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Throughfall, stemflow and interception losses of rainfall from coconut (*Cocos nucifera* Linn.)

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सार — पेलिकोड के अधिक वर्षा क्षेत्र में 108 दिनों के तूफान के रिकार्ड के आधार पर नारियल वृक्ष से वर्षा का सतत पतन, स्तंभ प्रवाह तथा अपरोधन क्षति मापे गए थे । नारियल की भण्डारण क्षमता 0.4 मि. मी. है तथा इससे होने वाली अपरोधन क्षति 10 मि. मी. प्रति-तूफान पायी गई । सतत पतन (मि. मी.) = 0.441 + 0.875 × वर्षा (मि. मी.) (आर. = 0.943, 0.01 सतह पर) के संबंध द्वारा तूफान वर्षा से 89 प्रतिशत सतत पवन का योगदान संगणित होता है। स्तंभ प्रवाह बहुत कम था और तूफानी वर्षा से इसका संबंध इस प्रकार था :

स्तंभ प्रवाह × 10^{-3} मि. मी. = — 22.154 + 23.629 × लॉग वर्षा (मि. मी.) (0.05 स्तर पर, आर = 0.683) । नारियल-वितान के नीचे सतत पवन के पार्श्विक वितरण पर पवन दिशा के प्रभाव को भी मापा गया था ।

ABSTRACT. The throughfall, stemflow and interception losses of rainfall from coconut (*Cocos nucifera* Linn.) were quantified based on 108 days of storm records in a high rainfall region at Pelicode. The coconut has a storage capacity of 0.4 mm and the observed interception losses from it were upto 10 mm per storm. The relationship, throughfall (mm) = —0.441 + 0.875 × Rainfall (mm) ($r = 0.943$, at 0.01 level) has accounted for 89 per cent in the throughfall from storm rainfall. The stemflow was very low and its relationship with storm rainfall was; stemflow × 10^{-3} mm = —22.154 + 23.629 × Log Rainfall (mm) ($r = 0.683$, at 0.05 level). The influence of wind direction on the lateral distribution of throughfall below coconut canopy was also quantified.

1. Introduction

The information on the receipt, storage and disposal of rainfall from agricultural canopies finds it application in the assessment of soil water, soil erosion, water yields etc. The wetting of the leaves by intercepted rainwater reduces the transpiration rate of vegetation (Rakhmanov 1958, Schindel 1963, Harr 1966, Nicolson *et al.* 1968, Stig Larson 1981) and hence influences crop growth and crop production. In humid tropical areas like Kerala where a large number of inter-crops are grown with coconut, the base trees always compete with the intercrops to intercept and direct water down through their stems.

Investigations on the quantification of throughfall, stemflow and interception losses of precipitation from forest canopies have been reported by many workers (Rutter 1963, Helvey and Patric 1965, Debral and Rao 1968, Brown and Barker 1970, Manokaran 1979). Such information for tree crops is meagre. The throughfall, stemflow and interception losses of rainfall from a coconut (*Cocos nucifera* Linn.), crop have been quantified and discussed in the present paper.

2. The study area and crop description

The experiment was located at the Coconut Research Station, Pelicode (12 deg. 06′ N, 75 deg. 12′ E, 250 m above msl). Pelicode receives an average annual rainfall of 3,500 mm distributed in about 115 days. About 20 per cent of the cropped area around Pelicode is under coconut cultivation.

The coconut trees (*C. V. Lacodive* Ordinary) under observation were 58 years old and planted during the year 1924. The crop has 28 standing leaves, out of which 7 vertically above, 12 horizontally and 9 vertically blow were distributed in a spiral shape in the crown. Each leaf was about 3 m length and 1 m width, nd splits in the veins to form upto 250 *linear lanceolte pinnae* which were about 5 cm wide and 100 cm long. The stem has a diameter of 23-24 cm and a hight of 990 cm and hence it has a surface area of 7467 sq cm. The crop was square planted with an approximate spacing of 7.6 × 9.0 sq m.

3. Experimental details and methodology

The rinfall, throughfall and stemflow measurements from different collectors were done manually every day at 0830 IST during the period. Out of the 108 days of records, only independent rainfall storms with duration less than 24 hours and with an intervening dry period of 12 hours were taken for the present analyses.

TABLE 1

Rainfall, throughghfall and stemflow occurrences from coconut 1981, Pelicode

Month	Frequency of occurrence (in days) of		
	Rainfall	Throughfall	Stemflow
Jun	26	26	25
Jul	24	24	21
Aug	26	26	25
Sep	15	15	12
Oct	11	11	10
Nov	6	6	4
Total	108	108	97

TABLE 2

Monthly rainfall, throughfall, stemflow and interception losses from coconut 1981, Pelicode

Elements (mm)	Jun	Jul	Aug	Sep	Oct	Nov	Total
Rainfall	1284.2	735.4	729.8	453.2	210.0	113.6	3526.2
Throughfall	1187.1 (92.4)	678.4 (92.2)	669.6 (91.8)	390.4 (86.1)	184.2 (87.7)	110.9 (88.8)	3210.6 (91.0)
Stemflow $\times 10^{-3}$	757.6 (0.1)	413.2 (0.1)	234.0 (0.0)	38.0 (0.0)	17.4 (0.0)	6.1 (0.0)	1466.3 (0.0)
Interception	96.4 (7.5)	56.6 (7.7)	60.0 (8.2)	62.8 (13.9)	25.8 (12.3)	12.7 (11.2)	314.3 (8.9)

(Figures expressed as percentage of rainfall are given in brackets)

The rainfall and evaporation (measured with a Class A pan) were recorded in an open field located in the station. The throughfall was collected from 14 plastic collectors of surface area of 200 sq cm each placed under the canopy uniformely in different geographical directions from the trunk (Fig. 3).

The throughfall in the normal planting space of 7.6×9.0 sq m per palm was obtained by weghting the point observations with the areas of concentric circles of 0-1½, 1½-2½, 2½-3½ m diameter from the trunk. The areal weighted throughfall was divided by the total area per palm to convert into mm units.

The stemflow from the trunk was monitored by fixing up a prefabricated metallic collars and the rainwater from the collars was drained into a jery can through a rubber tube. The stemflow in mm of depth was obtained by dividing the volume of stemflow by the area occupied by a single palm, *i.e.*, 7.5×9.0 sq m.

The interception losses (mm) were quantified by an indirect method by taking the difference in gross rainfall and the net rainfall (throughfall and stemflow) measurements.

4. Results and discussion

The observations made during the experimental period June-November 1981 at Pelicode are summarized as follows :

Monthly rainfall, throughfall, stemflow and interception losses

The frequency of rainfall, throughfall and stemflow occurrences during the period are given in Table 1. The monthly rainfall, throughfall, stemflow and interception losses from coconut are given in Table 2.

Pelicode has received 3526 mm of rainfall during June-November 1981 confined to 108 days. There was a gradual reduction in monthly rainfall from 1284 mm in June to 114 mm in November and correspondingly the number of rainy days also decreased from 26 in June to 6 in November.

About 86-92 per cent of the monthly rainfall has reached the soil surface as throughfall and it has occurred on all the rainy days. There was a slight reduction in throughfall with decrease in rainfall due to higher interception losses at low rainfall conditions.

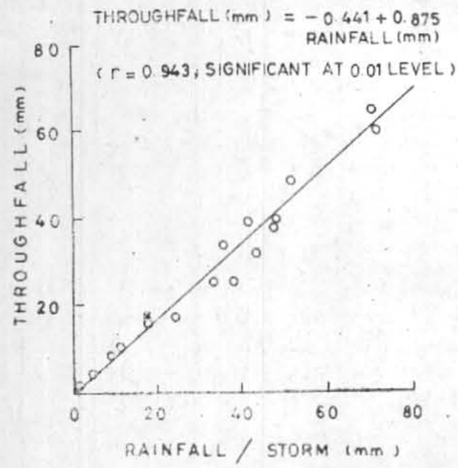

Fig. 1. Throughfall as a function of rainfall

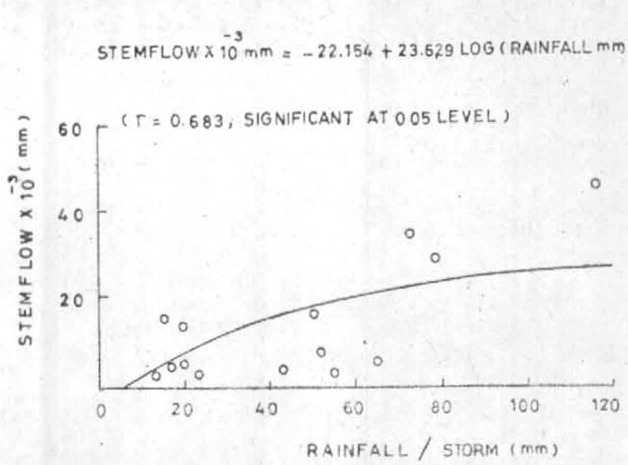

Fig. 2. Stemflow as a function of rainfall

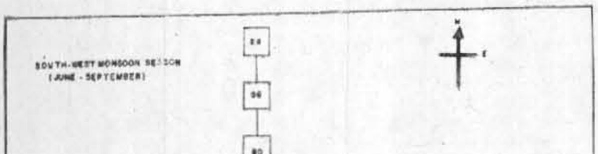

Fig. 3. Lateral variation of throughfall (actual/average, %) under coconut

The stemflow was on 92 per cent of the rainy days and constitutes less than 0.059 per cent of the monthly rainfall. The stemflow was less than one mm per month even *in June under high rainfall conditions.* The recorded quantity of maximum stemflow was 23 litres per day per palm. The most frequent quantity of occurrence being one litre per day per palm. The stemflow can be collected in high level tanks for gravity irrigation which will be sufficient to cover irrigation during the intervening dry periods of the rainy season. In certain parts of the region where saline and water logged conditions exist, the stem water is being collected using palm leaves as collars and is used for domestic purposes.

The monthly interception losses in June from coconut canopy and stem were upto 3 times higher than the Class A pan evaporation of the area which was about 3 mm per day during the period. Such monthly rainfall interception losses from coconut varies from 7.5 per cent of the rainfall in June to 13.9 per cent of the rainfall in September.

Storm rainfall relationships with throughfall and stemflow

The storm rainfall relationships with the throughfall and stemflow are shown in Figs. 1 & 2.

Since the storage capacity of the canopy and the interception losses were of smaller proportion compared to rainfall of the area, the throughfall gave a linear relationship with the storm rainfall. The relationship, throughfall (mm) $= -0.441 + 0.875 \times$ Rainfall (mm) ($r=0.942$ significant at 0.01 level) has accounted for 89 per cent in the throughfall.

The stemflow was increasing with storm rainfall logarithmically. The relationship, stemflow $\times 10^{-3}$ mm $= -22.154 + 23.629$ Log Rainfall (mm) ($r = 0.683$, significant at 0.05 level) has accounted for 47 per cent of the stemflow. Since the leaves of the coconut are split into small *lanceolate pinnae,* the palm does not drag much of the rain water through the trunk, but allows to go through besides what has remained for wetting of the canopy and the trunk. Stemflow was observed only for storms with rainfall of 5 mm and above.

The stemflow was in small quantity compared to the spacing of a palm 7.6×9.0 sq m and hence the throughfall forms the major portion of net rainfall. Therefore, from the relationship obtained between throughfall and storm rainfall, the storage capacity of coconut can be taken as 0.4 mm. The interception losses from larger storms were upto 10 mm per storm.

Lateral variation of throughfall

The percentage ratio of throughfall to the average throughfall at different lateral distances from the stem are shown in Fig. 3.

The west-south westerly winds in the area during June-September poured upto 1¾ times the average throughfall in the forefront portion from about 3 m away from the trunk from the direction from which the wind blows.

Since the wind blows from the east-northeasterly direction during October to November, the throughfall variation also changed accordingly. The lowest, upto half, of the average throughfall was observed 1 m away around the stem. The throughfall concentration at 3 m away from the stem is due to arrangement in the inclination of the leaves through which rain water runs and drips at that particular distance. The throughfall at 1 m around the stem was low due to the distribution of thick coconut frawns which will allow rainwater to run to greater distances. This process helps in reducing the soil erosion and in increasing soil stability at the root zone from the erosive nature of high intensity storms of the region in which rainfall was as high as 50 mm per hour.

5. Summary and conclusions

The throughfall, stemflow and interception losses of rainfall from coconut have been studied. The throughfall has occurred on all the rainy days when the storm rainfall was 5 mm and above. The monthly quantity of throughfall and stemflow were upto 92.0 and 0.059 per cent of the total rainfall. The throughfall was increasing linearly and the stemflow logarithmically with storm rainfall. The coconut canopy has a storage capacity of 0.4 mm and the interception losses were upto 10 mm per storm. The winds in the area have influenced the throughfall distribution below the canopy. The intercrops planted below 2 m lateral distance from the stem will have lower impact from high intensity rains as the throughfall was low in that horizon. Since major portion of the forest/agricultural lands in the west coast region of India are being converted into coconut gardens, the information on rainfall disposition from coconut canopies will be useful in assessing the erosivity of tropical rainfall and impact on the hydrological balance due to change in land use in the region.

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