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Canopy Effects on Rainfall Partition and Throughfall Drop Size Distribution in a Tropical Dry Forest

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Abstract: The energy distribution of natural rainfall droplets at different stages of canopy development in low-latitude semi-arid environments is still understudied. We assessed relationships between canopy development, gross rainfall (P) and throughfall (TF) characteristics in a tropical dry forest (TDF) with a total of 95 events of natural rain during December 2019–July 2021, in Northeast Brazil. One disdrometer was installed in an open field to record the gross rainfall and another under the deciduous vegetation canopy to record the throughfall. At the onset of the rainy season with a low leaf density, a larger fraction of rainfall was converted into throughfall, which declines as the leaf density increases. For events higher than 3 mm, the number of TF drops was always higher than that of P and with smaller diameters, regardless of the stage of canopy development, which indicates fragmenting of the rain drops by the vegetation canopy. The insights of this study are useful to quantify the impact of canopy development stages of a TDF on the characteristics of rainfall reaching the soil forest. Since those characteristics affect the water balance and soil erosion at the hillslope scale, the information provided is crucial for water and soil management.

Keywords: tropical dry forest; throughfall; disdrometer; rainfall; raindrops; attenuation of rainfall; Caatinga

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1. Introduction

Rainfall is the main source of water for tropical dry forests and essential to understand its relation to the hydrological processes of these regions. Vegetation intercepts the raindrops that would otherwise directly reach the forest soil and modifies both the temporal distribution of rainfall [1] and droplet characteristics, such as size, number, and volume [2]. A better understanding of rainfall interactions with vegetation enables model development on ecohydrological processes and supports the better management of natural resources [3–5].

Upon a rainfall event on a vegetated surface, the rain is partitioned into three components: interception—rainfall retained by the vegetation cover that is evaporated back into the atmosphere [4,6], stemflow—flow along the tree stem that conveys water to the root area, an important process during the dryer periods [7], and throughfall—rainfall that reaches the soil with no contact with the vegetation and leaf drip from the canopy [1,2,8,9].

Vegetation influences the spatial-temporal distribution of throughfall in quantity, intensity, particle diameter, particle velocity, and kinetic energy, impacting the hydrological processes of forest soils [8,10–12]. Vegetation characteristics such as the stages of canopy development, leaf shape, and branches [13–16] are known to promote different impacts on hydrological processes in different regions [17,18], e.g., a median throughfall was reported to vary between 70% and 80% in temperate and boreal sites and the tropics, respectively, and to be approximately 70% in arid and semi-arid regions [9]. The distribution of the particle size of throughfall under different types of trees has been assessed in different parts of the globe [1–3,8,11,12,19–21].

Throughfall drop size distribution may be used to better estimate throughfall kinetic energy in soil erosion studies [8], as the terminal velocity and erosive potential of rainfall are influenced by drop size and rainfall intensity, and throughfall drops tend to have a larger median size than gross rainfall precipitation. Studies have been conducted to assess the effect of rainfall characteristics on the interception process in tropical dry forests (TDF) [22–24], on interception modeling [25,26], and on the throughfall characterization at different stages of canopy development and time scales [5]. However, in tropical semiarid regions, variables such as particle diameter and velocity are hardly included in these studies due to the high cost of data acquisition equipment such as disdrometers. Studies on the attenuating role of deciduous vegetation of TDF on the size and velocity of raindrops at different stages of canopy development are still scarce.

Studies conducted in regions with other climates and vegetation types indicate that the canopy plays a major role in changing the characteristics of rainfall that reach the soil (e.g., duration, intensity, and drop size distribution), but data are scarce in low-latitude semi-arid regions. High-intensity rainfall events in those areas might be strongly impacted by the canopy, but the deciduous pattern of the vegetation might influence its role on rainfall partitioning over time. Therefore, this work aims to analyze the effect of the seasonally dry tropical forest vegetation on throughfall at different stages of canopy development in a low-latitude semi-arid environment under natural rainfall events.

2. Materials and Methods

2.1. Study Area

The study area is located in an experimental watershed in Iguatu CE, Northeastern Brazil. The geographic coordinates are: 6°23′ S and 39°15′ W (Figure 1) with an elevation of 218 m above the sea level.

The climate is a BSw'h' (semi-arid hot), with an average monthly temperature always above 18 °C in the coldest month and with well-defined rainy and dry seasons, according to the Köppen classification [27]. With an average annual rainfall of roughly 1000 mm, 84% is concentrated in the rainy season. March and April receive 43% of the annual rainfall [22], with a high occurrence of consecutive dry days [28,29]. The dry period occurs from June to December, with only 1% of the total annual rainfall [22], showing the high temporal variability of rainfall [28,30]. The annual potential evapotranspiration surpasses 2000 mm, which is within the 0.2 and 0.5 rainfall-to-potential evapotranspiration ratio described by [31] for semi-arid regions and has an aridity index of 0.48 [32] that also classifies the region as semi-arid, where water scarcity is observed 9 to 10 months per year [33].

The site under study is a tropical dry forest (TDF), locally known as the phytogeographic domain of Caatinga, and is being regenerated since 1978. The vegetation of the TDF is characterized as xerophytic, with varied physiognomy and floristics composed of small to medium-sized species; deciduous, thin, and small leaves; closed stomata; and the presence of well-developed root systems and adapted to drought-related water deficit, due to the irregularity of rainfall. The most frequent species belong to the families *Croton blanchetianus*, *Mimosa caesalpiniifolia*, and *Aspidosperma pyrifolium*, which represent 62% of the total relative density [34]. In addition, the average height of the plants is 5.2 m [34].

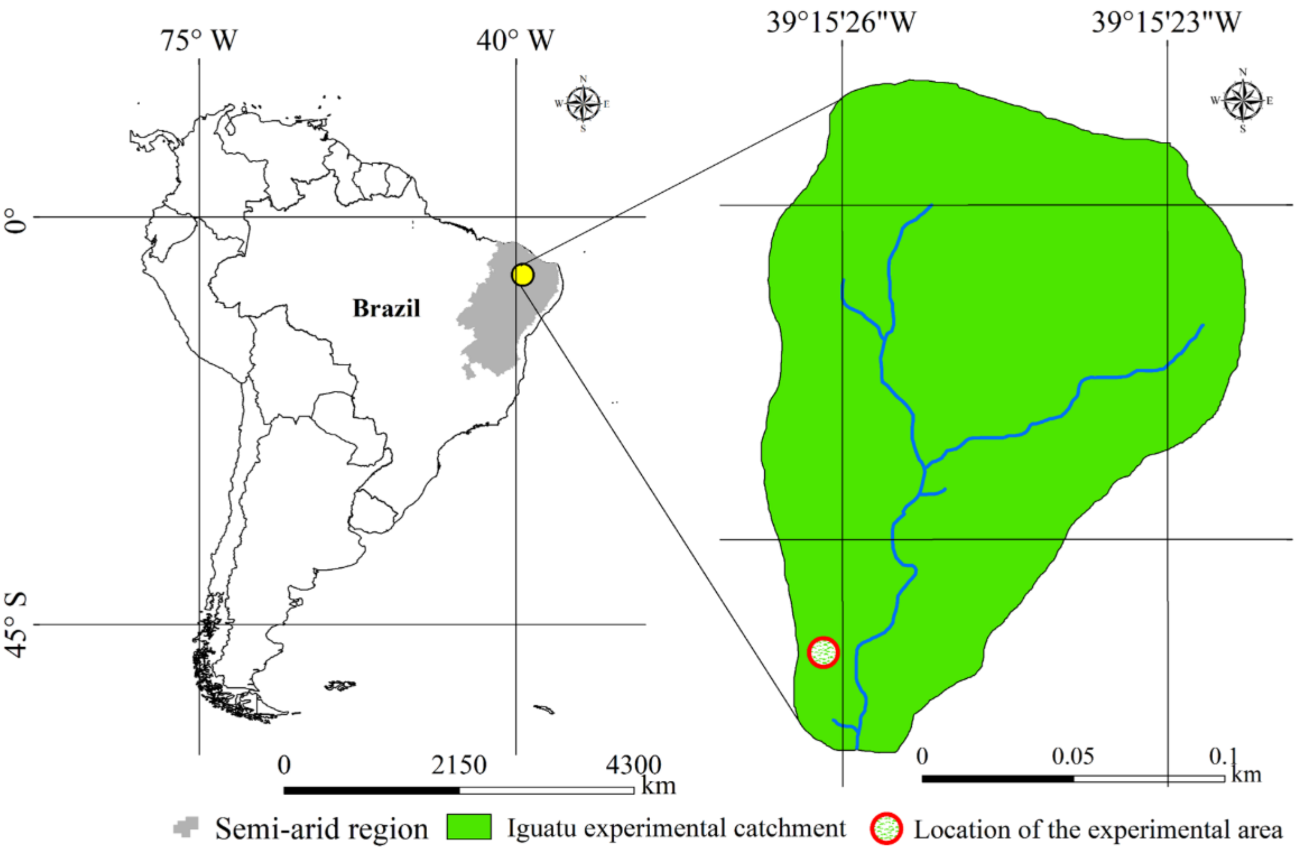

Figure 1. Location of the experimental area in the municipality of Iguatu CE, Northeastern Brazil.

2.2. Rainfall Monitoring with Disdrometer

Two laser precipitation monitors, Thies Clima 5.4110.xx.x00. V2.5x STD [35], were subsequently placed 30 m apart on ground stations to measure the properties of the hydrometeors under different conditions—one in the open field to record the gross rainfall (Figure 2c) and another under the vegetation canopy to record the throughfall (Figure 2d,e). The trees under which the disdrometer was placed are *Mimosa caesalpiniifolia*, and *Aspidosperma pyrifolium* and have their leaves and branches at distances between 1.5 and 5 m above the disdrometer. The disdrometers were not moved for the entire period of study, from December 2019 to July 2021, and were installed at a height of 1.5 m relative to the ground level.

The experimental setup (Figure 2) included the provision of a power supply for the disdrometers, as there was no electricity in the study area (Figure 2a,b). A global positioning system (GPS) receiver was used for date and time adjustments to avoid time reading errors. Data were stored in an external memory connected to a minicomputer (Raspberry) in .txt format and downloaded through the Wi-Fi network provided by the Raspberry interface. As an aid and reference to the disdrometer data, a HOBO rain gauge (Measurement Systems Ltd., Newbury, UK) with a surface area of 188.7 cm^2 with a data logger, was installed in the open field to monitor the gross rainfall (Figure 2f) at approximately 30 m from the open field disdrometer.

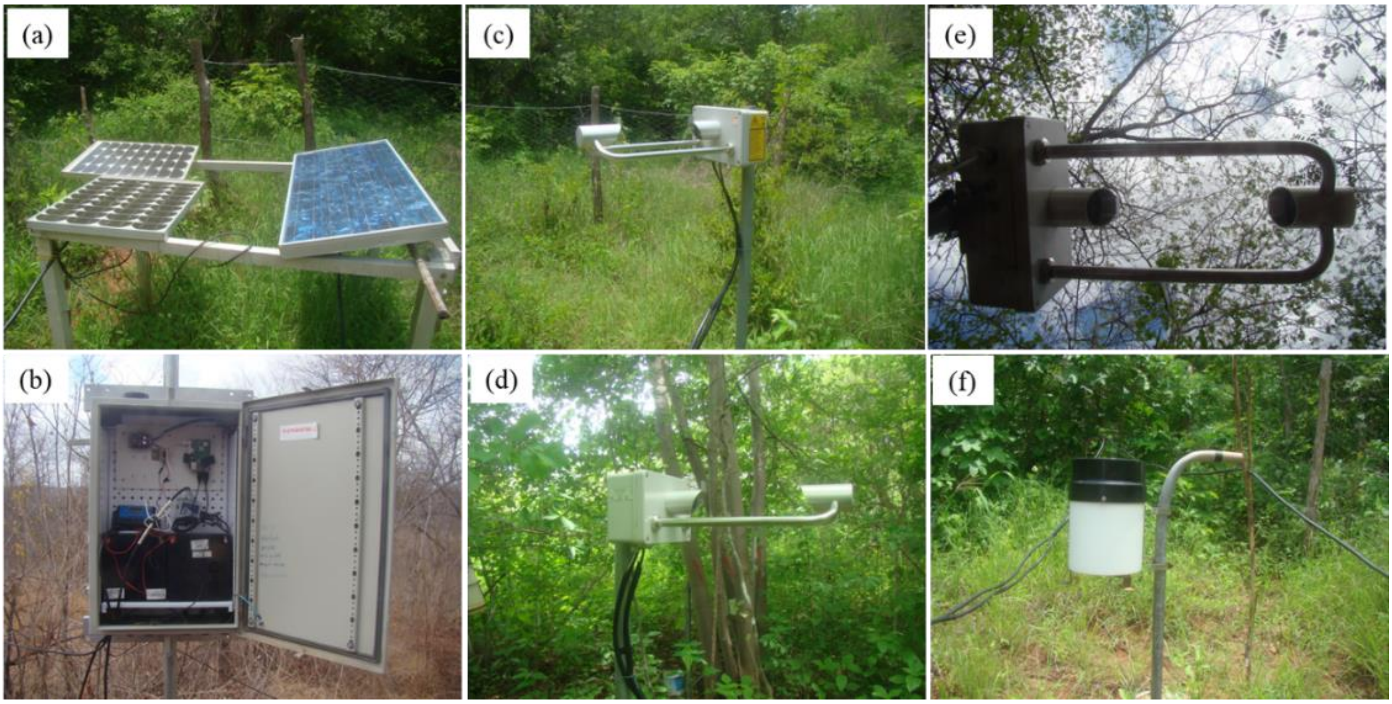

Figure 2. Experimental setup: (**a**) solar panel, (**b**) box with batteries, converters and Raspberry, (**c**) open field disdrometer, (**d**,**e**) disdrometer under TDF canopy, and (**f**) tipping-bucket rain gauge.

The disdrometer consists of a laser source, two sets of lenses, a receiver, and a digital signal processing unit [36]. When a hydrometeor falls through the light beam, the receiving signal is attenuated. The particle diameter is calculated from the amplitude of the attenuation, and the velocity at which the particle falls is determined by the attenuated signal duration [1–3,10,11,37,38]. Further information can be found in the equipment manual [35]. Both disdrometers have a factory calibration certification, which comprises the determination of the geometrical shape, size, and calibration of the drop volume.

The disdrometer output is a table in .txt format, with the count of all recorded particles (22 diameter and 20 particle velocity classes, see Table 1) that crossed the detection area of 45.6 cm^2 at every one minute. Each element of this table is associated with a diameter and particle velocity class. The first element stores the number of particles with a diameter between 0.125 and 0.250 mm and a particle velocity between 0 and 0.2 m/s; the second element stores the number of drops with the same diameter but with particle velocities between 0.2 and 0.4 m/s. The next 20 elements cover all particle velocities for the next diameter class and so on, covering diameters of 0.125 mm–8 mm and particle velocities ranging from 0.2 m/s to 10 m/s (Table 1). The result is a total of 440 columns—22 × 20 matrix [35].

Table 1. Diameter and particle velocity classes registered in the disdrometer.

Class	D (mm)	ACD (mm)	PV (m/s)	APS (m/s)
1	≥0.125	0.1875	≥0.000	0.652
2	≥0.250	0.3125	≥0.200	1.212
3	≥0.375	0.4375	≥0.400	1.779
4	≥0.500	0.6250	≥0.600	2.595
5	≥0.750	0.8750	≥0.800	3.567
6	≥1.000	1.1250	≥1.000	4.394
7	≥1.250	1.3750	≥1.400	5.101
8	≥1.500	1.6250	≥1.800	5.718
9	≥1.750	1.8750	≥2.200	6.267

10	≥2.000	2.2500	≥2.600	6.986
11	≥2.500	2.7500	≥3.000	7.759
12	≥3.000	3.2500	≥3.400	8.318
13	≥3.500	3.7500	≥4.200	8.693
14	≥4.000	4.2500	≥5.000	8.930
15	≥4.500	4.7500	≥5.800	9.061
16	≥5.000	5.2500	≥6.600	9.123
17	≥5.500	5.7500	≥7.400	9.170
18	≥6.000	6.2500	≥8.200	9.212
19	≥6.500	6.7500	≥9.000	9.249
20	≥7.000	7.2500	≥10.000	-
21	≥7.500	7.7500		
22	≥8.000	-		

D—diameter; ACD—average class diameter; PV—particle velocity; and APS—average particle velocity.

Both disdrometers recorded the following rainfall characteristics: rainfall quantity (mm), average rainfall intensity (mm h^{-1}), rainfall duration (h), average particle size (mm), particle diameter (mm), particle velocity (m/s), particle size distribution, total number of particles, and total particle volume (mm^3). These characteristics were recorded at 1-min intervals.

Individual rainfall events were separated by a minimum rainfall inter-event time of 6 h, as it is a criterion commonly used in hydrological studies and was established by [39] in the same study area. We assumed that there was no canopy or trunk water storage at the onset of the rainfall events. Such an assumption might interfere with the stemflow quantification but is expected to have little influence on throughfall [40], as this is the major component of rainfall partitioning and usually much higher than the canopy storage capacity, estimated as 0.5–1.0 mm [5,26].

During the period of study, there were 122 natural rainfall events, but due to technical problems, the disdrometer under the canopy recorded a throughfall of 95 rainfall events. For comparative analyses between the P and TF data, only the events that recorded both gross rainfall and throughfall were used.

2.3. Canopy Development Stages

The deciduous characteristic of the TDF impacts the dynamics of the rain interception process [5]; hence, changes in leaf density during the rainy and dry season were monitored. We assessed the development of vegetation during the study period through photographic records (Figure 3) taken with a NIKON D7200 SRLD camera, always at the same location and at the same position (height and angle). The association of vegetation aspect (from photographs) and density was supported by the study developed by [41] for the Caatinga vegetation, and applied with the same goal by [5] in our study site. The canopy density was used as a proxy to LAI to separate the different stages of canopy development and evaluate the role of vegetation in the redistribution of rainfall particles in the throughfall.

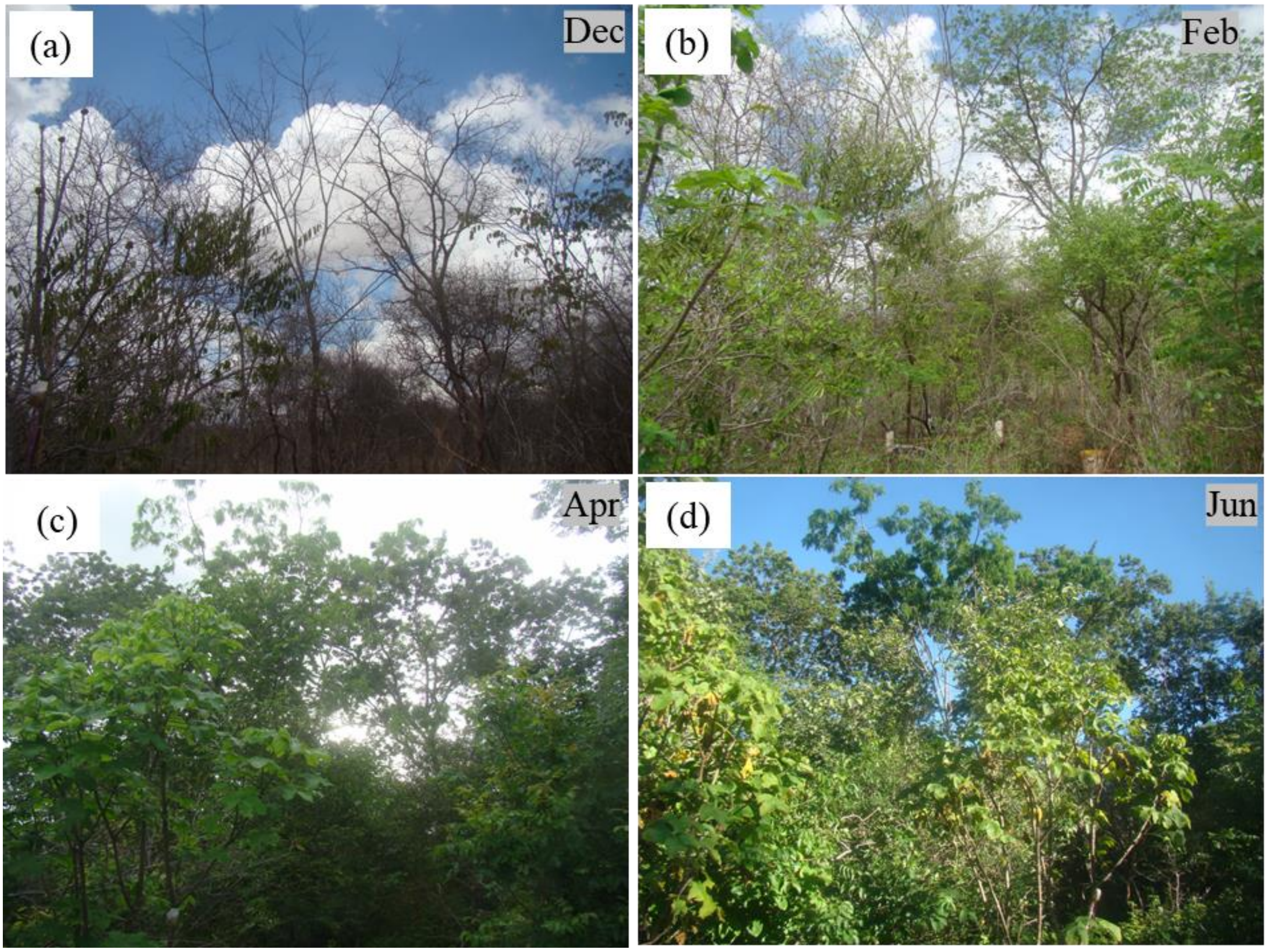

Figure 3. Photographic records of changes in leaf density during the study period: (**a**,**b**) during leaf development, (**c**) at maturity, and (**d**) during the fall period. Photos by the author.

The canopy stages were divided into three phases (Table 2): the first corresponding to leaf development after the dry season because of the deciduous nature of the vegetation and absence of leaves during the long dry season (Figure 3a) and the second phase, or the full development of leaf mass (Figure 3c), beginning at the end of February after the occurrence of the first rainfall events (Figure 3b) and lasting until April. In the third phase (May–July), leaf fall occurred, thus reducing canopy density, as observed in Figure 3d.

Table 2. Summary of the three stages of canopy development as a function of the rainfall depth and canopy density.

Period	Dec	Jan	Feb	Mar	Apr	May	Jun
Canopy stages		Low leaf Density		High leaf density		Period of leaf fall	
Total P ≤ 5 mm		37.9 mm		52.6 mm		15.0 mm	
Number of events		15		22		8	
Total P > 5 mm		248.9 mm		779.9 mm		114.6 mm	
Number of events		8		35		7	

Total P—cumulative rainfall (mm) by class as a function of the canopy development stage.

2.4. Data Analysis

The disdrometer data—a 22 × 20 matrix (22 classes of diameter and 20 classes of particle velocity)—was analyzed by linear regression and boxplots used to assess the distribution and characteristics of gross rainfall (P) and throughfall (TF) as a function of the canopy development stages and rainfall classes.

Data normality was tested by the Kolmogorov–Smirnov test, which indicated a nonnormal series ($p < 0.01$). Thus, the Wilcoxon nonparametric test was used to compare the medians of the P and TF data at the 99% confidence level for the different stages of canopy development and rainfall classes. All statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS) version 16.0, MINITAB version 18, and Microsoft Excel.

3. Results and Discussion

During the study period, from December 2019 to July 2021, 95 rainfall events were monitored for both gross rainfall and throughfall. Rainfall event separation was based on a 6-h minimum inter event time, as suggested by [39] for this region. The total event rainfall varied from 0.42 to 116.70 mm (Table 3), evidencing the high variability of rainfall in the region (Figure 4). The highest frequency of occurrence (48%) was recorded for events with a total rainfall below 5.0 mm (Table 3 and Figure 4)—the high occurrence of small rainfall events and high temporal variability are characteristics of tropical semi-arid regions of low latitude [22,33,42]. For more information on the contribution of low rainfall events to the understanding of the hydrological processes, see the research [5,43] in a tropical semi-arid region of low latitude.

Table 3. Descriptive statistics of the monitored rainfall events.

All Events								
Variables	**Number of Events**	**Mean**	**SD**	**Min**	**Max**	**Q1—25**	**Q2—50**	**Q3—75**
P (mm)	95	13.15	19.83	0.42	116.7	1.76	5.36	16.73
Classes of rainfall								
P ≤ 5 mm	45	2.34	1.46	0.42	4.98	1.17	1.7	3.62
P > 5 mm	50	22.87	23.45	5.27	116.7	9.12	15.7	23.8
	Canopy stages	P ≤ 5 mm		P > 5 mm				
		SD	CV	SD	CV			
	Low leaf density	1.42	0.56	29.7	0.95			
	High leaf density	1.47	0.63	25.07	1.01			
	Period of leaf fall	1.27	0.78	12.92	0.64			

P—Rainfall (mm); Percentiles—Q1—25th, Q2—50th (Median), and Q3—75th; SD–standard deviation; and CV–coefficient of variation.

Given the variability of the rainfall regime (droughts and irregular rainfall) and the study area being a TDF with vegetation adapted to water deficit, the rainfall events were separated into two distinct classes (Table 3 and Figure 4): events with a gross rainfall below 5.0 mm and events with a gross rainfall above 5.0 mm.

The characteristics of gross rainfall (P) and throughfall (TF) were analyzed according to the three stages of development, as described in Section 2.3. The relationship between P and TF at the three stages of canopy development is shown for the two defined rainfall classes (Figure 5), indicating that a higher canopy density reduces the proportion of rain that is converted into throughfall [5].

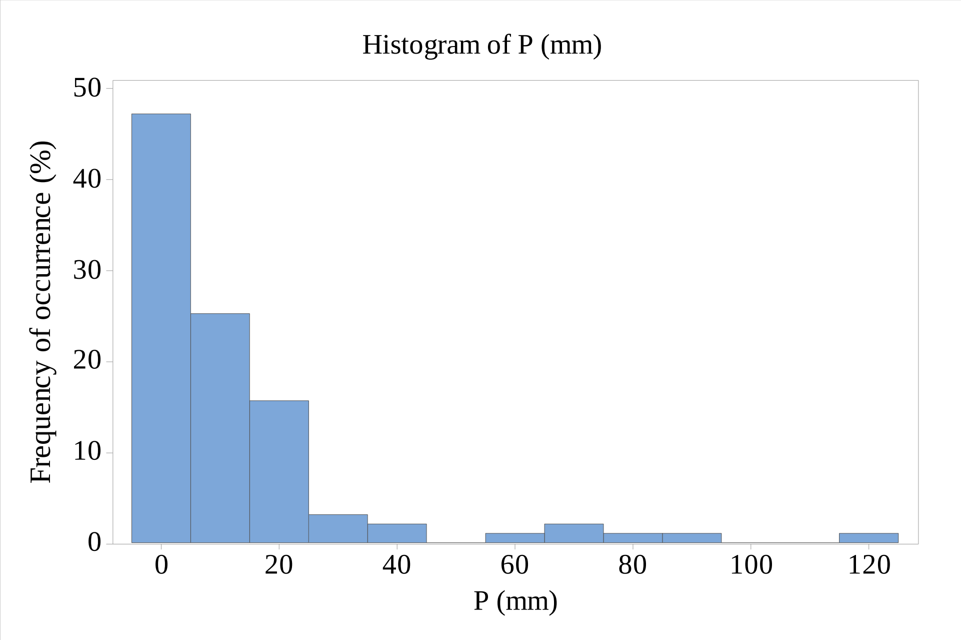

Figure 4. Frequency of occurrence of the monitored rain events.

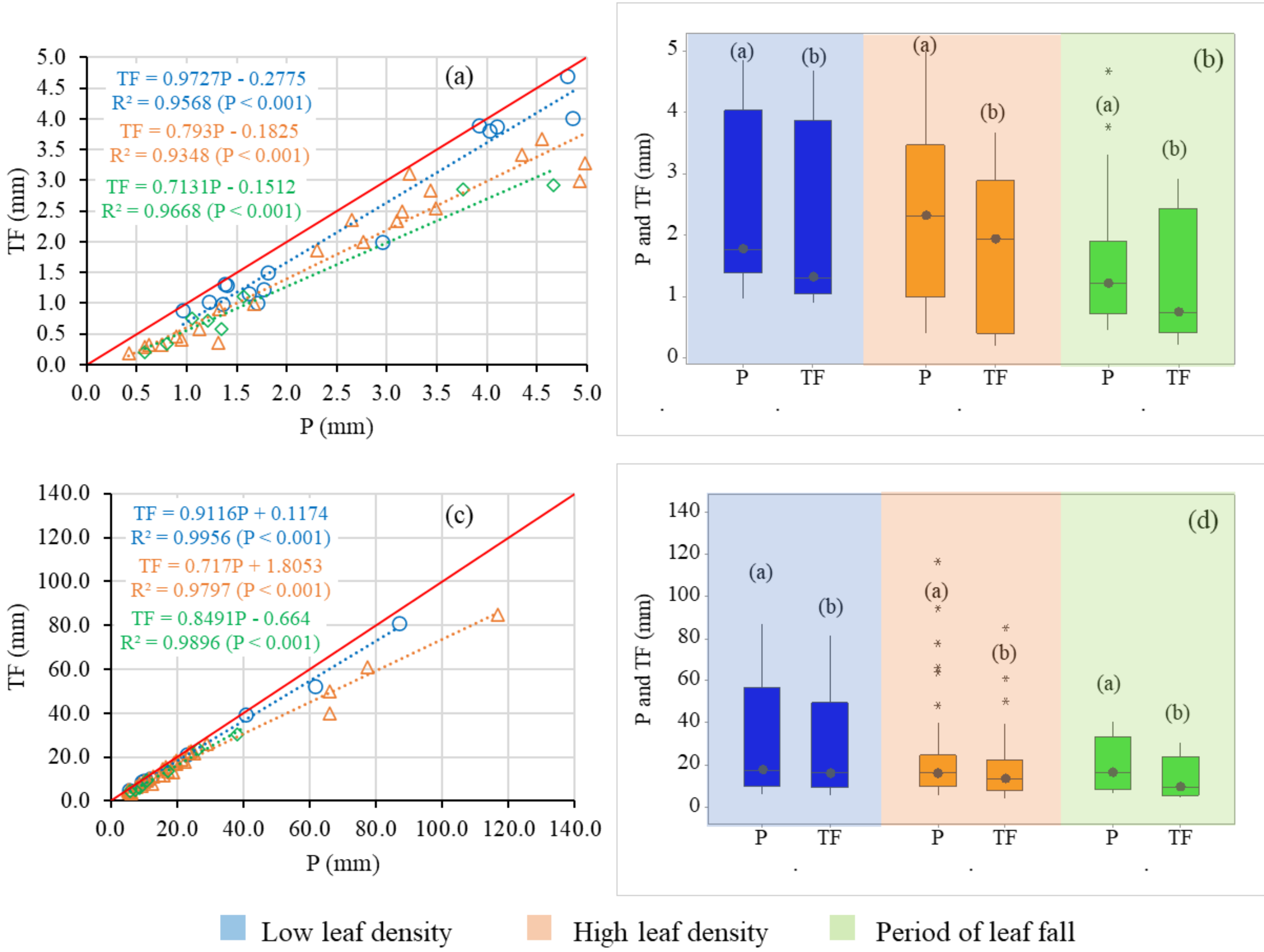

Figure 5. Relationship between gross rainfall (P) and throughfall (TF) in the three stages of canopy development: (Figures **a**,**b**) on the top means P ≤ 5.0 mm and (Figures **c**,**d**) on the bottom means P >

5.0 mm. * The colors in the figures indicate the different stages of canopy development. * Different letters (a, b) represent a statistically different median at the level of 1% by the Wilcoxon test.

At the three stages of canopy development, the throughfall is statistically lower ($p < 0.01$) than the gross rainfall, regardless of the total precipitate. The importance of vegetation cover in the temporary retention of precipitated water increases the duration of the rainfall under the vegetation, as discussed by researchers such as [3,5,11,21]. In our study, the mean duration of throughfall after a rainfall event has ceased was 10.6 min and 14.1 min for rainfall classes P ≤ 5 mm and P > 5 mm over the study period (Table 4). In the period with a high leaf density, for the class P > 5 mm, the throughfall duration was more variablem and the events of longer duration were more frequent, indicating that the saturated canopy continues to flow towards the ground after the end of the event [5,21].

Table 4. Mean throughfall duration after a rainfall event has ceased.

Canopy Stages	Throughfall Duration (min)	
	P ≤ 5 mm	**P > 5 mm**
Low leaf density	7.50	16.71
High leaf density	8.76	17.74
Period of leaf fall	15.50	7.80
Mean for the period	10.59	14.09

However, retention in the canopy is very difficult to quantify [44], because it does not depend only on the physical interception of droplets but is strongly influenced by deposition through the trunk or in smaller droplets that modify their initial trajectory, overestimating the total retention if modeled simplistically. After interception, a droplet may be retained on the leaf or bounce off the surface or break into a series of smaller droplets [45]. These bouncing and breaking droplets may continue their path through the canopy, depositing at lower levels or on the ground, or they may be retained, depending on the physical and chemical properties of the droplet and the leaf [46]. During the low leaf density phase of canopy development (Figure 5), throughfall was similar to gross rainfall for both P ≤ 5.0 mm and for P > 5.0 mm events, as expected [7]. Over 90% of gross rainfall turned into throughfall but they differed from each other at the significance level of 1% (Figure 5b,d).

As the canopy developed during the rainy season with a consequent increase in the leaf density, the P to TF ratio decreased by 23% and 11.7% for P ≤ 5.0 mm and P > 5.0 mm, respectively (Figure 5a,c). This reduction occurred due to the canopy interception process, in which 70% of the gross rainfall occurred as throughfall (Figure 5a,c) in all events at the significance level of 1%.

In the third phase of canopy development, when the leaves start to fall, the canopy continued to affect the interception process by converting 70–80% of the gross rainfall into throughfall (Figure 5a,c), with a significance level of 1%. The ability of a TDF to intercept rainfall is confirmed by the P to TF total number of drops ratio, relative to P (Figure 6). At the start of the rainy season, when the vegetation has a low leaf density, we observed that, for P ≤ 5.0 mm, the total number of drops of TF was always higher than that of P (Figure 6a).

The rainfall threshold for the number of drops of TF to be higher than for P was 3.0 mm (Figure 6a,b), regardless of the stage of canopy development and total rainfall.

These results confirm that, for a rainfall event below 3.0 mm upon a fully developed vegetation, a higher percentage of precipitated water is retained in the leaves and branches, contributing to greater losses by interception [4,22]—the smaller rainfall events may not reach the water retention capacity of the vegetation. When this capacity is reached, the balance after retention is usually small. Thus, the number of P drops is higher than TF drops (Figure 3a), considering that the vegetation capacity of the TDF ranges from 0.5 to 1.00 mm, as described by [5,26].

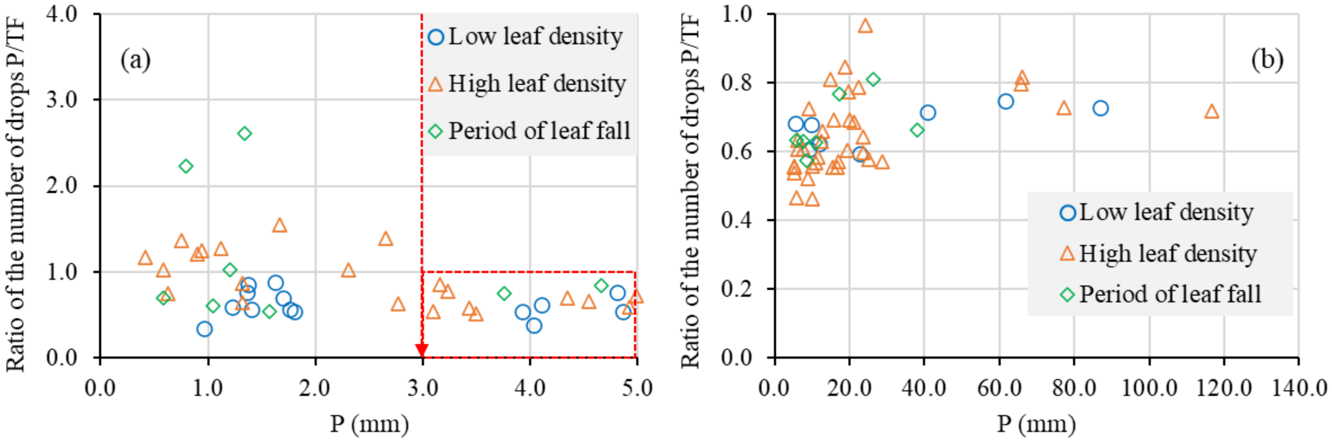

Figure 6. Ratio of the total number of drops of the gross rainfall (P) and throughfall (TF) in relation to total rainfall (P) for the three stages of canopy development for (**a**) P ≤ 5.0 mm and (**b**) P > 5.0 mm. The red line indicates the rainfall threshold for the number of drops of TF to be higher than for P.

Along with the canopy development during the rainy season and the consequent increase in leaf density, a higher influence of vegetation on the interception process was observed and resulted in lower values of gross rainfall to throughfall ratio [5]. As the canopy intercepted the rain, affecting its quantity and time distribution [6], the number of P drops differed from the number of TF drops [1]. However, as the rain persisted, the canopy storage capacity was reached, and the percentage of interception losses decreased, as also reported by [47]. When analyzing the total number of drops of the gross rainfall to throughfall ratio as a function of the total rainfall and stages of canopy development, throughfall always recorded a higher number of drops than the gross rainfall at the significance level of 1% for rainfall events above 3 mm (Figure 7). The increase in the number of drops under the canopy extended the time of contact of water with the soil, as discussed by researchers such as [3,5,12,21], enhancing the opportunity for infiltration and other hydrological processes in the basin.

Overall, throughfall corresponded to 80% of the gross rainfall that reached the soil as either free throughfall, canopy drop, or splash throughfall, [2,3]. However, for the rain class P ≤ 5.0 mm, there is a higher occurrence (1.9 times) of small drop diameters (0.125 < D1 ≤ 0.250 mm) of TF in relation to P statistically different at the significance level of 1%. The greater number of drops on throughfall when compared to gross rainfall, suggests that the vegetation morphology affected the droplets by dividing them into smaller drops, as observed by [10].

Throughfall is often categorized as droplets with a diameter below 1.5 mm generated by the moment transferred by rain to the canopy or by the intercepted water redistribution in the canopy, as canopy drips are composed of throughfall droplets with diameters greater than 1.5 mm [3,11,20,21].

The highest concentrations of drops of throughfall occur in the first classes of droplet diameters for both event classes (P ≤ 5.0 mm and P > 5.0 mm) (Figure 7) and can be explained by the fractionation of throughfall [2,3] by the TDF canopy. Although splash throughfall has smaller diameters than canopy drip, there is an increase in the number of droplets, as observed in this study.

Studies conducted in other parts of the world showed that the throughfall drop size distribution varies between and within rainfall events due to the strong vibration of the wind within the canopy that changes the direction of the droplet and, thus, the contact of the droplet with the branches and breaks the droplets into smaller ones [1,2,8].

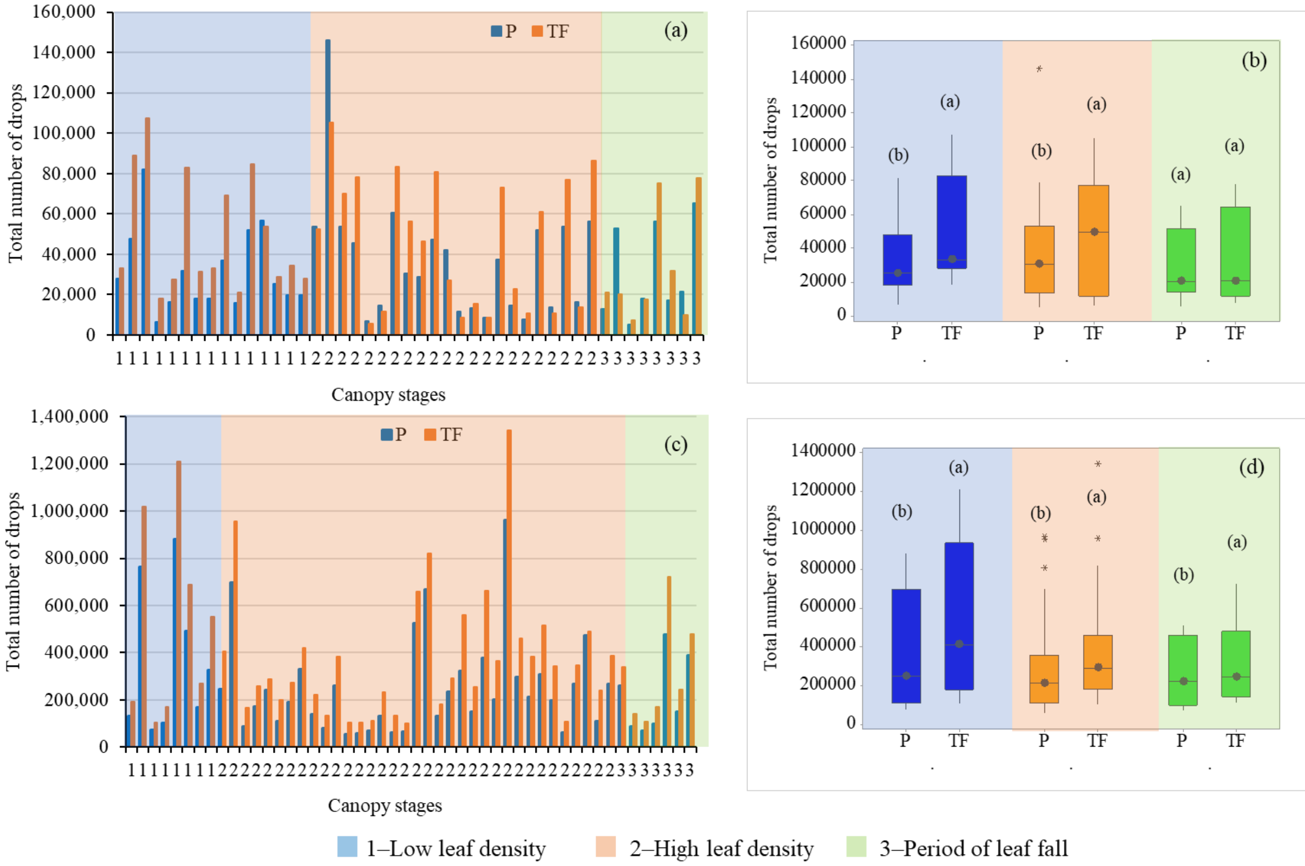

Figure 7. Total number of drops of gross rainfall (P) and throughfall (TF) for the three stages of canopy development: (Figures **a**,**b**)at the top means P ≤ 5.0 mm and (Figure **c**,**d at the bottom means**) P > 5.0 mm. * The colors in the figures indicate the different stages of canopy development. * Different letters (a, b) represent a statistically different median at the level of 1% by the Wilcoxon test.

The number of small diameter drops (D < 1.5 mm) increases in TF due to splash throughfall. The impact of larger drops on foliage generates splash drops, especially when the gross rainfall is of higher intensity and strong winds push the foliage during high rainfall events [2,8]. We identified that the number of drops per event is strongly correlated to the total event rainfall, regardless of the stage of canopy development. These results indicate that, in addition to the TF increase with the total rainfall, the number of TF drops also increases, which was also observed by [3,4]. In spite of the high frequency of smaller drops due to the fractionation process to splash throughfall, leading to a larger number of droplets on TF than on P, the total volume of gross rainfall is higher than throughfall at the significance level of 1% (Figure 8).

These results are in accordance with the review conducted by [8], who concluded that the canopy has the ability to fractionate the droplet into smaller droplets, regardless of the total precipitate and stage of canopy development, although the volume of P is always higher than in TF. Although 90% of the gross rainfall volumes were transformed into throughfall when the canopy of the TDF vegetation presented a low leaf density (first phase), they differed at the level of 1% (Figure 8b,d) for the rain class (P ≤ 5.0 mm). With the increase in canopy leaf density during the rainy season, a higher influence of vegetation on the attenuation of rainfall occurred. In this phase, the gross rainfall converted into throughfall was 72 and 80% for the rain classes P ≤ 5.0 mm and P > 5.0 mm (Figure 8), statistically different at the significance level of 1%.

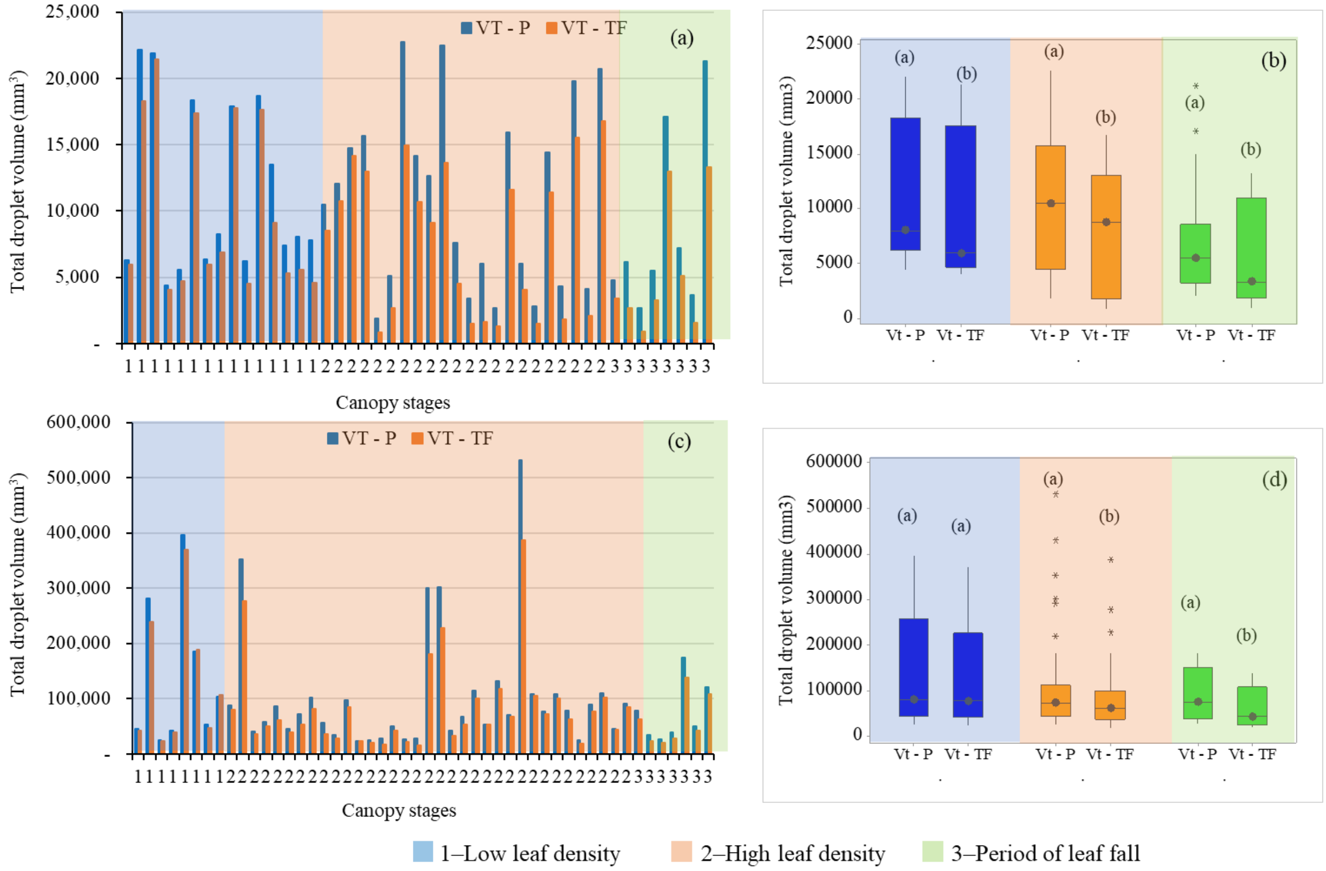

Figure 8. Total droplet volume of gross rainfall (P) and throughfall (TF) at different stages of canopy development: (Figures **a**,**b**) at the top means P ≤ 5.0 mm and (Figures **c**,**d**)at the bottom meansP > 5.0 mm. * The colors in the figures indicate the different stages of canopy development. * Different letters (a, b) represent a statistically different median at the level of 1% by the Wilcoxon test.

The results from this study may support studies on erosive processes in low-latitude tropical dry environments, where the deciduous nature of vegetation promotes a dynamic impact on the total TF, TF diameter size distribution of droplets, and TF duration at different stages of vegetative growth. For rainfall events above 3 mm, the number of drops of gross rainfall is always smaller than that of throughfall, emphasizing the importance of canopy in partitioning droplets. Nonetheless, the partitioning effect of the canopy becomes constant after a rainfall depth of 40 mm.

4. Conclusions

The monitoring of gross rainfall (P) and throughfall (TF) characteristics indicates that the deciduous character of the tropical dry forest (TDF) promoted changes in the proportion of P converted into TF, total number of drops, and total volume of drops in relation to the gross rainfall.

At the onset of the rainy season, after the long dry period and when the canopy presents a low leaf density, a larger fraction of rainfall was converted into throughfall, which declines as the leaf density increases during the rainy season. For events with a total rainfall higher than 3 mm, the number of TF drops was always higher than that of P, regardless of the total precipitation and stage of canopy development. On the other hand, the diameters of the TF drops were smaller than those of P, indicating that the vegetation breaks the droplets into smaller ones. In summary, throughfall presents a lower magnitude, higher duration, and higher number of droplets with smaller diameters than gross rainfall, with the differences being influenced by the canopy stage of development.

The findings of this study are useful to quantify the impact of a seasonally dry tropical forest on rainfall partitioning, contributing with information that is crucial for water and soil management, as well as the proposal of conservation practices. Rainfall characteristics impacted by the canopy affect the infiltration conditions and the overall water balance at the hillslope scale, including soil moisture and runoff generation. Furthermore, the kinetic energy of rainfall, which depends on the droplets' characteristics, controls the rainfall erosivity and, consequently, soil erosion. Acknowledging the role of vegetation on changing rainfall reaching the forest soil enables the development of more sustainable land use practices.

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