A Rapid and Non-Destructive Technique for Measuring the Area of Cucumber Leaves.

D.L. Visser
Institute for Horticultural Plant Breeding (IVT), P.O. Box 16, 6700 AA Wageningen, The Netherlands.

Leaf area measurements are an essential part of growth analyses. For most measurements, plants need to be defoliated so that leaf area can be measured with a photo-electrical area meter. Growth analyses have shown that in cucumber a large leaf area is desired for quick growth (3). For selection of fast-growing lines and for experiments with repeated measurements of the same plants, a non-destructive measuring technique is required. Also, when many leaves have to be measured, a rapid and efficient method is necessary.

As early as 1921, leaf area calculation was used for area measurements in one cucumber cultivar, based on three linear and two corner measurements (1). Differences from the actual area occurred and a correction factor was necessary. The error with single leaf measurements was $\pm$ 5%, whereas it was only $\pm$ 1.6% for total leaf area. In poplar a rapid method was developed using only length and width to calculate leaf area (4). The accuracy of this method was limited for individual leaves, but it was sufficient for total leaf area. A correction factor was necessary to calculate the actual leaf area. The correction factor was unique for each poplar clone in the study. Liebig (2) used this method in his experiments on productivity of two cucumber cultivars for which he used one correction factor.

Methods. At IVT, an experiment was run to determine whether the method of Liebig can be used in plant breeding, where different genotypes are involved. In the autumn of 1983 5 plants of 4 slicing cucumbers (F_1 hybrids Farbio and Birgit and 2 genetically uniform inbred lines K79341 and K79351) and 2 pickling cucumber cultivars (Hokus and Levo) were randomly grown in pots under normal glasshouse conditions. When most plants had 9 or more leaves, length and width of all leaves of each plant were measured 3 times and recorded to the nearest cm, according to a previously established random scheme. Width was measured on the narrowest leaf part between the first and the second main vein, and length between the base of the leaf and the point where the leaf is 1 cm wide (Fig. 1). This was done to avoid errors caused by differences in the shape of the leaf tips of different genotypes. Leaves smaller than 3 x 3 cm were not measured. Leaf area (LAC) was calculated as length x width. The leaves of each plant were also measured individually with a Li-cor 3100 area meter (LAM) to measure the actual leaf area.

Results: When measuring length and width of leaves ranging from 3 to 20 cm on a 1 cm scale, rounding off to the nearest cm causes errors. Therefore three separate measurements were made. The results of the LAC measurements on single leaves gave a variation of 5 to 30%, whereas for total leaf area it was about 2%. The use of a smaller measuring scale will reduce the difference between these measurements. However, this will increase the time necessary for collecting the data. For total leaf area, LAC can normally be calculated on the basis of one measurement.

The shape of the leaf depends on its position on the plant. Therefore the difference between LAC and LAM of individual leaves vary. In slicing cucumbers, LAC was nearly equal to LAM for young leaves, whereas for old leaves it was much greater than the LAM. With the pickling cultivars, however, the LAC of young leaves deviated more from LAM than the LAC of old leaves, as shown in Fig. 2. Differences between LAC and LAM of the middle leaves was intermediate to the difference of LAC and LAM of old and of young leaves.

A better agreement of LAC with LAM was found with measurements of total leaf area because the middle leaves, which were stable in shape, represented most of the total area and the influence of measuring errors was limited. The average total area per plant shows identical significant differences both for LAC and LAM between the six genotypes (Table 1). LAC gives a systematic overestimation of the total leaf area. This difference between LAC and LAM (LAC/LAM ratio) is caused by the different shape of the leaves of each genotype. The pickling cucumbers, Levo and Hokus, have a somewhat higher LAC/LAM ratio than the slicing cucumbers. Within the group of slicing cucumbers, K79341 and Farbio have a lower LAC/LAM ratio than K79351 and Birgit, indicating that for an accurate conversion of LAC into LAM a correction factor is necessary, which may be different for each genotype. The overall correlation between the average of total leaf area per plant of the 3 LAC measurements and the LAM is 0.99 ($y = 0.9005 x - 54.5$).

Conclusions. This experiment shows that for breeding and selection, total leaf area can easily be approximated by measuring length and width on a 1 cm scale, because the breeder is most interested in comparing inbred lines. For growth analyses, where the real leaf area is necessary, a more accurate method is needed.

Literature

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Table 1. Number of leaves, and total leaf area as measured (LAM) and as calculated (LAC) for 3 separate measurements.[z]

Genotype	Average number of leaves	LAM (cm^2)	LAC (cm^2)	LAC as % of LAM
K79341	9.2	1679 b	1876 b	(112)
Farbio	9.2	1459 b	1656 b	(114)
K79351	11.4	1966 a	2279 a	(116)
Birgit	9.2	1609 b	1893 b	(118)
Hokus	8.8	646 c	781 c	(121)
Levo	9.0	710 c	867 c	(122)

[z]Data are means over 5 plants and 3 measurements per genotype.

Fig.1: Diagrams of leaves with measuring points for length (L) and width (W).

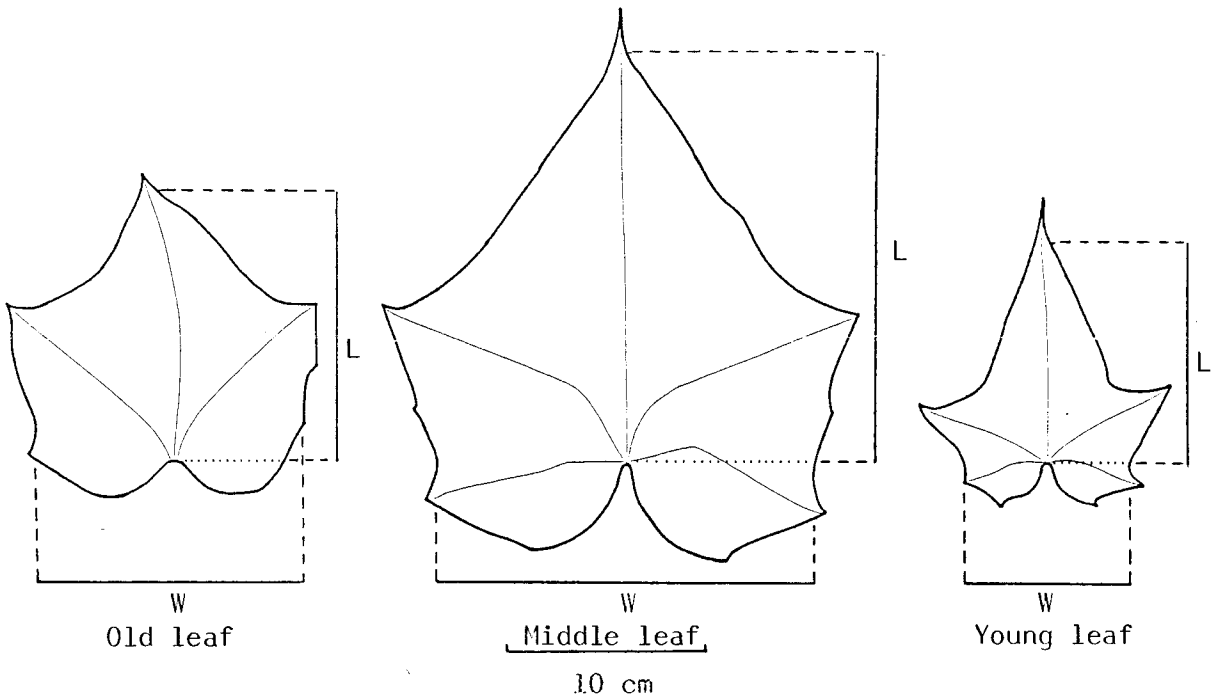

Fig.2: LAC in % of LAM according to leaf position for four slicing cucumbers and two pickling cucumbers.