

STABLE INFILTRATION RATE IN A YELLOW RED ARGISSOL IN CORN CROP AND GUANDU COVERAGE

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ABSTRACT: This research was carried out in an area in the rural campus of the Federal University of Sergipe (UFS), which studies the impact of soil management changes on production and physical soil attributes during fifteen years. The area was divided into three portions, treated with no-tillage, minimum tillage and conventional tillage. The aim of this work was to compare the stable infiltration rate in a yellow red Argisol in different managements and in a succession of sweet corn and guandu as soil cover, analyzing the impact of the agricultural use and the suitability of the Horton models (1940), Kostiakov (1932), Kostiakov-Lewis (1945) and Phillip (1957). The stable infiltration rate was determined in each plot using the double concentric ring methodology. The VIBK software was used to determine the estimated values of the stable infiltration rate by the mathematics models. In order to evaluate the performance of the infiltration values obtained in the field in relation to the values calculated by the models, comparative analyzes of the results were performed statistically through the determination coefficient (R^2). Statistical indices were also determined, such as residual mass coefficient (RMC), coefficient of adjustment (CA) and efficiency (EF). Within the limitations of each model, all generated statistically equivalent results, with the exception of the Kostiakov-Lewis model. It was concluded that milder forms of management provided higher rates of basic infiltration, mathematical models fit better on soils that suffered less anthropogenic action, and the Philips model was better suited to local conditions.

KEYWORDS: minimum tillage, no-tillage, conventional tillage.

VELOCIDADE DE INFILTRAÇÃO BÁSICA EM UM ARGISSOLO VERMELHO AMARELO NO CULTIVO DE MILHO E COBERTURA DE GUANDU

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RESUMO: Esta pesquisa foi realizada em uma área do campus rural da Universidade Federal de Sergipe (UFS), que estuda o impacto das mudanças de manejo do solo sobre a produção e atributos físicos do solo durante quinze anos. A área foi dividida em três parcelas preparadas com plantio direto, cultivo mínimo e plantio convencional. Objetivou-se em comparar a velocidade de infiltração básica em um Argissolo vermelho amarelo em diferentes manejos e em uma sucessão de milho doce e guandu, como cobertura do solo, analisando o impacto do uso agrícola e a adequação dos modelos matemáticos de Horton (1940), Kostiakov (1932), Kostiakov-Lewis (1945) e Phillip (1957). A velocidade de infiltração básica foi determinada em cada parcela utilizando a metodologia dos duplos anéis concêntricos. Para determinação dos valores da velocidade de infiltração básica pelos modelos matemáticos foi utilizado um software denominado VIBK e para avaliar o desempenho entre os valores da infiltração obtidos em campo em relação os valores calculados através dos modelos, foram realizadas análises comparativas dos resultados estatisticamente através do coeficiente de determinação (R^2). Para tornar a análise mais eficiente, também foram calculados os seguintes índices estatísticos: coeficiente de massa residual (CMR), coeficiente de ajuste (CA) e eficiência (EF). Dentro das limitações de cada modelo, todos geraram resultados estatisticamente equivalentes, com exceção do modelo de Kostiakov-Lewis. Concluiu-se que formas de manejos mais brandas proporcionaram maiores taxas de infiltração básica, os modelos matemáticos se ajustaram melhores em solos que sofreram menos ação antrópica e o modelo de Philips se adequou melhor as condições do local.

PALAVRAS CHAVE: cultivo mínimo, plantio direto, plantio convencional.

INTRODUCTION

The infiltration of water in the soil is the phenomenon consists of the passage of water from the surface to the interior of the soil, initially filling the macropores and with its saturation is started filling the micropores, until all the soil saturates, this behavior causes Its initial velocity is high and decreases with time, becoming constant at the moment of total soil saturation, the term basic infiltration velocity (VIB) is used for the stationary velocity reached at saturation. (SOBRINHO et al., 2003) and (ZAKWAN; MUZZAMMIL; ALAM, 2016).

The decrease in soil aggregation and soil stability leads to higher rates of soil water infiltration (NERIS et al., 2012), but in conventional soil tillage systems, infiltration tends to be larger soon after tillage on account of the soil agitation and subsequently decays and with

the growth of the cover the water infiltration velocity in the soil tends to increase again, especially at the end of the crop, when the roots are well developed (CARVALHO et al., 2015).

Driven by the wide diversity of soils in the world and the ambition to find a model that best simulates the natural conditions of the environment, numerous comparisons were made with infiltration models in an attempt to evaluate their adequacy, since the adequacy of the infiltration model for Determined location is subject to soil type and field conditions (ZAKWAN; MUZZAMMIL; ALAM, 2016). The conclusions about the best model are diverse, CARVALHO et al. (2015), concluded in their experiments that the methodology proposed by Horton is the most efficient, since CUNHA et al. (2015) concluded that the Kostiakov methodology expressed better The process of infiltration.

The aim of this work was to compare the stable infiltration rate in a yellow red Argisol in different managements and in a succession of sweet corn and guandu as soil cover, analyzing the impact of the agricultural use and the suitability of the Horton models (1940), Kostiakov (1932), Kostiakov-Lewis (1945) and Phillip (1957).

MATERIAL AND METHODS

It was used as basis for this work an experiment conducted in an experimental area of the Experimental Station of the Federal University of Sergipe, located in the city of São Cristóvão - SE, the region has an average rainfall of 1200 mm per year, with rainfall concentrated in the months of April to September. The area of the experiment is 3000 m² and its soil is classified as Red Yellow Argisol, the experiment exists since the year 2001 and consists of the planting of sweet corn (*Zeamays L.*) variety Biomatrix BM 3061 in succession with the cultivation of guandu (*Cajanus Cajan*), Figure 1, used only as soil cover, and studies the effects on the soil of three agricultural management systems of different intensity.

The area was divided in three bands, each one referring to a cultivation system, in the first one the conventional cultivation was used, where the disc leveling grid and the disk plowing were used, in the second range the minimum cultivation, which used only the Grading grid for soil revolution at the end of the harvest or in weed cases and in the last no-till, which does not use any agricultural machinery and each band was divided in subplots that measure 60 m², using the scheme of experimental bands.



Figure 1. Cover of guandu in a plot of conventional planting.

In the infiltration tests, double rings infiltrometers were used, consisting of two concentric rings, the largest one with 40 cm in diameter and the smallest one with 20 cm, both with a height of 40 cm. The tests were carried out after a period of at least three days of drought, so that the high humidity did not reduce the test time and influence the formation of the infiltration curve, since more sharp curves allow a better evaluation by the mathematical models.

As the objective was to compare the variation caused by soil management, the infiltration tests were performed as homogeneously as possible, so both discs were installed at 5 centimeters depth and the blade of the internal disc, where the readings were taken, were kept in a range of 10 to 15 centimeters, the readings also had predetermined intervals and at the end of each reading the sheet was returned to the height of 15 centimeters, in order to avoid a great variation in the hydraulic height, once the readings were repeated in a continuous interval of 20 minutes the test was finished. The tests lasted between 122 and 182 minutes.

The entire calculation process was carried out by software *VIBK* (SANTOS et al., 2015). In this program the Horton, Kostiakov, Kostiakov-Lewis and Philips models were implemented, equations 1 to 4, described by Brandão (2006).

Modelo de Horton:

$$I = i_f + (i_i - i_f) e^{-\beta t} \quad (1)$$

Modelo de Kostiakov:

$$I = k t^\alpha \quad (2)$$

Modelo de Kostiakov-Lewis:

$$I = k t^\alpha + i_f \quad (3)$$

Modelo de Philip:

$$I = f_1 t^{-1/2} + f_2 \quad (4)$$

Where:

I - estimated instantaneous infiltration rate, mm h⁻¹;

i_i - observed initial infiltration rate, mm h⁻¹;

i_f - final infiltration rate, mm h⁻¹;

t - infiltration time, min.

k, α, β, f₁, f₂ - statistical parameters of the models estimated.

The comparative analyzes of the results were statistically performed by the coefficient determination (R^2) to evaluate the performance of the infiltration values obtained in field in relation the values calculated from the models Kostiakov, Horton and Kostiakov-Lewis and Philip. The following statistical indices were calculated to make more efficient analysis: residual mass ratio (RMR), adjustment coefficient (AC) and efficiency (EF) as described by CUNHA et al. (2015).

$$RMR = \frac{\sum_{i=1}^n O_i - \sum_{i=1}^n P_i}{(\sum_{i=1}^n O_i)} \quad (1)$$

$$AC = \frac{\sum_{i=1}^n (O_i - \bar{O})^2}{\sum_{i=1}^n (P_i - \bar{O})^2} \quad (2)$$

$$EF = \frac{\sum_{i=1}^n (O_i - \bar{O})^2 - \sum_{i=1}^n (P_i - O_i)^2}{\sum_{i=1}^n (O_i - \bar{O})^2} \quad (3)$$

where:

O_i - It is the observed value,

P_i - it is the estimated value and "n" means the number of observations,

\bar{O} - it is the arithmetic mean of the observations,

\bar{P} - it is the arithmetic mean of the estimated values.

RESULTS AND DISCUSSION

In relation to the BIV obtained in the field, the soil that suffered less anthropogenic actions, that is, the soil treated with no tillage, returned better results, obtaining an infiltration rate 2.87 times greater than in the treatment with minimum tillage and 8.67 times greater than in the Conventional tillage, as can be seen in Table 1, similar results were evidenced in the works of Bono et al. (2012) and Gonçalves and Moraes (2012), where it was evidenced an expressively better result in plantations with the reduced use of agricultural machinery. In relation to the mathematical adjustments, it can be observed that the model that best adjusted the BIV was the one of Horton, that in all the managements obtained the result equal to the one obtained in the field.

Table 1. Basic infiltration velocity and statistical indices for the three types of management

Model	BIV (mm h ⁻¹)	R ²	RMR	AC	EF
No Tillage					
Observed values	78.00	1.0000	0.0000	1.0000	1.0000
Horton	78.00	0.9729	0.0422	1.0374	0.9396
Kostiakov	71.93	0.9929	0.0053	1.1734	0.9808
Kostiakov-Lewis	71.93	0.9975	0.1070	3.4212	0.6995
Philip	76.93	0.9987	0.0000	1.0025	0.9975
Minimum tillage					
Observed values	27.00	1.0000	0.0000	1.0000	1.0000
Horton	27.00	0.9656	0.0607	1.4447	0.9087
Kostiakov	22.30	0.9675	0.0444	1.8090	0.8823
Kostiakov-Lewis	22.30	0.9917	0.2439	5.4041	0.4531
Philip	17.67	0.9751	0.0000	1.0515	0.9509
Conventional tillage					
Observed values	9.00	1.0000	0.0000	1.0000	1.0000
Horton	9.00	0.9828	0.0549	1.3435	0.9482
Kostiakov	7.38	0.9908	0.0364	1.3020	0.9671
Kostiakov-Lewis	7.38	0.9913	0.2953	4.5513	0.5085
Philip	4.95	0.9879	0.0000	1.0245	0.9760

Regarding the coefficient of determination (R^2), in all methods of all managements, the results were satisfactory, all obtained over 96%, always being evidenced the best result in the Kostiakov model, Results that are similar to those obtained by Cunha et al. (2015), where the methodologies of Kostiakov, Kostiakov-Lewis and Horton were also used.

There was a very interesting result in the residual mass ratio (RMR) for the Philips method, in all the managements it approached quite the ideal, that is, the curve was adjusting very well, so that there were practically no residues, too It can be stated that for this method the volume of infiltrated water is the same as that obtained in the field. In relation to the adjustment coefficient (AC) and the efficiency (EF), the results were satisfactorily similar in all methods, except that of Kostiakov-Lewis, which could not be adapted to the soil.

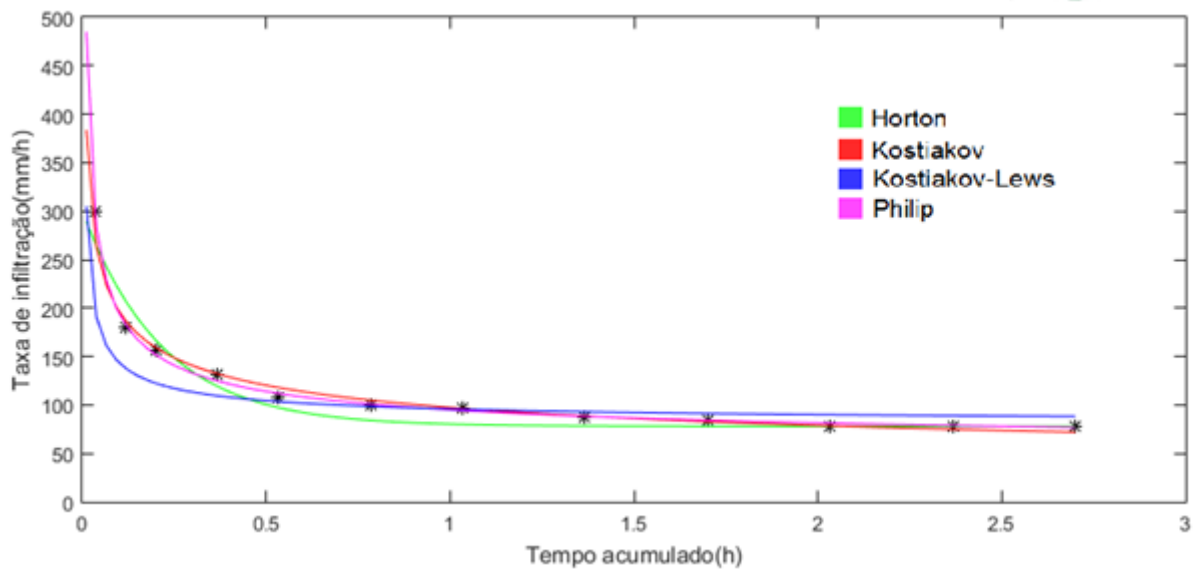


Figure 1. Rates observed and estimated of water infiltration in soil with conventional tillage on sweet corn using as cover guandu.

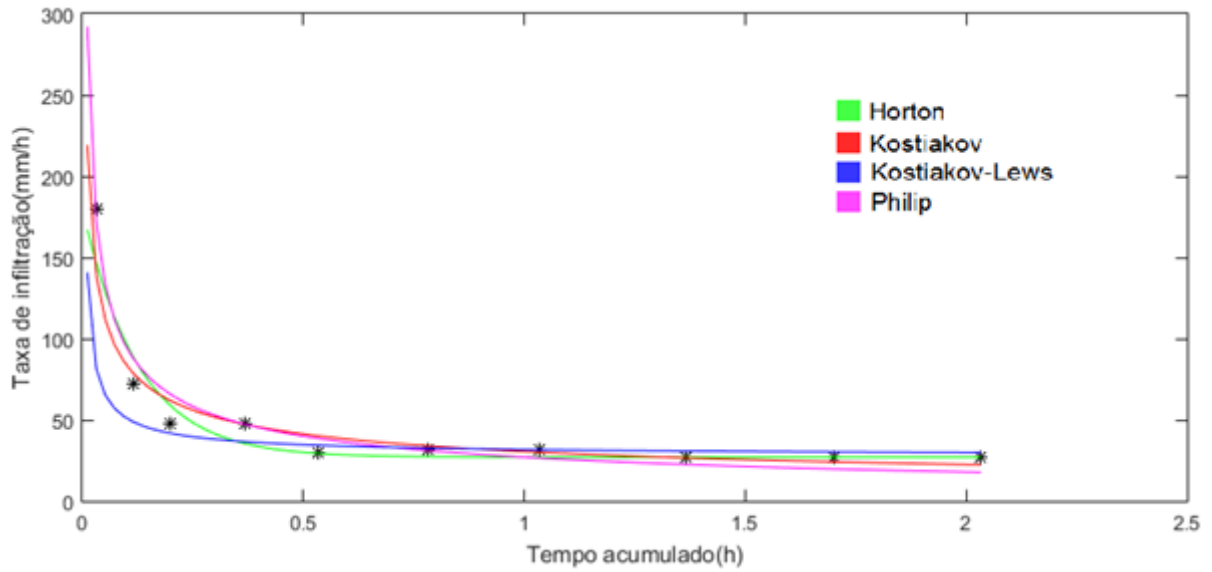


Figure 2. Rates observed and estimated of water infiltration in soil with minimum tillage on sweet corn using as cover guandu.

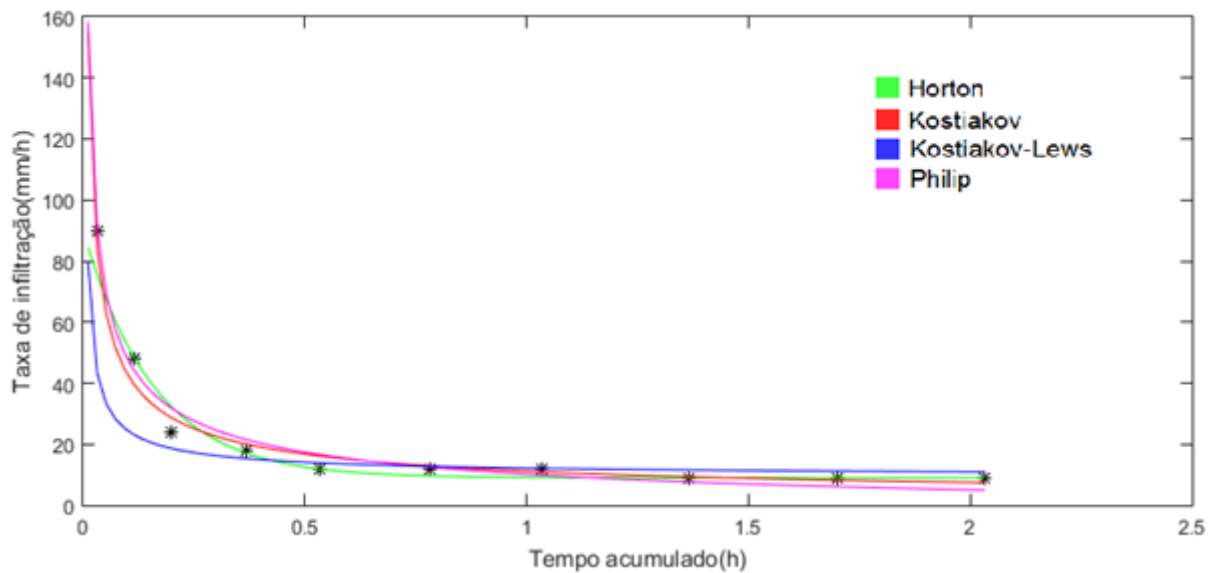


Figure 3. Rates observed and estimated of water infiltration in soil with conventional tillage on sweet corn using as cover guandu.

CONCLUSIONS

1. Soil managed with no-tillage obtained higher rates of soil water infiltration.
2. There was a good behavior of the curves in all the mathematical methods, especially the Philip, which was the most efficient and for Horton that obtained correctness in the adjustment of the VIB.
3. The treatment of the soil influenced the quality of the adjustment of the mathematical models of the soil water infiltration.

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