Variability of leaf parameters in the foliage of cocoa trees in Vanuatu

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Photosynthesis ability is one of the factors that affect yield elaboration in cocoa trees. Substantial variability is often seen when measuring gas exchanges in leaves. It is linked to their sampling within the tree and to measurement instability, irrespective of experimental conditions. In order to characterize the factors responsible for such variability, a study was carried out on the island of Espiritu Santo, in Vanuatu (15° latitude south) taking mature leaf samples from different accessible zones in the foliage, corresponding to zones in which gas exchange measurements are carried out.

Material and methods

Four hundred and thirty-two leaf samples were taken from 6 10-year-old trees of the Amelonado variety chosen at random in a population of 700 trees planted without shade, taking into account the orientation of the leaves, along with their height and their position along a terminal plagiotropic branch. All these leaves came from the same uniform leaf flush.

The parameters measured were the length, width and weight of each leaf. The parameters calculated were leaf density and leaf area, determined using two different methods: from the lengths and widths, or from the leaf density.

The results of the analyses of variance were expressed with a 5 % limit. The significance level of the differences (F test, proba p at 5%) is indicated on each figure by a specific frame colour and defined as follows:

Results and Discussion

There was a linear relation between the two methods used to calculate the leaf area.

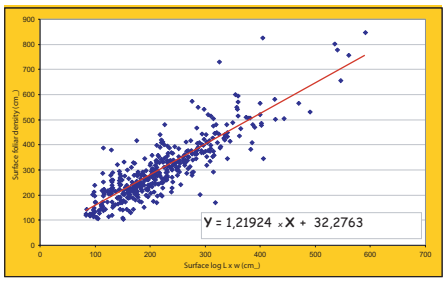

Figure 1. Graph of the correlation between the two methods used to calculate leaf area. The coefficient of correlation is 0.8656 (***) and the standard error is 60.281 for 432 observations.

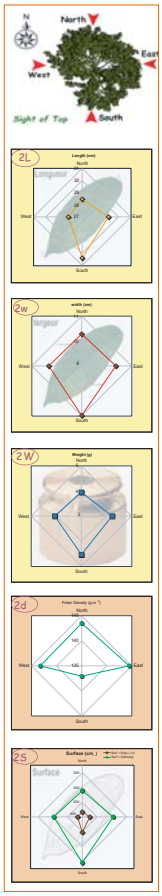

Figure 2. Effect of tree orientation on leaf length (2L), width (2w), weight (2W), density (2D) and area (2A).

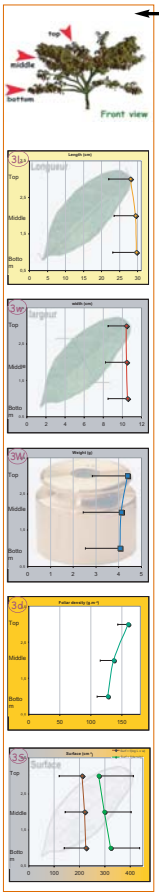

Figure 3. Effect of height in the tree on leaf length (3L), width (3w), weight (3W), density (3D) and area (3A).

These synthetic images of the cocoa tree were produced with the AMAP program, CIRAD—AMIS department.

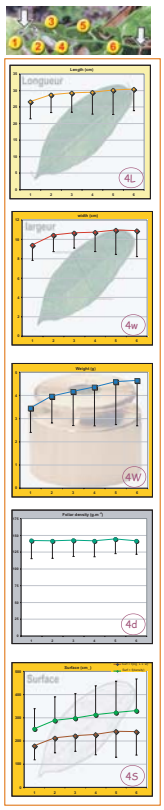

Figure 4. Effect of height in the tree on leaf length (4L), width (4w), weight (4W), density (4D) and area (4S).

Effect of leaf position in the tree

The effect of leaf orientation and sampling height was generally reflected in a significant increase in size represented by the length (figures 2L and 3L) and width (figures 2w and 3w) of the leaves.

The position of the leaf on the plagiotropic branch also significantly influenced its weight and size: the further the leaves were from the apex, the heavier (figure 4W) and the larger (figure 4L and 4l) they were.
Under these conditions, leaf density remained stable (figure 4D); the increase in leaf weight was therefore linked to the increase in area. However, density varied highly significantly depending on the orientation (figure 2D) and height of the leaf (figure 3D).

Irrespective of the calculation method used, the leaf area was greatest at the bottom (figure 3S) and south facing (figure 2A) parts of the tree, the parts least exposed to sunlight in the southern hemisphere.
The increase in leaf area was gradual along the plagiotropic branch figure 4A).

Conclusion

An analysis of leaf length, width and weight showed that the orientation, height and position of the measured leaf on the axis had a marked effect, without any interaction between those factors. The leaves least exposed to sunlight (south-facing and to a lesser extent east-facing) were always longer, wider and heavier, and therefore had a larger leaf area than the other leaves. The effect of orientation can therefore be explained by the difference in exposure.

When they belonged to the same leaf flush, the leaves had a stable leaf density. The increase in weight recorded was linked to the increase in area.

Repeatability of the measurements was validated, without any notable interaction with the self-shading phenomena noticed. These results mean that it will be possible to take into account characteristics linked to leaf positions within the plant when taking leaf samples to compare individuals within a population of cocoa trees.

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