BRIEF COMMUNICATION

# Leaf area estimation in a sugar beet cultivar by linear models

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## Abstract

An indirect method of leaf area measurement for Rizor sugar beet cultivar was tested. Leaves were sampled during two growing seasons in a Randomised Complete Block Design experiment. For 2002 samplings, leaf area [$cm^2$] was linearly correlated with maximum leaf width [cm] using all leaf samples ($r^2 = 0.83$, $p<0.001$) or using the means of the 8 sampling occasions ($r^2 = 0.97$, $p<0.001$). Correlations between leaf area and leaf midvein length [cm] were weaker ($r^2 = 0.75$, $p<0.001$ and $r^2 = 0.93$, $p<0.001$, respectively). For 2003 samplings, the area estimated by the equations was highly correlated to the measured leaf area.

*Additional key words*: leaf area; leaf length; leaf width; non destructive methods.

Plant organ traits are regulated by gene action (Aeschbacher and Benfey 1992). Leaf area is a morphological trait related to photosynthesis and Leaf Area Index (LAI) of sugar beet (Scott and Jaggard 1993). Relative leaf expansion rate (difference of leaf area between two successive determinations) under field conditions could serve as a tool for screening sugar beet genotypes for drought tolerance (Ober and Luterbacher 2002).

Leaf area (A) measurements, especially under field conditions, are often destructive and time consuming. Nevertheless, there is an old tradition of using non-destructive methods of A determination (see Květ and Marshall 1971 where also coefficients valid for sugar beet are given). The indiect methods include determining leaf area index (Röver and Koch 1995, de Jesus *et al*. 2001), A itself (de Jesus *et al*. 2001, Williams and Martinson 2003), or percentage of crop cover (van Henten and Bontsema 1995). The establishment of mathematical and especially linear relationships between A and one or more dimensions of the leaf is an advantageous way to determine A under field conditions (Lu *et al*. 2004). The aim of this work was to find simple equations relating A with leaf length (L) and width (W) for a commercial sugar beet (*Beta vulgaris* L.) cultivar Rizor.

Plants (from *SES EUROPE NV/SA*, Tienen, Belgium) were grown in a Randomized Completely Block Design with 6 replications. The study sites were adjacent and located 22 km SW from Larissa factory of *Hellenic Sugar Industry SA*. Seeds were mechanically drilled in six rows (8 m long) per plot, at 50 cm apart and at 15 cm spacing in the row. During the growing season, full protection was taken against cercospora, powdery mildew, weeds, and insects by sprayings. During the 2002 growing season, 8 leaf samplings were carried out (July 22nd, August 1st and 14th, September 2nd and 19th, October 1st and 16th, November 1st). At each sampling date, three representative, fully expanded leaves (per plot) were sampled. Leaves were sealed in plastic bags, put on an iced chest and transported to the laboratory where L, W, and A were measured. The same procedure was followed during 2003 growing season beginning on June 1st and repeated every two weeks (11 samplings).

Maximum leaf W, midvein L, and A were measured using *WinDias* image analysis system (*Delta-T Devices*, Cambridge, UK). All collected data were subjected to one-way ANOVA with sampling date as the main factor using *MSTAT-C* (version *1.41*, Crop and Soil Sciences Department, Michigan State University, USA). Correlation analyses (linear, logarithmic, polynomial, hyperbolic, and exponential) between leaf dimensions and A were assessed using *Excel 98* software (*MSOffice*, *Microsoft*).

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Table 1. Regression equations and coefficients of correlation ($r^2$) for sugar beet leaf area, A [$cm^2$] and maximum width, W [cm] or leaf midvein length, L [cm] when all measurements ($n$ = 144) or the mean of the 8 samplings ($n$ = 8) were used.

| | | $r^2$ | | $r^2$ |
|---|---|---|---|---|
| $n$ = 144 | $A = 18.925\ W - 80.542$ | 0.83 | $A = 16.377\ L - 174.100$ | 0.75 |
| | $A = 224.04 \ln(W) - 406.31$ | 0.81 | $A = 313.38 \ln(L) - 783.23$ | 0.73 |
| | $A = 0.349\ W^2 + 10.261\ W - 28.571$ | 0.83 | $A = 0.709\ L^2 - 1.612\ L - 97.971$ | 0.76 |
| | $A = 3.128\ W^{1.539}$ | 0.82 | $A = 0.233\ L^{2.156}$ | 0.74 |
| | $A = 30.016\ e^{0.128W}$ | 0.82 | $A = 15.761\ e^{0.111L}$ | 0.74 |
| $n$ = 8 | $A = 21.686\ W - 112.880$ | 0.97 | $A = 21\ L - 263$ | 0.93 |
| | $A = 260.67 \ln(W) - 497.39$ | 0.97 | $A = 415.8 \ln(L) - 1086.7$ | 0.93 |
| | $A = 2.554\ W^2 - 0.729\ W - 259.630$ | 0.99 | $A = 0.182\ L^2 + 13.739\ L - 191.250$ | 0.93 |
| | $A = 1901\ W^{1.744}$ | 0.98 | $A = 0.040\ L^{2.752}$ | 0.92 |
| | $A = 25.008\ e^{0.145W}$ | 0.99 | $A = 9.450\ e^{0.139L}$ | 0.92 |

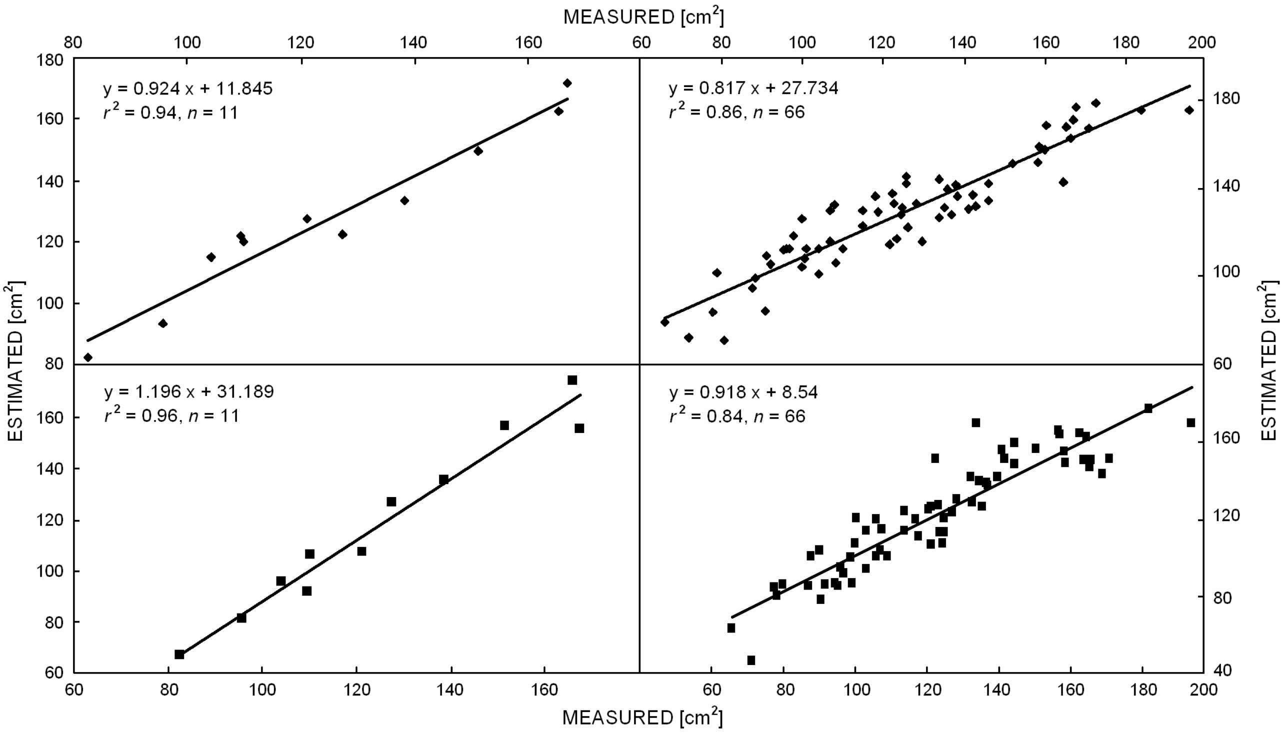


Fig. 1. Correlations between measured and estimated leaf area using all 2003 samplings ($n$ = 66) or the mean values ($n$ = 11) for width (◆) or midvein length (■).

For both years, significant differences between sampling occasions were found for the three traits determined (A, W, L). Regression equations showed that A was better correlated with W than with L (Table 1). This is in accordance with previous reports in grapevines (Williams and Martinson 2003). The correlation coefficients were higher when the mean values of the 8 leaf samplings were used to estimate A than when all measurements of L and W were used (Table 1). The polynomial regressions seemed to be the better expression in accordance with Manivel and Weaver (1974) for grapevine.

Fig. 1 shows the correlation equations between the measured A using 2002 and 2003 leaf samplings. The estimated A was highly correlated to the measured one, especially when mean values were used. Thus, the linear regressions are proposed as indirect method of A determinations for the Rizor cultivar.

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