An improved technique of rainfall analysis: a case study in Mapalana catchment

C M Navaratne, K D N Weerasinghe and C Rathnayake
Department of Agricultural Engineering, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya

Abstract
Apart from the magnitude of rainfall, measurement of onset, intensity and duration of each rainfall event is of paramount importance in Agriculture. A study was conducted to determine the above parameters and to find out the relationship between intensity and duration of rainfall. In this regard, an analysis of rainfall data in relation to the number of rainfall events received, magnitude, duration and intensity of rainfall during day time, night and twenty four-hour period for Yala and Maha seasons and for the year was carried out using daily rainfall data recorded by Tipping Bucket Recording Type Rain Gauge at Mapalana meteorological station during 2005 and 2006. The highest number of rainfall events of 41 and the longest duration of rainfall of 960 min. were recorded in October for Maha season and for the year whilst for Yala season they were in May (23) and June (580 min.) respectively. The greatest amount of rainfall of 368.5 mm and the highest rainfall intensity of 31 mm hr^{-1} were noted in November and February for Maha and for the year respectively. For the Yala season, they occurred in June (207.5 mm) and April (21 mm hr^{-1}) respectively. The amount of rainfall received was high (261 mm) in November during day time whereas it was high (155.5 mm) in June during night. The lowest number of rainfall events of 5 was noted in April during Yala and during the year and in December (9) during Maha season. The amount and duration of rainfall were less during August and April. The relationship between intensity and duration of rains received in less than one-hour duration in 2005 was determined using rainfall intensity - duration curves. The following regression equation was formulated between intensity and duration of rainfall.
$y = ax^{-b}$ *where* y *= intensity (mm/hr),* x *= Duration (min),* a, b *= constants*
The a and b constants for Mapalana were 64.58 and 0.36 respectively.
The formulated equation was tested with an independent rainfall data set recorded by the same Tipping Bucket Recording Type Rain Gauge in 2006 and the r^2 *value was 0.91. Therefore, the formulated equation can be recommended for Mapalana to determine rainfall intensity-duration relationship. However, values of a and b will vary from catchment to catchment depending on the characteristics of rainfall received. The analysis will enhance the quality and accuracy of rainfall related studies as it determines the onset, duration, amount and intensity of each rainfall event.*
Keywords: rainfall analysis, rainfall onset, rainfall intensity, rainfall duration, Tipping Bucket Recording Type Rain Gauge, intensity-duration curve

Introduction

Rainfall is one of major physical factors which influences agriculture in Sri Lanka. Attention has been paid to identify distribution of the rainfall pattern of the country temporally and spatially, and the magnitude of rainfall received per unit time for a particular area in the past (Abeysekara et al, 1983; Alles and Rathnayake, 1973; Navaratne, 2003; Nieuwolt, 1989; Panabokke and Walgama, 1974). It was realized that both rainless periods and excess of rainfall periods adversely affect the growth of crops, and the ultimate result is a reduction in yield. The onset, duration and intensity of each rainfall event are also of vital importance for crop production. In most past studies, the onset of rain and the rainfall intensity were analyzed using daily rainfall amounts recorded from

standard rain gauge (Waidyarathne et al., 2006; Piyasiri et al., 2004; Pieris et al., 2000 and Peiris and Kularatne, 2004). However, in this study, the variability of such rainfall indices within a day is considered since such information would be more useful for various management practices in short term crops. Further relationships between such indices were also studied.

Therefore, the study intends to analyze those parameters using the data obtained from the Tipping Bucket Recording Type Rain Gauge and to determine rainfall intensity – duration relationship in the study area. It will help to increase the accuracy as well as the quality of results obtained from rainfall studies and finally lead to better planning in agriculture.

Materials and methods

Study area

The study was concentrated on the Mapalana catchment in Matara district which is situated in the Southern Province of Sri Lanka, within latitude 6^0 03' - 6^0 07' N and longitude 80^0 34'- 80^0 39' E. The average elevation is about 50 m above MSL. A flood plain around the major river Nilwala is also found in the Mapalana catchment. It belongs to the WL_4 agro-ecological region based on agro-ecological map 2003.

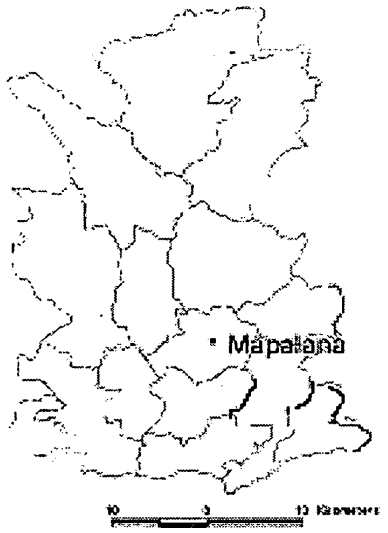


Fig.1. Location of Mapalana catchment in the Matara District

Tipping Bucket Recording Type Rain Gauge (TiB)

The Tipping Bucket Recording Type Rain Gauge (TiB) was installed in the Agro-meteorological station of Faculty of Agriculture, University of Ruhuna in 2003. The daily rainfall data recorded in 2005 and 2006 were used for the analysis. The data were recorded in the TiB in a graphical manner as amount of rainfall in mm in the Y axis and the rainfall period in hours in the X axis. By counting all vertical distances in the graph, the amount of rainfall during a particular rainfall was found. The horizontal lines in the graph indicate the no rainfall periods. The onset and duration of rainfall events were found observing the starting points and ending points of rising parts of the graph. If several rainfall events were received during a day, they can all be identified separately. The intensity of rainfall was the gradient of the graph. In this study, the period October to March was considered as *Maha* season, and April to September was taken as *Yala* season.

Results and discussion

Rainfall statistics in Mapalana during October 2005 – September 2006

Figure 2 and Figure 3 show the number of rainfall events and amount of rainfall received from October 2005 to September 2006 during day, night and 24 hr periods respectively. Even though the number of rainfall events was high in October, the amount of rainfall received was maximum in November for the *Maha* season and for the year. There is not much difference between the number of rainfall events received during day and night times. In *Yala* season, they were in May and June respectively. The lowest number of rainfall events and minimum amounts were observed in April and August.

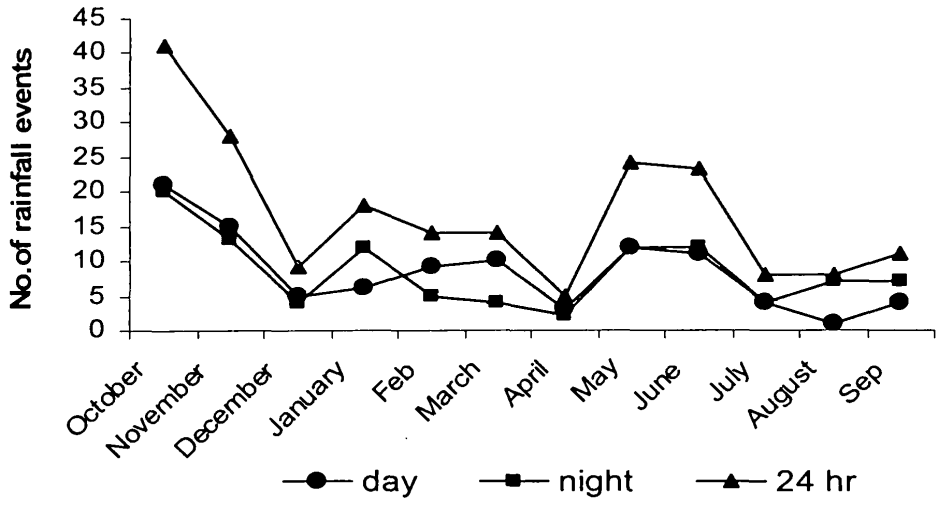


Fig. 2 Number rainfall events during October 2005 – September 2006

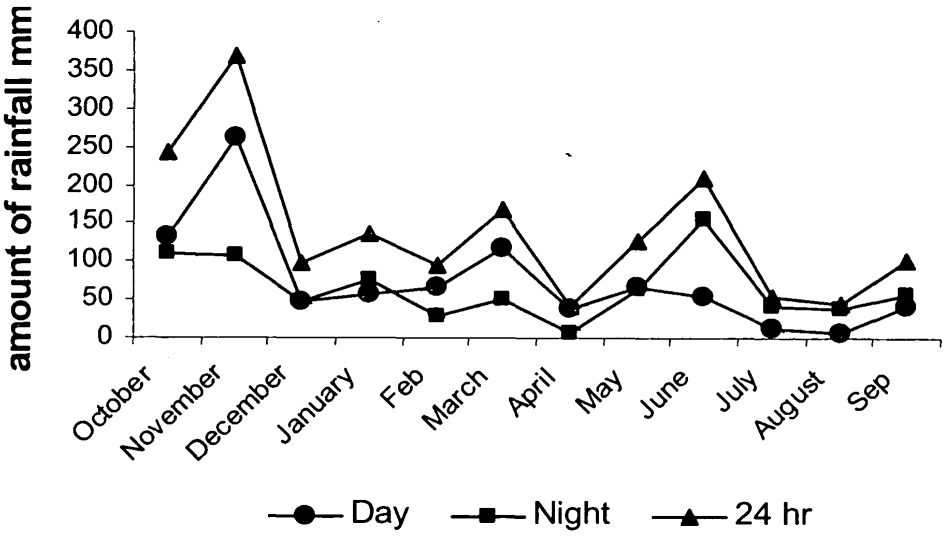


Fig. 3 Amount of rainfall received during October 2005 – September 2006

Figure 4 and Figure 5 indicate the duration and intensity of rainfall during the study period. The longest duration was recorded in October and the greatest intensity was noted in February for *Maha* and for 24 hr period. Even though the highest intensity was recorded in February, the number of rainfall events, the amounts as well as the durations

of rainfall were less compared to other months in the year. Again, the duration of rainfall was less in April and August compared to other months.

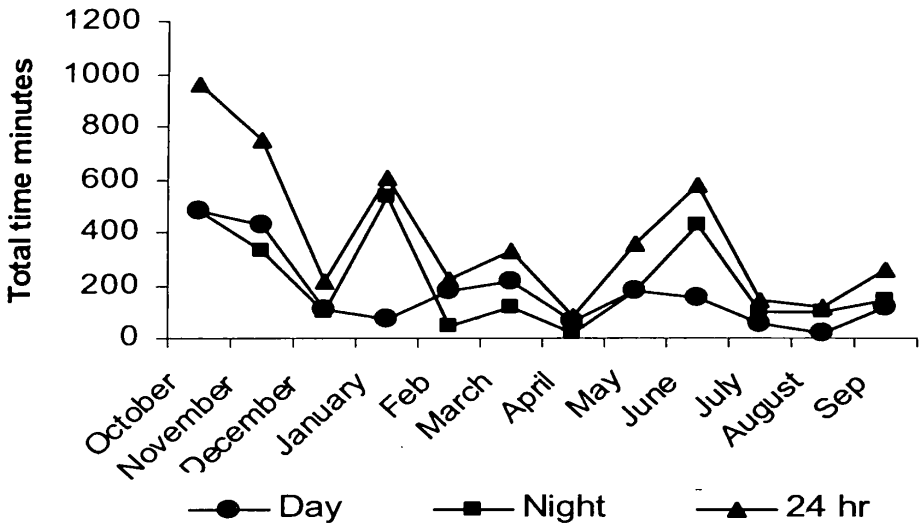
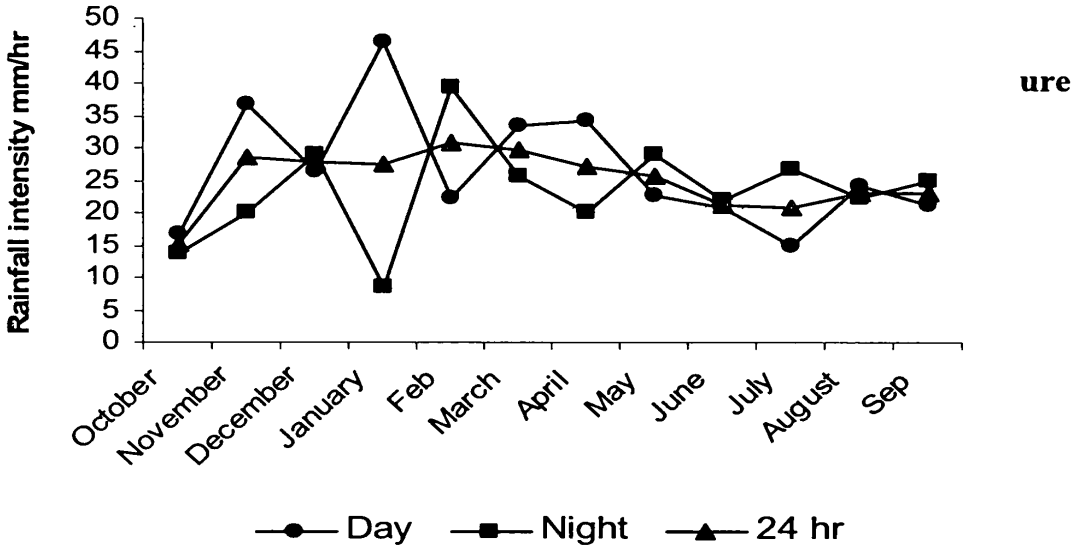


Fig. 4 Duration of rainfall during October 2005 – September 2006

The intensity of rainfall during the months varied from 15 to 31 mm hr^{-1} during a 24 hr period. The lowest intensity was observed in October as it recorded the highest duration. The greatest variation of rainfall intensity during day and night was shown in January. When individual rainfall events were considered, the maximum intensity of 120 mm hr^{-1} was observed on 17 June 2006 whereas the minimum was noted on 13 January during the study period.



ure

Fig. 5 Intensity of rainfall during October 2005 – September 2006

Relationship between intensity and duration of individual rainfall events

Figure 6 shows the relationship between the intensity and the duration of individual rainfall events for the Mapalana catchment in 2005. It reveals the negative non-linear relationship between intensity and duration (Dandekar and Sharma, 1979).

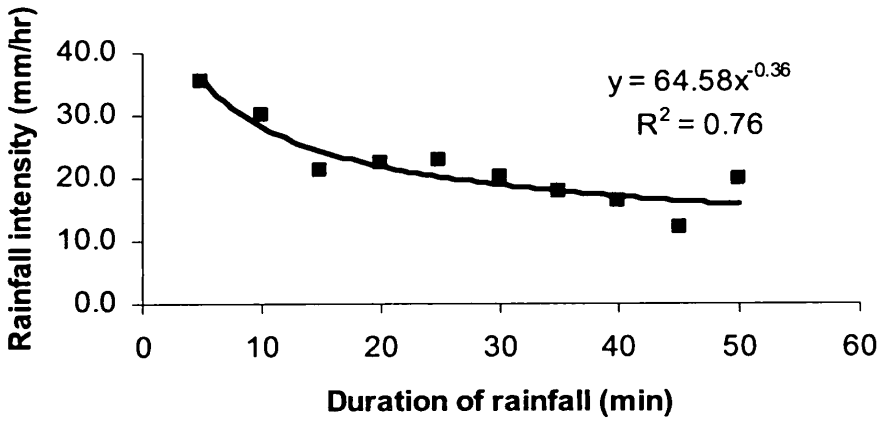


Fig. 6 Rainfall intensity-duration curve for Mapalana

The following regression equation was formulated between intensity and duration of rainfall.

$y = ax^{-b}$ ----------*(1)* where, y = intensity (mm/hr),
x = Duration (min),
a = constant (64.58 for Mapalana catchment)
b = constant (0.36 for Mapalana catchment)

The formulated equation was tested with an independent data set obtained by the same Tipping Bucket under the same experimental conditions for 2006. The calculated line and new data line is given in Figure 7.

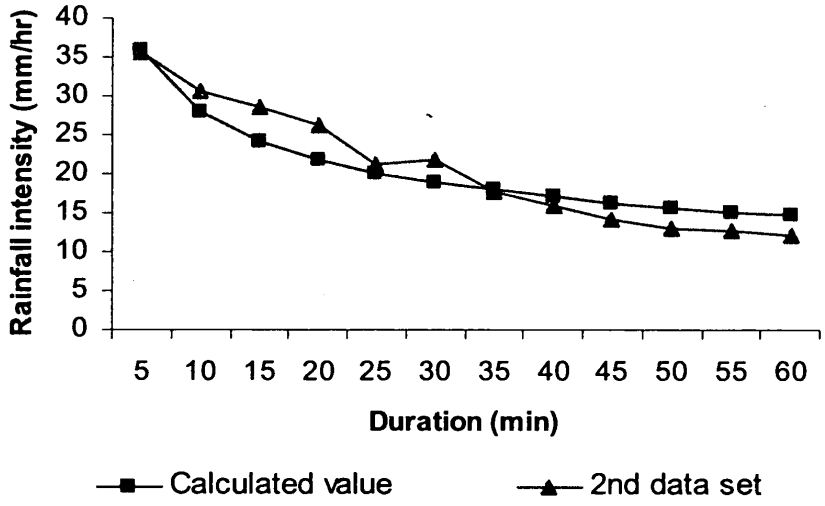


Fig. 7 Testing the calculated intensity-duration curve with an actual (2^{nd}) data set

Regression analysis was done between calculated and actual intensity-duration curves. It showed a significant correlation having the R^2 value of 0.91 (Fig.8). Therefore, Equation 1 can be recommended for the Mapalana catchment to carry out rainfall intensity-duration related studies. However, values of a and b may be identical for Mapalana and their suitability for other catchments should be tested.

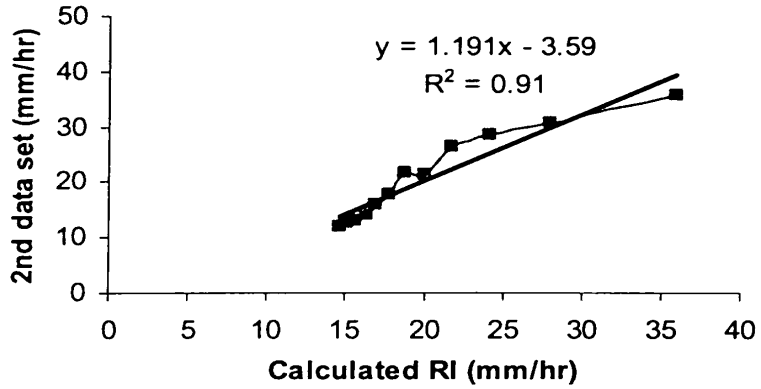


Fig. 8 Calculated values vs actual values by 2nd data set

Conclusions

Rainfall analysis using data from the Tipping Bucket Recording Type Rain Gauge determines the number of rainfall events during a particular period, and the onset, duration, magnitude and intensity of an individual rainfall event. It helps to identify the characteristics of each rainfall event clearly. Further, the analysis has formulated an equation to show the relationship between intensity and duration of rainfall. It also helps to determine flood peaks and to design hydrological structures more accurately. As this study considered only daily rainfall data of two years, further studies are recommended to formulate more accurate relationships.

References

Abeysekara S, Senevirathe E K, Leaker A and Ster R D. (1983). The analysis of daily rainfall for Agricultural purposes. *J.Nat.Sci.Coun.Sri Lanka* 11.

Alles, W S and Rathnayake, R P K. (1973). An improved demarcation of rainfall regimen zones in Sri Lanka. *Proc. Ceylon Ass. Advmt Sci.,* 29(1)

Chow, V T. (1964). Statistical and probability analysis of hydrologic data. pp.8.1-8.91.In: Linsley, R.K., Kohler, M.A. and J.L.H. Pauthu (eds), Hand book of Applied Hydrology, Mc grow Hill book company, New York.

Dandekar M M and Sharma K N. (1979). Water Power Engineering, Vikas Publishing House PVT Ltd. New Delhi.

Navaratne, C M. (2003). Low Cost Auto Irrigation System for Home Gardens Intensification to Minimize the Agro-Climatic Risk: A case study in Matara District. PhD. Thesis, Faculty of Agriculture, University of Ruhuna, Matara, Sri Lanka.

Nieuwolt, S. (1989).Estimating the Agricultural Risks of Tropical Rainfall. Agriculture and Forest Meteorology, 45 (1989), 251 – 263, Clsevier Science Publishers R.V.,Amsterdam.

Panabokke, C R and Walgama, A. (1974). The application of rainfall confidence limits to crop water requirements in dry zone agriculture in Sri Lanka. *Journal of National Science Council of Sri Lanka.* 2(2): 95-113.

Peiris, T U S, Peiris, T S G and Samitha S. (2000). *Journal of Tropical Agricultural Research,* 12:265-275

Peiris, T S G and Kularatne, J D J S. (2004). Analysis of climate change in Hambantota district in Sri Lanka. In Proceedings of the International Conference on Sustainable Water Resources Management in Changing Environment of the Monsoon Region. (Eds: Srikantha Herath, Assela Pathirana and S B Weerakoon), 17-19, BMICH, Colombo, Sri Lanka.

Piyasiri, C H, Peiris, T S G and Samitha S. (2004). Change in Rainfall and temperature of Low Country Wet Intermediate (IL1) Region of Sri Lanka. *Journal of Tropical Agricultural Research,* 16, 271-280.

Waidyarathne K P, Peiris T S G and Samitha S. (2006). Shift in onset of first inter monsoon rain in coconut growing areas in Sri Lanka. *Journal of Tropical Agricultural Research,* 18, 1-12.