Relations Between Leaf Area Index and Growth Characteristics of Florunner, Southern Runner, and Sunrunner Peanut[1]

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ABSTRACT

Growth characteristics of three commonly planted peanut cultivars were measured during the 1988 and 1989 growing seasons at the Wiregrass Substation in Headland, Ala., to develop equations for predicting leaf area index (LAI) from other growth varibales. These equations were needed to allow rapid estimation of leaf area loss from foliar-feeding insects or foliar-fungal pathogens. Conventionally planted and tilled fields of Florunner, Sunrunner and Southern Runner peanut (*Arachis hypogaea* L.) were sampled for plant vegetative stage, reproductive stage, height, number of leaves, leaf area, leaf dry weight, number of pods, pod dry weight, stem dry weight, and stand density. Most growth characteristics increased linearly ($p<0.05$) with time in both years. LAI was significantly correlated ($P<0.05$) with most growth variables for each cultivar. Linear regression was used to create equations for prediction of LAI from leaf dry weight (range of $R^2 = 0.93$ to 0.97) and number of leaves (range of $R^2 = 0.74$ to 0.95) for each cultivar, and all cultivars combined. Equations were also developed to predict LAI from plant height (range of $R^2 = 0.85$ to 0.96) and plant vegetative stage (range of $R^2 = 0.81$ to 0.83). These equations should be useful to those who wish to estimate LAI from other growth variables.

Key Words: Groundnut, *Arachis hypogaea* L., growth characteristics, leaf area index.

The principal peanut cultivars grown in Alabama are runner market types. Florunner was the predominant cultivar grown in 51% of all fields in 1988 (14). Sunrunner was grown in 29%, and Southern Runner was grown in 7% of Alabama peanut fields in 1988 (14).

Studies on the effects of environmental conditions (6, 13), agronomic practices (15, 20), and disease and insect pressure (3, 17, 21, 31) on peanut typically include information on various growth characteristics, such as leaf area and plant dry weight. Many studies on peanut culture focus only on the end products of yield and grade (7, 16, 17). Other researchers have examined growth characteristics of peanut to better understand energy partitioning (10) and provide information suitable for plant modeling efforts (5, 33).

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Prediction of leaf area from other growth characteristics has been developed for soybean (30), winter wheat (1) and winter barley (26), but not for peanut. Measurement of leaf area of peanut is time consuming, and precise estimates require devices such as a leaf area meter. Estimation of leaf area from other growth characteristics would allow rapid assessment for farmers or field scouts (8), entomologists, pathologists, breeders, physiololgists, and other scientists interested in leaf area. For example, these equations could allow rapid assessment of how a defoliating insect pest outbreak was affecting peanut leaf area. Estimates of how the infestation affects yield can then be made (12, 21, 23).

This study describes equations which can be used to estimate leaf area from other, easy to collect variables. Also, we describe the data that were collected to develop these relationships.

Materials and Methods

Data were collected in 1988 and 1989 in conventionally planted, tilled, and irrigated fields at the Wiregrass Substation at Headland, Ala. that were planted in early May. Peanuts were planted in row spacings of 91 cm in Dothan sandy loam soil with a pH of 6.5, and <1% organic matter. Fields were cultivated once and herbicides were applied as recommended by Alabama Cooperative Extension Service (11). In 1988, each cultivar was planted in 20-row plots, each 46 m long and treated with aldicarb at 2.24 kg (AI)/ha at planting for nematode control, with six to seven sprays of chlorothalonil at 1.25 kg (AI)/ha applied for leafspot control. In 1989, plant samples were taken from larger production fields on the Wiregrass substation that received similar pesticide applications as fields in 1988. Plant samples were taken on a weekly basis starting at 34 and ending 112 days after planting (DAP) in 1988. Sampling dates in 1989 were chosen when our laboratory was able to process samples. For Florunner, dates were 59, 72, 78, 86, 126, and 134 DAP; Sunrunner sampling dates were 71, 84, 90, 98, and 118 DAP;Southern Runner sampling dates were 49, 62, 68, 76, 114, 116, 124, 132, and 145 DAP.

On each sample date, seven plants per plot were randomly selected and observations were made on plant height, number of nodes on main stem of each plant above the cotyledonary node (V-stage) (2), reporductive stage of each plant (R-stage) (2), and number of pods per plant (immature and mature). Also, the stand density for one consecutive 30.4 cm of row was recorded starting with the plant already chosen.Four randomly selected plant samples (30.4 cm of row) were taken to the laboratory and the number of leaves, leaf area, leaf dry weight, stem dry weight (including stems, roots to about 5 cm, and petioles of leaves), and pod dry weight (including pods, pegs and flowers; together and not separately) were recorded for each. A leaf area meter (L13100 Area Meter, Li-Cor Inc., Lincoln Neb.) was used to estimate leaf area of fresh leaves. Leaves were dried to ≤ 1% mositure in an oven at about 60 C for one week and then weighed to the nearest 0.01 g on an electronic balance to estimate leaf dry weights. Stem and pod dry weights were dried and weighed as above.

Statistical analysis

Means and standard errors were calculated for each varibale at each sample date. When confidence intervals (mean $\pm$ 2* SEM) for consecutive dates of a variable did not overlap they were judged to either be increasing or decreasing. Increases in growth variables were judged linear when regressions on days after planting were significant at P<0.05. Correlation analysis was performed to determine how variables were related (22). Plant growth characteristics that were best correlated with leaf area were used to develop regression models that predict leaf area. Since obvservations were collected to develop regression equations and not to test for year, cultivar, or date effects, analysis of variance cannot be done on this data set. However, analysis of covariance was used to determine the partial contribution to the coeffiecient of determination (R^2) for year and cultivar effects for models using leaf dry weight, number of leaves and plant height to predict LAI. Linear regression (22, 29) and nonlinear regression using the multivariate secant method (9, 27) were used to create predictive models (27). For linear regression, both linear and quadratic models (22) were used to predict leaf area from leaf dry weight, number of leaves and plant height. In all cases, parameters from equations overlapped over cultivars ($\pm$2*SE), so data were pooled over cultivars. Individual observations were removed from analysis (outliers) when their standardized residuals (22, 29) were significant at P< 0.005.

After graphing leaf area on plant V-stage, it was apparent that leaf area might be normally distributed accoording to V-stage. A modification of the normal equation (22, 28) was used to predict leaf area from plant V-stage:

$Y_i = M^* \exp(-0.5^*((\text{V-stage}_i - \Omega)/\beta)^2)$

where Y_i = leaf area index, M represents the maximum predicted leaf area (cm^2), Ω is the V-stage where the maximum occurs, and B is the standard deviation (in V-stages) that encompasses 67% of the area under the curve (i.e., the mean $\pm$ the standard deviation; the breath of the relationship). The coefficient of determination (R^2) for nonlinear equations was calculated as:

$R^2 = 1 - (SEE/SSTO)$

where SSE = sum of squares for the error term and SSTO = sum of squares total (corrected for the form of the equation chosen) (4).

Results

Florunner

Plant height for Florunner peaked at 52 $\pm$ 3.1 cm at 83 DAP in 1988 and no significant decline was observed (Fig. 1). In 1989, plant height peaked at 54 cm $\pm$ 1.9 cm at 86 DAP and declined to 36.6 cm $\pm$ 2.4 at 126 DAP. Plant V-stage increased linearly throughout the season in both years (P< 0.05) with greater height recorded at corresponding dates in 1989. Plant R-stage increased linearly throughout the season in both years (P<0.05), with full maturity (R8) reached at 126 DAP in 1989.

Number of leaves (m^{-2}) increased linearly (P<0.05) throughout the season in 1988, while in 1989 no significant increase (P>0.05) was observed (perhaps due to fewer early season observations). LAI increased (P<0.05) throughout the season in 1988, while in 1989, LAI declined after peaking at 4.8 at 86 DAP. Leaf dry Weight (g/m^2) also increased linearly (P<0.05) throughout the season in 1988, while in 1989 it peaked at 353.5 + 113.5 g/m^2 at 86 DAP.

Stem dry weight (g/m^2) increased linearly (P<0.05) throughout the season in 1988, while the increase in 1989 was not significant (P = 0.11). Pod dry weight (g/m^2) increased linearly (P<0.05) from 69 through 112 DAP in 1988 and from 45 through 126 DAP in 1989. Number of pods (m^{-2}) increased linearly (P<0.05) in 1988 from 62 through 83 DAP when values plateaued. In 1989, number of pods also increased linearly (P<0.05) from 59 through 78 DAP.

Southern Runner

Plant height for Southern Runner (Fig. 2) increased linearly (P< 0.05) throughout the season in 1988, while in 1989 no significant trend occurred over dates sampled (P>0.05). Plant V-stage, R-stage and number of leaves (m^{-2}) increased linearly (P<0.05) throughout the season in both years. LAI and leaf dry weight (g/m^2) increased linearly (P<0.05) throughout the season only in 1988 while in 1989 no trend (P>0.05) occurred. Stem dry weight (g/m^2) increased linearly (P<0.05) through the season in both years. Pod dry weight (g/m^2) increased linearly (P<0.05) in 1988 from 90 DAP until harvest and from 72 through 112 DAP in 1989. Number of pods (m^{-2}) increased linearly (P< 0.09) from 83 through 105 DAP in 1988, and throughout the season in 1989 (P<0.05).

Sunrunner

For Sunrunner (Fig. 3), plant height increased linearly (P<0.05) in 1988, while in 1989 means did not increase (P> 0.05) over the range of dates sampled. Both V-stage and R-stage increased linearly (P<0.05) throughout the season in 1988 and 1989. Number of leaves (m^{-2}) increased linearly (P<0.05) throughout the season in 1988. In 1989, values peaked between 80 and 100 DAP with 2252 $\pm$412 leaves at

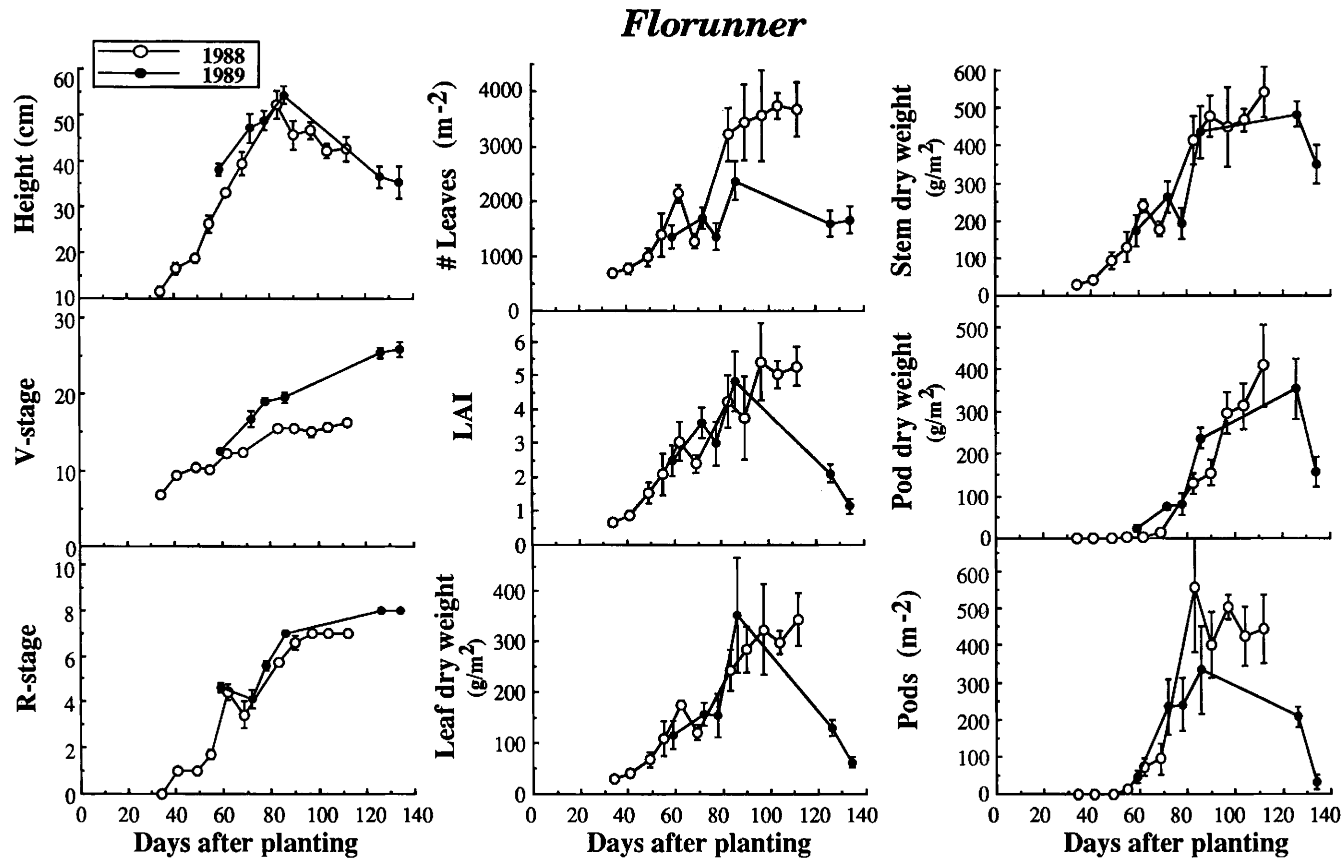

Fig. 1. Growth characteristics for Florunner peanut over both years (means and standard errors).

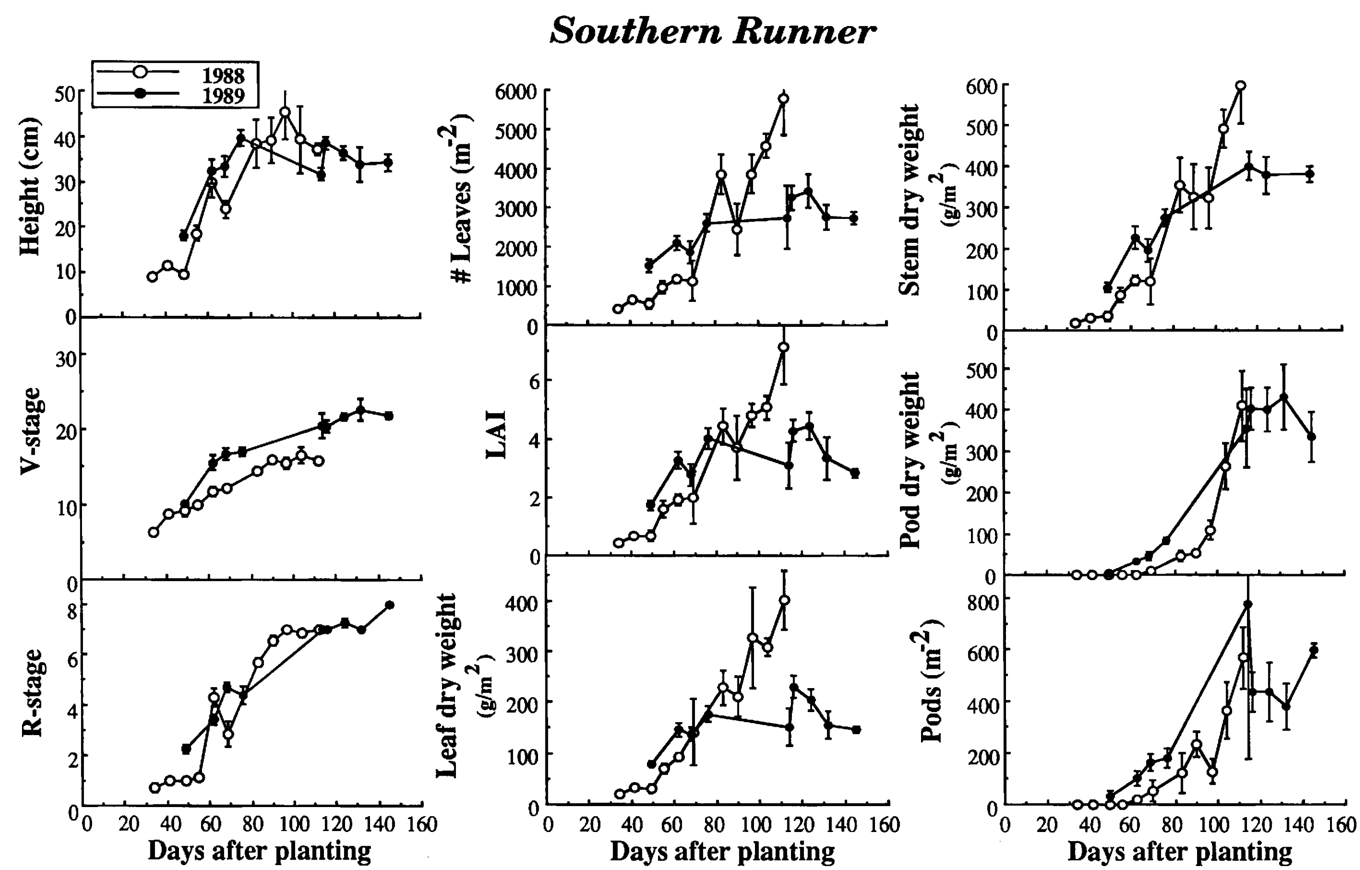

Fig. 2. Growth characteristics for Southern Runner peanut over both years (means and standard errors).

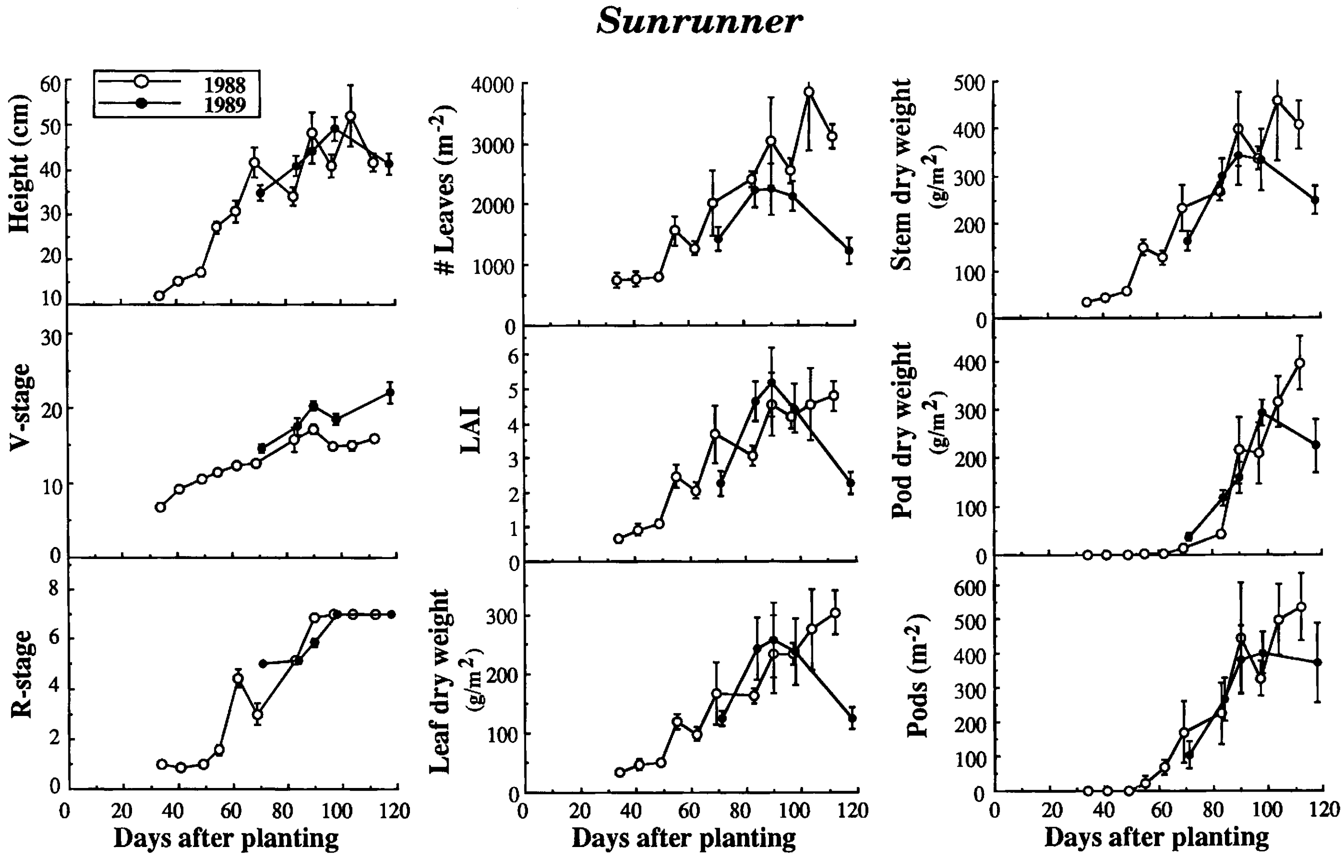

Fig. 3. Growth characteristics for Sunrunner peanut over both years (means and standard errors).

90 DAP, declining to 1236±206 leaves at 118 DAP. LAI and leaf dry weight (g/m^2) increased linearly ($P<0.05$) throughout the season in 1988, while in 1989 no significant trends or peaks ($P> 0.05$ and overlap of confidence intervals) were observed.

Stem dry weight (g/m^2) increased linearly throughout the season in 1988 ($P>0.05$), while in 1989 stem weight did not increase linearly ($P> 0.05$). Pod dry weight (g m^{-2}) increased from 80 DAP until harvest in 1988, while in 1989 values increased liearly from 70 through 98 DAP when values plateaued. Number of pods (m^{-2}) increased linerly ($P< 0.05$) in 1988 from 68 DAP until harvest and in 1989, means increased linearly ($P< 0.05$) throughout the season.

Correlation Analysis

Most of the growth characteristics of Florunner were positively correlated (Table 1). However, V-stage was not significantly ($P> 0.05$) correlated with number of leaves, LAI, or leaf dry weight. Stand density was not correlated ($P> 0.05$) with any other growth variable. Results for Southern Runner were similar to those of Florunner except V-stage was significantly correlated with number of leaves (r=0.63), LAI (r=0.63), and leaf dry weight (r=0.53). Values for Sunrunner differed from Florunner by having significant correlations between V-stage and : LAI (r=0.70), and leaf dry weight (r=0.67). Also, significant negative correlations were found for Sunrunner between stand density and V-stage (r= -0.72), R-Stage (r=-0.58), and plant height (r=-0.51).

Predictive Algorithms

Analysis of covariance was used to determine how much variance in LAI is explained by cultivar and year for predicting LAI from leaf dry weight, number of leaves, and plant height. Year and cultivar explain a significant amount of the variance in LAI ($P<0.05$) for leaf dry weight (partial R^2 = 0.93), but their overall contribution to improvement in R^2 is only 0.01 (Table 2).For number of leaves (partial R^2= 0.81), addition of cultivar and year increased R^2 by 0.03 and 0.02, respectively. For plant height (partial R^2=0.835), addition of cultivar and year increased R^2 by 0.04 and 0.01, respectively.

Both linear and quadratic models were staistically significant ($P< 0.0001$) when leaf dry weight was used to predict leaf area. All parameters, except intercepts for quadratic models, were significantly different from zero. Since parameters for each cultivar overlap, one equation can describe the relationship for all cultivars combined (Table 3, Fig. 4).

Table 1. Correlation analysis of peanut growth characteristics for Florunner combined over the 1988 and 1989 growing seasons[a].

	V-stage	R-stage	Height	Leaves	LAI	LDW[b]	SDen[c]	Stem[d]	PodW[e]
R-stage	0.85**								
Height	0.58*	0.79**							
Leaves	0.27	0.68*	0.66*						
LAI	0.24	0.63*	0.80**	0.89**					
LDW	0.27	0.66*	0.76*	0.91**	0.97**				
SDen	-0.39	-0.27	-0.33	-0.14	-0.01	0.09			
Stem	0.66*	0.91**	0.73*	0.86**	0.77**	0.82**	0.00		
PodW	0.62*	0.80**	0.52*	0.73*	0.67*	0.72**	-0.02	0.90**	
Pod#	0.68*	0.85**	0.74**	0.72*	0.69*	0.69*	-0.19	0.86**	0.86**

[a] Values followed by *, and ** are significant at $P < 0.05$ and $P < 0.001$, respectively.

[b] LDW, leaf dry weight.

[c] SDen, stand density.

[d] Stem, stem dry weight.

[e] PodW, pod dry weight.

Table 2. Results from predictive model development for predicting leaf area from either leaf dry weight, number of leaves, or $\log_{10}$ (plant neight) including terms for year and cultivar for each. Variables are listed in order to importance in improving model R^2.

Model & variables	Partial R^2	Model R^2	F=	P > F
1. Leaf dry weight	0.925	0.925	793.6	0.0001
Year	0.011	0.936	9.7	0.0032
Cultivar	0.008	0.944	3.4	0.0433
2. Number leaves	0.808	0.808	285.5	0.0001
Cultivar	0.032	0.840	5.7	0.0059
Year	0.023	0.863	8.4	0.0057
3. Log_{10} (height)	0.835	0.835	344.4	0.0001
Cultivar	0.035	0.870	7.3	0.0017
Year	0.014	0.884	5.7	0.0214

Table 3. Statistics for predicting leaf area index from leaf dry weight (g/m^2) using linear and quadratic models for each cultivar and combined over cultivars over the 1988 and 1989 growing seasons.

Cultivar	Parameters for independent variables[a]			F value, R^2 [b]
Linear model	b_0 (±SE)	b_1 (±SE)		
Florunner	0.593* (0.194)	0.014** (0.001)		215.0**, 0.93
Southern Runner	0.419* (0.190)	0.016** (0.002)		273.4**, 0.94
Sunrunner	0.368* (0.196)	0.017** (0.001)		265.9**, 0.95
Quadratic model	b_0 (±SE)	b_1 (±SE)	$b_2 \times 10^{-5}$(±SE)	
Florunner	-0.113 (0.249)	0.024** (0.003)	-2.48* (0.78)	228.8**, 0.97
Southern Runner	-0.224 (0.242)	0.027** (0.003)	-3.41* (0.91)	161.7**, 0.95
Sunrunner	-0.377 (0.269)	0.029** (0.004)	-3.73* (0.11)	234.2**, 0.97
Combined	-0.253 (0.137)	0.027** (0.002)	-3.25** (0.47)	636.6**, 0.96

a Form of equation: $LAI = b_0 + b_1*(X) + b_2*(X^2)$; where X= leaf dry weight

b F, and R^2 value for whole model.

* and ** Statistically significant at P < 0.05 and P < 0.001, respectively.

A more rapid means to estimate leaf area would be to count the number of leaves (Table 4, Fig. 5). All models were statiscally significant (P<0.0001), but quadratic parameters for Florunner, Sothern Runner, and the combined model were not significantly different (P>0.05) from zero.

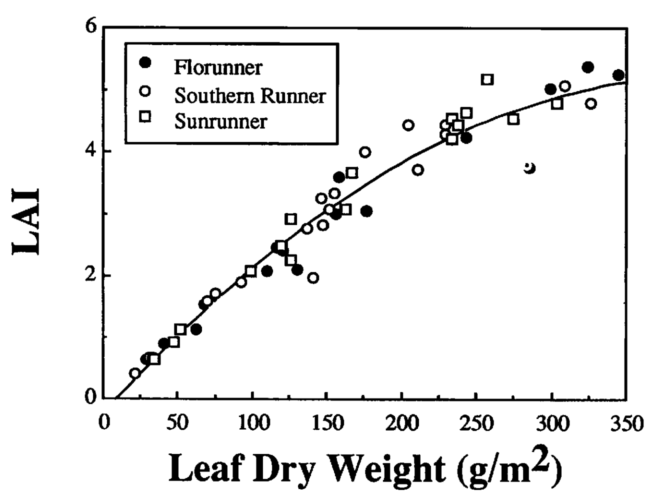

Fig. 4. Leaf area index on leaf dry weights over both years and all cultivars. Line is least-squares, best-fit for the quadratic model (one point is not graphed and was an outlier for Southern Runner; leaf area = 7.132, leaf dry weight=111.0 g).

Table 4. Statistics for predicting leaf area from number of leaves for linear and quadratic models for each cultivar and combined over cultivars over the 1988 and 1989 growing seasons.

Cultivar	Parameters for independent variables[a]			F value, R^2 [b]
Linear model	b_0 (±SE)	b_1 (±SE)		
Florunner	0.377 (0.824)	0.0013* (0.0002)		56.6*, 0.79
Southern Runner	0.297 (0.181)	0.0012* (0.0001)		320.6*, 0.95
Sunrunner	0.429 (0.482)	0.0014* (0.0002)		40.4*, 0.74
Combined	0.485** (0.186)	0.0012* (0.0001)		250.7*, 0.83
Quadratic model	b_0 (±SE)	b_1 (±SE)	$b_2 \times 10^{-7}$(±SE)	
Florunner	-0.83 (1.03)	0.0026* (0.0011)	-2.88 (2.30)	30.2*, 0.81
Southern Runner	0.12 (0.28)	0.0013** (0.0002)	-0.31 (0.40)	157.6*, 0.95
Sunrunner	-2.33* (0.51)	0.0046** (0.0005)	-7.44** (1.20)	100.3*, 0.94
Combined	-0.208 (0.321)	0.0019** (0.0003)	1.43* (0.50)	125.7**, 0.83

a Form of equation: $LAI = b_0 + b_1 * (X) + b_2 * (X^2)$; where X= number of leaves.

b F, and R^2 value for whole model.

* and ** Statistically significant at P < 0.0001 and P < 0 .05, respectively.

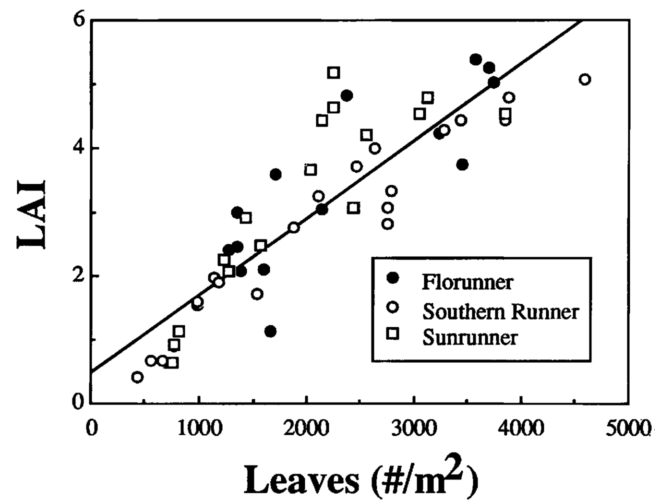

Fig. 5. Leaf area index on number of leaves over both years and all cultivars. Line is least-squares, best-fit for the quadratic model (one point not graphed- Southern Runner leaf area = 7.132, number of leaves = 1603).

Plant height was also a good predictor of leaf area. Because of non-constant variances for the linear model, Log_{10} transformations were used on leaf area index and plant height (Table 5, Fig. 6). This model resulted in significant regressions (P<0.0001) with high coefficients of determintaion (R2= 0.85 to 0.96), and all parameters were significantly different from zero (P< 0.0001).

A nonlinear relationship with V-stage was also examined to predict leaf area. Using the modified normal equation to predict leaf area from V-stage resulted in high coefficients of determination (R^2 =0.81 to 0.83) and parameters that were significantly different (P< 0.05) from zero (Table 6 and Fig. 7).

Discussion

Cultivar characteristics

The shape of our leaf area graphs (Fig. 1, 2, 3, and 7) corresponds well with the bell-shaped graphs reported by

Williams (32) for groundnut in Rhodesia, and Pixley et al. (24, 25) for peanut in Florida. Our maximum leaf area indexes (Fig.7) did not approach the higher values reported by Jaaffar and Gardner (15). However, they used a different technique based on a subsample and total dry weights of peanut plants, and may not have had as much foliar disease pressure.

Florunner (Fig. 1) had the sharpest canopy decline in 1989. This decline corresponds with the observation reported by Duncan et al. (10) of canopy decline at season end

Table 5. Statistics for predicting $\log_{10}$ (LAI) for $\log_{10}$ (plant height) for linear model for each cultivar and combined over cultivars over the 1988 and 1989 growing seasons.

	Parameters for independent variables [a, b]		
Cultivar	b_0 (±SE)	b_1 (±SE)	F value, R^2 [c]
Florunner	-1.52* (0.22)	1.27* (0.14)	79.6*, 0.85
Southern Runner	-1.65* (0.11)	1.42* (0.08)	326.6*, 0.95
Sunrunner	-1.72* (0.12)	1.43* (0.08)	318.6*, 0.96
Combined	-1.56* (0.10)	1.32* (0.06)	415.1*, 0.89

[a] All intercepts were not statistically different from zero, P > 0.05.

[b] Form of equation: $\log_{10}$(Leaf area index) = b_1*$\log_{10}$(plant height, cm).

[c] F, and R^2 value for whole model.

* Values are statistically significant at P < 0.001.

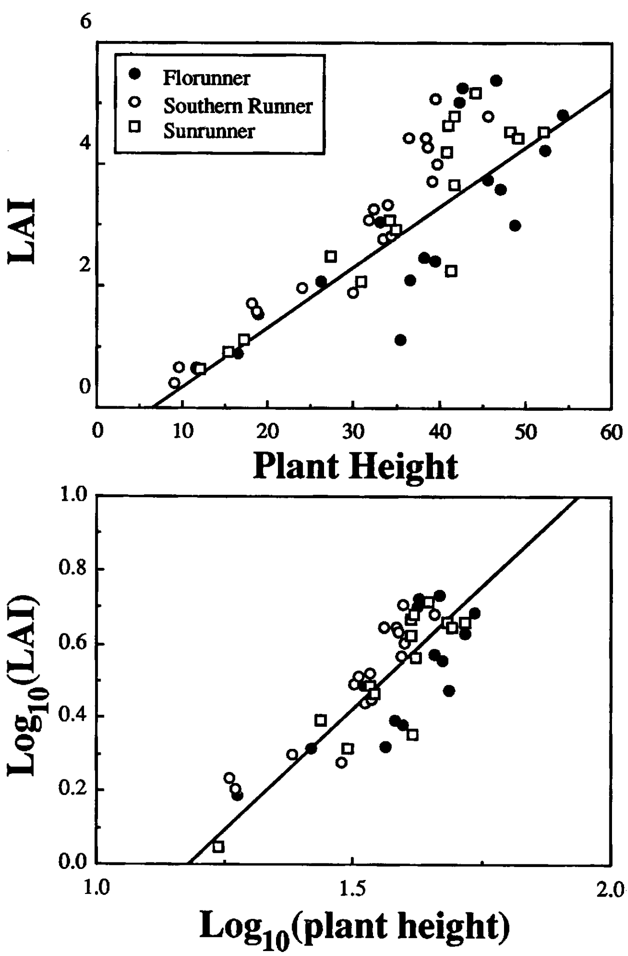

Fig. 6. Log_{10} leaf area index on Log_{10} plant height (cm). Line is least squares best-fit for linear model.

Table 6. Statistics for normal equation[a] relating V-stage to LAI for each cultivar and combined over cultivars over the 1988 and 1989 growing seasons.

Cultivar	M (±SE, cm^2)	Ω (±SE)	ß (±SE)	R^2
Florunner	4.54 (0.29)	17.1 (0.6)	5.0 (0.5)	0.82
Southern Runner	4.29 (0.25)	17.6 (0.5)	5.1 (0.6)	0.81
Sunrunner	4.60 (0.26)	17.1 (0.5)	4.4 (0.5)	0.83
Combined	4.47 (0.15)	17.3 (0.3)	4.9 (0.3)	0.81

[a] Form of equation: LAI = M *exp(-0.5*((Ω)/ß)^2)

where LAI is the leaf area index M is maximum leaf area, Ω is the midpoint, in V-stages, and ß is the standard deviation encompassing 67% of the area below the curve.

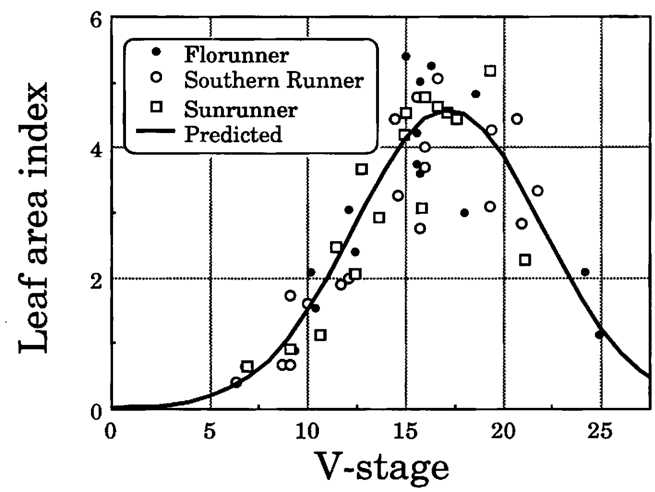

Fig. 7. Leaf area index on v stage. Line is derived from normal equation (one point not graphed and was an outlier- Southern Runner leaf area=7.132, v stage= 15.9).

attributed to 'late leaf diseases'. Also, Knauft and Gorbet (19) reported similar results for Florunner and seven other peanut lines as vegetative biomass per plant peaked between 88 and 118 DAP and then declined due to leafspot epidemics. Southern Runner's canopy (leaf area and leaf dry weight) did not decline, but did not significantly increase either over the range of dates observed (P> 0.05). The ability of Southern Runner to maintain its canopy throughout the season may be due to resistance to leafspot or its increased energy partitioning to leaf production (15-25% versus 7-8% for Florunner) even during peanut pod fill (25).

Stem dry weight, pod dry weight, and number of pods progressed similarly in both years and among cultivars. However, numerical declines were observed (although not significant) for Florunner at the last observation date in 1989. Many pods remained in the soil when plant were dug and inverted at this time, so the decline may be due to pod loss. This corresponds with the observation by Knauft et al. (16) where Florunner lost more than half its pod yield when harvested at 132 versus 118 DAP. In their study, however, fungicides were not used to control the leafpot epidemics. In comparison, Southern Runner, and other lines resistant to leafspot (19), typically required longer times to reach maximum pod yields and did not experience pod loss during the duration studied (17).

Greater precipitation in 1989 (Fig. 8) resulted in increased leafspot defoliation, and thus canopy suppression or decline

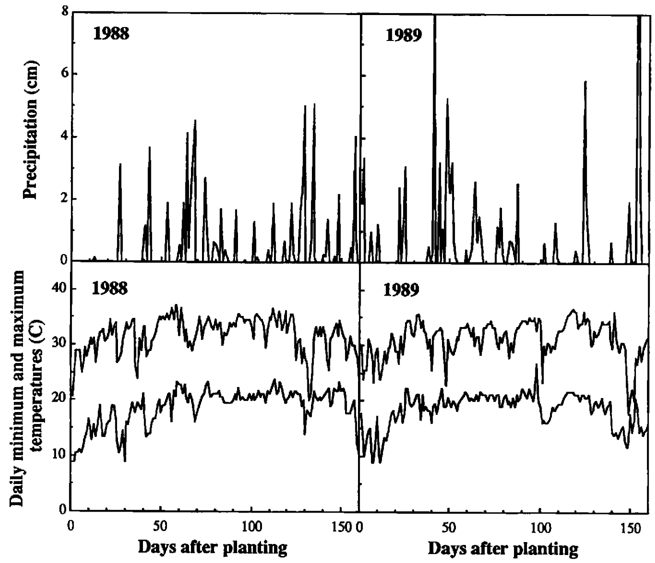

Fig. 8. Daily precipitation, minimum and maximum temperatures at the Wiregrass Experiment Station in Headland Ala. during the 1988 and 1989 growing seasons.

late in the season in all cultivars (number of leaves, leaf area, and leaf dry weights; Fig. 1, 2, and 3). Also, there appeared to be suppression in vegetative growth in 1988 due to lack of moisture during mid-season even though plots were irrigated, resulting in V-stages lagging behind values observed in 1989. However, plant height and R-stage did not differ over years.

Correlation Analysis

It was not surprising that most growth characteristics were positively correlated (Table 1). Of interest, however, were the significant negative correlations between stand density and V-stage, R-stage and plant height for Sunrunner. This could be due to the more corwded samples associated with reduced vegetative growth and delayed plant maturity. Knauft and Grobet (18) found that intrarow spacings of 5 or 30 cm did not affect progression of V-stage among 16 genotypes.

Leaf dry weight had the highest correlation with leaf area (Florunner, Southern Runner and Sunrunner; r=0.97 for each). The significant correlation of V-stage with LAI for Southern Runner (r=0.53) and Sunrunner (r=0.70) is similar to the values reported by Knauft and Grobet (19) (r=0.38 to 0.47), even though their correlation was between V-stage and the entire, aboveground plant mass.

Predictive Algorithms

Equation for predicting leaf area from leaf dry weight should be of value to those who do not have leaf area meters and are interested in estimating leaf area. These equations have already been used by members of our research group to examine the effects of leafspot epidemics on leaf area of Florunner and Southern Runner peanut under different management programs. Likewise, estimates from number of leaves should also prove useful for those who are interested in leaf area but require more rapid estimates. Using number of leaves, however, is not as precise as using leaf dry weights for predictions involving Florunner, Sunrunner, or all cultivars combined. We recomend using combined models for most predictive purposes as they would simplify methods. Combining over years is justified by the low additional improvement in R^2 (<2.3%), and combining over cultivars is justified by slight improvement in R^2 (<3.5%) and overlap in parameter estimates in regression equations (Tables 2, 3, 4, 5, & 6).

It is interesting that a negative quadratic component was significant ($P< 0.05$) for the combined regressions using leaf dry weight and number of leaves to predict leaf area (Tables 3 and 4). For leaf dry weights (Fig. 4), this may be due to heavier leaves being produced when greater leaf areas were reached. Cox reported (6) that leaf area per gram of leaflet declines as photosynthetically active radiation increases (i.e., more light = less LAI/g). This supports our findings since there is typically less cloud cover (and more available solar radiation) in Alabama during the latter part of the peanut growing season when this decline occurred.

For number of leaves (Table 4, Fig. 5), the negative quadratic component may be due to smaller leaves being produced later in the season which do not contribute as much to leaf area. This was noted for Sunrunner in 1989, when plants attempted to compensate for defoliation caused by leafspot by producing many small leaflets from defoliated nodes.

The linear models for prediction of leaf area from leaf dry weight and number of leaves provided roughly the same R^2 values, differing by only 0 to 3% (except for equations involving Sunrunner where there was a 20% increase in the coefficient of determination) (Tables 3 and 4). For predicting leaf area from leaf dry weight, the quadratic model should be used for each cultivar and the combined model since the quadratic terms were significant ($P< 0.05$).

When using the number of leaves to predict leaf area, the quadratic model should not be used for Florunner and Southern Runner since the quadratic component was not significant ($P>0.05$). However, the quadratic model should be used for Sunrunner or the combined model since the quadratic terms were significant ($P>0.05$).

Stem dry weight was not used in predictive equations even though it was the next most highly correlated variable with leaf area (r=0.77). Measuring stem weight is as labor intensive as counting number of leaves or obtaining leaf dry weight without improving on precision. Attempts to predict leaf area from total plant dry weight met with failure.

The equations using plant height were also good predictors of leaf area (R2 ranged from 0.85 to 0.95) and would be easy to use in the field. Plant height may be a good predictor because it reflects the health and condition of the canopy. Early in the season, plant height increases linearly as leaf area expands (Fig. 1, 2, and 3). When defoliation from leafspot occurred and leaf area was lost in our fields, plants became prostrate. However, plant height may change rapidly within short periods of time (e.g. a week) as plants tissues vary in turgor pressure. Thus, we do not recommend its use.

V-stage can also be used to predict leaf area quickly and easily in the field. The normal equation was chosen because its parameters have biological meaning. Also, the shape of the curve (Fig. 7) is appropriate because the leaf area of peanut in Alabama declines as the V-stage increases above the midpoint mostly due to leafspot epidemics. Knauft and Gorbet (19) also attempted to develop a relationship between V-stage and canopy, but they were unsuccessful. It should be emphasized that the relationships provided for predicting leaf area were derived from a data set where defoliation from insects was <10% and fungicides were applied every 14 days through the growing seasons to control leafspot (i.e. end of season defoliation due to leafspot ranged from 20-40%). Relationships for predicting leaf area from leaf dry weight or number of leaves should be valid over a wide range of growing conditions because these relationships are based on the leaf itself. However, predictions of leaf area from plant height and V-stage may not be valid when severe defoliation has occurred due to insects or leaf diseases since these plants will still have height or a certain number of V-stages, but little or no leaf area.

Conclusion

The growth characteristics of Florunner, Southern Runner, and Sunrunner cultivars were described over two growing seasons. Equations were developed that may be used by researchers asking diverse questions about effects on leaf area. The relationships for predicting leaf area from plant height or V-stage may be particularly useful to those developing pest management advisory systems whereby estimates of the amount of foliage present are needed to estimate the percentage of defoliation caused by an agent such as a group of defoliating insects.

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