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# LIMITATIONS IN THE USE OF LEAF DRY WEIGHT AND LEAF NUMBER FOR PREDICTING LEAF AREA OF SOYBEANS[1]

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## ABSTRACT

Equations relating leaf area to leaf dry weight and to leaf number were developed for soybeans [*Glycine max* (L.) Merr.] grown in windbreak-sheltered and unsheltered plots during the 1978 and 1979 growing seasons. For each growing season, equations developed for a particular treatment were found to be accurate in predicting leaf area of independent samples taken from that treatment only. In a different treatment or growing season, the equations gave inaccurate estimates. This inaccuracy in predicting leaf area of plants grown in a different treatment or season was attributable to the differences in specific leaf area and leaf size. Our data indicate that prediction equations for soybean leaf area which utilize leaf dry weight and leaf number should not be used for soybeans grown in a different environment because of inaccuracy of estimates.

**Additional index words: Windbreak-shelter, Prediction equations, Leaf area, *Glycine max*. (L.) Merr.**

LEAF area index is an input into all growth models used in the estimation of canopy light climate, photosynthesis, and evapotranspiration. Its determination is laborious, involving the measurement of leaf area (LA) of large numbers of plants harvested from a known plot area. Consequently, simpler and more rapid methods of LA determination are desirable. Some of the simpler methods now employed utilize the relationship between LA and leaf linear dimensions (1, 4, 6, 7, 11, 12, 13), leaf number (11), or leaf or plant dry weight (3, 8, 9, 11). The utility of an equation for predicting LA should be judged by its accuracy to predict LA of independent samples from season to season, and under different cultural and environmental conditions. Rosenberg (10) found an LA prediction formula developed by Davis in 1940(1) to be accurate in estimating the LA of his irrigated dry beans grown in 1962 and 1963. Sivakumar (11) developed prediction equations for soybean [*Glycine max* (L.) Merr.] LA using leaf dry weight (LDW) and leaf number (LN) as independent variables. As expected, his equations accurately predicted the actual values used in deriving them. The value of prediction equations comes from the ability of the equations to predict accurately for independent sources of data. We tested the accuracy of Sivakumar's (11) equations in predicting LA of our soybean plants and obtained LA estimates which differed significantly from the control leaf areas measured with an area meter. This observation prompted the study reported here. The objective was to investigate possible environmental and seasonal influences on the relationship between LA and LDW or LN, and thus on the utility of LA prediction equations utilizing LDW and LN as independent variables.

**Table 1. Regression equations relating leaf area to leaf dry weight or leaf number for soybeans grown in windbreak-sheltered and unsheltered plots during 1978 and 1979 growing seasons.**

| Year | Environment | Regression equation | S.E. of slope | $R^2$ | t test |
|---|---|---|---|---|---|
| 1978 | Sheltered | LA = 121.6 + 277.0 (LDW) | 3.16 | 0.98 | 18.63** |
| | Unsheltered | LA = 94.4 + 239.1 (LDW) | 3.42 | 0.96 | 15.33** |
| | Sheltered | LA = −282.3 + 43.9 (LN) | 8.32 | 0.98 | 8.71** |
| | Unsheltered | LA = −364.1 + 37.8 (LN) | 7.14 | 0.90 | 10.12** |
| 1979 | Sheltered | LA = 81.6 + 249.2 (LDW) | 2.80 | 0.98 | 13.42** |
| | Unsheltered | LA = 61.8 + 216.3 (LDW) | 5.17 | 0.98 | 17.51** |
| | Sheltered | LA = −298.0 + 36.1 (LN) | 7.16 | 0.98 | 9.67** |
| | Unsheltered | LA = −326.2 + 25.9 (LN) | 10.45 | 0.96 | 8.11** |

** Significant at the 0.01 probability level.

## MATERIALS AND METHODS

The study was conducted at the Univ. of Nebraska-Lincoln Field Laboratory, Mead, Nebr., during the 1978 and 1979 growing seasons. The soil was a Typic Argiudoll (Sharpsburg silty clay loam). The treatments consisted of windbreak-shelter and no shelter. Shelter from the wind was provided by a system of shelterbelts established in 1966 for windbreak research. The prevailing wind in Nebraska during the summer months comes from the south. 'Wayne' soybeans were grown at 326,000 plants/ha in north-south rows, 92 cm apart. Sampling to determine LA, LDW and LN was initiated at growth stage V2 (2) and continued at approximately weekly intervals throughout the growth of the crop. Twelve samples were taken during each growing season. During sampling, plants were cut at ground level from six randomly chosen 1 m lengths of row and taken to the laboratory. Leaf area was determined with an electronic area meter, Model LI-3000, and an accessory transparent belt conveyor, LI-3050 (Lambda Instr. Corp., Lincoln, Nebr.). Trifoliates were counted and dried at 70 C to a constant weight. Prediction equations for LA of plants grown in each of the treatments were computed for each growing season using LDW and LN as independent variables. Eight of the 12 samples collected during the growing season were used to compute each of these equations. The other samples were used to test the ability of the equations to predict LA of independent samples.

## RESULTS AND DISCUSSION

All linear regressions of LA on LDW or LN were highly significant ($P > 0.01$) (Table 1). For each growing season, equations developed for a particular treatment were

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**Table 2. Measured and predicted leaf area/plant of independent samples from the 1978 and 1979 sheltered and unsheltered soybean plots. Prediction equations used were those derived with leaf dry weight and leaf number data collected from same plots.**

| Year | Location | Days from planting | Measured leaf area | Predicted leaf area | |
|---|---|---|---|---|---|
| | | | | LDW† | LN‡ |
| | | | cm² | | |
| 1978 | Sheltered | 35 | 442.6 a** | 431.4 a | 429.2 a |
| | | 49 | 1,386.7 a | 1,354.3 a | 1,346.2 a |
| | | 62 | 4,278.2 a | 4,350.0 a | 4,314.4 a |
| | | 77 | 5,346.3 a | 5,398.7 a | 5,367.6 a |
| | Unsheltered | 35 | 332.4 a | 368.5 a | 322.8 a |
| | | 49 | 1,256.5 a | 1,280.1 a | 1,225.5 a |
| | | 62 | 3,464.2 a | 3,500.6 a | 3,514.8 a |
| | | 77 | 4,042.0 a | 3,980.3 a | 4,001.1 a |
| 1979 | Sheltered | 39 | 338.6 a | 326.4 a | 342.5 a |
| | | 53 | 1,180.1 a | 1,201.4 a | 1,224.6 a |
| | | 67 | 3,582.4 a | 3,621.0 a | 3,598.4 a |
| | | 82 | 5,068.2 a | 5,112.6 a | 5,092.2 a |
| | Unsheltered | 39 | 280.4 a | 298.6 a | 313.1 a |
| | | 53 | 1,045.2 a | 991.1 a | 1,010.0 a |
| | | 67 | 2,893.3 a | 2,856.3 a | 2,900.2 a |
| | | 82 | 3,780.1 a | 3,751.1 a | 3,804.4 a |

** Means in rows followed by the same letter are not significantly different at the 0.01 probability level using Duncan's Multiple Range Test.
† Leaf dry weight. ‡ Leaf number.

**Table 3. Measured and predicted leaf area/plant of the 1978 and 1979 sheltered and unsheltered soybean plots. Prediction equations used for any treatment were those derived with leaf dry weight and leaf number data collected from the other treatment during the same year.**

| Environment | Year | Days from planting | Measured leaf area | Predicted leaf area | |
|---|---|---|---|---|---|
| | | | | LDW† | LN‡ |
| | | | cm² | | |
| Sheltered | 1978 | 35 | 442.6 a** | 330.1 b | 298.0 b |
| | | 49 | 1,386.7 a | 1,150.7 b | 1,094.4 b |
| | | 62 | 4,278.2 a | 3,832.0 b | 3,796.4 b |
| | | 77 | 5,346.3 a | 4,110.4 b | 3,094.3 b |
| | 1979 | 39 | 338.6 a | 226.8 b | 215.5 b |
| | | 53 | 1,180.1 a | 882.3 b | 865.7 b |
| | | 67 | 3,582.4 a | 3,030.2 b | 2,994.0 b |
| | | 82 | 5,068.1 a | 4,739.2 b | 4,688.6 b |
| Unsheltered | 1978 | 35 | 332.4 b | 455.6 a | 498.3 a |
| | | 49 | 1,256.5 b | 1,612.0 a | 1,654.1 a |
| | | 62 | 3,464.2 b | 4,246.3 a | 4,184.0 a |
| | | 77 | 4,042.0 b | 4,883.6 a | 5,011.1 a |
| | 1979 | 35 | 280.4 b | 418.6 a | 433.2 a |
| | | 49 | 1,045.2 b | 1,582.4 a | 1,568.5 a |
| | | 62 | 2,893.3 b | 3,736.0 a | 3,692.3 a |
| | | 77 | 3,780.1 b | 4,560.2 a | 4,618.3 a |

** Means in rows followed by the same letter are not significantly different at the 0.01 probability level using Duncan's Multiple Range Test.
† Leaf dry weight. ‡ Leaf number.

found to be accurate in predicting LA of independent samples taken from that treatment (Table 2), but inaccurate in predicting LA of plants grown in a different treatment (Table 3). Equations developed for a particular growing season were also inaccurate in predicting LA of plants grown in another growing season (Tables 4 and 5).

The equations developed for unsheltered conditions always underestimated LA of sheltered plots, and vice versa. Similarly, equations developed for a treatment in 1979 underestimated LA of plants grown in that treatment in 1978, and vice versa. These inaccuracies in predicting LA of plants grown in a different treatment or season were attributable to the differences between treatments and between seasons in specific leaf area and leaf size (Table 6).

**Table 4. Measured and predicted leaf area/plant of 1979 sheltered and unsheltered soybean plots. Prediction equations used were those derived with leaf dry weight and leaf number data collected from the same treatment in 1978.**

| Location | Days from planting | Measured leaf area | Predicted leaf area | |
|---|---|---|---|---|
| | | | LDW† | LN‡ |
| | | cm² | | |
| Sheltered | 39 | 338.6 b** | 522.0 a | 498.4 a |
| | 53 | 1,180.1 b | 1,845.3 a | 1,788.1 a |
| | 67 | 3,582.4 b | 4,280.2 a | 4,322.4 a |
| | 82 | 5,068.1 c | 5,740.1 b | 5,860.7 a |
| Unsheltered | 39 | 280.4 b | 454.2 a | 486.1 a |
| | 53 | 1,045.2 b | 1,487.3 a | 1,472.6 a |
| | 67 | 2,893.3 b | 4,011.9 a | 4,063. a |
| | 82 | 3,780.1 b | 5,621.0 a | 5,590.0 a |

** Means in rows followed by the same letter are not significantly different at the 0.01 probability level using Duncan's Multiple Range Test.
† Leaf dry weight. ‡ Leaf number.

**Table 5. Measured and predicted leaf area/plant of 1978 sheltered and unsheltered soybean plots. Prediction equations used were those derived with leaf dry weight and leaf number data collected from the same treatment in 1979.**

| Location | Days from planting | Measured leaf area | Predicted leaf area | |
|---|---|---|---|---|
| | | | LDW† | LN‡ |
| | | cm² | | |
| Sheltered | 35 | 442.6 a** | 254.1 b | 242.8 b |
| | 49 | 1,386.7 a | 1,046.9 b | 1,100.0 b |
| | 62 | 4,278.2 a | 3,467.8 b | 3,511.1 b |
| | 77 | 5,346.3 a | 3,887.0 b | 3,910.4 b |
| Unsheltered | 35 | 332.4 a | 200.1 b | 186.6 b |
| | 49 | 1,256.5 a | 987.3 b | 933.4 b |
| | 62 | 3,464.2 a | 2,840.5 b | 2,783.1 b |
| | 77 | 4,042.0 a | 3,121.0 b | 3,084.4 b |

** Means in rows followed by the same letter are not significantly different at the 0.01 probability level using Duncan's Multiple Range Test.
† Leaf dry weight. ‡ Leaf number.

**Table 6. Average specific leaf area and leaf size during 1978 and 1979 growing seasons in windbreak-sheltered and unsheltered plants.**

| Year | Avg. SLA† | | Avg. leaf size | |
|---|---|---|---|---|
| | Sheltered | Unsheltered | Sheltered | Unsheltered |
| | cm²/g | | cm² | |
| 1978 | 326.8 a** | 294.2 b | 114.7 a | 110.4 b |
| 1979 | 293.2 b | 280.4 c | 105.9 c | 101.0 d |

** Means under SLA or leaf size followed by the same letter are not significantly different at the 0.01 probability level using Duncan's Multiple Range Test. † Specific leaf area.

Our data indicate that prediction equations for soybean LA that use LDW or LN give very inaccurate estimates of LA of plants grown in a different environment or season.

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