RAINFALL INTERCEPTION BY A PLANTATION OF TEAK (Tectona grandis, l.f.) IN IBADAN, SOUTH WEST NIGERIA.

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ABSTRACT

Total or gross rainfall, throughfall and stemflow were measured utilizing a $405m^2$ area of teak plantation located within the University of Ibadan Campus, over the period of June to September, 1991. From these data, interception loss was calculated by difference. The results showed that the teak plants intercepted 16% of the total or gross rainfall; whereas throughfall accounted for 81% and the balance of 3% was for stemflow. This result gives insight to the interception capacity of teak and hint on the amount of water use by the plant in the tropics. The implication of these findings in agroforestry lies especially in the fact that the rate of interception by plant canopies usually affect the water balance (hydrological cycle) and has bearing on the efficiency of aerially sprayed insecticides, fertilizers, fungicides and fire retardants.

KEY WORDS: *Interception loss, Gross Rainfall, Stemflow, Throughfall, Agroforestry.*

INTRODUCTION

The interception of rainfall by vegetation is recognized as a component of the hydrologic cycle (Chow et al. 1988; Mohamoud and Ewing, 1990). When the volume of interception is high, the effect on the hydrological cycle is also significantly increased. Interception loss in thus one of the main component of water use by forest because most of the rain intercepted is lost back into the atmosphere through the process of evapotranspiration. Hence, interception rates affect both the rate of evaporation and transpiration.

Most interception studies have concentrated attention on grasses, shrubs, low growing agricultural crops and natural forest canopies. For example, Thurow et al (1987), studied rainfall interception by two typical grasses and live Oak Mottles of the Edward's Plateau in Texas and found out that the grasses intercepted as much as 18% of the annual precipitation while the canopy of Oak mottles intercepted 25.4% of the annual rainfall. Haynes (1940) observed that maize plants intercepted as much as 22 per cent of the total rainfall. Earlier on, Wollny (1890) had shown that only 45 to 88 per cent of the rainfall reach the ground surface under cereals and legumes. The most recent interception studies have relied on laboratory rainfall simulation experiments involving crop residues. Direct field measurements of interception under forest systems are therefore not common in our environment. The reasons for this are not farfetched. Firstly, interception studies are costly to carry out especially under forest systems. Secondly, most agricultural engineers who are interested in interception are mostly concerned with low growing crops and not tree crops.

However, with the emergence of different kinds of tree plantations in especially Southern Nigeria, there is the need to examine the effect of different plantation trees on water yield or the hydrologic cycle. Indeed, with the replacement of the natural forest in most places in Southern Nigeria by plantations of rubber, teak, Gmelina, Cocoa, Palm trees etc. The annual hydrological or water cycle in these places may have been altered in terms of the interception, infiltration, runoff and evaporation losses. Most of these components of the hydrological system have been hardly studied under tree planations.

In most countries of Africa, interception studies have made slow progress. Infact, Hopkins(1965) provides the only available data on throughfall in the natural forest of Nigeria, whereas Okali (1980) remains the only Nigerian study on interception of rainfall. This study is therefore aimed at providing information on the components of rainfall interception under teak as this information is of considerable ecological significance and quite useful in agroforestry development and planning.

PARAMETERS STUDIED

Rainfall interception by plant canopies consists of three main components or parameters, namely, interception loss, throughfall and stemflow. The interception loss of rainfall from a canopy is the quantity of water which is retained by plant surfaces and eventually lost to the atmosphere (Ward 1975; Less 1980; and Sambasiva Rao, 1987.

Two definitions of interception loss exist. The first regards interception loss as the amount of rainfall retained on the aerial parts of the vegetation and subsequently evaporated. The second sees interception loss as that part or portion of rainfall retained on the plant canopy but which is later evaporated over and above that which would normally be transpired had there not been intercepted water. The former is referred to as gross interceptions loss and the latter is called net interception loss. This study considers the gross interception loss.

The second parameter, throughfall, refers to the precipitation that reaches the forest floor indirectly by dripping from the leaves and tree branches (leaf drip). Throughfall is generally greater in the open forest than in forest with dense canopy. Quantitatively, through fall is the difference between gross (total) or incident rainfall and the sum of canopy interception and stemflow (Sopper & Lull, 1967; Lee, 1980).

The third parameter, stemflow, is the water which passes over the leaves and branches of a tree and finally runs down the main tree trunk to the ground surface (trunk drainage). Throughfall and stemflow are very crucial parameters of interception.

The Fourth and final parameter is the gross or total rainfall. This is simply the volume of rainfall that occurs above the vegetation canopy or layer (Ward 1975). Measurement of gross precipitation above the canopy usually present a lot of problems but this can be avoided by measuring rainfall at ground level within clearings in the forest or outside the forested zone.

Interception studies are usually based on the interrelatedness of the phenomena of throughfall, stemflow and gross rainfall. Ward (1975) aptly illustrated the relationship in an equation form, thus:

$$I = R - (Rg + S) \quad \ldots\ldots \text{Eq. 1.}$$

Where I = Interception loss

R = Gross rainfall

Rg = Ground precipitation below the Vegetation canopy (throughfall)

S = Stemflow.

All the above components or parameters of interception, namely, gross rainfall, throughfall, stemflow and interception loss were examined the last parameter, interception loss was computed from the values of gross rainfall, throughfall and stemflow for each rainfall event as indicated in equation. I.

STUDY AREA

This study was carried out at the University of Ibadan teak (Tectona grandis L.f.) Plantation located at the North Gate of the University (Long. 07°28'N, Lat. 03°54'E). The plantation is 36 years old and is at a site with an altitude of between 200m and 220m above sea level. The entire plantation is 33 hectares and the density of stands is 800 to 1000 trees per hectare. This shows a stocking of 3.53m x 3.53m and 3.16m by 3.16m. Average tree heights were mostly in excess of 25 metres. The annual rainfall is variable ranging from 884mm to 1448.4mm with peaks in May/June and September/October. Only a section of the plantation measuring 405m^2 in area was utilized as the experimental site of this study.

MATERIALS AND METHOD

The study was done during the wet season of 1991 with the objective of determining the quantity of rainfall that is intercepted by teak plants. The study took 4 months of intensive field work which involved the daily measurement of the parameters of gross rainfall, throughfall and stemflow. The standard procedure for the measurement of interception loss in the field was adopted (See Ward 1975, Eze 1991). This involved the measurement of the parameters mentioned above. Twenty-two (22) rainfall events were monitored or measured. The interception loss was computed from the values of the parameters studied using equation I. Gross precipitation above the vegetation canopy was measured using a standard British-type 127mm Rain gauge which was installed in an open clearing within the plantation. Throughfall was measured using 5 Standard Rain-gauges which were randomly located within a 15m by 17m grid of the teak plantation. The volume of throughfall passing through the canopy into the Rain-gauges was measured after each rainfall event using a measuring cylinder. Stemflow was measured from 13 trees randomly selected for the purpose. The girth class, 0-50cm had 6 trees while those with girth greater than 51cm had 7 trees. The operation of the collection of the stemflow was done similar to the tapping of rubber from a rubber tree. A rubber tube or hose-pipe was attached to the lower end of the stem gutter to lead water running down the tree stem into plastic cans. The tube or hose-pipe was sealed to the stem gutter with the aid of bitumen, cellotapes and waterproof materials.

RESULTS AND DISCUSSION

Table I shows the result of the measurements. The components of gross rainfall, throughfall, stemflow and interception loss have been previously defined. The percentage interception loss per individual storm is in the last column of the table. The highest interception value of 31% was obtained for the rainstorm size of 5.2mm while the lowest value of -3% was gotten from the storm size of 3.7mm. The negative value of the latter was due to the fact that the throughfall value was greater than gross rainfall. The heaviest storm in the study measured 10.00mm and had an interception value of 4% proving once more the assumption that the proportion of interception decreases as storm size increases (Aston 1979; Chow et al, 1980). The plot of percentage interception against gross rainfall (Fig. 1) equally shows that interception decreases with increase in gross rainfall. This finding implies that whenever agrochemicals are sprayed on teak plants, much will be intercepted especially when the volume applied is small. On the other hand, very little will be intercepted when the volume of the applied agrochemical is much.

TABLE I: COMPONENTS OF INTERCEPTION UNDER TEAK

S/NO.	Storm Date	Gross Rain-fall	Through fall (mm)	Stemflow (mm)	Interception% (mm)	Interception Loss
1	29/6/91	8.6	5.9	0.6	2.1	24
2	1/7/91	10.0	9.0	0.6	0.4	4
3	2/7/91	3.5	2.8	0.0	0.7	20
4	6/7/91	3.3	3.2	0.0	0.1	3
5	7/7/91	3.7	3.8	0.0	-0.1	-3
6	10/7/91	5.7	3.4	0.0	1.3	23
7	16/7/91	3.3	2.5	0.0	0.8	24
8	20/7/91	6.3	5.4	0.0	0.9	14
9	24/7/91	5.2	3.6	0.0	1.6	3
10	28/7/91	3.2	2.5	0.0	0.7	22
11	2/8/91	2.9	2.5	0.0	0.8	10
12	5/8/91	4.3	3.8	0.3	0.2	5
13	14/8/91	3.9	3.1	0.0	0.8	21
14	20/8/91	3.3	2.7	0.0	0.0	18
15	21/8/91	3.2	2.5	0.0	0.7	22
16	23/8/91	3.6	3.4	0.0	0.2	5
17	24/8/91	2.9	2.2	2.0	0.7	24
18	29/8/91	2.8	2.6	0.0	0.2	7
19	30/8/91	*3.2	2.5	0.0	0.7	22
20	30/8/91	*3.1	2.2	0.3	0.6	19
21	4/9/91	*3.1	2.5	0.3	0.6	19
22	4/9/91	*5.3	4.0	0.5	0.8	15
Total		**94.4**	**76.1**	**3.0**	**14.9**	**AV=16%**

* Double Storms per day

Source: Fieldwork 1991.

Gross rainfall = *Throughfall + stemflow + interception*

Interception loss = *Gross Rainfall - (Throughfall + Stemflow)*

% Interception loss = $\frac{\textit{Interception loss}}{\textit{Gross Rainfall}} \times 100\%$

When the total amount of interception was calculated as a percentage of the total rainfall for all the 22 rain storms, the result gave 16%. In other words, on a storm by storm basis (i.e. rainfall event by rainfall event), the interception of gross rainfall by canopies of teak during the rainy season is 16%. On the other hand, when the total amount of throughfall was calculated as a percentage of the gross rainfall, it gave 81%. Similarly, the stemflow was computed as 3% of the gross rainfall. Though the stemflow values were generally small and for most times zero, there were grossly and high exaggerated for 13 rainstorms which were not used in this analysis. The explanation for this is still being sought in the literature.

From the on-going result, it is clear that teak plants often use or loose as much as 16% of water that comes through its canopy. This implies that whenever we apply agro-chemicals to teak plants aerially through the canopies we must make allowance for as much as 16% loss via the process of interception and later, evaporation. The throughfall value of 81% gives a picture of the effective rainfall as opposed to the gross or total rainfall. It is effective rainfall in the sense that it is the quality of rainfall that actually touch the ground and is thus available as soil moisture, runoff or even groundwater. It is also a reflection of the amount of natural water input to the plant (Jackson, 1979). The stemflow of 3% is quite negligible but suffice it to say that heavy stemflows have been known to affect the bearing capacity of some tree-crops like Cocoa (Abang, S. O.; Personnel Communication).

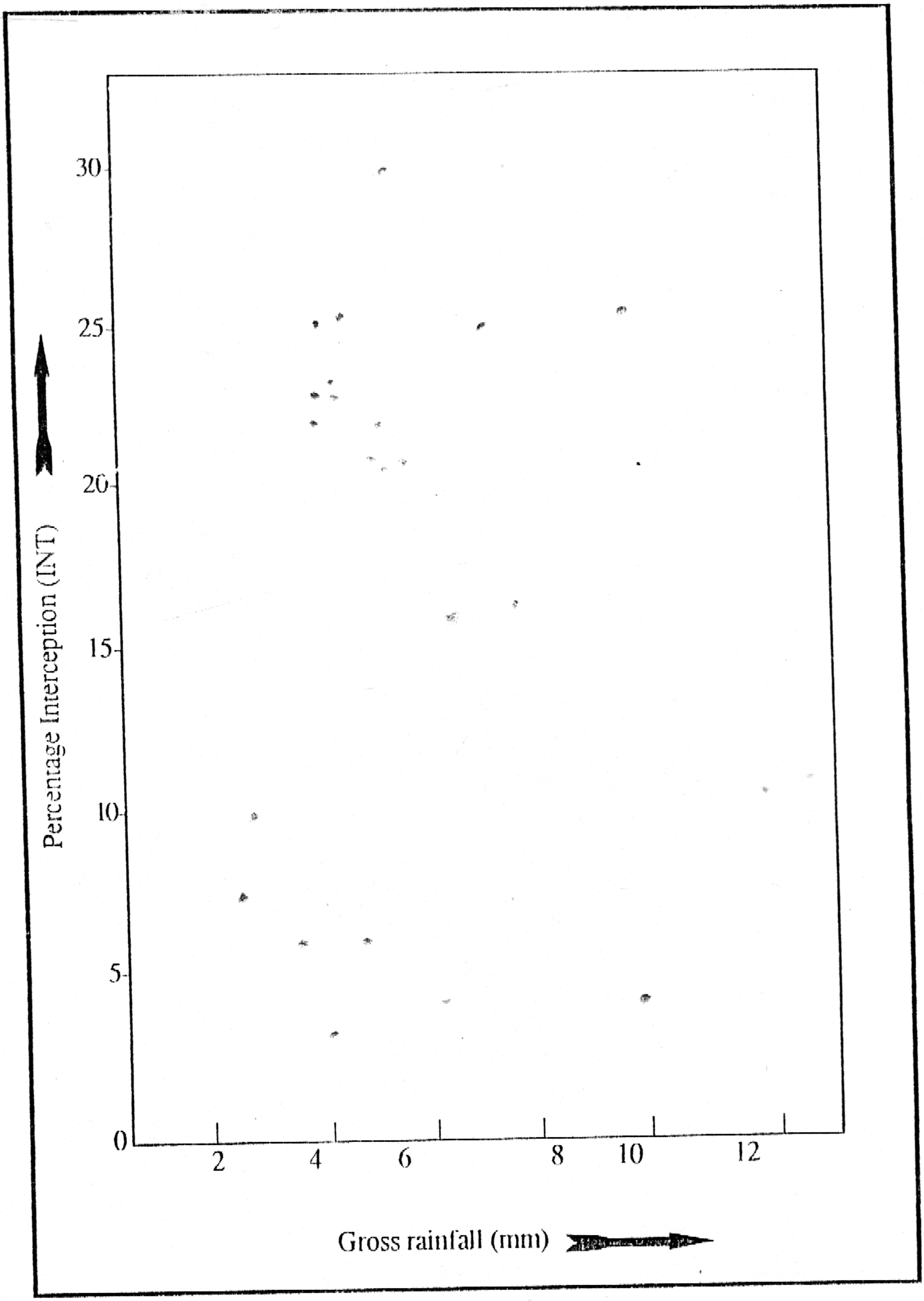

Fig.1: PERCENTAGE INTERCEPTION AGAINST GROSS RAINFALL

In any case, the clear volume of interception in this study shows the water use by teak plants (Jackson 1979, Okali 1980). Water use by plants has been defined as all the evaporation and transpiration loses from vegetation surfaces. Indeed to obtain, the total water use, estimates of transpirational (evaporative) water use must be undertaken in addition to the interceptional water use. Again, the usefulness of this result in agricultural operations deserves mention especially with respect to the application of agro-chemicals. For example, if teak coppice shoots intercept as much 16% of fertilizers, insecticides and fungicides, then the efficiency of these chemicals will be affected. On the other hand, the trapping or interception of salts, dust and air pollutants on vegetation surfaces may have tremendous negative consequences on the plant health and ecology. On the positive side, it has been discovered that aerially sprayed fungicides and fire retardants are more effective the longer they are intercepted and stored by vegetation surfaces (Aston, 1979).

For the agro-chemicals that are sprayed to control rodents, insects and fungi which attack the foliage, fruits and stems of trees, the active ingredients of the chemicals must be on the foliage, fruits and stems of the trees. In the circumstance, a high interception is more beneficial to the plant than a low interception. However, if the objective of spraying agro-chemicals s to control pests on the bols of stems, then arial spraying is definitely not ideal for plant like teak.

CONCLUSION

Widespread planting of trees in agricultural catchments (agro-forestry) is now very common in Nigeria. Trees affect the hydrology of catchments by altering the processes of interception, evaporation, infiltration, soil moisture and a host of other factors which influence agricultural productivity. Rao (1988), for example, reported rampant environmental crises such as soil erosion, landslides, mudslides and flooding following the conversion of the natural forest to rubber plantation in Thailand. The need to study the effect of tree plantations on the hydrological systems in Nigeria is yet to be realised even in the face of wanton deforestation and environmental crises.

This study is therefore a contribution to the analysis of water use by an agro-forestry tree specie - teak. The fact that the teak plants intercepted 16% of the gross rainfall in this study shows that teak in the form of plantation has a considerable effect on the hydrological cycle. It is therefore advisable to use teak sparingly in agro-forestry operations. There is however need for more studies on interception by other agro-forestry tree species so as to establish their effects on the hydrological cycle. In addition, this study concentrated on interceptional water use by teak since it is often difficult to measure transpiration in the field (Green et al, 1980). Above all, the implication of these findings in the application of agro-chemicals are hihglighted. In so doing, the study has illustrated the importance of the phenomenon of interception in agro-forestry.

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