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UNIFORMITY OF WATER DISTRIBUTION BY A SPRINKLER IRRIGATION SYSTEM ON A SOCCER FIELD

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Abstract
Soccer field grass can be compared to highly sensitive crops regarding water deficit and must be irrigated throughout the year to provide decent conditions for use. For this, efficient irrigation systems are necessary to save water and energy, and this is possible, provided that they are evaluated. Therefore, this paper evaluated the water distribution uniformity, by different methodologies, for an irrigation system installed in a grass soccer field. Also, the influences of multiple spacings between sprinklers and meteorological factors on the final results were assessed. The irrigation system had Falcon 6504 sprinklers, operating at the pressure of 320 kPa. Six field essays were conducted considering overlaying water depths originated from the same irrigation system considering spacings between sprinklers varying from 6 m x 6 m, 6 m x 9 m, 9 m x 9 m, 9 m x 12 m, 12 m x 12 m, 12 m x 15 m, 15 m x 15 m, 15 m x 18 m, 18 m x 18 m, 18 m x 21 m, 21 m x 21 m, 21 m x 24 m, 24 m x 24 m, 24 m x 27 m, 27 m x 27 m, 27 m x 30 m and 30 m x 30 m. The uniformity coefficients used were: Christiansen uniformity coefficient (CU), distribution uniformity coefficient (DU), absolute uniformity coefficient (U_A), statistical uniformity coefficient (U_S), Hart uniformity coefficient (U_H) and HSPA standard efficiency (U_{HSPA}). Meteorological data were obtained during the essays. Wind speed caused reduction in the length of the water jet applied by the sprinkler and also caused a bigger effect on the water distribution uniformity. Both CU and U_H showed higher values compared to the other coefficients. The increase in the spacing between the sprinklers resulted in reduced water distribution coefficients. To comply with technical and economic criteria, an arrangement of 12 m x 15 m between the Falcon 6504 sprinklers, operating at a 320 kPa pressure, is recommended.

Keywords: CU. Grass Field Irrigation. Irrigation Efficiency. Sprinkler Spacing.

1. Introduction

The grass for soccer fields, golfing, gardens and many others occupies large expanses of land and are highly sensitive to water deficit, requiring an appropriate irrigation management throughout the year. The water, when supplied in the right moment and quantity, guarantees that the grass field will be maintained in ideal conditions for proper practice of sports and aesthetic purposes (García-González et al. 2015; Siqueira et al. 2018). Thus, an adequate irrigation system presents itself as a relevant strategy to achieve these goals.

Irrigation is the world's major consumer of water, accounting for, on average, 70% of all its use (FAO-WWC 2015). In Brazil, this use reaches 68.4%, according to recent studies (Ana 2019). In 2050, it is expected that irrigation will remain the world's major water user, representing more than half of all abstractions from rivers, lakes and aquifers. Therefore, it is of increasing relevance that these water users worry about such vital resource and adopt irrigations systems that can perform with high efficiency, so the water will not be wasted, and the crops can perform their best, under the given conditions.

The conventional sprinkler irrigation system is largely used in Brazil (Alves et al. 2017). However, under adverse meteorological conditions, such as high temperatures, low air humidity and increased wind speed, this system does not perform in its full capacity, causing considerable losses of water, fertilizer, and electricity due to its lower efficiency (Molle et al. 2012; Sheikhesmaeili et al. 2016; Araújo et al. 2020). Siqueira et al. (2018) affirm that, although modern systems make use of advanced technologies to reduce water and energy consumption, it is not possible to reduce their wastes to zero.

Irrigation efficiency can be defined as the amount of water applied by irrigation that is, in certain quantity, absorbed by crops, being a fine indicator related to irrigation efficiency, water management and recent technologies in irrigation (Wu et al. 2019). Such efficiency is a result of application, distribution, and conduction efficiencies (Filgueiras et al. 2020).

The distribution efficiency can be obtained by the distribution uniformity, which consists in a measurable capacity of an irrigation system to apply an equal amount of water in the irrigated perimeter (Keller and Bliesner 1990; Mohamed et al. 2019). The distribution uniformity for different irrigation types is also influenced by different factors, related to each technique of irrigation (Andrade et al. 2015). Particularly for sprinkler systems, the uniformity is related not only to its mechanical aspects (flow rate, operating pressure, spacing, nozzle diameter, etc.), but also to meteorological conditions, especially wind direction and speed (Keller and Bliesner 1990; Faria et al. 2016). Its estimate is frequently evaluated based on the uniformity coefficients.

Among the coefficients used to express water distribution variability, the first was proposed by Christiansen (1942) and uses the absolute average deviation as a dispersion measurement (Christiansen uniformity coefficient - CU). Additionally, Wilcox and Swailes (1947) proposed a uniformity coefficient using the standard deviation as a dispersion measurement, for which only values above 75% are accepted (statistical uniformity coefficient - U_S). Criddle et al. (1956) introduced another uniformity parameter, this time considering the ratio between the lowest quartile average and the average water depth that was collected (distribution uniformity coefficient - DU). Hart (1961) also proposed a uniformity coefficient using the standard deviation as a dispersion measurement (Hart uniformity coefficient - U_H). Consequently, when the applied water depth has a normal distribution, CU and U_H will be equaled. Hart (1961) also proposed another coefficient related to the distribution uniformity, known as HSPA standard efficiency (HSPA standard efficiency - U_{HSPA}). Similar to U_H, when the applied water depth shows a normal distribution, U_{HSPA} and DU will be equaled. Karmeli and Keller (1975) proposed a uniformity measurement that includes the ratio of the maximum and minimum flows with the average (absolute uniformity coefficient - U_A).

Many studies have been conducted aiming to evaluate and define projects of irrigation systems based on their water distribution uniformity (Mohamed et al. 2019; Rodrigues et al. 2019; Araújo et al. 2020; Filgueiras et al. 2020). However, studies evaluating irrigation systems for soccer fields are insufficient in the literature. Therefore, this study evaluated, using different methodologies, the distribution uniformity of an irrigation system designed for a soccer field, and verified the influence of different spacings between sprinklers and meteorological factors on the final results.

2. Material and Methods

Study location

The essays of uniformity were conducted in a soccer field, during October and November 2019, located at “Clube Campestre de Viçosa” (Figure 1), situated in the city of Viçosa, Minas Gerais State, Brazil, with the following coordinates: latitude 20.7408º S, longitude 42.8629º W and altitude of 706 m, in the region known as “Zona da Mata Mineira”. Its local climate, according to the Köppen-Geiger classification is Cwa, consisting in a humid subtropical climate, with dry winters and hot summers (Alvares et al. 2013).

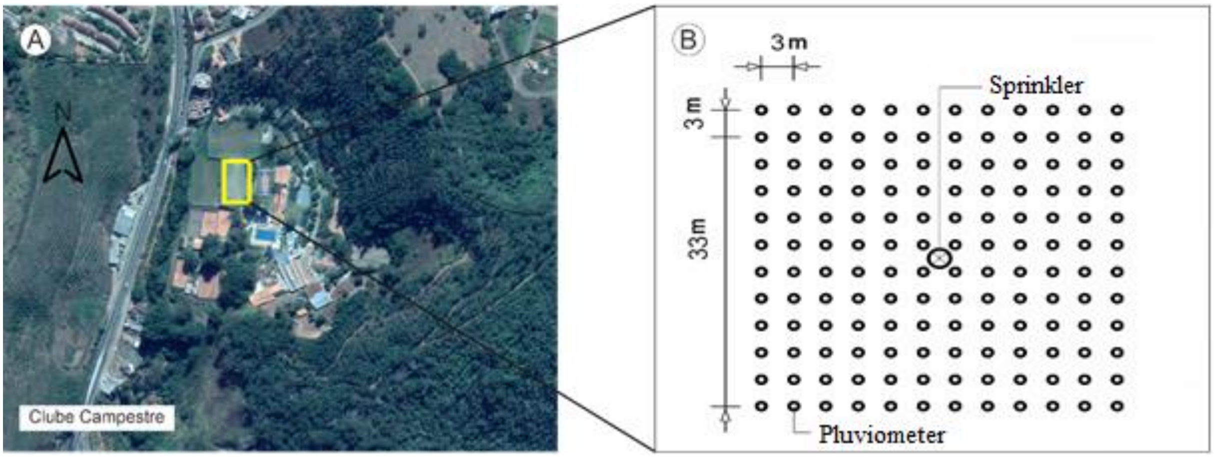

Figure 1. A – experimental area in relation to “Clube Campestre” in the city of Viçosa-MG; B – the sketch of the pluviometers’ arrangement for the essays of uniformity.

This work consisted of the evaluation of an irrigation system composed of rotor sprinklers, Falcon 6504 model (nozzle 14), made by Rain Bird company. This sprinkler is retractable, especially recommended for grass fields destined for sports practices or green spaces. The manufacturer’s recommendations estimate an ideal operating pressure within the interval from 250 to 550 kPa. Figure 2A represents the operating pressure versus flow rate function and in the Figure 2B the water jet length applied by the sprinklers. It is important to highlight that the adjusted models are only relevant to the operating pressure between 250 and 550 kPa. The field essays were carried out with an average pressure of 320 kPa, with an average flow rate of 2.835 m^3 h^{-1}.

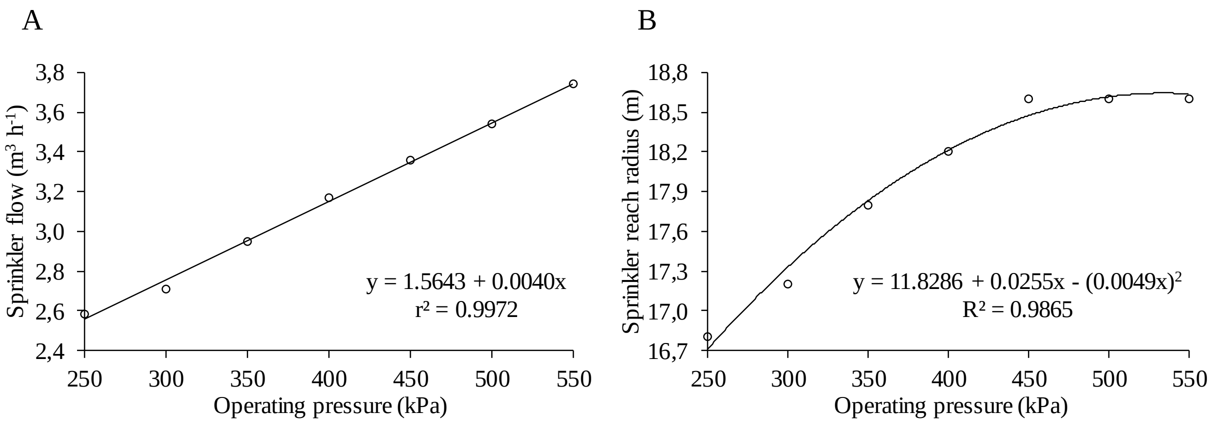

Figure 2. Technical features of Falcon 6504 (nozzle 14) sprinkler: A – flow versus operating pressure curve; B – water jet length as a function of operating pressure.

Sprinklers evaluation in the field

To evaluate the distribution uniformity, water collectors produced by Fabrimar® were used. The collectors were arranged around a single sprinkler, at a uniform spacing of 3 m x 3 m (Figure 1D). With such arrangement, each water collector represented a 9 m^2 squared area, complying with Brazilian regulation ABNT-NBR: 14244 (ABNT 1998). 12 columns and 12 rows of collectors were installed, resulting in a total of 144 water collectors around the single sprinkler, with a total coverage area of 1,296 m^2. The maximum distance between a collector and the sprinkler was 23.3 m, to make sure that the water depths would be zero at the extremities. All collectors were placed 0.70 m above ground, according to the methodology of Merriam and Keller (1978).

Six field essays were conducted, each one of them lasting for 40 min, under distinct meteorological conditions. During the essays, average air temperature, humidity, wind speed, solar radiation and vapor pressure deficit (es-ea) data were collected, as shown in Table 1. The average air temperature, relative humidity, wind speed and solar radiation data were measured by an automated meteorological station during the irrigation system experiments. These data were used to determine the actual vapor pressure and saturation vapor pressure using the average values obtained in the experiments. Thus, the saturation vapor pressure deficit was obtained by the difference between the two pressures mentioned.

Table 1. Average values of meteorological factors during the irrigation system's essays.

Date	Time	Air temperature (°C)	Air humidity (%)	Wind speed (m s^{-1})	Solar radiation (MJ m^{-2})	es-ea (hPa)
10/25/2019	2:45 pm	31.3	37.1	0.78	2.06	28.7
10/30/2019	6:20 pm	23.4	71.3	0.76	0.05	8.2
11/14/2019	2:20 pm	26.6	59.3	1.77	1.57	14.2
11/14/2019	3:40 pm	26.8	59.3	1.87	1.38	14.3
11/14/2019	8:05 pm	20.6	94.2	0.44	0.00	1.4
11/14/2019	9:25 pm	20.7	95.0	0,42.	0.00	1.2

At the end of each essay, the water depths contained in each collector were obtained, using a graduated cylinder with a maximum capacity of 15 mm, produced by Fabrimar®. Water evaporation was quantified by a pluviometer with an already known initial water volume. Also, at the end of the essays, the remaining volume was measured once again, so the variation obtained with this deduction represented the water evaporation occurred during the essays. This variation was added to all water collectors within the sprinkler's radius of throw, following the recommendations of Bernardo et al. (2019).

Distribution uniformity evaluation

Once all data were collected from the field essays, the readings were overlapped, simulating irrigation systems with sprinklers spaced by 6 m x 6 m, 6 m x 9 m, 9 m x 9 m, 9 m x 12 m, 12 m x 12 m, 12 m x 15 m, 15 m x 15 m, 15 m x 18 m, 18 m x 18 m, 18 m x 21 m, 21 m x 21 m, 21 m x 24 m, 24 m x 24 m, 24 m x 27 m, 27 m x 27 m, 27 m x 30 m and 30 m x 30 m, according to Bernardo et al. (2019). To analyze the spatial distribution of the water depths for each sprinkler arrangement, weighted interpolations (weight = 2) were carried out by the inverse of the distance (IDW). Afterwards, the water distribution uniformity was calculated using the following uniformity coefficients: Christiansen uniformity coefficient (CU), distribution uniformity coefficient (DU), absolute uniformity coefficient (U_A), statistical uniformity coefficient (U_S), Hart uniformity coefficient (U_H) and HSPA standard efficiency (U_{HSPA}), obtained by equations 1, 2, 3, 4, 5 and 6, respectively.

$$CU = 100\left[1 - \frac{\sum_{i=1}^{n}|X_i - \overline{X}|}{n\overline{X}}\right] \quad (1)$$

$$DU = 100\frac{X_{25\%}}{\overline{X}} \quad (2)$$

$$U_A = 50\left[\frac{X_{25\%}}{\overline{X}} + \frac{\overline{X}}{X_{12.5\%}}\right] \quad (3)$$

$$U_S = 100\left[1 - \frac{S}{\overline{X}}\right] \quad (4)$$

$$U_H = 100\left\{1 - \sqrt{\frac{2}{\pi}\left(\frac{S}{\overline{X}}\right)}\right\} \quad (5)$$

$$U_{HSPA} = 100\left(1 - 1.27\frac{S}{\overline{X}}\right) \quad (6)$$

Where CU means Christiansen uniformity coefficient (Christiansen 1942), in %; Xi, the observed precipitation, in mm; $\overline{X}$, average precipitation, in mm; n, the number of collectors; DU, Distribution uniformity coefficient (Criddle et al. 1956), in %; $X_{25\%}$, the average of 25% of the lower readings among all collectors, in mm; U_A, Absolute uniformity coefficient, (Karmeli and Keller 1975), in %; $X_{12.5\%}$, the average of 12.5% of the highest readings among all collectors, in mm; U_S, Statistical uniformity coefficient (Wilcox and Swailes 1947), in %; S, the standard deviation of the precipitation data, in mm; U_H, Hart uniformity coefficient (Hart 1961), in %; U_{HSPA}, HSPA standard efficiency (Hart 1961), in %.

Once all uniformity coefficients were obtained for each essay, the accumulated uniformity coefficient was also determined. For such purpose, the six values of the accumulated water depth were summed for each collector. Afterwards, the uniformity coefficients were determined using these accumulated values, making use of the same procedures for the non-accumulated water depth, following Equations 1 to 6.

Influence of climatic variables on the distribution uniformity

After determining the best spacing between the sprinklers for the irrigation system, the uniformity coefficients values for each experiment were plotted as a function of the meteorological variables, using scatter plots. In sequence, polynomial and linear regression models were fitted, selecting those the highest values of determination coefficient (r^2).

3. Results and Discussion

Figure 3 represents the distribution uniformity in different simulations of spacings between Falcon 6504 (nozzle 14) sprinklers, while operating at an average pressure of 320 kPa. Using the same average water depths allowed a better visual comparison among the different sprinkler spacings. It is convenient to mention that the application intensities, for each spacing configuration, were not the same. For example, the 30 m x 30 m configuration had an application intensity of 3.15 mm h^{-1}, so, with an average gross water depth of 10 mm, the irrigation system would have to operate for 3 h and 10 min. For the 6 m x 6 m configuration, however, the application intensity is 78.75 mm h^{-1}. So, for the same average gross water depth of 10 mm, this irrigation system would operate for 8 min only.

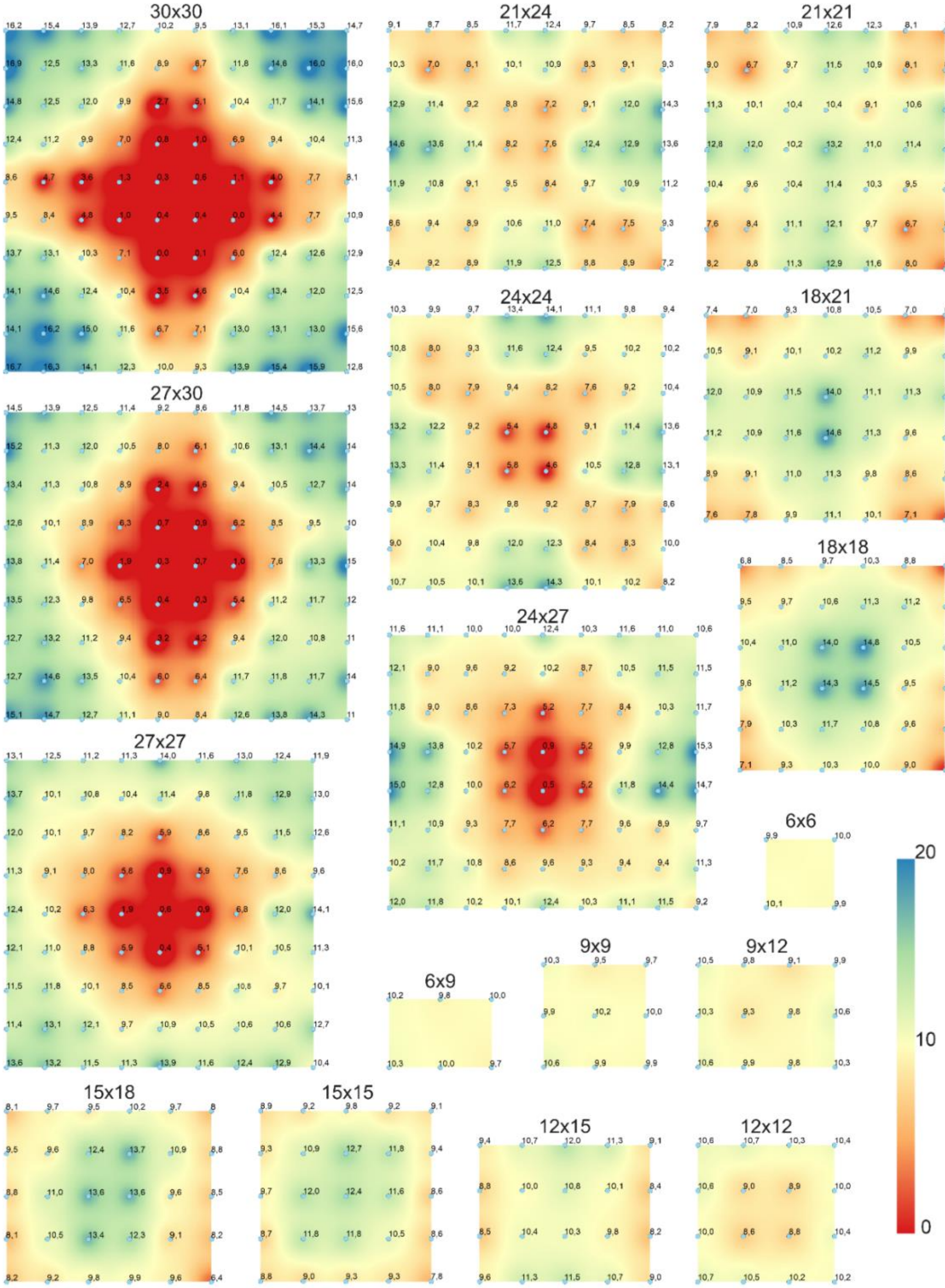

Figure 3. Distribution uniformity for the application of an average water depth of 10 mm for multiple simulations with different arrangements of Falcon 6504 (nozzle 14) sprinklers with an operating pressure of 320 kPa.

The increase in spacing between the sprinklers led to a greater irregularity in water depth distribution (Figure 3). It occurred due to the lower overlapping between the water depths, compared to smaller spacings. Consequently, in theory, with spacings above 24 m x 27 m it would not be possible to irrigate the central region of the squared area of 9 m^2 relative to the four sprinklers. A solution for such obstacle would be to employ a triangular configuration, so the central region could be well covered by the three sprinklers. This triangular setting, however, poses a considerable challenge for the project and operation for rectangular areas.

During the tests, wind speed led to reduction in the water jet length applied by the sprinkler. Figure 4 shows that the wind speed caused a linear reduction in the length of the jet applied by the Falcon 6504 (nozzle 14) sprinkler, operating at an average pressure of 320 kPa. According to the regression equation, a 2.5 m s^{-1} wind speed led to a water jet length of 14.3 m. Therefore, besides the increase in sprinkler spacing, wind speed also causes reduction in the overlapping of the applied water depths and, consequently, reduction in the irrigation distribution uniformity. Reduced wind speed values are vital to ensure an adequate irrigation efficiency, especially for sprinkler systems, since such variable might result in major impacts on water application and distribution (Keller and Bliesner 1990; Faria et al. 2016). A strategy to overcome such problem is the practice of overnight irrigations since it might be a way to reduce the effects of high wind speed. According to Munhoz and Garcia (2008), night periods have lower thermal gradients, resulting in reduced wind speed.

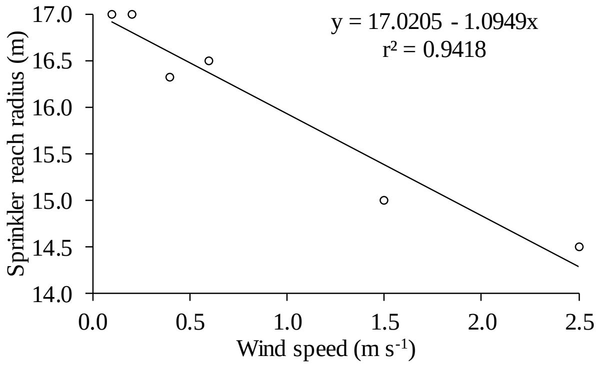

Figure 4. Maximum water jet length applied by the Falcon 6504 (nozzle 14) sprinkler, operating at a pressure of 320 kPa, as a function of wind speed.

Despite the existence of a numerical disparity, the uniformity coefficients indicated similar behaviors between the different spacing simulations using the Falcon 6504 (nozzle 14) sprinklers, operating at an average pressure of 320 kPa (Figure 5A). It can also be observed that the Christiansen (CU) and Hart (U_H) coefficients showed nearly equal values. Such occurrence was already expected, since Hart (1961), the developer of U_H, reported that when the applied water depth has normal distributions, CU can be equaled to U_H.

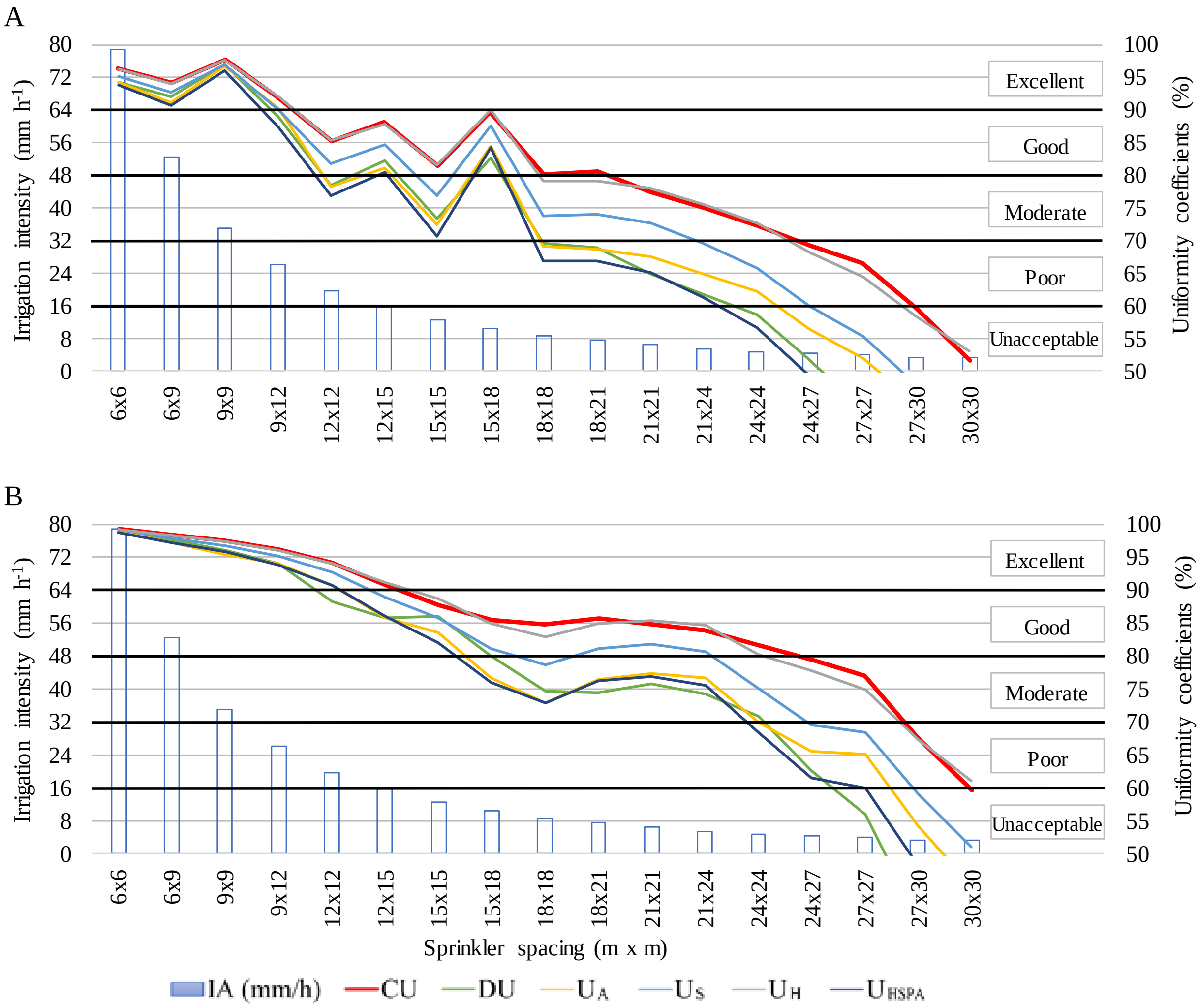

Figure 5. Water distribution uniformity coefficients as a function of multiple arrangements of the Falcon 6504 (nozzle 14) sprinkler, operating at a pressure of 320 kPa: A – collected average water depths; B – collected and overlapped water depths.

CU and U_H values were higher than those of the other evaluated coefficients. Generally, the lowest values were observed for the distribution uniformity coefficient (DU), absolute uniformity coefficient (U_A) and the HSPA standard efficiency (D_H), in this sequence. Cunha et al. (2009), working with the same uniformity coefficients to evaluate a conventional sprinkler irrigation system, verified that CU had higher values, followed by U_S, U_A, U_H, DU and U_{HSPA}. DU is more restrictive and will usually be lower compared to CU, once DU calculation will only consider 25% of the water collectors with the smallest amount of water. Keller and Bliesner (1990) also affirmed it and added that DU can be related to CU by the expression: DU = 100 - 1.59 (100 - CU). After obtaining CU with this equation, it was possible to note an underestimation of only 0.48% when compared to DU, obtained based on the collected water depths.

Mantovani (2001) ranked CU as "excellent" (CU > 90%), "good" (80 < CU < 90), "reasonable" (70 < CU < 80), "poor" (60 < CU < 70) and "unacceptable" (CU < 60). In accordance with Figure 5A, it can be noted that the Falcon 6504 (nozzle 14) sprinkler arranged with the 9 m x12 m spacing led to a distribution uniformity ranked as "excellent". It can also be noted regarding Figure 5A that the 12 m x12 m and 18 m x21 m spacings resulted in "good" distribution uniformity, according to Mantovani (2001). On the other hand, the 30 m x 30 m arrangement led to a distribution uniformity ranked as "poor".

Regarding Figure 5B, the water depths collected from the same pluviometers were overlapped for each one of the six essays, and their uniformity coefficients were also calculated with these values. It was found that the coefficients with the accumulated water depths (Figure 5B) showed higher values compared to the average uniformity coefficients (Figure 5A). These uniformity increments were 5.7, 7.2, 6.6, 6.9, 5.6 and 8.7% for CU, DU, U_A, U_S, U_H and U_{HSPA}, respectively.

Araújo et al. (2020) overlapped water depths originated from ten sprinkler irrigation systems and observed a 7.1% increase in CU values. The water distribution along the irrigated area varies with time, which promotes a significant difference in uniformity, considering multiple irrigations. Due to the random pattern related to precipitation variation, caused by meteorological parameters such as wind speed, a specific point in the irrigated area might receive in different irrigation events an equal, higher or lower water depth compared to the average water depth. Thus, the same specific point which might have received a deficit water depth and consequently reached a deficit state regarding the surrounding points, could also receive a water depth above the average in the following irrigation event, partially or completely supplying the initial deficit related to the first irrigation. Hence, when the average CU is assumed, it is not taken into consideration that a given region which received different water depths might, over time, have a CU value that is higher and more representative of the area.

Considering the water depth overlapping strategy for the distribution uniformity calculation (Figure 5B), it was observed that the systems arranged in a maximum distance of 12 m x15 m were classified as "excellent", according to Mantovani (2001). It is well known that the lower the water distribution uniformity, the lower the irrigation efficiency, and consequently, the higher the gross water depth. For this reason, aiming at a reduced water and energy consumption, an arrangement between the Falcon 6504 (nozzle 14) sprinklers of 12 m x15 m is recommended for irrigation of soccer fields and the like. Smaller spacings could also be recommended considering the technical aspects of the system engineering; however, under an economic view, these arrangements would require more sprinklers, increasing the project's final cost.

The irrigation system associated with the Falcon 6504 sprinklers, spaced by 12 m x15 m and operating with a pressure of 320 kPa, will promote an application intensity of 15.75 mm h^{-1}. So, this specific arrangement can be considered as ideal and can be recommended exclusively to areas with a basic infiltration rate (BIR) equal to or higher than the system's application intensity, according to Bernardo et al. (2019). In areas with a BIR above 15.75 mm h^{-1}, the spacings between sprinklers will have to be increased, so the application intensity is lower compared to the area's BIR, in order to prevent surface runoff and promote water and energy saving.

Despite the recommending the spacing between sprinklers through the overlapped water depth methodology, additional studies are required to consolidate and make this procedure practicable. In these future studies, it is recommended to evaluate the number of experiments required to overlap the water depths and calculate distribution efficiency using a uniformity coefficient.

It can also be verified in Figure 5B that irrigation systems with spacings between 15 m x15 m and 24 m x 24 m have "good" distribution uniformity, according to Mantovani (2001). It is worth mentioning that the 15 m x 15 m to 24 m x 24 m arrangements could also be recommended for irrigation systems in commercial crops. Sheikhesmaeili et al. (2016) suggest that, regarding sprinkler irrigation, a minimum value for CU of 80% is acceptable to employ these configurations in commercial crops. However, it is known that the lower the water distribution uniformity, the higher the difference between irrigation depths and the average water depth. Such lower distribution uniformity results in a decreased irrigation efficiency; therefore, an increased gross water depth will be required, compared to the net water depth. In fact, the smaller the irrigation efficiency, the more time it will take for the irrigation systems to apply the same net water depth. Thus, the inner areas that received smaller water depths will be partially corrected, due to an increase in water application caused by a longer irrigation time. At the same time, these inner areas that would already receive higher water depths, due to the increased irrigation time, will receive an even larger water depth. A direct consequence will be an excessively moist soil, not being able to provide reasonable conditions for an extended sport activity. Thus, it can also lead the cultivated crops to hypoxia, besides leaching of nutrients and increased energy and water expenditure.

In agriculture, commercial crops show certain plasticity, and such effects are not easily noticeable in the results, such as reduction in overall productivity. For soccer field grass irrigation, however, these problems are more easily found since they result in a more relevant visual outcome. This fact was verified by Silva et al. (2010) in a work with grass (*Paspalum notatum*), conducted in Viçosa, Minas Gerais State, Brazil. The authors performed a sensory analysis regarding this specific grass and verified that applied water depths equivalent to 100% of crop evapotranspiration led to "good" and "very good" classifications. For the other conditions, however, the classifications were "poor" and "very poor".

Besides the increase in sprinkler spacing, the meteorological factors also affected the water distribution uniformity (Figure 6). The increase in relative humidity caused a linear increase in CU (Figure 6B), for the 12 m x15 m arrangement. The remaining factors caused a decreasing linear effect. The best fit, based on r^2, was found for wind speed (Figure 6C), followed by air relative humidity (Figure 6B) and solar radiation (Figure 6D). Regarding wind speed, its increase reduces the water jet length, also reducing the water distribution uniformity, as verified by Figure 4. Robles et al. (2017), studying the wind speed effect on distribution uniformity, found a CU of 89% for low wind speed and 67% for high wind speed conditions.

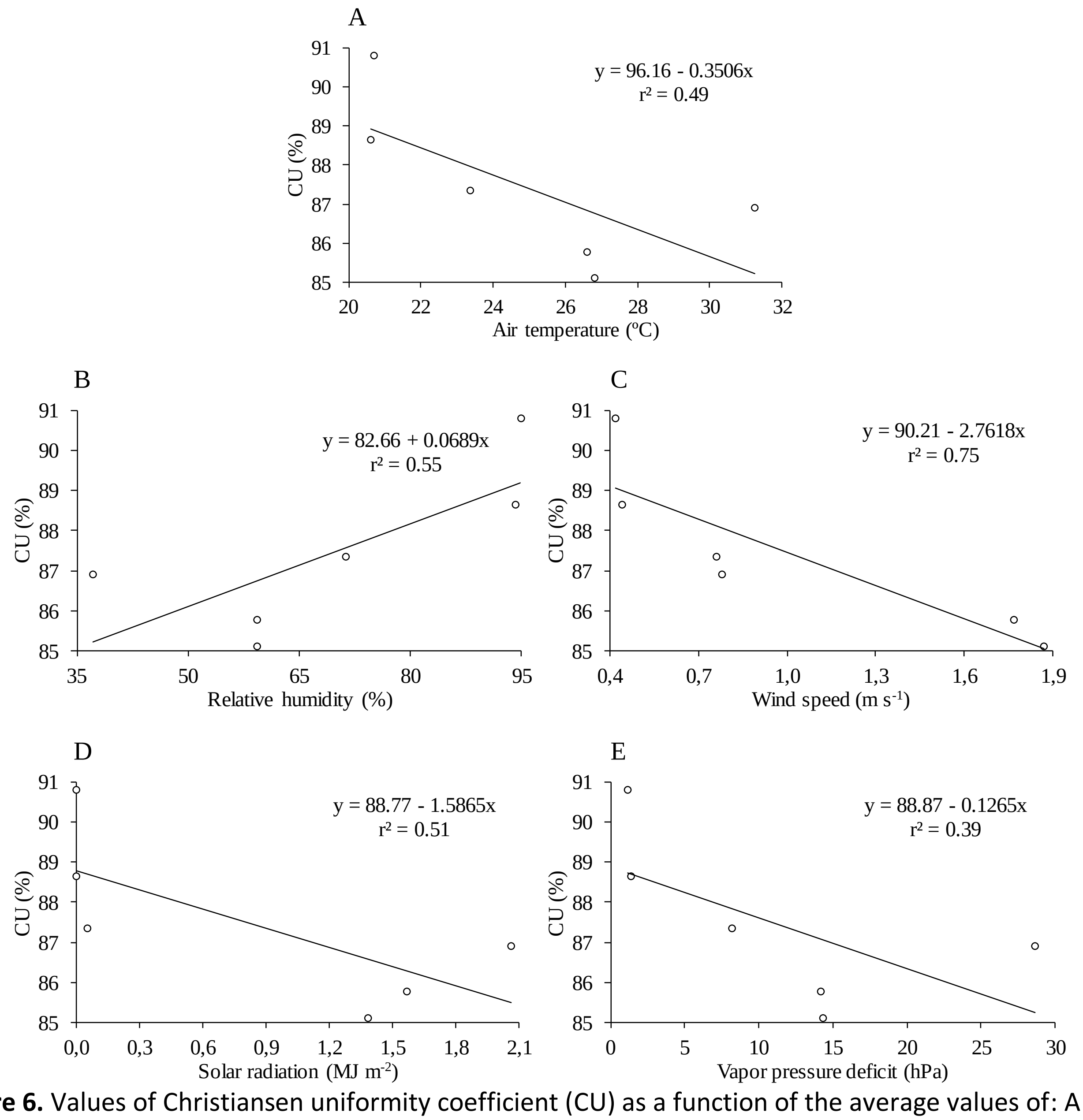

Figure 6. Values of Christiansen uniformity coefficient (CU) as a function of the average values of: A – air temperature; B – relative humidity; C – wind speed; D – solar radiation; E – vapor pressure deficit during the essays with the Falcon 6504 (nozzle 14) sprinkler, spaced by 12 m x 15 m.

Through r^2, it is also possible to attest that wind speed is the variable with highest correlation (r) with the distribution uniformity given by CU. Siqueira et al. (2018) also found similar results when evaluating a sprinkler system for a soccer field, in Brazil. These authors verified that wind speed was the variable with the strongest effect on distribution uniformity. According to Rodrigues et al. (2019), both water depth intensity and wind direction affects the destination of particles. Therefore, the wind has a considerable influence on the area's water distribution. So, to promote an increase in water distribution uniformity, it is necessary to perform the irrigations during nighttime, when wind speed has its lowest values. Overnight, the irrigation will also have a higher application efficiency due to reduced rates of evaporation and drift of water droplets.

The reason behind the reduced evaporation overnight is related to the lower vapor pressure deficit and air temperature. For the reduced drift of water droplets, however, it is a result of lower wind speed values.

4. Conclusions

Wind speed reduced the water jet length applied by the Falcon 6504 sprinkler, and it was the meteorological factor that showed the strongest influence on water distribution uniformity.

The Christiansen (CU) and Hart (U_H) uniformity coefficients showed similar values and were also higher than the other coefficients. Generally, the lowest values were associated with the distribution (DU), absolute (U_A) and HSPA standard efficiency uniformity coefficients, in this sequence.

The increase in spacing between the Falcon 6504 sprinklers led to reduction in water distribution uniformity. To meet both economic and technical criteria, the 12 m x 15 m arrangement, operating at a pressure of 320 kPa, is recommended.

Due to the random pattern regarding the water distribution by the sprinklers, the accumulated CU showed higher values compared to the average CU, presenting itself as an alternative to determine the irrigation efficiency. However, additional studies are required to consolidate such procedure.

Authors' Contributions: ANDRADE, L.M.: acquisition of data, analysis and interpretation of data; PACHECO, J.C.C.: acquisition of data, analysis and interpretation of data; COSTA, G.L.L.: acquisition of data, analysis and interpretation of data; ALENCAR, C.A.B.: acquisition of data, analysis and interpretation of data; CUNHA, F.F.: conception and design, analysis and interpretation of data, drafting the article. All authors have read and approved the final version of the manuscript.

Conflicts of Interest: The authors declare no conflicts of interest.

Ethics Approval: Not applicable.

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