Proceedings of the Iowa Academy of Science

Volume 62 | Annual Issue Article 13

1955

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Photoperiodic responses of plants have been the subject of many investigations. Garner and Allard (1920) working with soybeans and tobacco found that length of day played an important role in floral development. They further reported (1923) a close relationship between temperature and photoperiod in plant growth. Most of the common species of cultivated plants now have been investigated to determine their photoperiod requirements for flower bud initiation. Extensive literature reviews on this subject have been published by Murneek and Whyte (1948) and Leopold (1951).

Although the literature pertaining to the photoperiodic response of certain crop plants such as soybeans, corn, and tobacco is extensive, only a few similar experiments dealing with small grains have been reported. Gfeller and Goulden (1954) showed that a light intensity of 1500 candle power or more is necessary for satisfactory growth of oat plants. Wiggans and Frey (1955) found that photoperiods of 18 to 24 hours caused a more rapid maturation of commonly grown oat varieties than did those of 12 to 15 hours.

The study reported herein was conducted to determine the effect of different length periods of light on the date of heading, tillering, and plant height of oats.

Materials and Methods

Five varieties of oats, Bond, Clintland, Missouri 0-205, Simcoe, and Victorgrain, were grown in a soil mixture of one part sand, two parts loam, and one part peat at the rate of three seedlings per four-inch pot. The pots were placed on greenhouse benches from 8 AM to 5 PM daily and moved into 3′ x 3′ x 4′ growth chambers (Wiggans, 1953) from 5 PM to 8 AM. Four pots of each variety were used in each photoperiod treatment. Varying photoperiods were obtained by the use of two 20-watt fluorescent bulbs (one daylight and one white) in each chamber. Photoperiods used in this experiment were 24, 18, 15, and 9 hours, and 9 hours plus 1 extra hour at midnight. The experiments were conducted in two greenhouses where temperatures of 70°F. ±2° and 58°F. ±2°, respectively, were maintained. The duration of the experiment was 90 days, from planting to harvest.

[1]Journal Paper No. J-2755, of the Iowa Agricultural Experiment Station, Ames, Iowa. Project Nos. 1139 and 1176. In cooperation with the Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

The data recorded for each variety and photoperiod-temperature treatment were heading date, number of head-producing and non-head-producing tillers per plant, and plant height.

Results

The growth and development of the oat plants were slower when subjected to the short day-length than when long day-length treatments were used. Internode elongation and flower organ development were retarded. The average number of days from planting to heading for the various variety-photoperiod treatments in the 70°F. greenhouse are given in table 1. The number of days necessary for plants to head when grown under photoperiods of 18 and 24 hours was essentially the same. However, with photoperiod treatments of less than 18 hours the oat plants required more time to come into head. There was considerable difference between varieties in the time required to come into head in the various photoperiods, with Clintland needing the shortest and Victorgrain the longest interval. None of the varieties produced heads under the 9 hour photoperiod, but when the dark period was interrupted by one hour of light each variety produced heads. The sum of 10 hours of light with the latter treatment could not account for the production of heads by the oat plants because in another experiment no heads were produced when 12 continuous hours of light were supplied to the plants. The distribution of light during a 24 hour period must also be important to floral initiation and production. This phenomenon has been noted previously by others (Leopold, 1951). As is shown by the analysis of variance in table 2 there was no significant interaction between oat varieties and photoperiod treatments. Early maturing varieties such as Clintland, Bond, and Missouri 0-205 head earliest under each photoperiod treatment while Simcoe and Victorgrain were latest under each photoperiod.

Table 1

Number of days from planting to heading for five oat varieties grown at five different photoperiods in a 70°F. greenhouse.

Variety	Photoperiod (hours)				
	9*	9+1**	15	18	24
Bond	....	60	53	44	43
Clintland	....	58	49	42	39
Mo. 0-205	....	58	54	47	46
Simcoe	....	65	58	53	51
Victorgrain	....	67	64	57	56

*None of the plants headed within 90 days after planting with the 9 hour photoperiod.

**Photoperiod of 9 hours continuous light plus 1 hour in the middle of the dark period.

Table 2

Analysis of variance for days from planting to heading of five oat varieties grown at five different photoperiods.

Source	D.F.	SS	MS
Total	79	162.0	
Varieties	4	25.0	6.3**
Treatment	3	43.0	14.3**
Var. x Treat.	12	26.0	2.2
Sampling error	60	84.0	1.4

**Significant at the 1% level.

The average number of days from planting to heading for each variety grown under different photoperiod treatments in the 58°F. greenhouse are given in table 3. In general the varieties required from 10 to 12 days longer to head when grown in the 58°F. greenhouse than when grown under the same photoperiod treatment in the 70°F greenhouse. There was a tendency for this interval to narrow at the shorter photoperiod treatments.

Table 3

Number of days from planting to heading for five oat varieties grown at five different photoperiods in a 58°F. greenhouse

Variety	Photoperiod (hours)				
	9*	9+1**	15	18	24
Bond	....	64	56	56	53
Clintland	....	62	57	55	53
Mo. 0-205	....	66	60	57	56
Simcoe	....	72	60	60	60
Victorgrain	....	77	66	62	60

*None of the plants headed within 90 days after planting with the 9 hour photoperiod.

**Photoperiod of 9 hours continuous light plus 1 hour in the middle of the dark period.

The average number of heads per oat plant 90 days after planting in the 70°F. and 58°F. greenhouses are given in tables 4 and 5, respectively. The average number of heads produced per plant, from 2.1 to 3.5, was approximately the same for both temperatures under the 18 and 24 hour photoperiod treatments. The varieties produced more heads per plant under the 15 hour treatment in the 58°F. than in the 70°F. greenhouse. Under the photoperiod treatment of 9 hours plus 1 hour at midnight the varieties formed two groups with respect to heads produced per plant. Bond, Clintland, and Missouri 0-205 produced a relatively high number while Simcoe and Victorgrain produced a low number of heads

Table 4

Average number of heads produced per plant from five oat varieties grown at five different photoperiods in a 70°F. greenhouse.

Variety	Photoperiod (hours)				
	9*	9+1**	15	18	24
Bond	....	2.3	2.1	2.7	2.8
Clintland	....	2.0	1.7	2.2	2.6
Mo. 0-205	....	2.4	1.9	2.6	2.3
Simcoe	....	1.4	1.7	2.2	2.3
Victorgrain	....	1.3	1.7	2.5	3.5

*None of the plants headed within 90 days after planting with the 9 hour photoperiod.

**Photoperiod of 9 hours continuous light plus 1 hour in the middle of the dark period.

Table 5

Average number of heads produced per plant from five oat varieties grown at five different photoperiods in a 58° F. greenhouse

Variety	Photoperiod (hours)				
	9*	9+1**	15	18	24
Bond	....	1.9	2.5	3.2	2.6
Clintland	....	1.7	2.5	2.5	2.3
Mo. 0-205	....	1.8	2.8	2.6	2.7
Simcoe	....	1.4	2.4	2.1	2.1
Victorgrain	....	0.8	3.1	2.6	3.0

*None of the plants headed within 90 days after planting with the 9 hour photoperiod.

**Photoperiod of 9 hours continuous light plus 1 hour in the middle of the dark period.

Table 6

Analysis of variance of head producing tillers for five oat varieties grown at five different photoperiods.

Source	D.F.	SS	MS
Total	79	228.0	
Variety	4	34.0	8.5**
Treatment	3	65.0	21.7**
Var. x Treat	12	33.0	2.1
Sampling error	60	96.0	1.6

**Significant at the 1% level.

per plant. The analysis of variance for heads per plant, given in table 6, indicates a highly significant difference between varieties and between treatments, but a non-significant variety by photoperiod interaction in the 70°F. greenhouse. The analysis of the data from the 58°F. greenhouse was similar.

In general the shorter photoperiod treatments produced the higher number of potential head-producing tillers per plant, as would be expected. Temperatures at which the oats were grown had little effect upon the number of potential head-producing tillers per plant.

Height of the oat plants was taken as the average height of the heads of the plant above ground level. As shown in table 7 there was a decrease in plant height with an increase in length of photoperiod in the 70°F. greenhouse. The variances between varieties, between photoperiod treatments, and for the variety by photoperiod treatment interaction all were highly significant. In the 58°F. greenhouse the plants were from 2 to 3 inches shorter than were those in comparable photoperiods in the 70° F. greenhouse.

Table 7

Average plant height (inches) of five oat varieties grown at five different photoperiods in a 70°F. greenhouse.

Variety	Photoperiod (hours)			
	9+1*	15	18	24
Bond	32.3	34.0	28.2	29.2
Clintland	30.5	34.2	26.4	28.2
Mo. 0-205	34.6	38.8	34.2	34.3
Simcoe	34.1	37.1	36.1	36.0
Victorgrain	24.8	25.3	26.4	26.0

*Photoperiod of 9 hours continuous light plus 1 hour in the middle of the dark period.

Discussion

These data show that length of photoperiod and temperature influence the rate at which an oat plant matures, the number of tillers (both head-producing and non-head-producing) per plant, and plant height.

Oats, in general, can be classified as long-day plants, since they do not produce seed at photoperiod intervals of 9 or 12 hours unless the dark period is interrupted by a short interval of light. With the use of 18 to 24 hours photoperiods, with fluorescent light as the supplemental source, it is possible to mature four generations of oats in a 70°F. greenhouse in one year. This technique is now being used to hasten the development of oat varieties in the variety improvement program at Iowa State College.

Summary

Five varieties of oats were grown under various photoperiod and temperature conditions. Heading date, tiller number, and plant height were measured. Oats grown under long photoperiods headed

sooner than did those under short photoperiods. A photoperiod of longer than 12 hours was found necessary for oats to produce heads. Some varieties formed more head-producing tillers than others under different photoperiod conditions. Long day-lengths reduced plant height slightly.

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