

THE LENGTH OF THE PHOTOPERIODICALLY EFFECTIVE TWILIGHT PERIOD¹

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The results of studies of critical photoperiods emphasize the importance of knowing the exact length of any photoperiods employed experimentally. Since most experiments are at present conducted under photoperiods artificially regulated in length this information is usually available. However, in the past the natural photoperiod has frequently been employed for either long or short days, and even at present it is sometimes necessary to employ natural photoperiods experimentally, especially in field studies. Little attention has been given to accurate determination of the lengths of the natural photoperiods, the time from sunrise to sunset usually having been taken as the length of the photoperiod. In only a few papers, such as one by Forster, Tincker, Vasey and Wadham (3) and one by Magruder and Allard (4), has the twilight period been considered.

In view of the results of studies on the minimum light intensities which are effective photoperiodically, it would appear that the naturally occurring effective photoperiod is always somewhat longer than from sunrise to sunset. Austin (1) found the minimum photoperiodically effective light intensity for *Rudbeckia bicolor* and *Cosmos sulphureus* to be between 0.4 and 1.8 foot candles. Borthwick and Parker (2) found the light intensity necessary to prevent induction of Biloxi soy beans to be between 0.5 and 1.0 foot candle. Similar ranges have been found in other species which have been studied. Obviously, such light intensities are attained some time before sunrise and persist until some time after sunset.

In an effort to secure some information on the length of the photoperiodically effective twilight period the writer conducted six series of light intensity measurements, beginning before sunset and continuing until a photronic foot candle meter (Weston, No. 614) graduated to one foot candle failed to deflect. Two similar series of readings were made in the morning, beginning as soon as the scale was visible and extending until after sunrise. Readings were made at frequent intervals, in order to determine the time at which the light intensity was 1 foot candle. This was arbitrarily considered to be the minimum photoperiodically effective light intensity, since the actual minima for species studied do not vary greatly from this. The measurements of light intensity were made in an open portion of the Botanical Gardens at the Ohio State University in Columbus, Ohio 40° N.). Measurements were made at normal incidence, *i. e.*, with the face of the cell at right angles to the direction of the sun's rays, or, before sunrise and after sunset, as near normal incidence as possible. The data secured are presented in Table I.

Assuming 1 foot candle as the minimum light intensity which is photoperiodically effective, the lengths of the effective twilight periods measured varied from 11 to 28 minutes, the mean being 19 minutes. The presence of clouds shortened the length of the photoperiodically effective twilight period materially, the mean being 17 minutes for cloudy days and 26.5 minutes for clear days. The range of effective twilight for this latitude is therefore from about 10 minutes on very cloudy days to about 30 minutes on clear days. Since both the morning and evening twilight periods must be considered, the photoperiodically effective twilight may range from about 20 minutes on cloudy days to about an hour on clear days.

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Since the critical light intensity for some species is less than 1 foot candle these limits might be extended somewhat, but not greatly, as the failure of the needle of the photometer to deflect occurred on the average only 4 minutes after (or before) the 1 foot candle point was attained. On the other hand, even if the minimum effective light intensity is 2 foot candles the length of the effective twilight would not be shortened by more than a few minutes, due to the rapid change in light intensity just before sunrise and just after sunset.

TABLE I
LENGTH OF THE PHOTOPERIODICALLY EFFECTIVE TWILIGHT PERIODS ON SELECTED DAYS

Date (1939)	Sky Condition	Time of Sunrise (R) or Sunset (S)	Time when Light Intensity was 1 Foot Candle	Minutes of Effective Twilight
July 6	Cloudy.....	R. 5:06 A. M.	4:48 A. M.	18
July 19	Cloudy.....	R. 5:15	5:00	15
July 5	Cloudy.....	S. 8:07 P. M.	8:27 P. M.	20
July 11	Clear.....	S. 8:05	8:30	25
July 12	Scattered clouds.....	S. 8:04	8:25	21
July 13	Clouds over sun.....	S. 8:04	8:15	11
Aug. 10	Clear.....	S. 7:38	8:00	28
Aug. 19	Cloudy.....	S. 7:28	7:45	17

LITERATURE CITED

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