
S (%)	36.900a	19.820b	0.150ns	0.011*	0.949ns
ATML (m)	0.080a	0.081a	0.637ns	0.914ns	0.988ns

Averages followed by the same lower case, at the same column, do not differentiate between them by the Tukey test in 5%. ^{ns} not significant, $^{(**)}$, $^{(*)}$ significant in 1% and 5% probability, respectively, by the F test and variance analysis (ANOVA).

Although it is already known that the disk plow has a bigger capacity of mobilization when compared with the harrow (Carvalho Filho et al., 2008), in this present study, this difference was not detected. At the moment of soil tillage, the soil was slightly crumbly, showing 14% humidity, therefore, just below the ideal. According to Ros et al. (2011), the low humidity promotes a resistance increase of soil deformation, which may reflect in the action depth of the tillage equipments.

The average thickness of mobilized layer results indicates that both equipments did not reach the expected cutting depth by the adjustment. It demonstrates the importance of determining those parameters as a routine in the agricultural activities, especially in places that adopt conventional tillage, once the producer can check with more precision the adjustment efficiency of the used equipments on the soil tillage. The cutting depth bellow the necessary can affect the fertilizers and others products incorporation, as well as the root development (Bengough et al., 2011), which can reflect on the final crop productivity.

Elevation area and soil swelling results demonstrate that independently of the number of readings made on the field through the pin microrelief meter, the tillage with disk plow is more expressive in promoting modification in relation to the natural soil profile when compared with harrow (Table 2), corroborating with the data obtained by Carvalho Filho et al. (2007) which verified that the disk plow and moldboard plow promoted bigger soil mobilization, breaking deeper layers when compared with harrow.

It should be noted that the no detection of significant differences between the number of readings made through the pin microrelief meter neither the observance of significant interaction between the factors under study show again that obtaining 100 readings would be enough to collect the parameter information needed to the determination of surface soil micro relief before and after the tilling promoted by the actives equipment organs.

CONCLUSIONS

The present study showed that independently of the soil tillage, disk plow or harrow, the collection of 100 readings through a pin microrelief meter was enough to the surface micro relief determination, before and after the tillage, with no precision loss in relation with the traditional method.

This study offer an adaption of the traditional methodology reducing the readings to 100 samples readings by a pin microrelief meter, providing an optimization on the work in the field.

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