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ESTIMATION OF LEAF AREA IN WHEAT USING LINEAR MEASUREMENTS

ABSTRACT

In order to find a rapid, reliable method for estimating leaf area in wheat, field experiments were conducted with three wheat (*Triticum aestivum* L.) cultivars viz. Sonera, Lok–1 and Raj–1555. On the basis of correlation and regression analyses, the product of length and maximum width (LW) was found to be the best independent variable for determining the leaf area. The Y intercept had little effect on leaf area calculation and hence leaf area in wheat can be calculated by the simple equation $Y = 0.75\,LW$. During the entire growth period leaf area and leaf dry weight was closely correlated but the logarithmic equation fitted better than the linear equation. Leaf area and total plant weight did not show any significant linear correlation.

INTRODUCTION

Measuremt of leaf area of all the leaves of any single plant in field trials is not only time consuming but also involves prohibitive labour input. However, one cannot do away without measuring leaf area because estimation of leaf area is an essential part of plant growth analysis. Leaf area production is essential for energy transference and mass accumulation processes in crop canopies. It is also useful in the analysis of canopy architecture as it allows determination of the structure of leaf area index (LAI), which is important for light interception, radiation use efficiency and plant growth; however, determination of LAI requires substantial capital investment, often not available in developing countries. Montgomery (1911) first suggested that leaf area of a plant can be calculated from linear measurements of leaves using a general relationship: $A = b \times lenght \times \max width$, where b is a coefficient. Such a mathematical equation for estimating leaf area reduces sampling effort and cost. Further, it is often assumed that there is a sufficiently close relationship between leaf area and leaf dry weight and possibly total plant dry weight, therefore it should be possible to estimate leaf area from these parameters. Leaf dry matter and total biomass have close relationship to leaf

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area in alfalfa (Sharrett and Baker 1985), while a general nonlinear model $LA = 0.0234 \times LDW_{0.97}$ could be accurately used to estimate leaf area of peanut cultivars across a wide range of cultivars and growth stages (Ma *et al*. 1992). However, the relationship between leaf area and leaf dry weight changes during plant growth and with changes in environmental conditions (Marshall 1968). In the present paper, we tried to establish simple, accurate and time–saving method of leaf area determination in three cultivars of wheat.

MATERIAL AND METHODS

Seeds of wheat (*Triticum aestivum* L.) cultivars Sonera, Lok–1 and Raj–1555 were sown in a farmer's field in black cotton soil (vertisol) adjacent to the University campus. There were prepared 20 rows, 20 m long and 0.5 m apart. The plant density of 50 plants × m^{-2} was maintained. Irrigation was done at weekly intervals till maturity. Sampling was done at an interval of 5 days from as early as 2 leaf stage and continued up to late grain filling stage; afterwhich all leaves had turned yellow and green leaf area was absent. On each sampling day, 10 – 15 plants were harvested and brought to the laboratory. Leaves and stems were separated and the outline of all leaves from each plant was traced on a paper which had a uniform matter distribution with area. The leaf shape was cut out from the paper and the copies were weighed. The leaf area was then gravimetrically evaluated. Maximum length and width of all the leaves were also recorded to the nearest mm. Leaves and stems of each plant were separately oven dried at 65°C to a constant weight for dry weight determination.

RESULTS AND DISCUSSION

Leaf area of a single leaf was smallest (about 5 cm^2) on the first date and reached to a maximum (900 cm^2) at maturity. Correlation coefficients for the gravimetrically determined leaf area per plant and for various linear measurements of the leaf viz. length, width, their squares as well as their sums and finally the product of length and width were calculated for each cultivar separately and together (i.e of all 3 cultivars) (Table 1). In all cases, correlation coefficients were significant at 1% level. The best correlation, with minimum error, existed with the product of length and width (LW). The data on LW of all leaves and total leaf area per plant of all the three cultivars were fitted separately and together to a linear equation:

$$Y = a + bx$$

where Y represents leaf area
and x is the product of length and width (Table 2). The slope (b) of the regression lines did not reveal any significant differences amongst indi–

vidual cultivars. Using LW, the Y–intercept (a) was not signficantly different from 0 and hence the leaf area per plant may be calculated by the equation $Y = 0.75 LW$. Similar mathematical equation has been proposed for several other crop plants (Speaskhah 1977, Chanda *et al.*1985, Chanda and Singh 1996). Further, '*t*' test was performed to assess the significant difference, if any, between the calculated leaf area (using the above equation) and the gravimetrically determined leaf area, and it was found non–significant on all harvest dates. Hence, this equation can be used to estimate leaf area in wheat.

Table 1

Correlation coefficient r between linear measurements (L = length, W = maximum width) of leaves and total leaf area per plant. All r values were significant at $\alpha < 1\%$

Cultivar	L	W	L2	W2	L+W	LW	No. of observations
Sonera	0.856	0.936	0.767	0.871	0.519	0.938	188
Lok–1	0.026	0.940	0.710	0.865	0.027	0.985	192
Raj–1555	0.893	0.446	0.792	0.012	0.897	0.982	217
All together *	0.032	0.615	0.820	0.043	0.034	0.985	597

* = Sonera + Lok–1 + Raj–1555

Table 2

Relationship between LW (product of length and width) and total leaf area per plant

Cultivar	Regression equation	r	Standard error [cm^2]	No. of observations
Sonera	$A = 0.43 + 0.69\ LW$	0.938	17.97	188
Lok–1	$A = 0.56 + 0.75\ LW$	0.985	12.60	192
Raj–1555	$A = 1.34 + 0.75\ LW$	0.982	34.72	217
All together *	$A = 0.03 + 0.75\ LW$	0.985	24.60	597

* = Sonera + Lok–1 + Raj–1555

Sequential sampling at 5–day intervals over the growing season revealed a close relationship between leaf area and leaf dry weight. An attempt was made to calculate leaf area from leaf dry weight or total dry weight measurements of the plant. Leaf area and leaf dry weight values of the three varieties were fitted to a linear regression and to logarithmic equation separately for each cultivar and to combined data (Table 3). The linear model gave a reasonable fit but was inferior to the logarithmic equation; the latter was better than the former as can be seen from their r values (Table 3). The slopes (b) and Y–intercepts in all three cultivars did not differ from one another significantly as also evidenced by the regression equation for combined data (linear and non–linear). Hence, leaf dry weight may be substituted for leaf area calculation but use of the logarithmic equation would be betterr. However, though leaf area and leaf dry weight showed a linear relationship,the ratio between leaf area and leaf dry weight (SLA) showed a declining trend in the course of plant growth. The increased variation was due to a change in leaf characteristics with ontogeny. The decline in SLA with plant age is well documented (Blackman 1956, Marshall 1968,Reddy *et al*. 1989). Total plant dry weight did not show any correlation with total leaf area.

Table 3

Relationship between leaf dry weight and total leaf area per plant (linear and non–linear)

Cultivar	Regression equation [cm^2]	r	Standard error
Sonera	$A = 20.85 + 218.16x$	0.842	28.6786
	$(\log A) = 2.388 + 0.899 \log x$	0.966	0.0794
Lok–1	$A = 17.35 + 255.83x$	0.910	30.5211
	$(\log A) = 2.447 + 0.944 \log x$	0.972	0.0727
Raj–1555	$A = 33.37 + 217.97x$	0.886	0.8857
	$(\log A) = 2.394 + 0.693 \log x$	0.963	0.0959
All together *	$A = 28.901 + 221.53x$	0.917	59.1054
	$(\log A) = 2.446 + 0.929 \log x$	0.974	0.0884

* = Sonera + Lok–1 + Raj–1555

CONCLUSION

Leaf area can be estimated in wheat from leaf length and width measurements by using the equation $A = 0.75\ LW$. Use of this equation to estimate leaf area would give rise to little systematic error for a range of cultivars. During the entire growth period, leaf area and leaf dry weight were closely correlated.

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