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Use of Leaf Size-Leaf Area Relationship to Estimate Leaf Dry Matter in Tobacco (*Nicotiana tabacum L.*).

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ABSTRACT

The relationships of leaf size to leaf area and the leaf area to leaf dry weight were determined in tobacco plants as an estimate of leaf dry weight.

Three leaf positions on the stalk, the 5th, 10th, and 15th, were utilized. Leaves were removed, maximum length and width measured, and their area traced to the nearest cm^2 using graph paper. Leaves were then dried in an air-forced drying oven.

The study had revealed that 5th and 10th leaf positions had no significant effect on leaf size-leaf area relationships. The leaf area showed significant relationship to leaf dry weight in tobacco leaves.

INTRODUCTION

A measure of leaf size and leaf area is desired in many studies on growth, water relations, and metabolic activity of plants (2,6). A mathematical model can be obtained by correlating length times width, to the actual leaf area of a sample of leaves using regression analysis (9,12). Mathematical models have been given for numerous crops (1,11,14,15,18). The need for rapid, nondestructive estimates of leaf dry weight in tobacco (*Nicotiana tabacum L.*, cv. Virginia 95) grown under Libyan conditions has led to studies relating leaf size to leaf area, and to development of separate prediction equations for estimating leaf area and leaf dry weight for different leaf positions on the stalk.

MATERIALS AND METHODS

The experiment was conducted at Sidi Mesri Experimental Station, General Tobacco Company, Tripoli. Tobacco seeds were sown in seedbeds in February, 1976. After 105 days seedlings were transplanted to the field. Plot size was 5×6 m. Distances between furrows and between plants within the raw were 1.0 and 0.5 m, respectively. There were 14 plots selected randomly and treated similarly. Analysis of the upper 30 cm soil and of the irrigation water used in the experiment are shown in Table 1. NPK

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Table 1 Analysis of soil (0–30 cm) and irrigation water used in the experiment.

Analyzed parameters	In soil	In irrigation water
	meq/l (sat. ext.)	meq/l
Ca	5.00	3.5
Mg	1.50	1.4
Na	0.74	1.7
K	0.20	0.1
CO_3	0.20	0.2
HCO_3	2.00	2.0
SO_4	2.80	1.9
Cl	1.80	2.2
pH	8.20	8.1

fertilizers were top dressed three weeks after transplanting at the rates of 50 kg N/ha (ammonium sulfate), 30 kg P/ha (calcium superphosphate), and 50 kg K/ha (potassium sulfate).

Plants were topped as soon as the embryonic flower head emerges above the upper leaves to improve the physical and chemical properties of leaves. According to TSO (17) plants with poor growth may be necessary to top down to about 12 leaves, whereas with vigorous development as many as 18 leaves should be left on the plant.

For good crops the usual range is approximately 15 to 17 leaves. In this study plants were topped down to 15 leaves. The maximum possible number of leaves in this variety is about 22 (10). It is generally considered that leaf positions after the 17th have little or no value for cigarette manufacturing (4). Suckers were removed promptly as soon as they developed.

Three leaf positions were selected for this study to represent the whole plant (4). The leaves were cut from the bottom at the 5th, 10th, and 15th positions. Measurements of leaf size, area, and dry weight were made from 84 plants selected randomly from 14 plots in August 1976. Maximum length and width were measured to the nearest mm. The leaf was then flattened on 1 mm graph paper, and its area was traced and determined to the nearest cm^2. The leaves were then dried in air-forced drying oven at 65°C for 48 hours to determine leaf dry weight.

RESULTS AND DISCUSSION

Results of statistical analysis showed that only the 15th leaf position differed significantly from other leaves in length, width and area. There was no significant effect of all leaf positions on leaf dry weight, indicating that the first step in leaf growth is an accumulation of dry matter followed by area expansion (Table 2).

Leaf size and leaf area

The relationship between product of length X width (LW) and area (A) was determined by fitting linear equation to the data. Lal and Subba Rao (8) have demonstrated a logarithmic relationship between leaf size and leaf area. Equations for quadratic, and cubic relationships have also been determined (15). The linear equation was chosen for simplicity in this study.

Table 2 Effect of leaf position on the stalk on length (L), width (W), length x width (LW), actual area (A), and leaf dry weight (D).

X_i	Leaf position 5th	10th	15th	LSD 0.05
L cm	61.3	58.9	57.5	2.9
W cm	32.9	29.9	28.4	2.1
LW cm^2	2032	1758	1656	303
A cm^2	1262	1151	1062	168
D g	8.14	8.57	7.58	n.s.

*n.s. = not significant.

The correlation coefficient (r) between product of length x width (LW) and area (A) was found to be highly significant in all leaf positions on the stalk. Table 3 gives the relationship between the product of length and width (LW) and leaf area (A) for different leaf positions on the stalk and for all leaves.

Three mathematical equations involving the product of maximum leaf length x width (LW) as independent variable, were formulated for estimating leaf area for different leaf positions on the stalk by use of linear regression equation, $Y_i = a + bX_i$. In this equation Y_i and X_i are dependent and independent variables, respectively, and a and b are constants (regression parameters).

F-tests using the 5th, 10th, and 15th leaf positions were significant for both a and b values. For this reason a 4th regression equation including all leaves was tested. There was no significant difference in a and b values between 10th leaf position and all leaves, indicating that it is possible to use the 10th leaf position for estimating bestfitting line for all data. According to these results, the leaf average area of tobacco (cv. Virginia 95) could be estimated by leaf sampling from the 10th position and using the common regression equation valid for all leaves. The average area of tobacco leaves could be estimated by using the following regression equation:

$$\bar{A} = 295 + 0.475\ LW, \quad (1)$$

where,

$\bar{A}$ = average leaf area
LW = product of maximum length x width of the 10th leaf position.

These results are in agreement with prediction equation given by Suggs *et al.* (16). However, the regression parameters (a and b) in both studies were different due to differences in cultivar used in both experiments.

Table 3 Regression analysis involving length x width (LW) variable for predicting the area (A) of different leaf positions on the stalk.

Leaf position	$\bar{X}$	$\bar{Y}$	a	b	R^2
5th	2032	1262	124	0.560	0.88
10th	1758	1151	290	0.490	0.78
15th	1658	1062	284	0.470	0.62
All leaves	1816	1158	295	0.475	0.83

$\bar{X}$ and $\bar{Y}$ are the mean values of (LW) and (A) respectively.
a and b are the regression parameters.
R^1 is the coefficient of determination.

Leaf dry weight

Three prediction equations involving A for three leaf positions on the stalk were established to estimate the leaf dry weight by regression analysis (Table 4). F-tests using 5th, 10th, and 15th leaf position were non-significant for both a and b values, indicating that a common regression equation could be used for estimating leaf dry weight of all leaf positions. This equation is given as:

$$D = 1.03 + 0.0062\ A, \qquad (2)$$

where,

D = leaf dry weight (g) and
A = leaf surface area (cm^2)

Table 4 Regression analysis involving area (A) variable for predicting the leaf dry matter (D) on different leaf positions on the stalk.

Leaf position	$\overline{X}$	$\overline{Y}$	a	b	R^2
5th	1262	8.14	−1.96	0.008	0.630
10th	1151	8.57	−1.79	0.009	0.616
15th	1062	7.58	−0.92	0.008	0.552
All leaves	1154	8.18	+1.03	0.0062	0.552

$\overline{X}$ and $\overline{Y}$ are the mean values of (A) and (D) respectively.
a and b are the regression parameters.
R^2 is the coefficient of determination.

The relationship of leaf area to leaf dry weight has previously been studied in different crops (7,13). Robinson and Massengale (13) found leaf weight and leaf area in Moapa alfalfa to be highly correlated.

From equation (1) and (2) it is possible to estimate the average dry weight in tobacco leaves from (LW) measurements taken from the 10th leaf position. These equations were rechecked using actual field data and their accuracy was found to be over 95%, which means that these results are of a high practical importance.

The exact values of the parameters a and b in prediction equations are not unique. Although the applicability of the suggested prediction equations to other cultivars, other environmental and management conditions is not known. However, for other crops (3,5,11) factors such as soil temperature, leaf age, plant age, plant population, fertilization, relative humidity, and salinity have shown little or no effect on these relationships.

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الاستفادة من دراسة العلاقة بين ابعاد الورقـــة ومساحة السطح فى تقدير الوزن الجاف لاوراق نباتات الدخان المزروعة محليا

يوســـف مطـــر

المستخلـــــص

تم فى هذا البحث دراسة العلاقة بين ابعاد الورقة (اقصى طول واقصى عرض) ومساحة السطح كذلك دراسة العلاقة بين مساحة السطح بالوزن الجاف ، ولدراســة ذلك تم اختيار عدد ثلاثة اوراق متمثلة بالموضع الخامس ، العاشر والخـامس عشر من على الساق من عدد ٨٤ نباتا موزعين بالتساوى ومختارين عشـــوائيا من ١٤ قطعة تم زراعة الدخان (صنف فيرجينيا ٩٥) فيهما فى سيدى المصرى ـ طرابلس ـ ليـبيا ٠ وبعد نضج الاوراق النهائى تم ازالتها واخذ ابعادها وتقدير مســاحة سطحها بالورق البيانى ثم تجفيفها فى الفرن على درجة ٦٥ م لمدة ٤٨ ساعة وتقـدير وزنها الجاف ٠

وتوضح النتائج ان العلاقة بين حاصل ضرب الابعاد بمســاحة السطح علاقة خـط مستقيم والميل موجب كذلك العلاقة بين مساحة السطح والوزن الجاف علاقة خــط مستقيم والميل موجب كذلك العلاقة بين مساحة الســطح والوزن الجاف علاقة خـط مستقيم والميل موجب ومن دراسة المعادلتين المتحصـــلتين امكن تقدير الوزن الجـاف لنباتات الدخان المزروعة محليا من أحد القياسات على الابعاد فقط ٠