Published July, 1982

NOTES

CALCULATION OF THE LENGTH OF DAY[1]

T. C. KEISLING[2]

ABSTRACT

With the advent of sophisticated computing capability many tables and curves that were standard methods of obtaining values in the past can be computed directly with the appropriate formulas. The photosensitivity of many agronomic crops makes knowing the length of hours that the light intensity is above a certain critical level useful. A formula for calculating daylength is presented and methods indicated for obtaining the desired beginning and ending light intensity at any location. The only information necessary to utilize the formula is the latitude of the location and the critical light intensity of interest for the particular crop being used.

Additional index words: **Photoperiod, Daylength, Flowering, Flower induction.**

PHOTOPERIOD sensitive reactions in plants are responsive to hours of natural darkness. This response is expressed in the days to floral initiation, flowering, and maturity, all of which relate to the date of planting. Temperature and other factors usually confound the relationship. Francies (1970, 1972) summarized the information concerning photoperiods with given light intensities. He presented his results in graphs and tables which require interpolation and do not easily lend themselves to ease of analyses by computers or calculators. Computers are now being utilized in several states to deliver information to growers concerning production practices to be implemented at a given time. If an information delivery system for photosensitive crops are to be developed, then an easy straightforward method to calculate the associated daylength is needed.

Calculation Equation

The equation for calculating sunrise and sunset or from civil twilight at sunrise and sunset can be obtained from most astronomy textbooks (Vorontsov-Vel'iaminov, 1969). The formula for daylength in hours is as follows:

$$\text{Day length} = \frac{2}{15} \cdot \text{arc cos}\,[\cos\alpha \sec\phi \sec\delta - \tan\phi \tan\delta] \quad [1]$$

Where

α = zenithal distance in degrees of the sun at the event of interest

ϕ = latitude in degrees, north hemisphere is positive and

δ = the declination of the sun in degrees.

The equation relating the declination of the sun to time of year is:

$$\delta = \text{arc sin}\,\{0.39779 \cdot \sin\lambda\} \quad [2]$$

The constant 0.39779 is the sin (obliquity of the ecliptic = 23.44 degrees) (U.S. Naval Observatory 1981) and

$$\lambda = M + 1.916 \sin M + 0.020 \sin 2M + 282.565 \quad [3]$$

M is the sun's mean anomaly in degrees and is defined by

$$M = 0.985600t - 3.251 \quad [4]$$

[1] Contribution from the Dep. of Agronomy, Univ. of Arkansas, Fayetteville, AR 72701. Published with the approval of the Director of the Arkansas Agric. Exp. Stn. Received 17 Aug. 1981.

[2] Associate professor, Dep. of Agronomy, and Extension Agronomist—Soybeans, Univ. of Arkansas, located at P. O. Box 391, Little Rock, AR 72203.

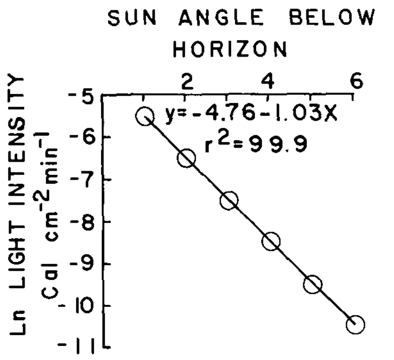

Fig. 1. Relationship between the angle of the sun below the horizon and the natural logarithm of the light intensity. Data taken from Francis (1970).

where t is the Julian Date. The calculation of λ utilizing the above method was derived by L. E. Doggett and J. Seeberger (1982). The Julian Date is corrected for leap year by adding 0.25 to the date for each year following the leap year. The above equations are easily programmed on a modern hand-held calculator or a computer.

To obtain the desired angle, α, to give a daylength beginning and ending with the desired light intensity, the relationship between the angle of sun below the horizon and the light intensity shown in Fig. 1 can be used (Francis, 1970). The relation shown in Fig. 1 can be expressed as:

$$B = -4.76 - 1.03 \cdot \ln(\text{Light Intensity}) \quad [5]$$

Where B is angle of the sun below the horizon and ln is the natural logarithm of the light intensity in cal/cm^2/min. Once B is determined:

$$\alpha = 90 + B \quad [6]$$

where 90 is the value of α in degrees at sunrise and sunset.

More complex variations of Eq. [1] are used by the U.S. Weather Bureau, but the complex variations are only necessary close to the polar regions which are not of agronomic significance. The equations and methods described herein do not take into account the influence of dust, clouds, fog, etc. These variables would cause quite complex complications and without local direct light intensity measurements cannot be easily resolved.

Example Problem

The length of day with light intensity greater than 2.206×10^{-3} cal/cm^2/min at Stoneville, Miss. (Lat 33°24.3′) is required for 20 July 1981 or a Julian Date of 201, 1981.

To calculate B, substitute 2.206×10^{-3} into Eq. [5] which gives $B = 1.54$. Equation [6] is then utilized to find the zenithal distance in degrees when the required light intensity is obtained. The zenithal distance computed is 91.54 degrees.

The Julian Date utilized in Eq. [4] is 201. Substituting $M = 194.8546$ obtained from Eq. [4] into Eq. [3] gives λ of 476.939 which, substituted into Eq. [2], gives the angle of declination of the sun as 20.77 degrees. Substituting into Eq. [1] results in a daylength of 14.20 hours between morning and afternoon light intensities of 2.206×10^{-3} cal/cm^2/min.

LITERATURE CITED

1. Doggett, L. E., and J. Seeberger. 1982. Almanac for computers. p. B5-B7. Nautical Almanac Office, U.S. Naval Observatory, Washington, D.C.
2. Francis, C. A. 1970. Effective daylengths for the study of photoperiod sensitive reactions in plants. Agron. J. 62:790–792.
3. ———. 1972. Natural daylengths of photoperiod sensitive plants. CIAT Tech. Bull. No. 2. 32 p.
4. U.S. Naval Observatory. 1981. The Astronomical Almanac. U.S. Government Printing Office, Washington, D.C.
5. Vorontsov-Vel'iaminov, B. A. 1969. Astronomical problems: an introductory course in astronomy. Pergamon Press. New York.

LEAF PHOTOSYNTHETIC RESPONSE TO FOLIAR FERTILIZER APPLIED TO CORN PLANTS DURING GRAIN FILL[1]

H. J. Harder, R. E. Carlson, and R. H. Shaw[2]

ABSTRACT

Foliar fertilization of field crops has received renewed interest as a method of increasing seed yield by supplying additional nutrients to the leaves to delay the normal depletion of nutrients in the leaves during reproductive stages. It has been hypothesized that application of foliar fertilization may delay natural leaf senescence. We tested this by estimating leaf photosynthesis in field-grown corn (*Zea mays* L.) plants using a $^{14}CO_2$ uptake procedure. A small segment of the leaf material enclosed in a chamber is exposed to $^{14}CO_2$ for a short time period. Leaf samples are then analyzed using standard radiotracer techniques. In 1976 and 1977 $^{14}CO_2$ uptake rates were measured on a number of days between silking and plant maturity in conjunction with a larger experiment relating the response of corn to foliar fertilizer application and soil moisture deficits. The experimental plants were field-grown in a Nicollet loam soil (an Aquic Hapludoll, fine-loamy, mixed, mesic).

These measurements indicated that the rate of leaf photosynthesis was depressed by as much as 17% the day following foliar-fertilizer application, but had nearly recovered by the 2nd day. A similar pattern occurred in leaf conductance. No difference in the seasonal trend of photosynthetic rate was detected between control and foliar-fertilizer treatments.

Photosynthetic patterns after foliar-fertilizer application may warrant further investigation, as significant yield reductions were noted in these experiments. Because the technique used in our experiments monitors rate of photosynthesis on small, intact leaf segments, total-canopy photosynthesis and transpiration measurements could reveal helpful information.

Additional index words: **$^{14}CO_2$ uptake, Conductance, Leaf diffusive resistance, *Zea mays* L.**

Foliar fertilization during grain-fill has been the subject of recent investigations, but yield results have been inconsistent (Garcia and Hanway, 1976; Robertson et al., 1977; Kargbo, 1978; Sesay and Shibles, 1980; Harder et al., 1982). A nutrient spray, balanced in proportions as needed by the developing

[1] Journal Paper No. J-10356 of the Iowa Agric. and Home Econ. Exp. Stn., Ames, IA 50011. Projects 2088 and 2290. Received 19 Aug. 1981.

[2] Formerly graduate student, now MCC Country Representative, Box 785, Dacca 2, Bangladesh; professor, and distinguished professor, Agricultural Climatology, Agronomy Dep., Iowa State Univ., Ames, IA 50011.