Driptips and Splash Erosion

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Introduction

The general mechanics of the water on leaves and its effects on soils remains unknown. Most of the research on the acuminate tips of leaves has focused on the rate of water removal from leaf surfaces and the possible advantages of rapid water removal (Richards, 1966; Dean and Smith, 1978). These studies investigated the rate of drying of leaves after wetting, so the results imply that the adaptive significance of driptips is related to a post-rain process, but not to water removal during rainfall. While there is evidence that driptips facilitate drying (Dean and Smith, 1978), the magnitude of the difference in water on leaves with and without driptips is sufficiently low that it could represent differences retained as an adhering drop at the leaf tip.

An alternative approach is the investigation of the role of driptips during rainfall. Superficial observations suggested that driptips serve as spouts for water running off the leaf surface and, further, that the drop size of water falling from driptips is much smaller than drops falling from less acuminate leaf tips. More recently, Williamson (1981) has demonstrated that the degree of development of the driptip is highly associated with drop size of leaf runoff. (Drop volume, mm^3, is linearly related to the logarithm of leaf width, measured at 3.0 mm from the end of the driptip.

Drop size is important to splash erosion: the loosening of soil particles and detritus impacted by drops. While particles may be splashed relatively short distances (0-5 mm), soil loss may be significant where splash is accompanied by shallow water flow over the soil surface. In such action, called sheet erosion, soil transport capacity is directly related to the velocity and quantity of flow. However, particle detachment is proportional to the kinetic energy of rainfall, and kinetic energy of a drop increases as the square of the terminal velocity, which increases with drop size (Wischmeier, 1977).

Driptip development is associated with tropical understory plants, where drops from leaf runoff may never achieve terminal velocities. Therefore, the unsolved question is whether driptips actually result in less particle displacement. This is the hypothesis that was tested.

Methods

We used the same leaf of <u>Dieffenbachia</u> sp. (Araceae) with a well-developed drip tip for each experiment. The leaf was placed at four different heights from the soil: 10, 50, 100, and 200 cm. Because there was no rain the day of the experiments, we gently dropped 200 ml of water on the leaf using a graduated cylinder. The leaf was previously wet with a sponge. One different white sheet of paper, 28 x 21.6 cm, was placed very close to the point of splashing for each height and test. After the splashing every paper was dried and weighed. The experiments were repeated three times for each height using the whole leaf, three times after the leaf tip was cut off to a 3 mm width, and another three times after cutting the leaf tip to a 10 mm width. The first two width tests were made at different points at the same location after cleaning the soil of leaves and other big pieces of organic material, and the third test, in another location close to the first one, using the same procedures. The leaf was held on a stick with the hands to keep the same angle for all tests.

A transect of 30 meters x 1 meter was made close to the sites of experimentation. The width of each leaf 3 mm from the tip and the height of the leaf from the soil were measured for 3 individuals of 17 different species of plants in the understory.

Results

The total weight of soil obtained in each experiment is given in Table I. (The data obtained from the analysis of variance is given in Tables II and III. It reveals that, in general terms, more soil is eroded at greater heights and, more importantly, as the tip was cut (see also graphic I).

Since the uncut leaf and the first cut were tested in the first site, and the second cut took place in the second site, we did different ANOVAs (Table II) because we were working with soils that may have had different conditions.

On the other hand, in the transect we calculated the mean width 3 mm from the tip for the 17 understory species. Because the individuals were not chosen randomly and we did not expect any normal distribution, we used non-parametric statistics. More concretely, the Spearman rank correlation coefficient was used because of all the statistics based on ranks, the SRCC was the earliest to have been developed and is perhaps the best known today. It is a measure of association which requires that both variables be measured in at least one ordinal scale so that the objects of individuals under study may be ranked in two ordered series. As we can see in Graphic II, there was a negative correlation (-0.74) between average width of leaf measured 3 mm from the tip and the average height, which means that drip tip width is inversely related to leaf height on a plant.

Discussion

The results seem to indicate that there is the correlation that was predicted in the literature cited above. This preliminary study is still incomplete and no generalizations concerning the effects of driptips on soil erosion will be drawn. However, it does seem that they do reduce soil erosion and more extensive studies need to be conducted.

The main difficulty that we encountered during the experiments was how to hold the leaf in a stable position, taking into consideration that it was done manually. Sometimes the angle of the leaf with respect to the soil varied. As a result of this we strongly recommend that for future studies using similar techniques and/or objectives, some sort of mechanical device should be developed.

Literature cited

Dean, J. M. and A.P. Smith. 1978. Behavioral and morphological adaptations of a tropical plant to high rainfall. Biotropica 10: 152-154.

Literature cited (cont.)

Richards, P. W. 1966. The tropical rain forest, Cambridge at the University, England.

Williamson, G. B. 1981. Driptips and splash erosion. Biotropica (in press).

Wischmeier, W. H. 1977. Soil erodibility by rainfall and runoff, in Erosion: research techniques, erodibility and sediment delivery (T. J. Toy, editor), Geo Abstracts Ltd., Norwich, England, pp. 45-72.

Table I

Factor B: Treatment of leaf	Factor A: Height at which leaf tip is held 10 cm	50 cm	100 cm	200 cm	Σ
Whole Leaf	0.095	0.199	0.089	0.142	Σ= 1.148
	0.053	0.044	0.057	0.169	
	0.061	0.039	0.057	0.143	
	Σ=0.209	Σ=0.282	Σ=0.203	Σ=0.454	
First Cut	0.026	0.031	0.210	0.187	Σ= 1.652
	0.109	0.000	0.323	0.125	
	0.102	0.088	0.213	0.232	
	Σ=0.237	Σ=0.118	Σ=0.753	Σ=0.544	
Second Cut	0.030	0.056	0.019	0.068	Σ= 0.656
	0.076	0.097	0.075	0.059	
	0.017	0.042	0.095	0.022	
	Σ=0.123	Σ=0.195	Σ=0.189	Σ=0.149	
Total	Σ=0.569	Σ=0.595	Σ=1.145	Σ=1.147	ΣΣ = 3.456

Table II

Model I ANOVA

Source of Variation	df	SS	MS	F
Subgroups	11	0.140	0.013	
Height	3	0.035	0.012	6.00**
Leaf Treatment	2	0.041	0.021	10.50***
Height x Leaf Treatment Interaction	6	0.064	0.011	5.50**
Within Subgroups	24	0.048	0.002	
Total	35	0.188		

** $p < 0.01$

*** $p < 0.001$

$F_{0.01[3,24]} = 4.72$; $F_{0.01[2,24]} = 9.34$; $F_{0.01[6,24)} = 3.67$

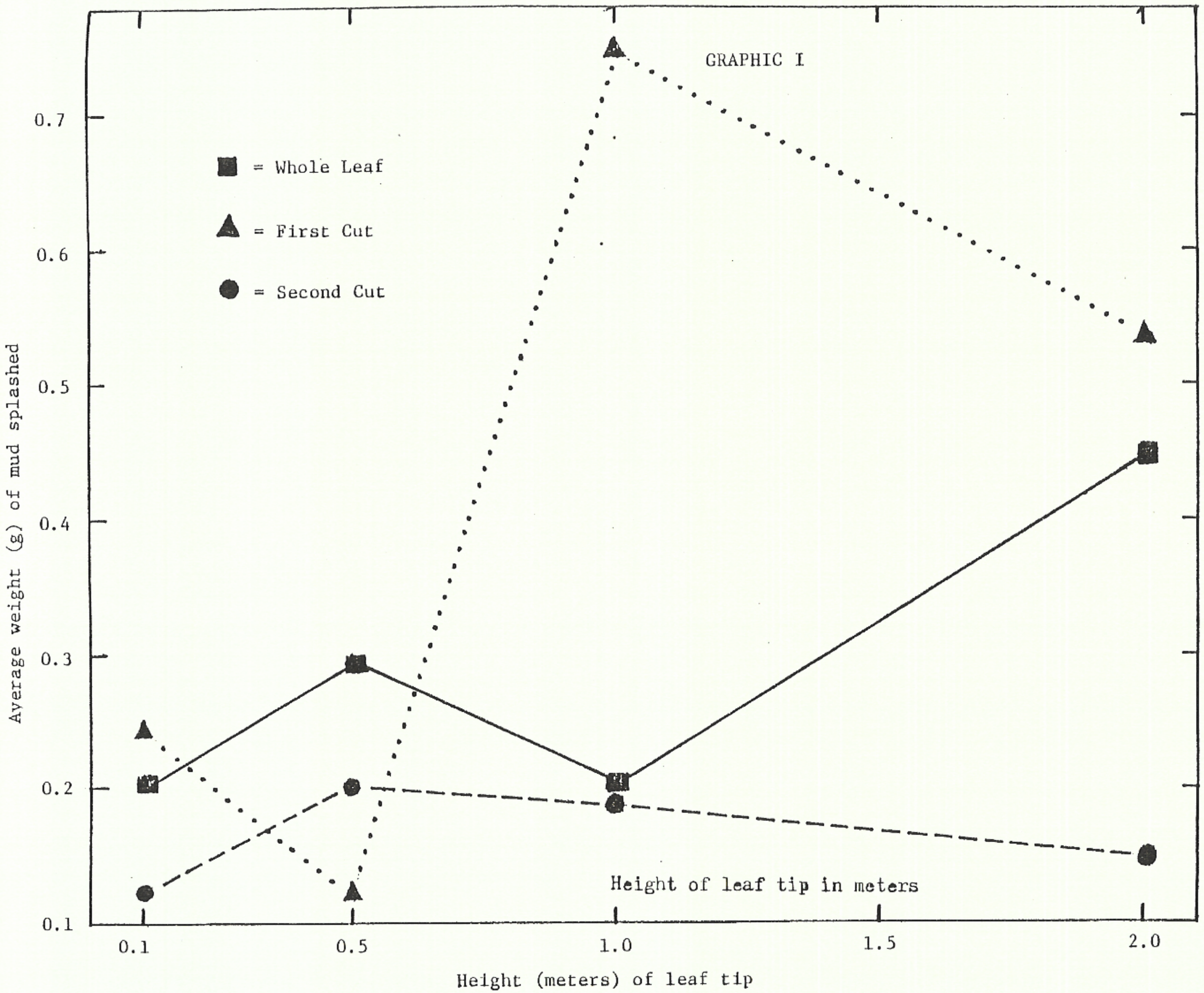
Table III

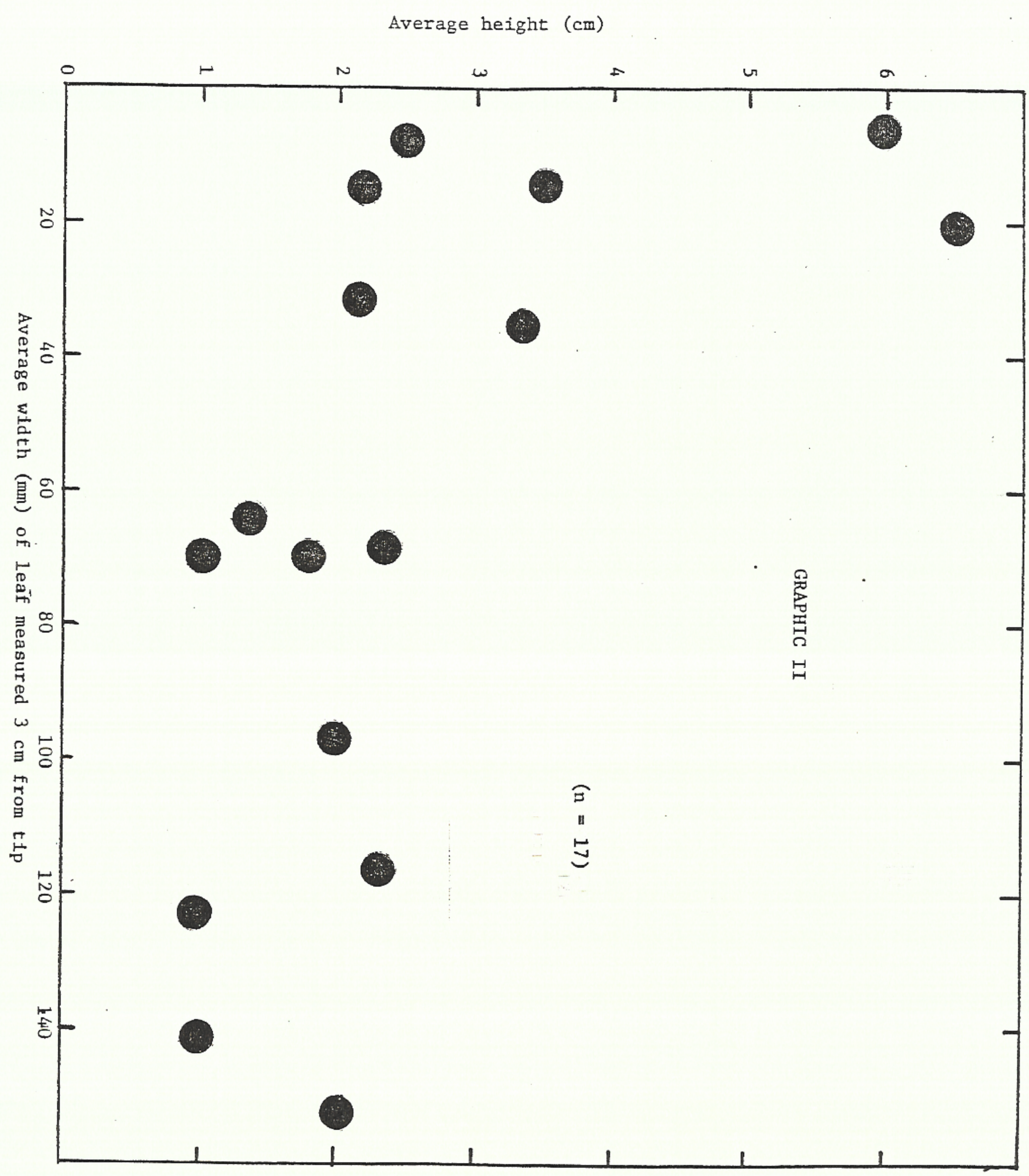
Model I ANOVA

Source of Variation	df	SS	MS	F
Subgroups	7	0.109	0.016	
Height	3	0.052	0.017	8.50**
Leaf Treatment	1	0.011	0.011	5.50*
Height x Leaf Treatment Interaction	3	0.046	0.015	7.50**
Within Subgroups	16	0.038	0.002	
Total	23	0.147	0.061	

* p 0.05

** p 0.01


GRAPHIC I
= Whole Leaf
= First Cut
= Second Cut
Height of leaf tip in meters
Average weight (g) of mud splashed
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.1
0.5
1.0
1.5
2.0
Height (meters) of leaf tip


GRAPHIC II
(n = 17)
Average height (cm)
0
1
2
3
4
5
6
Average width (mm) of leaf measured 3 cm from tip
20
40
60
80
100
120
140