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VALIDATING EQUATIONS TO ESTIMATE SUBFACTOR C_{iII} FOR CORN RESIDUE COVER

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ABSTRACT

Erosion is one of the main causes of soil degradation. Model validation is a vital step in developing a valid and applicable tool to predict soil erosion. The aim of this study was to evaluate models that predict the cover and management subfactor (C_{iII}) for interrill erosion. A full factorial design was used, with five doses of corn residue (0; 0.05; 0.15; 0.40 and 0.80 kg m^{-2}), four slope gradients (5.2%; 10.6%; 15.3% and 36.4%) and two repetitions, under simulated rainfall. D_i and the C_{iII} were assessed in 0.5 x 0.75 m experimental plots, with recently tilled soil. Soil loss at a 5.2% slope gradient with no soil cover was 458.30 kg ha^{-1}, which could be lowered to 67.13 kg ha^{-1} by using 90 % cover with corn residues. The soil lost in the treatment without cover at a 36.4% gradient could be reduced 7 times by adopting 90% soil cover. The equations $C_{iII} = e^{-2.50\ CS/100}$, $C_{iII} = e^{-2.33\ CS/100}$ and $C_{iII} = e^{-2.238\ CS/100}$ generated good estimates for C_{iII}, despite overestimating the subfactor in relation to the actual values recorded. The results also demonstrated that corn stover is effective at reducing interrill erosion.

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INTRODUCTION

Erosion is not only a geological process, but one of the main causes of soil degradation worldwide. Agricultural practices have intensified erosion rates in relation to soil production (Amundson *et al*., 2015; Xie *et al*., 2019). Almost 40% of the Earth's soil is used for agriculture (Foley, 2017, Alewell *et al*., 2019), and worsening soil erosion is a major challenge for sustainable development. Research has focused on predicting erosion risks in agricultural areas and developing less aggressive soil management techniques. Soil erosion is a complex phenomenon to study since it involves climate, soil, topography and management aspects. As such, several models have been proposed to predict erosion:The Universal Soil Loss Equation (USLE) by Wischmeierand Smith (1978); Revised Universal Soil Loss Equation (RUSLE) by Renard *et al*. (1997); and the Water Erosion Prediction Project (WEPP) developed by an interagency team from the United States Department of Agriculture (USDA) and Agricultural Research Service (ARS) in 1985 (Flanagan *et al*., 2007). In order to apply these models, there is a need for studies that relate plant cover to erosion processes, such as those by Martins Filho *et al*. (2009), Xin *et al*. (2016) and García-Gonzalez *et al*. (2018).

Plant cover is the single most important factor in dissipating the kinetic energy of rain (Cogo *et al*., 1984; Panachuki *et al*., 2011; Almeida *et al*., 2016); in addition to preventing splash erosion, it also reduces runoff speed, helping to improve water infiltration and maintain soil surface roughness (Brown and Norton, 1994; Lal, 1998; Wilson *et al*., 2004; Xin *et al*., 2016). There are three ways in which plant cover can reduce soil erosion (Foster, 1982; Martins Filho *et al*., 2004): 1) the plant canopy intercepts raindrops (C_{iI},effect I); 2) plant residue comes into direct contact with the surface (C_{iII},effect II) and 3) plant residue is incorporated into the soil (C_{iIII}, effect III). The relationship between the detachment rate and plant cover in interrill erosion has been modeled according to Bradford and Foster, 1996:

$$D_i = K_i\, R\, I\, S_f C_i \tag{1}$$

where D_i is the interrill erosion rate (kg m^{-1} s^{-1}); K_i the interrill erodibility (kg s^{-1} m^{-4}); R the runoff rate (m s^{-1}); the rainfall intensity (m^{-1} s^{-1}); S_f the slope factor and C_i the soil cover coefficient. Factor C_i is the product of a combination of subfactors and, according to Foster (1982), can be calculated as follows:

$$C_i = C_{iI} C_{iII} C_{iIII} \tag{2}$$

where C_{iI} is related to the cover provided by the plant canopy; C_{iII} to plant residue cover on the soil surface and C_{iIII} the effect of incorporating plant residue in the soil as a function of its use and management. According to Martins Filho *et al*. (2004), when soil cover consists only of plant residue, the cover and management factor (C_i) is equal to subfactor C_{iII} (effect 2), in which case subfactors C_{iI} and C_{iIII} have unit values. Due to the presence of crop residue on the soil surface, Laflen *et al*. (1985) proposed the following equation to estimate C_{iII}:

$$C_{iII} = e^{-2.5\, CS/100} \tag{3}$$

where $C_{iII}$is the soil cover subfactor for crop residue; e the base of natural logarithms; and CS the percentage of interrill surface covered by residue. Braida and Cassol (1999) used the following equation to calculate C_{iII} for corn cover crops:

$$C_{iII} = e^{-2.33\, CS/100} \tag{4}$$

However, in a study by Martins Filho *et al*. (2004), the authors proposed a novel equation to obtain C_{iII} for corn cover crops, as follows:

$$C_{iII} = e^{-2.238\, CS/100} \tag{5}$$

Studies aimed at estimating subfactor C_{iII} as well as calibrating and validating models for this purpose are still scarce. Calibration and validation of soil erosion models are important because they enable parameters to be adjusted to minimize errors and demonstrate whether a model is capable of making accurate predictions for a specific situation. As such, the aim of the present study was to determine subfactor C_{iII} for corn residue cover; assess the effect of corn residue cover on reducing interrill erosion and validate equations presented in the literature to estimate C_{iII}.

MATERIAL AND METHODS

The study was conducted in red latosol, in an experimental area at the Teaching, Research and Production Farm (FEPP) of São Paulo State University's (UNESP) School of Agricultural and Veterinary Sciences, in Jaboticabal, São Paulo state (SP), Brazil. The experimental area was kept clear of vegetation and plant residue for 12 months. A completely randomized full factorial design was used, with five levels of corn residue, four slope gradients and two repetitions, totaling 40 plots. The plots (0.50 m wide by 0.75 m long; 0.38 m^2) were delimited using steel sheets on the sides and upper border, with a gutter along the lower border leading to a 0.10 m outlet. Seven days before the tests, the soil was plowed once and lightly diskedtwice, following the slope gradient. The average gradients used were 5.2; 10.6; 15.3 and 36.4%.

A previously leveled and calibrated rotating-boom rainfall simulator with veejet 80100 nozzles was used to simulate rain and produce eroded sediments between the rills of the plots, as proposed by Swanson (1965). Rainfall intensity was determined by 36 rain gauges aligned in the direction of the slope, as described by Martins Filho *et al*. (2004). Twenty-four hours prior to testing, 55.0 mm h^{-1} of rain was applied for 20 minutes to evenly wet the soil. Plastic shade netting was used to dissipate the energy of the raindrops in the plots and prevent damage to the soil surface. Next, the plots were covered with canvas sheeting to prevent water loss through evaporation and potential damage from natural rain storms. For the final test, five doses (0.00; 0.05; 0.15; 0.40 and 0.80 kg m^{-2}) of corn stover were distributed over the surface and borders of each plot, in line with the relevant treatments. The stover was obtained from a maize crop grown in the experimental area, which was harvested and taken to the laboratory for grinding.

The percentage soil area covered was assessed using a 0.50 m graduated ruler, based on the method described by Adams and Arkin (1977). After 24 hours of rainfall at 55.0 mm h^{-1}, a further 60 minutes of rain was applied at an average intensity of 66.7 mm h^{-1} for 60 minutes. A second round of rainfall simulations was performed in another 20 plots, using the same treatments and experimental procedures described for the first set, as shown in Figure 1.

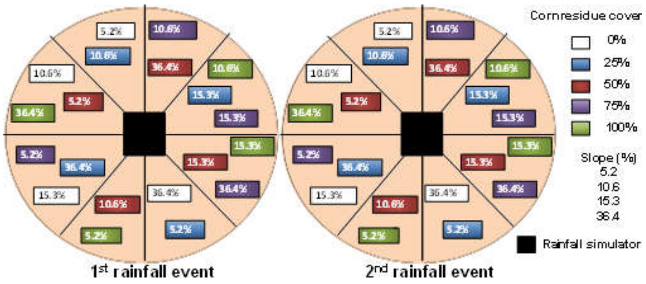

Figure 1. Schematic diagram of plot distribution in the area of the rainfall simulator

Sampling was performed in the fifth minute of rain simulation and every five minutes thereafter, in order to measure sediment concentrations and runoff flow rate. The samples were collected in glass containers, and collection time was recorded. Next, the containers were sealed and sent to the laboratory for quantification of sediment concentration and solution volume in order to determine soil (D_i) and water loss rates (R). Statistical analyses were performed using STATISTICA software (Statsoft, 1994). Validation of the models used here involved measuring the accuracy of the estimates obtained by analyzing their agreement with the actual values measured in the field. The same software was also used for analysis of variance, and linear and nonlinear regression. Validation tests for models proposed in the literature were based on the statistical parameters described by Loague and Green (1991),Lengnick and Fox (1994) and Vanuytrecht *et al*. (2016), as follows:

Root mean square error (RMSE),

$$RMSE = \left[\sum_{i=1}^{n} (P_i - O_i)^2\right]^{0.5} \tag{6}$$

Relative root mean square error (RRMSE),

$$RMSE = \left[\sum_{i=1}^{n} (P_i - O_i)^2\right]^{0.5} \left(\frac{100}{O}\right) \tag{7}$$

Efficiency (EF),

$$EF = \left[\sum_{i=1}^{n} (O_i - O)^2 - \sum_{i=1}^{n} (P_i - O_i)^2\right] / \sum_{i=1}^{n} (O_i - O)^2 \tag{8}$$

Mean Difference (MD),

$$MD = \sum_{i=1}^{n} (P_i - O_i)/n \tag{9}$$

where O_i is the measured value; P_i the predicted value; i the index from 0 to n; n the sample space and O the mean of the measured values. Since there is no established standard for model validation, when the predicted and measured values were the same, the values of RMSE, EF and MD were considered to be 0; 1; and 0, respectively.
The accuracy of RRMSE can be classified in terms of simulation performance as: < 10% excellent; 10-20% good; 20-30% weak; and >30% poor (Jamieson *et al*. 1991). The effect of corn residue cover in direct contact with the soil (subfactor C_{iII}) was determined using model (1) ($C_{iII} = D_i / (K_i\ I\ R\ S_f)$), where D_i is the average interrill

erosion rate in the plots with soil cover, obtained in the last 20 minutes of runoff sampling. The D_i values measured in plots without soil cover in the final 20 minutes of runoff sampling were used to establish interrill erodibility (K_i). The slope factor (S_f) was determined as reported by Martins Filho *et al*. (2003):

$$S_f = 1.061 - 1.037\, e^{-4\,\text{sen}\,\theta} \qquad (10)$$

where e is the base of natural logarithms and θ the slope angle in degrees.

RESULTS

Soil losses declined significantly as soil cover increased (Table 1). Soil loss at a 5.2% slope gradient with no soil cover was 458.30 kg ha-1, which could be lowered to 67.13 kg ha-1 by using 90 % corn residue cover. The steepest gradient (36.4%) was responsible for the highest soil losses at all levels of soil cover (Table 1). However, the 1,448.33 kg ha^{-1} of soil lost in the treatment without cover at a 36.4% gradient could be reduced to 188.67 kg ha^{-1} by adopting 90% soil cover (Table 1). In the absence of soil cover, the highest and most significant soil losses occurred at slope gradients of 36.4 and 15.3%, in this order (Table 1). The decline in soil loss (SL) was proportionally greater at gradients of 15.3 and 36.4% with low soil cover (SC) percentages, since there was a significant reduction in SL from 25% SC onwards in relation to 0% SC (Table 1). Figure 2 shows a graphic representation of the experimental data and equations obtained, which demonstrate the exponential decline in SL as a function of SC.

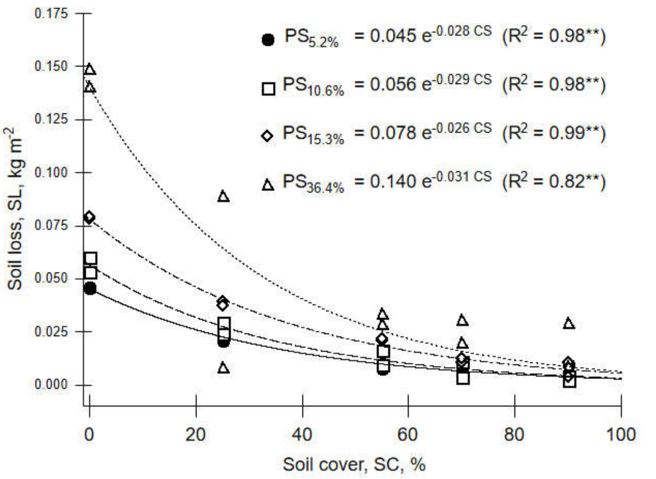

Figure 2. Soil loss (SL) by interrill erosion as a function of slope gradient (%) and soil cover (SC) in the form of corn stover. Where d% = 5.2%; 10.6%; 15.3%; 36.4%

The results of adjusted regression (Figure 2) were $R^2 \geq 0.98$ for slopes of 5.2 to 15.3% and 0.82 at 36.4%. The average values for estimated and measured C_{iII} predicted by Eqs. (3), (4) and (5) are shown in Table 2, indicating a rise in percentage soil cover as the amount of corn residue applied increased. Sub factor C_{iII} estimates obtained with Eqs. (3), (4) and (5) only differed significantly from the measured average values at a slope of 36.4% with 25% soil cover. However, analysis of the different gradients indicated that applying 0.05 kg m^{-2} of corn residue provided coverage of 25%, that is, the area exposed to direct raindrop impact declined by 25%. If interrill erosion only declined due to the exposed area, there would be a 25% reduction in erosion rates. However, considering that the C_{iII} value in this treatment was 0.46 at a slope gradient of 5.2% (Table 2), it can be concluded that this level of coverage decreased soil losses by 54% when compared to no soil cover and that the highest corn residue dose (0.80 kg m^{-2}) reduced losses by 86% (Table 1).

At a slope of 10.6%, C_{iII} obtained with a dose of 0.05 kg m^{-2} was 0.48 (Table 2). As such, there was a 52% decrease in soil loss under these conditions and the application of 0.80 kg m^{-2} reduced erosion by 94% at this gradient when compared to the treatment with no soil cover (Table 1). At an average slope of 15.3%, a C_{iII} value of 0.27 was recorded for a corn stover dose of 0.15 kg m^{-2} (Table 2). Given that the subfactor was 1.00 in the treatment without soil cover, it can be concluded that this coverage level reduced soil losses by 73%, with a 91% decrease at a dose of 0.80 kg m^{-2} (Table 1). A C_{iII} value of 0.21 was recorded at a corn residue dose of 0.15 kg m^{-2} and 36.4% slope (Table 2), that is, erosion declined to 21% when compared to the treatment with no soil cover. As such, interrill erosion decreased by 79% when 0.15 kg m^{-2} of corn stover was applied to the soil surface (Table 1), reaching 87% at a dose of 0.80 kg m^{-2}.

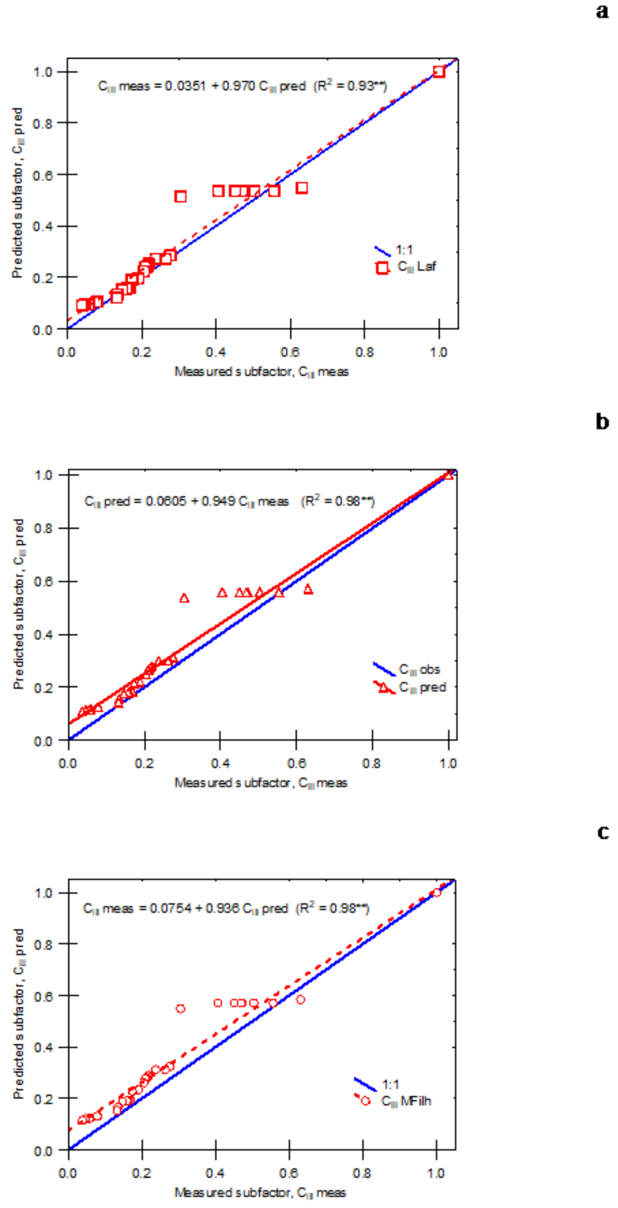

Figure 3. Measured and predicted values for subfactor C_{iII}: A) Eq. (3); B) Eq. (4); C) Eq. (5).

The results presented in Table 2 support the generalized use of Eqs. (3) to (5) to estimate sub factor C_{iII}. Figure 3 shows the measured and predicted C_{iII} values obtained with Eqs. (3), (4) and (5), demonstrating that all three equations tend to overestimate the actual values. The RMSE values of 0.050; 0.063 and 0.071 (Table 3) obtained with Eqs. (3) to (5), respectively, indicate good reliability and quality for estimated versus measured values. With respect to RRMSE, Eqs. (3) to (5) exhibited good performance in estimating C_{iII} (Table 3), with RRMSE between 10 and 20%, according to the criteria described by Jamieson *et al*. (1991).

Table 1. Soil loss (SL) by interrill erosion as a function of slope gradient and soil cover (SC) in the form of corn stover

Slope	Soil cover, SC, %				
	0	25	55	70	90
%	------------------------	------------------------	Kg m^{-2}	------------------------	------------------------
5.2	0.045830 aC	0.021073 abA	0.008913 bA	0.007362 bA	0.006713 bA
10.6	0.056540 aBC	0.026925 abA	0.012962 bA	0.007364 bA	0.003269 bA
15.3	0.078527 aB	0.038318 bA	0.021224 bA	0.011420 bA	0.007073 bA
36.4	0.144833 aA	0.048473 bA	0.030925 bA	0.025106 bA	0.018867 bA

Means followed by the same lower case letter in the row and upper case letter in the column do not differ significantly according to Duncan's test at 5%.

Table 2. Average estimated and measured C_{iII} values

Slope	Dose	Soil cover (SC)	C_{iII}measured	C_{iII}Eq.(3)	C_{iII}Eq.(4)	C_{iII}Eq.(5)
%	Kg m^{-2}	%				
	0	0	1.000 a	1.000 a	1.000 a	1.000 a
5.2	0.05	25	0.460 a	0.524 a	0.548 a	0.561 a
	0.15	55	0.195 a	0.263 a	0.288 a	0.302 a
	0.40	70	0.161 a	0.177 a	0.199 a	0.212 a
	0.80	90	0.147 a	0.120 a	0.139 a	0.150 a
	0	0	1.000 a	1.000 a	1.000 a	1.000 a
10.4	0.05	25	0.481 a	0.535 a	0.559 a	0.571 a
	0.15	55	0.234 a	0.231 a	0.255 a	0.269 a
	0.40	70	0.135 a	0.126 a	0.145 a	0.157 a
	0.80	90	0.059 a	0.102 a	0.119 a	0.129 a
	0	0	1.000 a	1.000 a	1.000 a	1.000 a
15.3	0.05	25	0.488 a	0.542 a	0.565 a	0.578 a
	0.15	55	0.270 a	0.267 a	0.292 a	0.306 a
	0.40	70	0.145 a	0.158 a	0.179 a	0.192 a
	0.80	90	0.090 a	0.093 a	0.109 a	0.119 a
	0	0	1.000 a	1.000 a	1.000 a	1.000 a
36.4	0.05	25	0.343 b	0.535 a	0.559 a	0.571 a
	0.15	55	0.214 a	0.257 a	0.281 a	0.296 a
	0.40	70	0.175 a	0.160 a	0.181 a	0.193 a
	0.80	90	0.132 a	0.109 a	0.127 a	0.137 a

Means followed by the same letter in the row do not differ significantly according to Duncan's test at 5%.

Table 3. Performance parameters of Eqs. (3), (4) and (5) in predicting subfactor C_{iII}.

Equation	RMSE	RRMSE (%)	EF	MD
(3)	0.050	12.983	0.98	0.024ɨ
(4)	0.063	16.216	0.97	0.041ɨ
(5)	0.071	18.463	0.96	0.051ɨ

RMSE: root mean square error; EF: model efficiency; MD: mean difference;ɨ does not differ statistically from zero according to the t test at 5% significance

In terms of efficiency (EF), it can be inferred that Eq. (3) displayed the highest EF and Eq. (5) the lowest (Table 3), meaning the former was more efficient (3). Mean difference (MD) > 0.0 demonstrates that the actual C_{iII} values were overestimated in the predicted measures obtained by Eqs. (3), (4) and (5). However, MD values did not differ significantly from 0.0 in any of the cases tested according to the t test ($p < 0.05$), although the lowest MD was obtained with Eq. (3).

DISCUSSION

Soil losses due to water erosion: Plant residue spread over the soil surface reduces particle detachment by decreasing the area directly exposed to the impact of raindrops, which lowers sediment concentration in the runoff and reduces soil erosion, as observed by Dickey *et al.* (1985), Silva *et al.* (2012) and Rocha Junior *et al.* (2018). This is corroborated by the results presented in Table 1, whereby the presence of corn stover on the soil surface significantly reduced interrill erosion from 33.5 to 91.2 % at slope gradients of 5.2% and 36.4% when compared to no soil cover. The highest and most significant soil losses, obtained in treatment with no cover, were largely due to the formation of a seal or crust on the soil surface. When soil is wet or exposed to the direct action of rainfall, as occurred in the present study, a surface seal forms, which dries into a crust (Yan *et al.*, 2015; Xin *et al.*, 2016) that significantly reduces water infiltration, thereby increasing surface runoff and water erosion (Assouline, 2004; Armenise *et al.*, 2018).

Previous studies have reported a rise in water erosion as slope gradient increases (Foster and Martin, 1969; Kinnell, 2000; Assouline and Ben-Hur, 2006; Donjadee and Chinnarasri, 2012; Zhao *et al.*, 2015; Wu *et al.*, 2018). However, soil erosion does not rise continually with increases in slope gradient, since there is a critical gradient at which runoff and erosion behavior change (Ma *et al.*, 2019). Thus, other authors have observed a decline in water erosion as slope gradient increases (Horton, 1945; Liu *et al.*, 2001). Due to differences in research methods, soil properties, prevailing hydrometeorological conditions and farming practices etc., the critical gradient varies significantly among studies (Ma *et al.*, 2019).

The critical gradient has been estimated to vary from 41.5° to 50° (Liu *et al.*, 2001); however, values below 30° (< 58%) have been obtained under laboratory and simulated rainfall conditions (Fu *et al.*, 2011; Zhang *et al.*, 2017). The critical gradient for soil erosion on a slope depends on particle size, soil density, surface roughness, duration of the rainfall event, excess rain on the surface of the area studied and the friction coefficient of soil, etc. (Liu *et al.*, 2001 and Ma *et al.*, 2019). As such, a critical gradient was not reached in the present study since the slope gradient ranged from 3 to 20° (5.2 to 36.4%) with a respective increase in soil erosion. In Brazil, maize cultivation areas generally have a slope gradient of less than 12% (6.8°) in order to facilitate mechanical harvesting. Thus, our results are consistent with cultivation conditions in the country and the effects of slope steepness on water erosion for mild gradients (< 10°), such as those studied by Kosmas *et al.* (1997) and Assouline and Bem-Hur (2006), that is, with a gradient of less than 18%. In our study, the highest soil losses were recorded at a slope gradient of 36.4% (~20º), since steepness significantly influences SL by interrill erosion. These findings (Table 1) are similar to those reported in other studies (Kateb *et al*., 2013; Fang *et al*., 2015; Wu *et al*., 2018), which demonstrated a rise in soil erosion as slope gradient increased. The high and significant soil losses observed for steeper slopes (15.3 and 36.4%) without soil cover indicate that, above 15.3% (~27º), the gradient is relevant in interrill erosion when soil is completely exposed. This corroborates the findings of Martins Filho *et al*. (2004) and Martins Filho *et al*. (2009). By contrast, plant residue on the soil surface reduces the velocity of interrill water flow because soil cover generally raises the hydraulic roughness of the surface, thereby increasing flow depth (Foster, 1982). Crop residue dissipates the kinetic energy of rain and, to some extent, runoff, lowering flow velocity and preventing soil detachment and sediment transport (Engel *et al*., 2009; Rodríguez-Caballero *et al*., 2012). The significant reductions in soil loss of 49 and 33% at slope gradients of 15.3 and 36.4% (Table 1), respectively, at the lowest coverage level (25%) confirm the effectiveness of plant residue cover in decreasing the transport capacity of surface flow and sediment concentration in the runoff. Similarly, another study demonstrated that a 20% soil cover in corn residue reduced soil erosion by more than 50% when compared to a no-till surface (Dickey *et al*., 1985). Conservation tillage is defined as a system that leaves 30% or greater crop cover on the soil surface. Thus, our results may be significant for soil conservation plans in areas planted with maize at slope gradients above 15.3%. There was an exponential decline in soil loss (SL) for all the slopes as a function of increased soil cover (Figure 2). This result is similar to those reported by Cantalice *et al*. (2009) and Martins Filho *et al*. (2004), who also observed a relationship between SL and SC with sugarcane and corn residue, respectively.

In the equations adjusted for erosion (SL) as a function of soil cover (SC) (Figure 2; $SL = a\ e^{b\ SC}$, where a and b are constant), with and without corn residue, b values varied from -0.026 to -0.031, which is within the stipulated ranges of -0.03 to -0.07 (Laflen *et al*., 1980; Laflen and Colvin, 1981 and Dickey *et al*., 1985) and -0.0235 to -0.0816 for cultivated areas (Gyssels *et al*., 2005). The values for intercept a indicate soil losses due to erosion in the absence of cover, and were 32, 39 and 54% lower for slopes of 5.2, 10.6 and 15.3%, respectively, than the intercept value at a gradient of 36.4%.

Subfactor C_{Iii}estimates: In regard to subfactor C_{iII} predictions (Table 2), our findings differ from those obtained by Martins Filho *et al*. (2004), who found significant differences between measured and predicted C_{iII} values obtained by Eq. (3) for crop residue doses of 0.05 to 0.80 kg m^{-2} at a slope gradient of 36.4%. The authors recommended that further research be conducted for medium slopes of 36.4% to ensure better calibration for C_{iII} predictions on steeper slopes. According to Braida and Cassol (1999), the decline in soil loss reflected by C_{iII}values in the treatments was due to the effect of crop residue on sediment transport by surface runoff and a possible decrease in detachment resulting from greater flow depth, as well as the direct effect of the residue on the soil. The tendency of all three equations to overestimate measures (Figure 3) highlights a key point in statistical modeling. According to Garosi *et al* (2019), assessing the results obtained is generally the most important stage in the modeling process. As such, accuracy and precision measures such as R^2, RMSE, EF and MD reflect differentiation and reliability as aspects of the performance Eqs. (3) to (5) in estimating subfactor C_{iII} (Table 3).
The RMSE values obtained were close to zero, whereas Loague and Green (1991) report they should ideally be zero. The accuracy of RRMSE can be classified in terms of simulation performance with Eqs. (3) to (5), according to the criteria of Jamieson *et al*. (1991). All three equations exhibited good performance in estimating subfactor C_{iII} (Table 3). Model efficiency (EF) assesses not only the linearity of the values obtained, but the relative differences between measured and estimated values (Risse *et al*., 1993). This parameter compares the measured values to the 1:1 line (Figure 3), where measured and estimated values are equal. An efficiency value of 1.0 indicates a perfect model, which was not the case here. The EF measure indicates whether a model describes data better (EF>0) than simply the mean of measured values (Movedi *et al*., 2019). It is equivalent to Nash-Sutcliffe efficiency (Ali and Abustan, 2014), with authors such as Moriasi *et al*. (2007) providing the following model ratings: EF > 0.65, very good; 0.54 to 0.65, adequate; and 0.5 to 0.54, satisfactory. In this respect, the equations tested here obtained EF > 0.65, indicating very good performance in estimating C_{iII} (Table 3). According to Lengnick and Fox (1994), a positive signal for MD indicates, on average, that predicted values overestimate measured values (Table 3). However, the lack of a significant difference between the MD values obtained by Eqs. (3), (4) and (5) mean that the standard deviations between measured and estimated C_{iII} values do not enable us to infer which is the best equation.

CONCLUSION

The results demonstrated that equations $C_{iII} = e^{-2.50\ SC/100}$, $C_{iII} = e^{-2.33\ SC/100}$ and $C_{iII} = e^{-2.238\ SC/100}$ generated good C_{iII}estimates for corn residue used as soil cover (SC), despite overestimating predictions when compared to actual values. Corn stover is effective at reducing interrill erosion used as soil cover, as reported in the literature. This is corroborated by our findings, since the lowest soil coverage (25%) confirmed the effectiveness of corn residue cover in reducing the transport capacity of surface runoff as well as sediment concentration.

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