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Review

Dripping Rainfall Simulators for Soil Research—Performance Review

Vukašin Rončević [1,*], Nikola Živanović [2], John H. van Boxel [3], Thomas Iserloh [4] and Snežana Štrbac [1]

[1] Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Njegoševa 12, 11000 Belgrade, Serbia
[2] Faculty of Forestry, University of Belgrade, Kneza Višeslava 1, 11000 Belgrade, Serbia
[3] Institute for Biodiversity and Ecosystem Dynamics (IBED), University of Amsterdam, Science Park 904, 1098 XH Amsterdam, The Netherlands
[4] Department of Physical Geography, Trier University, Universitätsring 15, 54296 Trier, Germany
* Correspondence: vukasin.roncevic@ihtm.bg.ac.rs

Abstract: Rainfall simulators represent often-used equipment for soil research. Depending on their performance, they could be appropriate for some soil research or not. The aim of this research is to provide insight into the capabilities of existing dripping rainfall simulators (DRS) to mimic natural rainfall and the frequency of simulated rainfalls of certain characteristics, facilitate the selection of rain simulators that would best meet the needs of soil research and to reach a step closer to the standardization of rainfall simulators. DRS performance was analyzed integrally, for simulators with more than one dripper ($DRS_{>1}$) and with one dripper ($DRS_{=1}$). A statistical analysis was performed for the performance of the DRS, wetted area, drop size, rainfall intensity, duration and kinetic energy. The analysis showed that DRS can provide rainfall that corresponds to natural rainfall, except in terms of the drop size distribution and wetted area. However, usually there are more factors that do not correspond to natural rainfall, such as the median drop size, volume and kinetic energy. Metal and plastic tubes (MT and PT) as the most present dripper types showed a strong relation between the outer diameter (OD) and drop size, while the inner diameter (ID) relation was moderate-to-weak. However, when increasing the range of MT drippers, for diameter size, the relation significance becomes very strong for bouts ID and OD. With the increase in the ID of PT, the relation deviates from the logarithmic curve that represents all drippers together. The sizes of the drops generated by the drippers are mostly in the range between 2 and 6 mm, while the number of drops smaller than 2 mm is relatively small. The intensity and duration of the simulated rain can be successfully produced to match natural values, with the most frequently simulated short-term rainfall of a high intensity. Most simulations were conducted at a fall height of up to 2 m, and then their number gradually decreases as the height gets closer to 5 m. Most simulations (58.6%) occur in the range between 20-90% KE, then 33.0% in a range of 90-100%, with only 8.4% lower than 20% KE.

Keywords: dripping rainfall simulators; drippers; simulator performance; soil research; rainfall simulator review

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1. Introduction

Rainfall simulators represent often-used equipment for soil research. According to the process of the formation of water drops, rainfall simulators can be divided into simulators that generate drops by spraying (Spraying Rainfall Simulators—SRS) [1–5] and by dripping (Dripping Rainfall Simulators—DRS) [6–9]. In addition to the mentioned groups, there is also a group of simulators that generate drops using the combined action of the two processes (Combined Rainfall Simulators—CRS). They usually involve nozzles or drippers that primarily create precipitation and different metal meshes, modifying the precipitation. They are created in an attempt to compensate for the shortcomings of simulators from the two previously mentioned groups [10–15]. Rainfall factors that are significant in terms of their impact on soil are the amount, intensity, duration and regime of precipitation [16–19], distribution raindrop sizes [20–22], spatial distribution [23], raindrop size, falling speed [24,25], direction of fall [26,27], direction of movement [18], kinetic energy [28], momentum [29] temperature [30] and chemical composition of rainfall [31].

It is important to keep in mind that simulator design and performance are mutually conditional, so to understand the simulator design it is necessary to analyze their performance as well [32]. By analyzing the rainfall simulators and comparing them with each other, the main differences in their performance were noted. SRS provides a distribution of water drop sizes that is more similar to natural precipitation, enables the establishment of the terminal velocity of the drops at a lower height and is advantageous in terms of the ease of manufacture, portability, the surface they can cover, handling and the price of the simulator [33,34]. On the other hand, DRS generate precipitation in a wider range of intensity, with the possibility of changing the intensity of precipitation without a significant change in the size of the drops and achieving greater uniformity of the spatial distribution of precipitation [9,34–36]. Simulators with only one dripper, by their design, enable a special analytical approach in the study of soil with the individual erosive action of drops on the soil [22,37–42].

Different research criteria and available resources have led to the development of simulators of specific design and performance [6,12,35,43–50].

Until now, several studies have been carried out in which rain simulators were presented, classified, and analyzed, in which their design was described, and some of their performances and areas of use were presented [34,51–55]. However, even though individual characteristics of the simulator and the general characteristics of the groups to which they belong are presented, a comparative analysis of the simulator performance factors is missing. Analysis of the individual performance of a relatively small number of simulators were provided by [55], while [56] conducted a detailed comparative analysis of the performance of 13 small portable rain simulators, of which two types are DRS, while the others are SRS.

The aim of this research is to review performances of DRS and CRS in which, during the primary phase, precipitation is created only by drippers. This research should provide insight into the capabilities of simulators to mimic natural rainfall and the frequency of simulated rainfalls of certain characteristics, facilitate the selection of rain simulators that would best meet the needs of soil research and reach a step closer to the standardization of rainfall simulators.

2. Materials and Methods

Due to the large number of data and the required extensive analysis, only the performance of DRS was analyzed in the research. ResearchGate, Google Scholar, KoBSON, COBISS, Academia.edu, JSTOR and Scopus internet databases of scientific works were used during the research. A search was conducted for all available scientific papers describing DRS and papers that include a wide range of thematically related papers to soil research in which DRS are used starting from 1941 until today. Together with the performance of DRS, this analysis has also included the performance of CRS in which, during the primary phase, precipitation is created only by drippers.

In order to analyze the performance of DRS, descriptive and numerical data sorted by category for each type and subtype of the simulator [32] were extracted from the papers, namely: surface and shape of the wet area of the plot, Christiansen's coefficient of uniformity of spatial distribution of precipitation, intensity and duration of simulated precipitation, diameter, the height of fall and kinetic energy of the generated drops.

In addition to the aforementioned categories of data, we also analyzed the data on the origin and temperature of the water used during the simulations, because these are also important factors.

The analysis of the performance of the rainfall simulator was carried out integrally for simulators with one dripper ($DRS_{=1}$) and more than one dripper ($DRS_{>1}$). However,

$DRS_{=1}$ was not used in the analysis of the distance between the drippers, the surface and the shape of the wetted area of the plot, the Christiansen coefficient of uniformity of spatial distribution of precipitation and the intensity of the precipitation. The performance analysis of the simulator, i.e., the factors of simulated rainfall, includes a descriptive and relational statistical analysis of the numerical values of the factors and the agreement of those values with the values of the factors of natural rainfall. Droplet kinetic energy was determined from the fall height and drop diameter data using the [57] numerical model for determining the raindrop terminal and achieved velocity.

The types and subtypes of simulators, whose performance was analyzed, were separated and presented in the work of [32]. Considering that not all the data according to the separated categories were available for every type or subtype of the simulator, an independent comparative analysis of the available data was carried out within categories.

The collected data were classified and presented using the LibreOffice 4.4 software package. Additionally, statistical data analysis was performed using LibreOffice 4.4 and IBM SPSS Statistics 20 software packages.

3. Results and Discussion

Out of a total of 188 scientific papers included in the analysis, 51 different types and 27 subtypes of $DRS_{>1}$ were singled out in 149 papers (Table S1 in Supplementary Materials), and in the remaining 39 papers, as many as 25 different types and 4 subtypes of $DRS_{=1}$ (Table S2) [32].

3.1. Wetted Area

The wetted area of $DRS_{>1}$ represents the surface of the experimental plot that is exposed to simulated rainfall. The shape is most often rectangular but can also be round, and its dimensions are determined by the shape and dimensions of the projected drippers surface [7,58–61].

In the analysis, two sets of data were combined: the exact and approximate wetted area. The first set represents explicitly stated values of the area or dimensions of the wetted area. The second dataset represents the wetted area data based on the assumption that the dimensions or a covered area of the water tank with drippers above correspond to the dimensions and area of the wetted area below. The second dataset gives values that are usually slightly overestimated; however, for a general analysis, this can be neglected.

The largest number of simulators covers a wetted area between 0.2 and 0.6 m^2 (Figure 1). A smaller number of simulators have a wet surface area below 0.2 m^2 and in the range of 0.8–1.0 m^2, while the number of simulators with a wetted area larger than 1.0 m^2 is significantly lower. One rainfall simulator had a wetted area of 36 m^2 [9]. Wetted areas covered by rain simulators of a modular design were not included in the analysis, but only the wetted areas were covered by separate modules.

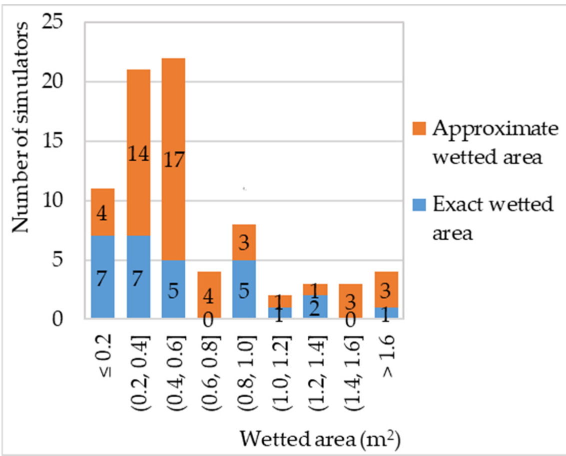

Figure 1. The number of DRS simulators with different wetted surface sizes.

3.2. Drop Size

Natural or simulated rainfall drop size is defined by the diameter of a sphere whose volume is identical to the drop volume, although raindrop shape usually is not entirely spherical [62–64]. The choice of drippers for the DRS is often based on the experience of previous research or personal empirical knowledge, under the assumption that drippers in the form of tubes and holes with a smaller internal diameter (ID) generate drops of a smaller diameter and vice versa, neglecting other factors that affect the size of the drops. However, when fitting logarithmic functions, the dripper diameter of metal and plastic tubes (MT and PT) showed a strong relation for the dripper's outer diameter (OD), while the relation for the dripper's ID is moderate-to-weak (Figure 2a,b). For some of the drippers, both the ID and OD values were available, so their pairs can be noticed on the graphic.

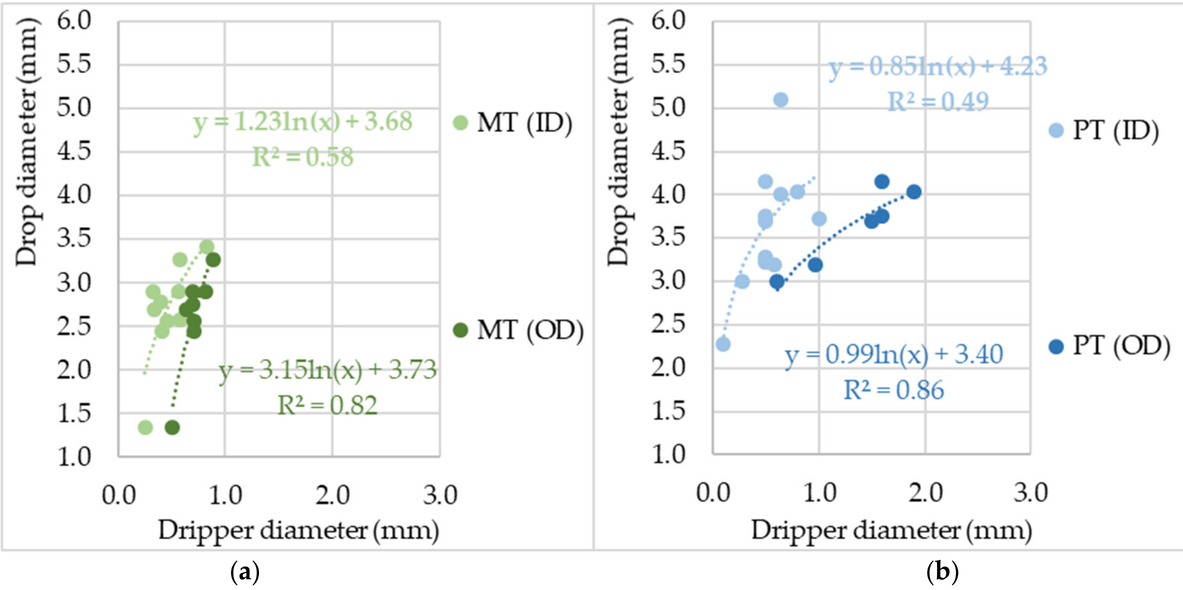

Figure 2. The influence of MT (**a**) and PT (**b**) drippers OD and ID on the drop diameter. Note: drippers whose corresponding drop diameter sizes were modified by the action of air, vibrations and inserted threads, and drops and drippers whose diameters were given in a range, were excluded from the analysis.

However, when increasing the range of the MT drippers' diameter size the relation becomes very strong, R^2 = 0.96 and 0.97, for both the ID and OD. Additionally, the logarithmic function that describes that relation is in accordance with data obtained by [65], where water drops were generated using hypodermic needles (Figure 3). On the other hand, observations by [66] showed that as the dripper diameter increased, the detached drop weight became less dependent on the dripper diameter.

In general, the relation between drippers and drop diameter, described using the logarithmic equation, shows a very strong relation for the dripper's OD, and a weaker but still strong relation for the ID (Figure 4). That is in accordance with [12], who roughly estimated that at the same water pressure, the OD size of the dripper determines the size of the drop.

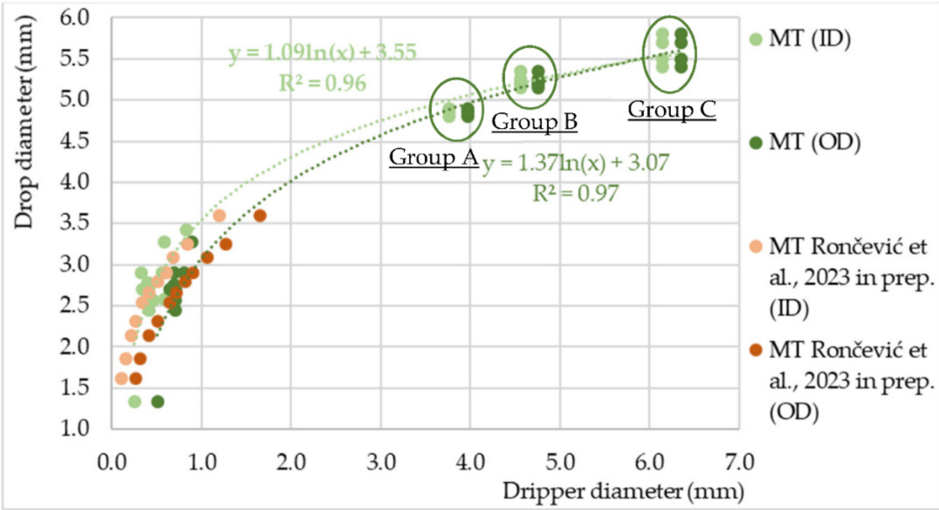

Figure 3. The influence of MT and PT drippers' ID and OD size on the drop's diameter with expanded diameter range (groups A, B and C) of MT drippers [67] in comparison to research of [65] Note: drippers whose corresponding drop diameters size were modified by the action of air, vibrations and inserted threads, and drops and drippers for which the diameter was given in a range, were excluded from the analysis. The equations shown exclude the data from the research of [65].

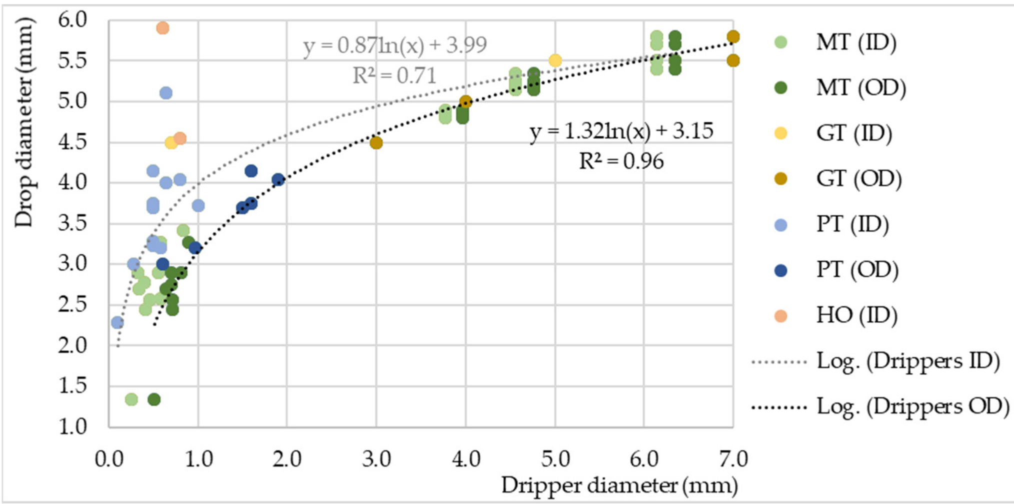

Figure 4. The influence of different types of drippers' ID and OD on drop diameter size (GT—glass tubes, and HO—holes in boards and tubes). Note: drippers whose corresponding drops diameter size were modified by the action of air, vibrations and inserted threads, and drop and dripper diameters given in a range, were excluded from the analysis.

It is obvious that with the increase in the ID of the plastic tubes, the relation deviates from the logarithmic curve that represents all drippers together. Additionally, there are HO drippers whose values deviate from the logarithmic curve too, but they are specific because they have an almost infinite outer diameter (Figure 4). It is suggested that a possible reason for such a deviation could be the dripper material. However, based on the research of [68–72], drippers made from different materials such as glass, brass, stainless steel, Teflon, all show no significant difference in drop size. The material type rather determines the thickness of the tube wall. Metal tube drippers generally have a thinner wall than plastic or glass tube drippers. Based on the data of drippers that had given both an ID and OD size, the thickness of different type tube walls was, respectively, <0.31, 0.33–1.10 and 2.00–2.30 mm. Depending on the geometry of the dripper tip, the drops are formed either at the ID (tubes with sharp, conical tip) or at the OD of the tip (blunt, flat tip) [72–75]. Therefore, when describing the relation between the dripper diameter and drop size, the assumption is that metal tube drippers have a different logarithmic distribution than plastic or glass tubes, because of their thinner wall (Figure 2a,b and Figure 4), regardless of whether they are sharp or blunt.

However, drop size is not exclusively correlated with dripper diameter, surface tension or dripper tip geometry. The size of the drop depends on numerous other factors; among them are dripping intensity, dripping tip position and geometry, length-to-diameter ratio, water temperature and environmental atmosphere condition [67,72,76].

In addition to the dripper diameter and type, the dripping speed is also a factor that was taken into account for soil research using rainfall simulators. [25]. With the rise in the dripping speed, the drop size of the MT drippers rises too, until it starts to decline at some point [65]. Separated data groups A, B and C, which can be seen in Figure 3, represent the research data of [67]. Three MT drippers of different diameters generated drops whose diameters differ due to different dripping intensities and have values of 2, 4, 8 and 12 cm^3. Although the dripping intensity difference is quite big, the drop size does not differ much. On the other hand, the difference was larger in the research of [50]. They used PT drippers with an ID of 0.5 mm and an OD value of 1.6 mm, at two different dripping intensities of 160 and 200 mm/h, resulting in drop sizes of 3.75 and 4.15 mm, respectively (Figures 2a,b and 4).

Additionally, the influence of water temperature on the size of the generated drop is significant [76]. Water used in rainfall simulations with DRS can be distilled water [37,39,77,78] or water available from the environment, which is most often water from the water supply network [79–84]. Of the physical characteristics of water, the temperature is most often mentioned [42,85–87], while the chemical composition of water is given in rare cases [63,83,88,89]. Based on the analysis of the recorded water temperature values in the available scientific works, it was determined that its values are predominantly in the range of 5–30 °C, with the most common values recorded in the range of 15–20 °C (Figure 5).

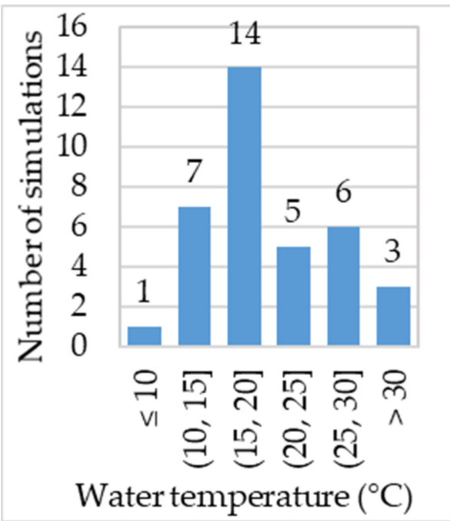

Figure 5. Measured water temperature values during rainfall simulations.

Modifications of dripper performance via air flow and vibration were carried out in order to expand the range of drop sizes, primarily with the aim of also generating drops with smaller diameters [90,91]. Additionally, threads inserted in drippers were applied primarily to achieve capillary movement of water in the dripper and reduce flow, despite the fact that they change the diameter of the generated drop [44,92]. In some cases, drippers in the form of tubes are inserted telescopically into each other (with water flow in a direction from the smaller to larger dripper diameter) in order to form drops corresponding to the ending dripper with the largest internal diameter, with a reduced intensity of dripping, thus facilitating dripping intensity regulation [67,93].

The sizes of the drops generated by the drippers are mostly in the range between 2 and 6 mm, while the number of drops smaller than 2 mm is relatively small (Figure 6). Although it is stated that the diameter of the drops of natural precipitation can reach 6, 7 and even 8 mm, it rarely exceeds 4 mm [94–96]. Falling drops are stable at terminal velocity until they reach a diameter of 4.6 mm, after which they break up into smaller ones due to the air resistance encountered during their fall, becoming definitely unstable with a diameter above 5.5 mm [97]. On the other hand, the maximum value of the median volume diameter (D_0) of natural precipitation is only 2.0-2.5 mm at an intensity of 25–200 mm/h [98], which is in agreement with the observations of other researchers [21,99], whereas higher values have been reported also [100–102]. However, these D_0 values refer most often to rains of a relatively high intensity, while rains of a lower intensity occur more often and achieve relatively lower D_0 values [103]. Accordingly, it is important to determine the method of generating drops with a diameter smaller than 2 mm in order to carry out simulations of rainfall with a smaller diameter. Drops of a larger diameter are successively produced with DRS. Although they occur much less often, they can cause considerable soil erosion.

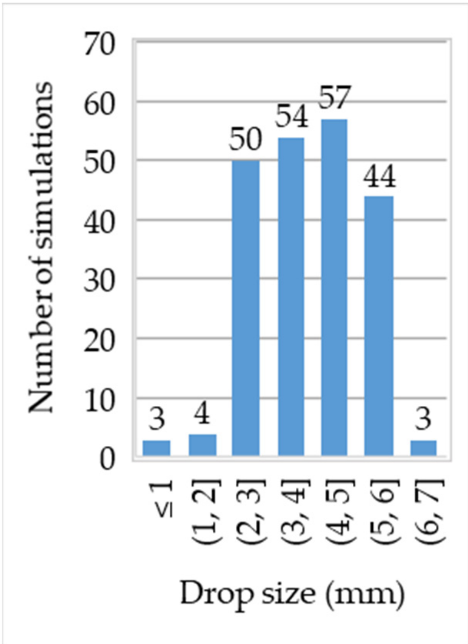

Figure 6. The number of simulations at different sizes of drop diameter. Note: drippers whose corresponding drop diameter sizes were given in a range were excluded from the analysis.

Drippers that generated drops of less than 2 mm dominantly belong to the drippers in the form of metal tubes whose performance is modified by the influence of air flow and vibrations, while the drippers used in the work of [104] generated drops of less than 2 mm with a relatively small dripper diameter, while in the work of [105], the drops were generated using electrical pulse generator technology. [84] did not state how such a small drop diameter was generated. [85] state that the dimensions of the hypodermic needle size 25 G (gauge number represents the standardized size of hypodermic needles) produced a drop with a 1.34-mm diameter. This is not in accordance with the expected diameter values assumed on the basis of the diameter of the drops usually obtained by drippers with gauge numbers 26 and 27, which produce a drop of a relatively bigger diameter [25,80,106]. Additionally, it is not in accordance with the research of [65]. Drops whose diameter is at the upper limit of the size of the drops of natural precipitation are not a problem to generate with drippers (Figure 7).

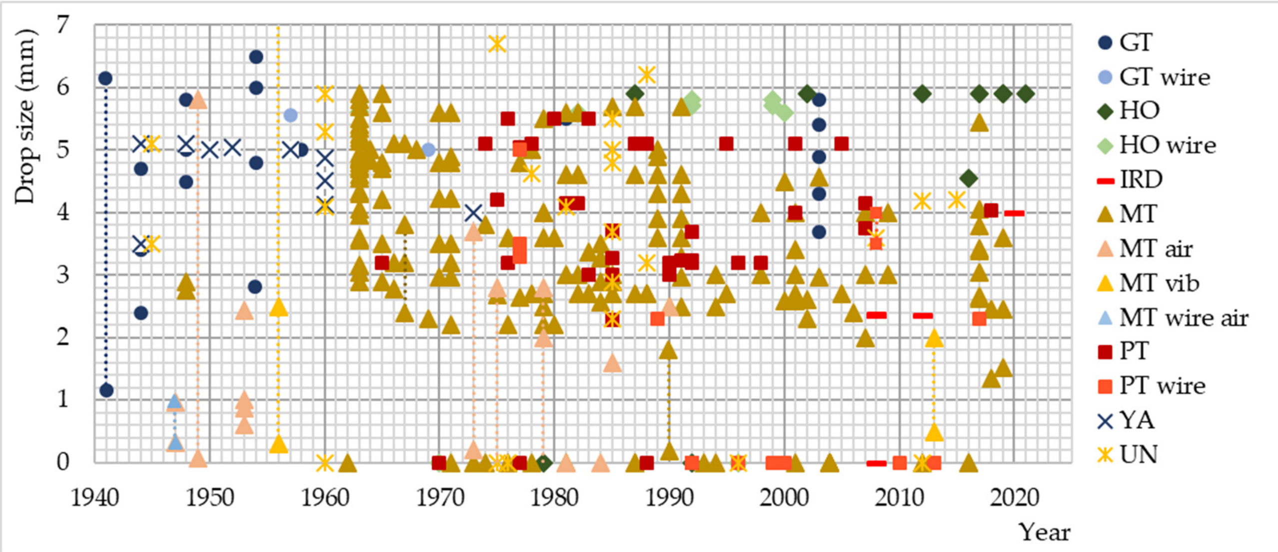

Figure 7. Type and subtype (modified performance drippers) of drippers and corresponding sizes of generated drops used in previous rainfall simulations (GT—glass tubes, GT wire—glass tubes with threads, HO—holes in dripper reservoir, HO wire—holes in dripper reservoir with threads, IRD—irrigation drippers, MT—metal tubes, MT air—metal tubes under the influence of air flow, MT vib—metal tubes under the influence of vibration, MT wire air—metal tubes with threads under the influence of air flow, PT—plastic tubes, PT wire—plastic tubes with threads, YA—hanging yarn and UN—unspecified dripper type). Note: for markers located on a horizontal line with a value of 0, the diameter of the generated drops was not specified [32]. Also, dotted lines represent simulated drop diameter values that are given in a range.

3.3. Rainfall Intensity and Duration

The rainfall intensity of DRS is regulated by regulating the pressure or water flow in the hydraulic system of the simulator [32,107–110].

The most common values of simulated rainfall intensities range up to 50 mm/h, and then their number gradually decreases for the ranges of 50–100 mm/h, 100–150 mm/h and over 150 mm/h, with a maximum value of over 1600 mm/h (Figure 8).

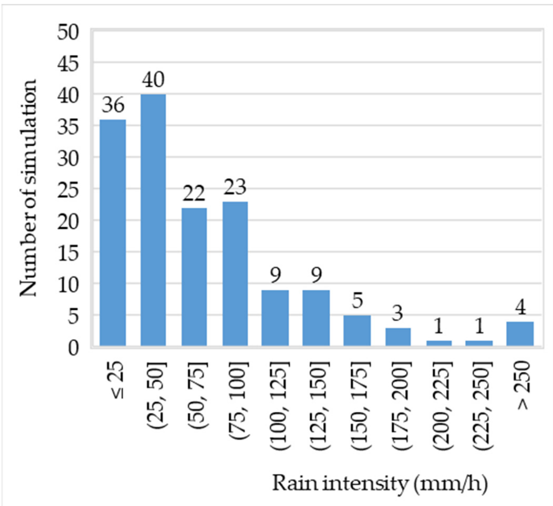

Figure 8. Number of simulations at different intensities of simulated precipitation. Note: simulations with a single dropper or those for which intensity values are given in a range are not included in the analysis.

Rainfall intensity is correlated with drop size median volume (D_0), which, as suggested by [111], is the best parameter for representing the drop size distribution of rainfall. However, the relationship is site specific [112] (Figure 9). With an increase in the intensity of precipitation, the value of D_0 also increases [101,111,113–116]. However, some researchers state that after reaching a rainfall intensity of about 70–100 mm/h, the D_0 hardly changes and stabilizes [98,103,117–120], while some even report that the D_0 decreases [103,121–123] (Figure 9).

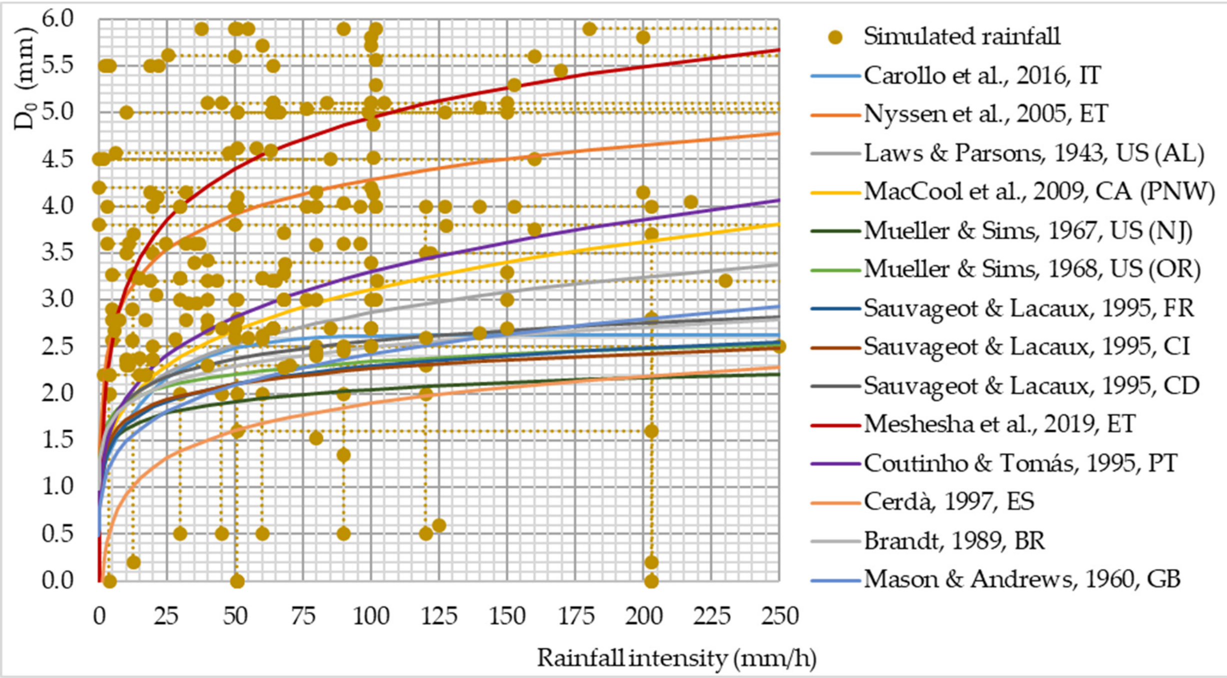

Figure 9. D_0 as a function of intensity for natural and simulated rainfalls. Note: two capital letters after reference represent the ISO Alpha-2 country code that designates countries in which measurements have been conducted [21,54,99–102,113,124–128]. Note: dotted lines represent simulated D_0 and rainfall intensity values that are given in a range.

Given that $DRS_{>1}$ generate precipitation whose drop size uniformity coefficient is theoretically 100% (in practice it will be somewhat lower), the values of the D_0 should correspond to the diameter of any such generated drop. Although it is possible using $DRS_{>1}$ to generate precipitation intensity in the range of the D_0 that occurs in nature, there is a relatively small number of simulated precipitations that corresponds to natural precipitation. D_0 values usually rise until a rainfall intensity between 50–75 mm/h is reached, achieving maximum D_0 values ranging from 2.0–2.7 mm at a precipitation intensity ranging from 75–200 mm/h (Figure 9).

The duration of the simulated rainfall is determined by the availability of water necessary for the simulation and the intensity of the rainfall. If the water necessary for the simulation is available in unlimited quantities, the duration of the simulation is also unlimited, while on the other hand, if the amount of water is limited, the duration of the simulation directly depends on the intensity of precipitation [32]. The largest number of simulations was conducted for a duration of less than 30 min, then the number of simulations gradually decreased to a duration of 2 h, while only a few simulations were conducted for a duration longer than 2 h (Figure 10).

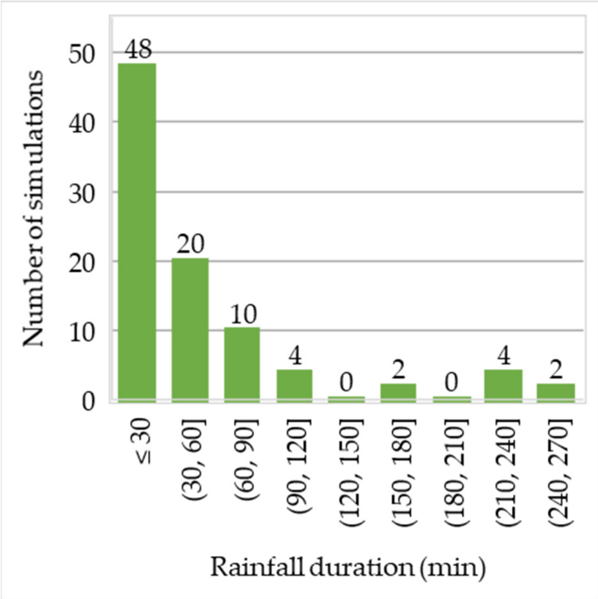

Figure 10. Number of rain simulations at different durations. Note: data whose duration values are given in ranges are not included in the analysis.

In addition to the D_0, rainfall intensity is also correlated with rainfall duration. The simulated and natural precipitation intensity for the return period of 1–5 years for different geographical areas mostly coincides (Figure 11).

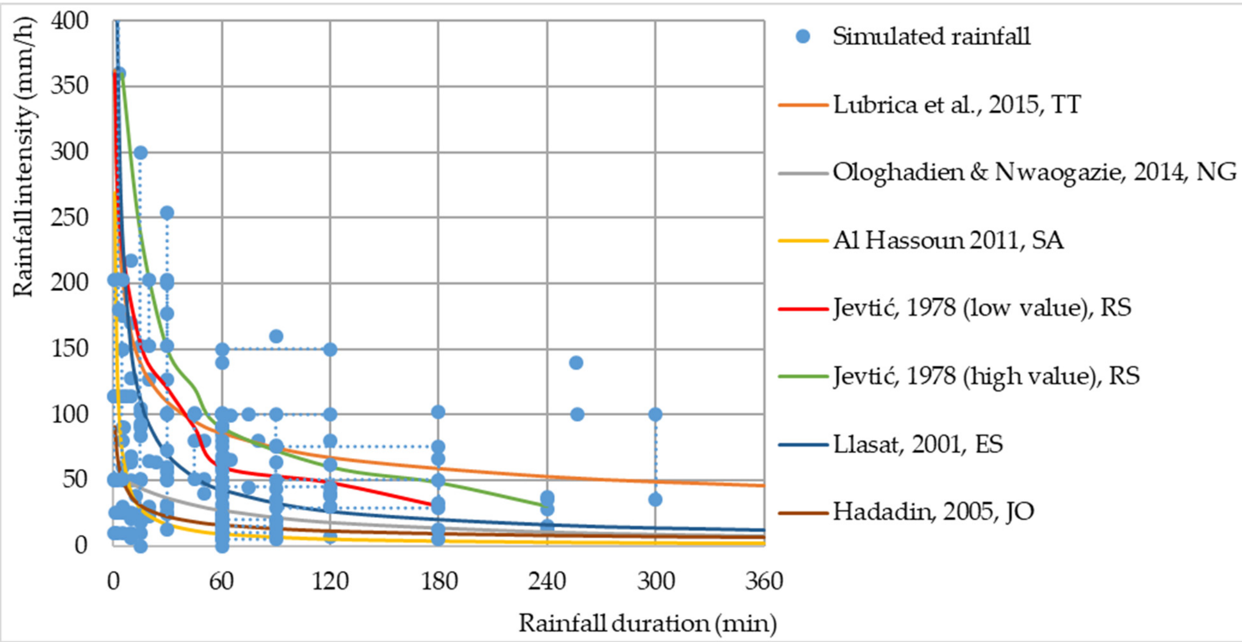

Figure 11. Rainfall intensity as a function of the duration of natural and simulated rainfalls. Note: two capital letters after reference represent the ISO Alpha-2 country code that designates countries in which measurements have been conducted [23,129–133]. Note: dotted lines represent simulated rainfall duration and rainfall intensity values that are given in a range.

3.4. Kinetic Energy (KE)

The KE of rainfall is determined by the size distribution of raindrops and their falling speed. Since the diameter of the drop and the height of the fall are known for $DRS_{>1}$, it is possible to calculate the KE of such precipitation. There are several works that determined the terminal velocity of drops of different diameters under given conditions [57,104,134–136] however, during simulations, due to the insufficient height at which the drops were placed, terminal velocities were often not reached. Given that the change in drop velocity does not occur linearly with the change in drop height and is different for drops of different diameters, there is no single equation that could represent this relationship [57]. For the purposes of the research, a mathematical model by [57] for determining the terminal and achieving the speed of drops of different diameters at different heights of drops was applied for the determination of the achieved speed, i.e., the KE of drops in the previous simulations (Figure 12).

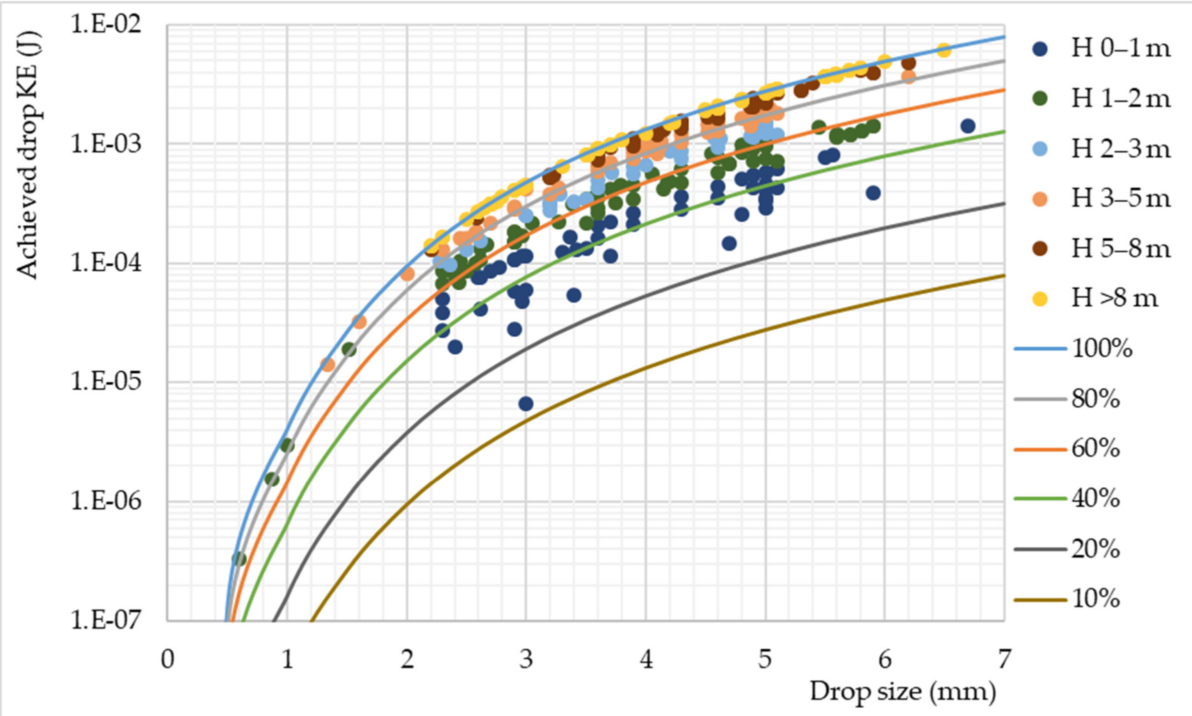

Figure 12. Achieved drop KE of simulated precipitations for different heights based on the mathematical model of [57]. Note: the analysis did not include simulations for which drop height values were given in a range.

For 1-mm drops, the required height to achieve 90% of terminal velocity would be proximately 1.5 m, and for 2-mm drops it would be about 4.0 m, after which it increases to about 5.5 m for bigger drops [57]. Figure 13 shows the representation of different fall heights during the simulations, where it can be seen that most simulations were conducted at a fall height of up to 2 m (43.7%), and then the percentage decreases gradually as the height gets closer to 5 m (31.1%). Falling heights over 5 m occupy 25.2% of all simulations and occur relatively equally, while the highest recorded falling height is 14 m. However, depending on the diameter of the drop, the presented values of the drop height may or may not be satisfactory in terms of achieving the terminal drop speed [57].

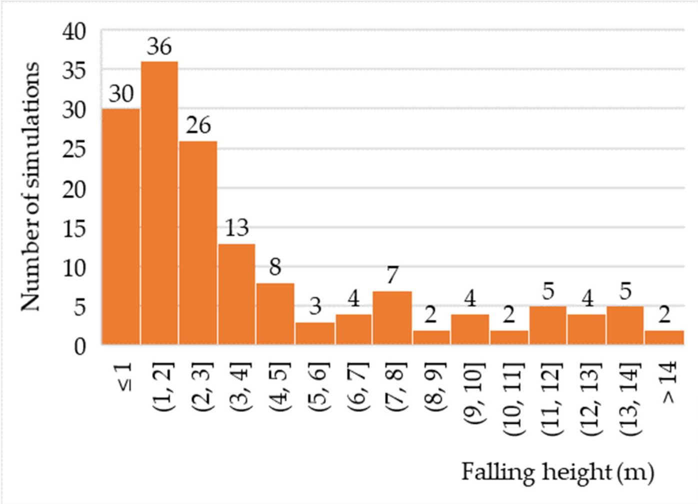

Figure 13. Number of simulations at different heights of simulated precipitation [32]. Note: data whose values are given in ranges are not included in the analysis.

The number of simulations with a KE lower than 30% have a steep rise within categories, after which their number slowly falls with the increase in the KE until reaching the category of 90-100%, which comprises 33.0% of simulations. Most the simulations (58.6%) occur in the range between 20 and 90% KE, while only 8.4% are lower than 20% KE. Drops smaller or equal to 2-mm diameter achieved a KE in a range of 60-80% in 28.6% of the simulations, while 71.4% of the simulations achieved over 85% of the KE (Figure 14).

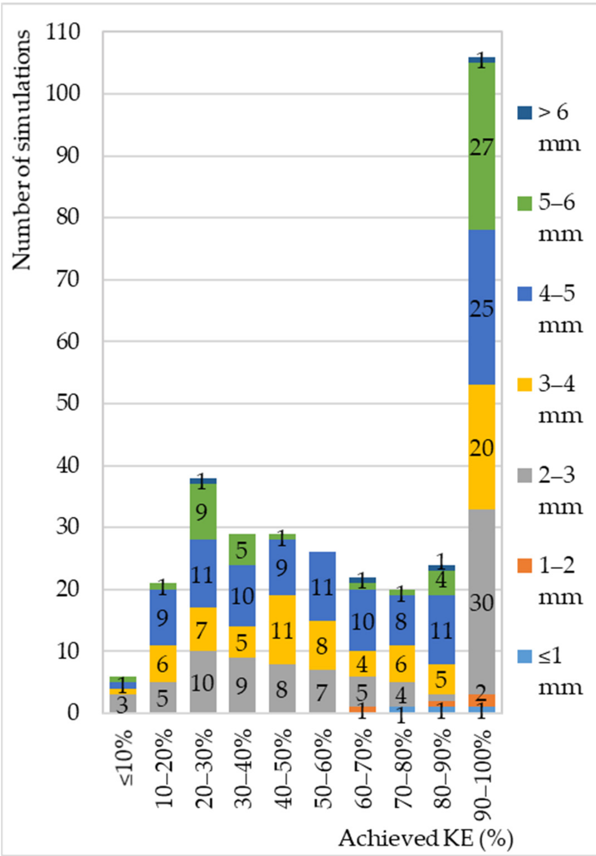

Figure 14. The number of simulations at different values of the achieved KE in relation to falling drops of different diameters. Note: data whose values of drop diameter or fall height are given in ranges are not included in the analysis.

4. Conclusions

The analysis of the performance of DRS determined their ability to properly simulate rainfall. Research showed so far that DRS can provide rainfall that correspond well with natural rainfall, except in terms of the drop size distribution and wetted area, which can be cited as the biggest shortcoming of DRS; on the other hand, usually there are more factors that do not correspond to the natural conditions, such as the median drop size volume and kinetic energy.

The wetted area of most rainfall simulators has a square shape, is relatively small and can be increased by using a modular design simulator.

MT and PT as the most present drippers type showed a strong relation between the OD and drop size, while the ID relation is moderate-to-weak. However, when increasing the range of MT drippers' diameter size, the relation becomes very strong for both the ID and OD. A logarithmic relation between the drop diameter and MT diameter matches very well with the data of [65]. With the increase in the ID of the plastic tubes, the relation deviates from the logarithmic curve that represents all drippers together. It is suggested that a possible reason for such a deviation could be the dripper material. Metal tube drippers generally have a thinner wall than plastic or glass tube drippers. Metal drippers have a different logarithmic relation than plastic or glass tubes because they have a thinner wall.

In addition to the dripper diameter and type, the dripping speed is also a factor that was taken into account for soil research using rainfall simulators. Although the dripping intensity in relation to the MT drippers' difference could be quite high, the drop size does not differ much. On the other hand, the difference was larger for thicker wall tubes.

Water used for simulations is usually distilled water or water available from the environment, which is most often water from the water supply network. The water temperature is predominantly in the range of 5–30 °C, with the most common values recorded in the range of 15–20 °C.

The sizes of the drops generated by the drippers are mostly in the range between 2 and 6 mm, while the number of drops smaller than 2 mm is relatively small. Given that, the maximum value of the median volume diameter (D_0) of natural precipitation is usually only 2.0–2.5 mm, and given that high-intensity precipitation occurs less frequently, it is important to determine the method of generating drops with a diameter smaller than 2 mm in order to carry out simulations of rainfall more similar to natural rainfall. Drippers that generated drops of less than 2 mm dominantly belong to the drippers in the form of metal tubes, whose performance is modified by the influence of air flow and vibrations.

The intensity and duration of the simulated rain can be successfully produced to match natural values, with the most frequently simulated short-term rainfall of a high intensity. The most common values of simulated rainfall intensities range up to 50 mm/h, and then their number gradually decreases for the ranges of 50–100 mm/h, 100–150 mm/h and over 150 mm/h, with a maximum value of over 1600 mm/h. The largest number of simulations was conducted for a duration of less than 30 min, then the number of simulations gradually decreased to a duration of 2 h, while only a few simulations were conducted for a duration longer than 2 h.

Most simulations were conducted at a fall height of up to 2 m, and then the percentage gradually decreases as the height gets closer to 5 m. Falling heights over 5 m occur relatively equally, while the highest recorded falling height is 14 m. However, depending on the diameter of the drop, the presented values of the drop height may or may not be satisfactory in terms of achieving the terminal drop speed.

Most of the simulations (58.6%) occur in the range between 20–90% KE, then 33.0% in the range of 90–100%, and only 8.4% are lower than 20% KE.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/w15071314/s1, Table S1: Classification of $DRS_{>1}$ according to water moving mechanism and water tank with drippers type and shape, with listed literature sources of papers in which simulators are described or applied (W. pump—water pump; CCW—cloth on chicken wire; Not Spec.—not specified; WTD—water tank with drippers). Note: background colors signify different groups in a classification table only to make it easier for reader to observe data. Table S2: $DRS_{=1}$ with the listed sources of papers in which they are described or applied (References [137–261] are cited only in the Supplementary Materials).

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