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Characteristics of tree canopy affecting throughfall and interception of rainfall in a stand of silver oak (*Grevilia robusta*)

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ABSTRACT : The importance of forestry systems as a source of water storage has been recognized due to need for climate change mitigation. The volume of water which is caught by the vegetation and subsequently evaporated is called interception loss. Some interception values are determined from silver oak tree in the Cauvery catchment, Karnataka. Both net rainfall and pattern of throughfall are correlated with a number of factors such as climatic factors, type of rainfall, wind and vegetation factors. Individual storm appears to be the main factor in the determination of throughfall and interception loss. Over the six months period, a total rainfall of 1600 mm was measured in the open field. Of this total, on an average, only 48 per cent (768mm) reached the ground as throughfall; 49 per cent (775 mm) being attributed to the average interception loss.

KEY WORDS : Forestry, Water, Climate, Catchment, Throughfall

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World-wide there is a mounting interest in the relationship between land use and water resources. This has come about mainly because most developing (and developed) countries are experiencing a degradation of land and water resources, whereas the need for these resources is increasing .

To the hydrologist and the soil conservator the interception of precipitation by trees is an important factor in the hydrological cycle. Removal of the vegetative cover, especially the forest cover, may result in a higher frequency of flooding and accelerated soil erosion. Forest canopies can also 'slow down' the speed of raindrops before they hit the soil, thus reducing the soil water pressure.

For a given precipitation, the evapotranspiration, initial loss, infiltration and detention storage requirements will have to be first satisfied before the commencement of runoff. When it rains over a catchment not all the rainwater over a catchment directly reaches the ground . A part of it might be caught by the vegetation and subsequently evaporated. The volume of water so caught is called interception. The intercepted precipitation may follow one of the three possible routes:

– It may be retained by the vegetation as a surface storage and returned to the atmosphere by evaporation: a process termed as interception loss.
– It can drip-off the plant leaves to join the ground surface or the surface fall; this is known as throughfall and
– The rainwater may run along the leaves and branches and down the stem to reach the ground surface. This part is called stem fall.

The amount of water intercepted in a given area is extremely difficult to measure. It depends on the species compositions of vegetation, its density and also on the storm characteristics. It is found that coniferous trees have more interception loss than deciduous ones. Agricultural crops in their growing season also contribute high interception losses (Subramanya, 2007).

The objective of the study is to present interception loss and throughfall data with respect to characteristics of tree canopy. *Grevillea robusta*, an exotic species which occupied major portion of the coffee estates in Kodagu district, Karnataka was considered for the study.

METHODOLOGY

Kodagu district with an area of 4,102 Km^2 is the smallest district in the state of Karnataka. Located in the South-Western part of Karnataka state between North latitude 11^0 56' and 11^0 52' and East longitude $75^0$22' and $76^0$12', it falls in the high precipitation zone with picturesque topography occupying the Eastern and Western slopes of the Western Ghats (Anonymous, 2007). Closed with primeval forest or glassy

glades and broken by a few cultivated villages, it has configuration, which presents a grand panorama, verdant valleys, ravines, fast falling mountainous streams, lofty peaks and awe-inspiring spurs. The terrain and climatic conditions here are unique and nature has bestowed the district with abundance of forest wealth. It enjoys typical tropical climate. In the economy of the State , Kodagu enjoys a distinct place in view of its international reputation as a prominent coffee-producing center.

A major part of the year consists of rainy season as the monsoon period starting in June lasts till the end of September. Even during post monsoon months of October and November, study area receives significant amount of rainfall. Precipitation falling through the canopy was measured with 16 standard daily 200mm rain gauges placed under a tree used for shading of coffee plantation. This plantation is situated 25 kms away from district headquarters and consists of a number of species, the most common one being silver oak.

At the site, the trees are approximately 15 years old with an average tree height of 10 meters and an average trunk diameter of 30 cms. The average distance between trees is 5 x 5 m giving a density of about 400 trees to the hectare. Canopy coverage is roughly 40 to 50 per cent. The gauges were positioned as shown in Fig A. This allowed various factors which determine the net rainfall beneath a tree cover to be separated out and their relative importance is discussed. In order to obtain interception values that represent a large area, Reynold and Leyton (1963) suggested that random positioning following each storm was the most suitable procedure ,if the recorded interception was to be a representative figure. In the present study , gauges 1 to 8 are oriented to North East-South West directions and thus parallel tree alignment.

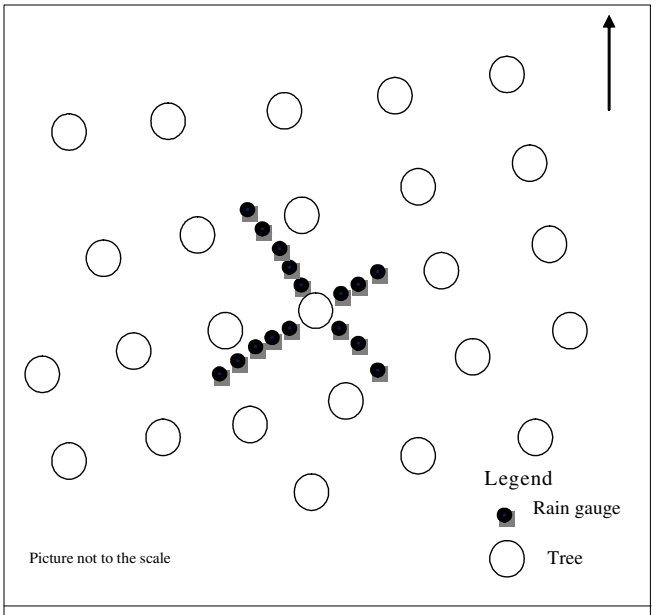

Fig. A: Distribution of the 16 rain gauges in the plantation, in relation to the silver oak trees

All throughfall recorded in these gauges has been compared with records from an open-sited gauge which was erected about 300 meters away from the edge of the plantation.

Over the 6 month period from end of May, 2009 until the end of November, 2009, a total of 53 rainfall events were recorded; the rainfall at the open site varying from 0.5 mm to 150 mm. the spacing within this range was reasonably uniform up to 40 mm, with 47 events being recorded below this figure; while for events above 40 mm, the spacing was far wider.

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussions have been presented under following sub heads:

Climatic factors :

The through fall values for each event were converted to a percentage of the gross rainfall recorded at the open site.

The 16 percentages, one for each rain gauge, were averaged for each event and the average values were correlated with gross rainfall for each events. Using the method of least squares, the linear correlation co-efficient relating the percentage throughfall (excluding stem fall) to rainfall was +0.569. This is significant at 1 per cent level. The square of the linear correlation co-efficient showed that 26 per cent of the variance of the through fall during varying events is accounted by the storm aggregates. Table 1 shows the trend of through fall and interception loss, where the 53 recorded events total and their associated through falls were divided arbitrarily into 5 classes. Calculated interception loss is also shown. Initially rainfall may be completely intercepted, but once maximum storage of the tree has been reached, drops will accumulate on the leaf and branch surfaces and begin to fall on the ground. One event of 10 mm resulted in an average through fall of 33 per cent, while two storms of 15 mm produced throughfall of 6 per cent and 19 per cent. The average for storms ranging from 1.3mm to 24 mm was 22 per cent.

Types of rainfall :

During the month of July 2009, five storms of continuous

Table 1: Trend of throughfall and interception loss with event class

Rainfall per event (mm)class	0-25	26-50	51-75	76-100	101-125
Average through fall (%)	22	40	54	56	62
Average interception loss (%)	78	60	46	44	38

Table 2: Average throughfall percentage associated with continuous periods of rainfall					
Rainfall per event (mm)	55	106	108	198	200
Average through fall (%)	55	58	59	57	74

Table 3 : Average throughfall and rainfall per event with no wind							
Rainfall per event (mm)	0.5	25	33	66	81	100	110
Average through fall (%)	33	42	41	57	55	70	63

Table 4 : Average throughfall and rainfall per event with strong wind				
Rainfall per event (mm)	53	182	190	200
Average through fall (%)	27	49	46	41

Table 5: Total average throughfall and interception loss from May 2009 to November 2009																
Gauge No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Average through fall (%)	60	56	48	59	57	31	30	26	51	53	55	54	34	56	52	40
Average interception loss (%)	37	41	49	38	40	66	67	71	46	44	52	43	63	41	45	57

rainfall, rather than showers have been recorded and the average through fall are shown in Table 2.

Wind :

During the initial stages, wind probably affects net rainfall by decreasing the time taken for canopy saturation to occur during storm. Hence,wind strength may also be an important variable. Seven events with little or no wind have been recorded and their results are set out, with their appropriate throughfall in Table 3.

Table 4 shows figures for four events which were accompanied by strong winds

Vegetation factors :

Throughfall totals will vary with different species due to the variation in the type of foliage, shape of the canopy and whether the species is deciduous or evergreen. With deciduous types, seasonal changes may also have to be considered due to the loss of foliage during the cold season. This results in a reduction of surface area which in turn cause reduced interception and evaporates from the vegetation.

Table 5 shows the average throughfall of the 53 events as recorded by each gauge is set out together with the losses caused through interception

The individual rainfall event total seems to be the main factor determining throughfall and interception loss. Linear correlation analyses suggest that, assuming a given event aggregate, any increase in the duration will result in a higher average throughfall; if rainfall is continuous rather than showering, less precipitation will be intercepted and a greater throughfall will be recorded (Hamilton and Rowe, 2000). During rainfall with which there is no wind, throughfall will also be relatively high. Throughfall generally increases away from the stems, however this is dependent upon wind direction and strength. Gauges exposed to the wind will record relatively high throughfalls. In contrast these figures can be applied to a wider area only with the thorough study of climatic condition prevailing over the area canopy characteristics and plantation density. This study shows the importance of forest cover as a protection against soil erosion during heavy rainfall and further to modify the streamflow.

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