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COEFICIENTES DE UNIFORMIDADE NA IRRIGAÇÃO POR ASPERSÃO CONVENCIONAL EM ÁREA DE PASTAGEM CULTIVADA

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1 RESUMO

Neste estudo, objetivou-se analisar o desempenho de um sistema de irrigação por aspersão convencional, caracterizado por um espaçamento de 12 x 12 metros, implementado em uma área de capim-mombaça (*Panicum maximum* Jacq. cv. Mombaça), localizada no município de Iguatu, CE. Essa análise baseou-se na avaliação dos seguintes parâmetros: Coeficiente de Uniformidade de Christiansen (CUC), Coeficiente de Uniformidade Estatística (Us) e Coeficiente de Uniformidade de Distribuição (CUD). A avaliação do desempenho do sistema de irrigação por aspersão convencional em análise revela uma variedade de resultados. O coeficiente Us (73,00%) foi classificado como "Razoável", indicando uma uniformidade relativamente satisfatória na distribuição de água. No entanto, os coeficientes CUC (67,98%) e CUD (66,67%) foram classificados como "Ruim" e "Razoável", respectivamente, sugerindo que a uniformidade de distribuição de água na área é insatisfatória. Conclui-se que a distribuição de água de irrigação na área em estudo está razoavelmente comprometida, evidenciada pelos baixos valores observados em todos os coeficientes de uniformidade avaliados, os quais estão abaixo dos padrões recomendados como minimamente ideais pela literatura científica especializada.

Palavras-chave: homogeneidade da irrigação, padrão de distribuição de água, performance hidráulica.

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UNIFORMITY COEFFICIENTS IN CONVENTIONAL SPRAY IRRIGATION IN CULTIVATED PASTURE AREA

2 ABSTRACT

In this study, the objective was to analyze the performance of a conventional sprinkler protection system, characterized by a spacing of 12 × 12 meters, implemented in an area of Mombaça grass (*Panicum maximum* Jacq. cv. Mombaça), located in the municipality of Iguatu, CE. This analysis was based on the evaluation of the following parameters: the Christiansen uniformity coefficient (CUC), the statistical uniformity coefficient (Us) and the distribution uniformity coefficient (CUD). Evaluating the performance of the conventional sprinkler supervision system under review reveals a variety of results. The Us coefficient (73.00%) was classified as "reasonable", indicating relatively satisfactory uniformity in water distribution. However, the CUC (67.98%) and CUD (66.67%) coefficients were classified as "poor" and "reasonable", respectively, demonstrating that the uniformity of the water distribution in the area was unsatisfactory. It is concluded that the distribution of control water in the area under study is reasonably compromised, as evidenced by the low values observed in all the uniformity coefficients evaluated, which are below the standards recommended as minimally ideal by specialized scientific literature.

Keywords: irrigation homogeneity, water distribution pattern, hydraulic performance.

3 INTRODUCTION

The practice of irrigated agriculture is recognized as one of the agricultural activities that demands the greatest amount of water. Therefore, it cannot be considered only a means of meeting the water demand of plants since it involves important aspects of the relationships among humans, the environment and the sustainable use of natural resources and, therefore, needs to be well dimensioned and managed to ensure good uniformity of water application (Rodrigues *et al.*, 2024).

Conventional sprinkler irrigation is essential in agriculture for several reasons, including efficient water use, which aims to minimize waste and is highly important in areas with water shortages. The ability to distribute water evenly ensures that the plants in the crop receive the same amount of water. In addition to its versatility, it can adapt to various types of soil and crops, which offers good economic benefits, with reduced operating costs, energy and labor, and increased agricultural productivity.

Saretta *et al.* (2018) stated that the design of a conventional sprinkler irrigation system is based on the sizing of the items that make up the system and should be divided into two phases: agronomic and operational sizing and, subsequently, hydraulic sizing. The design should consider the maximum evapotranspiration that the crop will be able to present in the vegetative cycle and the highest manometric height that must be exceeded to carry out irrigation.

However, in addition to these factors, it is necessary to achieve minimum irrigation uniformity in all irrigation events, given that the uniformity of water application in irrigation directly affects water use efficiency and crop yield. In turn, the assessment of irrigation uniformity has been

neglected at the farm level, and the information generated by assessments of this nature can govern the adoption of some simple management measures in the systems, which would result in a marked improvement in irrigation performance, reaching satisfactory levels of uniformity and efficiency (Maroufpoor; Maroufpoor; Khaledi, 2019).

Therefore, the objective of this study was to evaluate and analyze a conventional sprinkler irrigation system, with a spacing of 12 × 12 meters, implemented in an area where mombaça grass (*Panicum maximum* Jacq. cv. Mombaça), in the municipality of Iguatu, CE, on the basis of the values of the Christiansen uniformity coefficient (CUC), statistical uniformity coefficient (Us) and distribution uniformity coefficient (CUD).

4 MATERIALS AND METHODS

The evaluation of the conventional sprinkler irrigation system was conducted in November 2023 in the experimental area of mombaça grass (*Panicum maximum* Jacq. cv. Mombaça) of the Federal Institute of Education, Science and Technology of Ceará (IFCE) - Iguatu *campus*, located in the municipality of Iguatu - CE. This municipality is located in the south-central region of the state of Ceará, at an altitude of 217.8 m above sea level, with coordinates of 06° 21' south latitude and 39° 17' west longitude. The local climate is classified as BSw'h', characterized as semiarid or very hot, according to the Köppen methodology, and the soil is classified as sandy loam (0–20 cm).

The system evaluated is a conventional mesh sprinkler system, and one of the paddocks of the experimental area was selected to conduct the tests because of its representativeness. The instruments used to evaluate the irrigation system consisted of Fabrimar collectors, graduated test tubes in millilitres, timers, containers with a capacity of 20 liters, hoses and measuring tapes.

Initially, to demarcate the study area, rain gauge collectors were positioned in 3 × 3 meter grids, at an average height of 60 centimeters above the ground surface, between six sprinklers. During the tests, sprinkler flow measurements were taken via pipes connected to the nozzles of each sprinkler, a 20-liter tank and a precision stopwatch. The flow rate was determined as the arithmetic mean of five replicates for each sprinkler and for each corresponding paddock.

During irrigation, each collector intercepted all the water discharged during a two-hour period, which coincided with approximately half of the total irrigation time adopted in the experimental area. At the end of the tests, the volumes of water collected were measured via 15-millimeter graduated cylinders from Fabrimar.

The evaluation of the performance and efficiency of the conventional sprinkler irrigation system was based on the following parameters: the Christiansen uniformity coefficient (CUC), the statistical uniformity coefficient (Us), and the distribution uniformity coefficient (CUD).

The Christiansen uniformity coefficient (CUC) was obtained from equation 1:

$$\mathrm{CUC} = 100\mathrm{x}\frac{[1-\sum_{i}^{n}|\mathrm{Qi}-\mathrm{Q}|]}{\mathrm{nQ}} \quad (1)$$

where Qi = the precipitation collected in each collector (mm); Q = the average precipitation collected from all the collectors (L h $^{-1}$); and n = the number of collectors analyzed.

For the distribution uniformity coefficient (CUD), equation 2 was used:

$$\mathrm{CUD} = \frac{\mathrm{q25\%}}{\mathrm{qm}} \times 100 \quad (2)$$

where Q25% = average of 25% of the total collectors with the lowest rainfall (mm)

and where qm = average of the rainfall collected in the collectors in the subarea (mm).

The statistical uniformity coefficient (CUE) is another coefficient that can be used to determine the uniformity of irrigation systems and was calculated via Equation 3:

$$\mathrm{CUE} = 100 \,.\left(\frac{\mathrm{S}}{\mathrm{X}}\right) \quad (3)$$

where S = the standard deviation of the precipitation data; Xi = the observed depth in collector i, mm; and X = the average precipitation, mm.

5 RESULTS AND DISCUSSION

The uniformity of water distribution over an irrigated area is measured by uniformity coefficients, which are used to evaluate the efficiency of the uniformity system. In this case, the calculated values of the coefficients presented in Table 1 indicate how uniformly the water is distributed by the irrigation system.

Table 1. Values of the Christiansen uniformity coefficient (CUC), statistical uniformity coefficient (Us), distribution uniformity coefficient (CUD) and respective classifications of the coefficients of the conventional sprinkler irrigation system evaluated.

Coefficients	Calculated values (%)	Classification
CUC	67.98	Bad
Us	73.00	Reasonable
CUD	66,67	Reasonable

Source: Author

The performance of the conventional sprinkler irrigation system under analysis can be considered “mixed” according to the calculated values shown in Table 1. Classification was proposed by Mantovani (2001). On the basis of the classification proposed by Mantovani (2001), the “reasonable” classification of the Us coefficient shows relatively good uniformity in terms of water distribution. The CUC and CUD coefficients, on the other hand, are called “poor” and “reasonable”, respectively, indicating that the uniformity of the water distribution in these areas is less satisfactory (Table 1).

These results suggest that there are areas where conventional sprinkler irrigation systems can be improved. For example, water is more uniformly distributed than other coefficients are, according to statistical uniformity (Us), whereas CUC and CUD suggest significant variations in water distribution in some parts of the irrigated area.

Table 2. The performance values of conventional sprinkler irrigation systems are classified according to the Christiansen uniformity coefficient (CUC), the statistical uniformity coefficient (Us) and the distribution uniformity coefficient (CUD).

Classification	CUC	US	CUD
		(%)	
Excellent	> 90	90 – 100	> 84
Good	80 – 90	80 – 90	68 – 84
Reasonable	70 – 80	70 – 80	52 – 68
Bad	60 – 70	60 – 70	36 – 52
Unacceptable	< 60	< 60	< 36

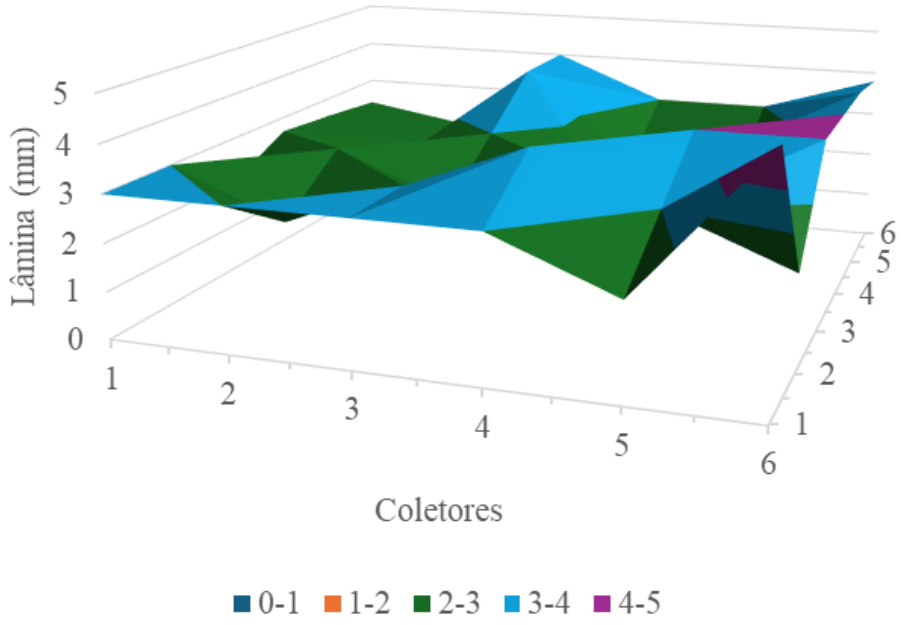
Source: Mantovani (2001).

In-depth investigation is necessary to determine the causes of differences in water distribution, as the results can prompt a more comprehensive investigation. The uniformity of integrity can be affected by factors such as water pressure, sprinkler deficiency, and proper maintenance checks of the irrigation system.

Although these results raise concerns, they also present opportunities for improvements in irrigation systems. Identifying and correcting deficiencies can contribute to a uniform distribution of water, which can lead to more efficient water use, increasing productivity and reducing operating costs. The discussion surrounding these findings highlights the importance of assessing irrigation system efficiency via uniformity coefficients, as well as the need for research and action to improve the uniformity of water distribution.

Figure 1 presents a graphic representation of the precipitation collected during the sprinkler test installed in the experimental area. A considerable rainfall range can be observed in both paddocks evaluated, which possibly helps explain the low values of the parameters found in the analysis of the irrigation system performance.

Figure 1 Spatial distribution of the water layer on the soil surface, referring to the distribution uniformity test with sprinklers spaced 12 × 12 m apart.



Source: Author.

The inefficiency of sprinkler irrigation under field conditions, which is widely documented in the scientific literature, is directly related to the significant nonuniformity in water distribution, as demonstrated in the graphs presented. This phenomenon is corroborated by previous studies, such as that of Bernardo *et al.* (2019), which highlight not only the influence of uniformity in water distribution but also the losses associated with evaporation and wind drift.

The latter are influenced mainly by the wind speed, relative humidity and air temperature. The differences observed between the water deficit and excess peaks in Figure 1 may be directly related to the action of the winds during the test.

6 CONCLUSIONS

The distribution of irrigation water in the study area is reasonably compromised, **as** evidenced by the low values observed in all the uniformity coefficients evaluated, which are below the standards recommended as ideal by the scientific literature.

This finding **highlights the** unsatisfactory performance of the irrigation system evaluated, which is practically inadequate for the type of crop under analysis.

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