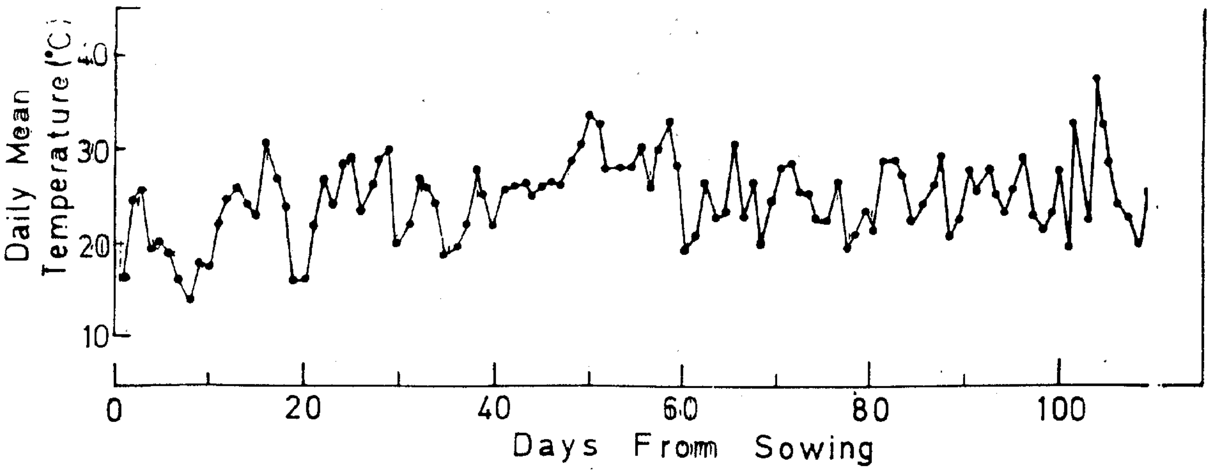

Figure 5. Daily mean temperature registered during the growth period.

DISCUSSION

Variations in RGR during the growth period are the result of the interaction NAR x LAR. That is the reason why they show the same pattern of decline through the growth period (Figures 1, 2 and 3).

However, as the NAR values are more variable, it can be said that RGR depends more on LAR than on NAR. The variations of NAR were due to the sensitivity of this parameter to changes in solar radiation (Horie, 1977). Temperature and soil water content were always near the optimal values, whereas solar radiation showed large fluctuations (Figures 4 and 5).

The results show a decline of the LAR values due to variations in SLA during the growth period (Table 1) since LWR values are fairly constant. This probably was a result of assymetrical distribution of the assimilates between leaves and other organs.

The HI of the two populations did not differ substantially even though the grain yield per plant was significantly lower for HD plants than for LD plants (Table 2).

It is concluded that under irrigation and high solar radiation the growth indexes studied at both densities were not different. However, as the HD plots have great ability to cover the soil earlier than the LD plots (showed by the evolution of LAI), yields per unit area were similar indicating that in the HD treatment low yields per plant were compensated by high plant populations.

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LITERATURE CITED

DONALD, C.M. and HAMBLIN, J. 1976. The biological yield and harvest index of cereals as agronomic and plant breeding criteria. *Advances in Agronomy,* 28:301 — 359.

HORIE, T. 1977. Simulation of sunflower growth. I. Formulation and parametrization of dry matter production, leaf photosynthesis, respiration and partitioning of photosynthates. *Bulletin of the National Institute of Agricultural Sciences.* Series A. No. 24 pp 45 — 69 (Japan).

WARREN WILSON, J. 1966. High net assimilation rates of sunflower plants in an arid climate. *Annals of Botany,* N.S. vol 30, No. 120:745 — 751.

WARREN WILSON, J. 1966. Effect of temperature on net assimilation rate. *Annals of Botany,* N.S. vol 30, No. 120:753 — 761.

WATSON, D.J. 1952. The physiological basis of variation in yield. *Advances in Agronomy,* 4:101 — 144.

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ESTIMATION OF LEAF AREA ON SUNFLOWER PLANTS.

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ABSTRACT

Correlation between leaf area, maximum width and length of individual leaves has been studied in sunflower plants. The results obtained by multiplying width times length gave a good estimation of leaf area but the width alone was considered the best with a r^2 of 0.97.

No significant differences exist between both estimates (L x W or W alone) and it is concluded that a field scale can be built for leaf area determinations using only the width value. This method diminishes the work by eight times.

INTRODUCTION

Foliar area is a valuable indicator of plant growth, because it is intimately related to dry matter accumulation, transpiration, yield and, especially, the photosynthetic capacity of the plant.

In many trials, it would be important to have some data on foliar area; however, there is no information on this value due to the amount of time needed for its determination, or to the fact that it is necessary to destroy the plant material when certain methods are applied.

Actually, there are rapid methods for obtaining the foliar area, but they bring about the destruction of the measured leaves, e.g. electronic planimeters.

Methods based on the relation between leaf surface and the product of its length and width have also been developed; these methods have the advantage of not being destructive.

The idea that gave origin to this work was that of finding a single linear measure related to the leaf surface, in such a way as to permit the construction of a scale in which the measurements of the estimative parameter could be replaced by the estimated leaf surface.

BACKGROUND

Williams (1953), given the need of having a non-destructive way of determining foliar area in tomatoes, developed a method based on photographic patterns of leaves in different stages of development. These patterns covered all the range of possible leaves and, by analogy, the approximate area of each leaf could be determined.

Stickler *et al.*, (1961), worked with 6 grain sorghum hybrids in order to find a relation between maximum length and maximum width of leaves with the corresponding foliar area. They found that there is a close relation between the product of both measurements and the leaf area, and determined a constant relation of 0.747. They also mentioned that this relation is similar to the one obtained for maize by several authors, the first of whom was E. Montgomery.

Mckee (1964), working with 8 maize hybrids and looking for a non-destructive method to determine foliar area, studied the relations between these parameters and the product of maximum length (L) times width (W), and also the relation between foliar area (A) and each of those measurements independently. Assuming a linear relation between the two parameters, the following equations were obtained:

$A = L \times W \times 0.73$

$A = L \times 6.73$

The correlation coefficients were 0.99 and 0.89, respectively. A strict correlation between the leaf length and width, $r^2 = 0.94$, was also found, but the width measurements was not utilized in the calculation of the area.

These formulae allow the estimation of leaf area on one plant or on a plot basis, by multiplying the sum of the measurements by the respective factor.

Chaud and Sharma (1976) described three models for estimating foliar area in maize. One of them, in which the foliar area is estimated by multiplying length times maximum width, times a constant, 0.73708, was considered the best.

Hatfield *et al.*, (1976) studied the use of a non-destructive portable electronic apparatus to determine foliar area. They worked with different soybean and maize cultivars, and determined that this apparatus makes the measurements with the same precision than a planimeter. It is more exact than the formula $L \times W \times 0.75$, because this formula can have small variations according to the cultivar used. They also determined that it could be of greater precision when one has damaged leaves. It was calculated that with this method it is possible to measure approximately 150 maize leaves per hour.

Trehan *et al.*, (1975) stated that sunflower foliar area could be determined by multiplying leaf length times maximum width times the constant 0.6798.

Other authors working in sunflower found a positive correlation ($r = 0.9749$) between the sunflower foliar area determined with a planimeter and that estimated as the product of width by length by the constant 0.6462.

Schneiter (1978) studied the application of a formula that makes use of the length and width, in different genotypes and at different densities. He found that estimations were highly efficient for both the two cultivars and the three densities used. The applied formula was $(L \times W \times 0.6683) - 2.45$. The r^2 value, found by applying that formula as an estimator, was 0.904. Other formulae based on a single measurement were also analysed, and high values of r^2 were also found for: length (0.850), squared length (0.867), width (0.925) and squared width (0.951).

As can be concluded from these works, the product of leaf length times width is the best estimator of foliar surface. However, any of the two measurements *per se* can be good estimators. We want to make clear that the estimating ruler can be constructed on the basis of a single equation or on the basis of several equations that estimate sectors of a curve relating both variables. It can also be constructed without having an equation obligatorily.

MATERIALS AND METHODS

The material for this investigation was collected in the experimental field of INTA, Balcarce, situated at Lat. S. 37°45' and Long. W 58°18', in Buenos Aires Province, Argentine Republic. The soil is a Tipic Argiudol, with an approximate organic matter content of 6%. The environmental conditions for that year were favorable for the crop; the yield in the experimental field oscillated between 2,000 and 4,000 kg ha^{-1}. More than 300 leaves of different sizes were collected from plots of hybrid and open-pollinated varieties. The collected leaves were set on cardboard, their contours were delineated and, subsequently cut. The maximum length and the corresponding surface of each of the 'leaves' made of cardboard were determined by means of an electronic planimeter.

The total paired data were grouped into three categories: big, medium-size and small leaves, according to the area surface. Each group had, approximately, 100 units. A second order polynomial regression curve was fitted to describe the relationship between leaf length and leaf area within each of these categories, and for the pooled data.

RESULTS AND DISCUSSION

The r^2 values and the calculated "t" values for the B_1 and B_2 coefficients, with corresponding degrees of significance, for each set of leaves analysed, are shown in Table 1.

Table 1. The r^2 and "t" values of regression coefficients for the relationship between leaf width and leaf area.

Set	r^2	"t"B_1	"t"B_2	No. of leaves
1 — small leaves	0.971	0.23	10.18+	100
2 — medium-size leaves	0.897	0.25	1.44	100
3 — big leaves	0.926	−1.49	4.03+	100
4 — sm + med + big	0.986	5.45+	28.86+	300

As can be seen in Table 1, a high degree of association was shown between length and the corresponding surface. The r^2 values show the fitness of the values estimated by the regression equation with the real values.

For the set formed by all the leaves of different sizes, the r^2 value is the highest, but this could be due to the higher number of degrees of freedom. However, it does not differ much from other values previously found by Pereyra (1978) of 0.967 and by Schneiter (1978) of 0.951. On the basis of this information, the equation for the pooled data was used as a primary model for the construction of the estimating scale.

Based on these data, we have the idea of assessing the preceding information, and if it is true that any of the measurements *per se* could be a good estimator of foliar area, it would give us the possibility of constructing a ruler in which the linear measurements would be replaced by the estimated surface; this would facilite the determination and would avoid calculations. With this idea in mind, the relation between the surface determined with a planimeter and the measurements of width and length, and the product of both measurements, were studied in a set of leaves. The information obtained from the study of this set of leaves was similar to the one found by Schneiter (1978). This is, the best estimator is the product of length by width, but leaf width was a better estimator than leaf length, with an r^2 equal to 0.951.

Using a computer program, which selects the equation of first to fifth order that best fits the available data, it was found that a second order equation fitted the data well — its coefficients being statistically significant. A first ruler was constructed on the basis of the equation found, with the purpose of assessing its practicality.

For this, we made a comparison of the time invested in estimating foliar area with the ruler that had been constructed, or by measurements of leaf width and length and making the corresponding calculations. It was concluded that, by using the ruler, the invested time could be reduced 8 times (Pereyra, 1978).

The present study was carried out with the objective of adjusting the ruler mentioned in the previous communication, by studying the relation between width and leaf area in sets of small, medium-size and big leaves, independently as well as a single set because the equation on which the ruler was based ($y = -15.0 + 4.29\,x + 0.56\,x^2$), has a problem. By having an x coefficient different from 0 (−15.0), it is apparent that the estimation of small values will depart from the possible real values. In order to improve the estimations in this part of the scale, the equation obtained by means of the study carried out with the smallest leaves was used.

This equation had, also, an x coefficient different from though very close to, 0 therefore, the closest equation that passes through the origin was calculated. This equation was used to develop a nab for leaves with width $\leqslant$ 21cm. The two equations used to construct a final scale were:

for x(width) values between 0 and 21 cm... $Y = 0.8\,x + 0.697\,x^2$

for x(width) values greater than 21 cm... $Y = -15 + 4.29\,x + 0.56\,x^2$

As a reference, a sequence of the calculated pairs of values for a series in which the width increased 2 cm, are given below:

width cm	estim. area cm^2	width cm	estim. area cm^2
3	8.67	23	383.71
5	21.42	25	445.54
7	39.75	27	512.89
9	63.65	29	584.77
11	93.13	31	661.16
13	128.19	33	742.08
15	168.83	35	827.51
17	215.03	37	917.46
19	266.81	39	1011.94
21	324.17	41	1110.93

LITERATURE CITED

CHAUD, P. and SHARMA, N.N. 1976. Constant for determining leaf area index in maize. *Indian Journal of Agronomy* 21:171 — 173.

HATFIELD, J.L., STANLEY, C.D. and CARLSON, R.E. 1976. Evaluation of an electronic foliometer to measure leaf area in corn and soybean *Agronomy Journal* 28:234 — 236.

MCKEE, G.W. 1964. A coefficient for computing leaf area in hybrid corn. Agronomy Journal 56:240 — 241.

PEREYRA, V.R. 1978. Metodo rapido para estimar area foliar en girasol (Helianthus annuus L). Oleico (I.N.T.A. Manfredi) no 3:35.

SCHNEITER, A.A. 1978. Non-destructive leaf area estimation in sunflower. *Agronomy Journal* 70:141 — 142.

STICKLER, F.C., WEARDEN, S. and PAULI, A.W. 1961. Leaf area determination in grain sorghum. *Agronomy Journal* 53:187 — 188.

TREHAN, K.B. *et al.,* 1975. Measurement of leaf area in sunflower (Helianthus annuus L.). *Science & Culture* 41:238 — 239.

WILLIAMS, R.F. 1953. Estimation of leaf area for agronomic and plant physiological studies. *Australian Journal Agricultural Research* 5:235 — 246.

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PHOTOSYNTHESIS IN SUNFLOWER LEAVES: RUBP CARBOXYLASE PROPERTIES, ACTIVITIES AND QUANTITATIVE DETERMINATION.

PHOTOSYNTHESE CHEZ LE TOURNESOL: ACTIVITE, PROPRIETES, DOSAGE DE LA RUBP CARBOXYLASE.

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ABSTRACT

The photosynthetic assimilation rate of Sunflower, a C3 species, is similar to C4 plants (e.g. Maize). A more active or abundant RUBPC could explain this fact.

The highest carboxylase activity was found in young and just mature leaves, they were used for purification procedures and protein investigations. Sunflower purified RUBPC displayed a higher activity than that from other C3 plants (e.g. Soybean, French Bean). K_m (RuBP an $KHCO_3$) of Sunflower enzyme was the same as Soybean's; but V_{max} of Sunflower protein is four times greater. For quantitative determination of RUPBC, antiserum was obtained from a rabbit after injection of the enzyme purified by ammonium sulfate fractionation, sucrose density gradient centrifugation and chromatofocusing. The carboxylation efficiency of Sunflower eems to be correlated with the quantity and the properties of RUBPC.

INTRODUCTION

Parmi les végétaux supérieurs, on distingue principalement les plantes de type C3 dont le taux d'assimilation photosynthétique (12 à 28 mg $CO_2.dm^{-2}.h^{-1}$) est inférieur à celui des aspèces de type C4 (40 à 60 mg.$CO_2.dm^{-2}.h^{-1}$) (Zelitch, 1971). Une anatomie foliaire particulière et la présence d'une PEP carboxylase très active permettent aux végétaux C4 une meilleure valorisation du CO_2 absorbé.

Le Tournesol, espèce C3, présente la particularité d'avoir un taux de photosynthèse élevé (40 mg $CO_2.dm^{-2}h^{-1}$), proche de celui des plantes C4 (Lloyd et Canvin, 1977). Parmi les facteurs responsables de cette forte activité photosynthétique, on peut noter une faible résistance stomatique et un niveau élevé de saturation en lumière (Potter et Breen, 1980; Hesketh, 1963). Au niveau biochimique et enzymatique, il nous a paru intéressant d'étudier la RuBP carboxylase (E.C. 4.1.1.39) du Tournesol. En effet