Vol. 48 APRIL 1, 1934 No. 7

JOURNAL OF AGRICULTURAL RESEARCH

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JOURNAL OF AGRICULTURAL RESEARCH

VOL. 48 WASHINGTON, D.C., APRIL 1, 1934 No. 7

RELATION OF LENGTH OF DAY TO GROWTH OF TIMOTHY [1]

By MORGAN W EVANS, *associate agronomist, Division of Forage Crops and Diseases*, and H. A. ALLARD, *senior physiologist, Division of Tobacco and Plant Nutrition, Bureau of Plant Industry, United States Department of Agriculture*

INTRODUCTION

Since 1920, when Garner and Allard [2] first announced their discovery of the principle of photoperiodism, many investigators have published results of studies of this phenomenon as it applies to many kinds of plants.[3]

In some plants, earliness and lateness are not the only characteristics that are affected by changes in the length of day. It has been shown that in timothy (*Phleum pratense* L.) not only time of blooming but also elongation of the internodes of the stems and the number of elongated internodes per culm are affected by the length of day.[4]

In a preliminary test conducted in 1930 it was found that timothy plants that bloom and mature early when grown under natural conditions respond to days artificially made of uniform lengths in a different way from plants that are later in their development. This discovery suggested the desirability of conducting an experiment for the purpose of determining the responses of timothy plants that bloom and mature at different times to days that range in length by uniform gradations from relatively short to relatively long.

When plants propagated vegetatively from a single original timothy plant are grown at stations in different latitudes, it has been found that in the Northern Hemisphere the season for blooming of these plants does not progress from south to north at the uniform rate per day of one quarter of a degree, as predicted in Hopkins' bioclimatic law.[5] On the contrary, the plants bloom relatively later at the southern stations and relatively earlier at the northern stations than this law prescribes.[6] One possible explanation for this is that the development of the plants in the South during early spring is delayed by the relatively short days that occur in southern latitudes, and in northern latitudes the development is hastened by the relatively long days that occur during late spring and early summer.

[1] Received for publication Nov. 17, 1933; issued June 1934.

[2] GARNER, W. W., and ALLARD, H. A. EFFECT OF THE RELATIVE LENGTH OF DAY AND NIGHT AND OTHER FACTORS OF THE ENVIRONMENT ON GROWTH AND REPRODUCTION IN PLANTS. Jour. Agr. Research 18: 553–606, illus. 1920.

[3] LUBIMENKO, V. N., and SZEGLOVA, O. A. L'ADAPTION PHOTOPÉRIODIQUE DES PLANTES. Rev. Gén. Bot. 40: [577]–590, [675]–689, [747]–768, illus. 1928.

[4] EVANS, M. W. THE LIFE HISTORY OF TIMOTHY. U.S. Dept. Agr. Bull. 1450, 56 pp., illus. 1927.

[5] HOPKINS, A. D. PERIODICAL EVENTS AND NATURAL LAWS AS GUIDES TO AGRICULTURAL RESEARCH AND PRACTICE. Monthly Weather Rev. Sup. 9: 5–42, illus. 1918.

[6] EVANS, M. W. RELATION OF LATITUDE TO TIME OF BLOOMING OF TIMOTHY. Ecology 12: 182–187, illus. 1931.

MATERIAL AND METHODS

For this investigation selected timothy plants were used. These plants are referred to as strains of timothy. All the strains listed in tables 2 and 3, except the last four, were selected from plants grown from seed of American origin; the last four originated from seed from northern Europe and are later than plants ordinarily occurring in meadows in the United States. These strains have been arranged in a series, according to the dates when the first florets bloomed on plants growing with natural illumination at Washington, D.C., in 1931. They represent uniform gradations from the earliest to the latest. The experiment was conducted at the Arlington Experiment Farm, Rosslyn, Va., near Washington, D.C.

On December 16, 1930, each of several plants was divided, and each subdivision, bearing the same number that had been assigned the original plant, was placed in a 3-inch pot. On January 26, 1931, each plant was transferred to a 4-inch pot. The plants were grown in a cool greenhouse (50° to 55° F.) until February 18, 1931, when they were removed to coldframes built upon trucks on tracks. These trucks were moved out of doors for 10 hours each day until the final tests under the various lengths of day began; during the remainder of the time they were kept in dark houses.

After the experiment was begun, plants of each strain were grown under all or part of the following numbers of hours of illumination each day: 10, 12, 12.5, 13, 13.5, 14, 14.5, 15, 16, 17, and 18. In addition, one or more plants of each strain, used as controls, were grown under the natural lengths of day.

The length from sunrise to sunset of the longest day occurring at Washington is 14 hours and 54 minutes. The plants grown with uniform lengths of day less than this maximum were placed in metal cans or buckets on trucks, which were moved into ventilated dark houses for that part of each day during which the plants received no illumination. The plants grown with 15 hours or more of illumination each day were placed out of doors, where the length of day was extended as desired by means of electric lights placed over the plants.

The plants that received 14.5 hours or less of illumination were out of doors each day for the periods indicated in table 1, from the date the test began until the final records were obtained.

TABLE 1.—*Time during which timothy plants receiving illumination for 10 to 14.5 hours daily were out of doors*

Date when test began	Length of period of illumination each day	Hours during which plants were out of doors	Date when test began	Length of period of illumination each day	Hours during which plants were out of doors
	Hours			*Hours*	
Apr. 11	10	From 6 a.m. to 4 p.m.	May 18	13.5	From 5 a.m. to 6:30 p.m.
Do	12	From 6 a.m. to 6 p.m.	Do	14	From 5 a.m. to 7 p.m.
Do	12.5	From 6 a.m. to 6:30 p.m.	Do	14.5	From 5 a.m. to 7:30 p.m.
Do	13	From 5 a.m. to 6 p.m.			

Artificial light was required in order to obtain constant illumination for 15, 16, 17, and 18 hours each day, periods representing approximately the maximum lengths of day for the latitudes 41°, 48°, 53°, and 57°, respectively. This added illumination was furnished for

each group of plants by four 200-watt gas-filled tungsten lights with reflectors, built according to standard specifications. These lights were placed at each corner of a square of such dimensions that the distance from center to center of the lights was 3 feet. The lights, which were kept about 2 feet above each group of plants, were arranged on an adjustable frame so that they could readily be raised as the plants increased in height. Each set of plants was screened by partitions high enough to cut off the direct rays of its group of lights from all the other sets of plants.

In order to maintain illumination for a uniform period each day, it was necessary to use electric lights for different lengths of time. Constantly decreasing daily periods of artificial light were required up to the midsummer solstice, and constantly increasing periods of light after the solstice. Four electric time switches were used to control the required decrements or increments of artificial light, and the necessary changes were made each day. The tests under all four lengths of day, from 15 to 18 hours, began April 11. The lights were turned on at 5 p.m., and were kept on for different periods, so that the different groups of plants were illuminated for 15, 16, 17, and 18 hours, respectively, from sunrise each day.

EXPERIMENTAL RESULTS

EFFECTS OF DIFFERENT LENGTHS OF DAY ON DIFFERENT PHASES OF GROWTH

Insofar as vegetative growth is concerned, the plants thrived under all lengths of day within the range of this experiment. There were, however, great variations (1) in the time when the heads emerged from the enclosing leaf sheaths, (2) in the time of occurrence of the flowering process, (3) in the characteristics of the stems, and (4) in the development of the stems.

TIME WHEN HEADS EMERGE FROM ENCLOSING LEAF SHEATHS

The date of emergence of the earliest head of each plant from within the enclosing leaf sheath is shown in table 2.

In general, the later in the season the heads appeared on plants grown with natural illumination, the greater was the number of hours of illumination required for the development of the inflorescences on plants of the same strain grown with artificial light. Plants of the 2 strains that were earliest under natural conditions produced inflorescences when subjected to only 10 hours of light each day. Plants of 1 of the 4 strains that were latest under natural illumination required day lengths of 14.5 hours, while none of the plants of the other 3 strains of this group produced inflorescences under less than 15 hours of illumination daily. Plants of the other strains had a minimum light requirement of between 10 and 14.5 hours each day for the development of inflorescences; in general, the minimum number of hours of illumination required tended to increase gradually as the time of heading became later on the plants of these strains when grown under natural conditions.

As the number of hours of illumination each day increased, the date of heading on the plants of any strain gradually became earlier until the optimum day length had been attained; after this, even with continued increase in the length of day, the date of heading remained practically the same. This statement may be illustrated by the

TABLE 2.—*Dates in 1931 when the first heads appeared on plants of different strains of timothy, grown with natural daylight from 10 hours to full length of day each day and with added artificial light to obtain illumination of 15 to 18 hours daily, near Washington, D.C.*[a]

Strain no.	Date of emergence[b] of first heads in plants grown with indicated hours of illumination											
	Full day	10	12	12.5	13	13.5	14	14.5	15	16	17	18
19456	May 20	June 22	May 18	May 18	May 20	(c)	(c)	(c)	(c)	(c)	(c)	(c)
19457	May 25	June 23	June 5	June 3	June 3	May 22	(c)	(c)	(c)	(c)	(c)	(c)
19458	May 26	----------	----------	June 15	June 16	(c)	(c)	(c)	(c)	(c)	(c)	(c)
15092	May 28	----------	June 27	June 8	June 15	May 28	May 28	May 28	May 18	May 15	May 13	May 13
11902	May 26	----------	June 24	June 10	---do----	---do----	May 26	May 25				
	June 1	----------	July 24	July 1	June 25	June 3	June 1	June 1	May 20	May 18	May 14	May 18
6127	June 8 June 10 June 12	----------	----------	----------	----------	June 18 June 27	June 15	June 8	May 25	May 20	May 19	---do----
6743	June 8 June 6	July 20	----------	June 26	June 27	June 11	June 8	June 4	---do----	June 1	---do----	May 15
11966	June 13 June 16	----------	----------	----------	July 22	July 3 June 23	June 22 June 15	June 17 June 13	May 29	May 21	---do----	May 16
9220	June 18	----------	Aug. 3 July 31	July 21 July 11	Aug. 3 July 13	July 7 July 13	June 26 June 30	June 19	June 1	May 19	May 18	May 18
12421	June 19	----------	----------	----------	----------	July 14	---do----	June 22	June 5	May 25	May 20	May 21
15485	June 25 June 26	----------	----------	----------	----------	July 22	July 9	June 30	June 8	May 26	May 22	May 22
19416	June 27 June 30	----------	----------	----------	----------	----------	July 10	June 27	---do----	---do----	May 21	May 21
15445	July 3 July 7	----------	----------	----------	----------	----------	----------	----------	June 20	June 1	May 26	May 26
19459	July 3 July 6 July 11	----------	----------	----------	----------	----------	----------	----------	June 13	May 29	May 23	May 21
19460	---do--- July 15	----------	----------	----------	----------	----------	----------	July 20	June 16	June 1	---do----	May 23
19461	July 13 July 17	----------	----------	----------	----------	----------	----------	----------	June 18	June 3	May 25	May 25

[a] To obtain daily exposures of 10 to 14.5 hours required keeping the plants in a darkened house for a certain number of hours each day; to obtain daily exposures of 15 to 18 hours required the use of artificial light to supplement the normal length of day.

[b] Leaders indicate that no heads emerged under the period of illumination specified; more than 1 date of emergence or line of leaders merely indicates that the test included 2 or more sets of plants.

[c] No plants were grown under this period of illumination.

records of the plants of strain no. 9220 (table 2). Under natural conditions, the first head appeared on the control plant on June 18. On the plant grown with 10 hours of light each day, no inflorescence developed; on that grown with 12 hours of light the tip of the first head appeared on July 31. With increasing length of day the time of heading gradually became earlier, until with 16 hours of illumination the time of heading occurred on May 19. When exposed to 17 and 18 hours of light each day, the heads of the plants appeared on May 18, practically the same date as on the plant grown under a 16-hour day.

Time of Flowering

The relative dates at which the first florets appeared on plants of the different strains grown with different periods of illumination corresponded, in a general way, to the relative dates at which the first heads had appeared on the same plants about 12 to 15 days earlier.

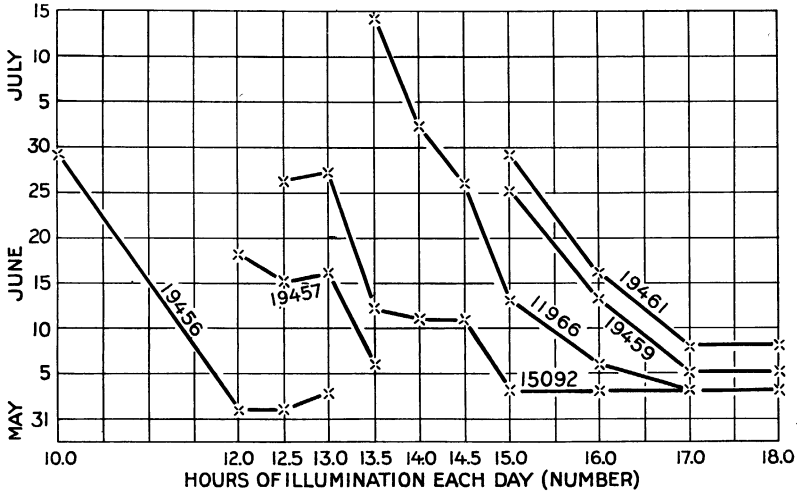

FIGURE 1.—Dates in 1931 when the first florets bloomed on different timothy strains (indicated by numbers), grown under various constant daily periods of illumination.

In plants that under natural conditions range gradually from very early to very late the response to days of different lengths, as indicated by the time of flowering, is quite consistent (table 3). On the control plant of strain no. 19456, the first florets bloomed on June 3; this was the earliest plant to bloom under natural conditions. On the plant of this strain grown with 10 hours of light each day, the first florets bloomed on June 29. As the date of flowering became later on plants of the different strains grown under natural conditions, the minimum number of hours of illumination under which any florets bloomed gradually increased, until, in the case of strain no. 19461, which was the latest to bloom under natural illumination, no florets appeared on plants grown under days of uniform length of less than 15 hours.

As the length of day increased, the dates on which the florets on the plants of any particular strain bloomed gradually became earlier up to the optimum period of illumination, after which there was no further increase in earliness. This tendency is shown by the records in table 3 and the curves in figure 1. Under natural conditions, the first florets

TABLE 3.—*Dates in 1931 when the first florets opened on plants of different strains of timothy, grown with natural daylight from 10 hours to full daylight each day and with added artificial light to obtain illumination of 15 to 18 hours daily, near Washington, D.C.*[a]

Strain no.	Date of first flowering[b] of plants grown with indicated hours of illumination											
	Full day	10	12	12.5	13	13.5	14	14.5	15	16	17	18
19456	June 3	June 29	June 1	June 1	June 3	(c)	(c)	(c)	(c)	(c)	(c)	(c)
19457	June 8	----------	June 18	June 15	June 16	June 6	(c)	(c)	(c)	(c)	(c)	(c)
19458	June 11	----------	----------	June 27	June 26	(c)	(c)	(c)	(c)	(c)	(c)	(c)
15092	June 12 June 13	----------	July 14	June 22 June 26	June 27 June 29	June 12 ---do-----	June 11 June 13	June 11 June 12	June 3	June 3	June 3	June 3
11902	June 17 June 18	----------	Aug. 4	July 13	July 10	June 19	June 16	June 18	June 6	---do-----	---do-----	Do.
6127	June 19 June 23	----------	----------	----------	----------	June 29 July 6	June 26	June 22	June 8	June 5	---do-----	Do.
6743	June 22 June 23	----------	----------	----------	July 17	June 25	June 29	June 19	June 12	----------	---do-----	Do.
11966	June 26 June 30	----------	----------	----------	--------- ---------	July 14 July 20	July 2 July 6	June 26 June 29	June 13	June 6	---do-----	Do.
9220	June 29 July 2	----------	----------	----------	----------	----------	---do-----	July 2	June 16	June 5	---do-----	Do.
12421	June 30	----------	----------	July 18	Aug. 1	July 23	July 13 ---do-----	July 3	June 15	June 8	June 5	June 4
15485	July 6 July 7 July 9	----------	----------	----------	----------	----------	----------	July 20	July 9	June 20	---do-----	---do-----	June 5
19416	July 11 ---------	----------	----------	----------	----------	----------	----------	----------	July 11	June 22	---do-----	---do-----	June 4
15445	July 14 July 20	----------	----------	----------	----------	----------	----------	----------	----------	July 2	June 16	June 12	June 8
19459	July 17 July 20	----------	----------	----------	----------	----------	----------	----------	----------	June 25	June 13	June 5	June 5
19460	July 22 July 25	----------	----------	----------	----------	----------	----------	----------	July 29	June 29	June 16	June 8	June 4
19461	---do----- July 27	----------	----------	----------	----------	----------	----------	----------	----------	---do-----	---do-----	---do-----	June 8

[a] To obtain daily exposures of 10 to 14.5 hours required keeping the plants in a darkened house for a certain number of hours each day; to obtain daily exposures of 15 to 18 hours required the use of artificial light to supplement the normal length of day.

[b] Leaders indicate that no florets opened under the period of illumination specified; more than 1 blooming date or line of leaders merely indicates that the test included 2 or more sets of plants.

[c] No plants were grown under this period of illumination.

on plants of no. 11966 bloomed on June 26. When the plants were grown under days 10 to 13 hours long, no florets bloomed; when they were grown with 13.5 hours of light, florets began to bloom on July 14. As the length of day increased, the date of blooming became gradually earlier up to days of 17 hours, under which the earliest florets bloomed on June 3. When the length of day was increased from 17 to 18 hours, the date of earliest bloom remained the same, June 3. There was a similar response to days of different lengths in the plants of other strains.

The later the plants of any strain of timothy grown under natural conditions produce inflorescences and florets in bloom, the greater is the length of day required for normal development when the plants are grown with days of various constant lengths. This statement is illustrated in figures 2 to 6, which show the plants as they appeared on July 1. The plants of strain no. 19456, the earliest under natural conditions, when grown with 12 hours of light each day produced

FIGURE 2.—Plants of timothy strain no. 19456, grown under different lengths of day, as indicated by number of hours on containers. The control plant (*C*) was grown under natural length of day. Photographed July 1, 1931.

inflorescences on which florets had bloomed before July 1. The plants of strain no. 15092 required a day of about 13.5 hours, and those of strain no. 6127 a day of 14 hours for normal growth. The plants of no. 19461, which was the latest strain used in this experiment, required a day of 16 hours for the production of normal culms with inflorescences.

If the natural length of day is too short for the development of culms and inflorescences of any timothy plant, it may be artificially increased, by means of electric light, to the daily number of hours of illumination which the plant requires. This is illustrated in figure 7, which shows plants of strain no. 19461 grown with natural illumination and with 15, 16, 17, and 18 hours of light each day. On the plants grown with natural illumination no inflorescences appeared until July 13, whereas on the plants grown with 16, 17, and 18 hours of light each day, normal culms and inflorescences had developed before June 25.

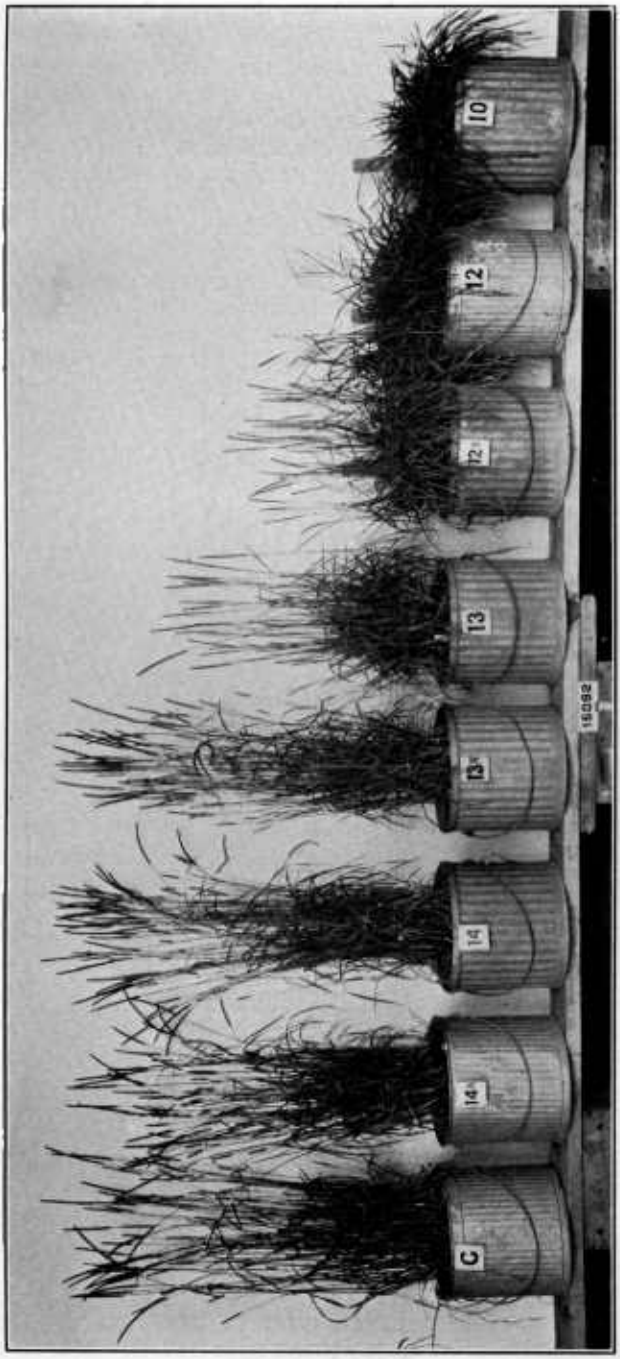

FIGURE 3.—Plants of timothy strain no. 15092, grown under different lengths of day, as indicated by number of hours on containers. The control plant (*C*) was grown under natural length of day. Photographed July 1, 1931.

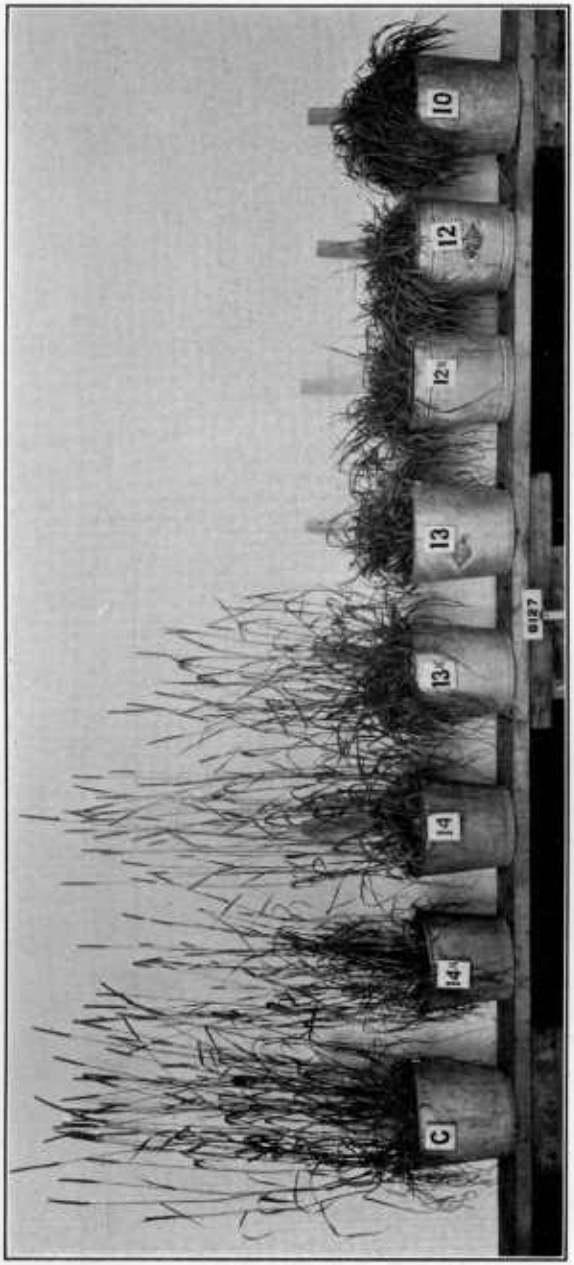

FIGURE 4.—Plants of timothy strain no. 6127, grown under different lengths of day, as indicated by number of hours on containers. The control plant (*C*) was grown under natural length of day. Photographed July 1, 1931.

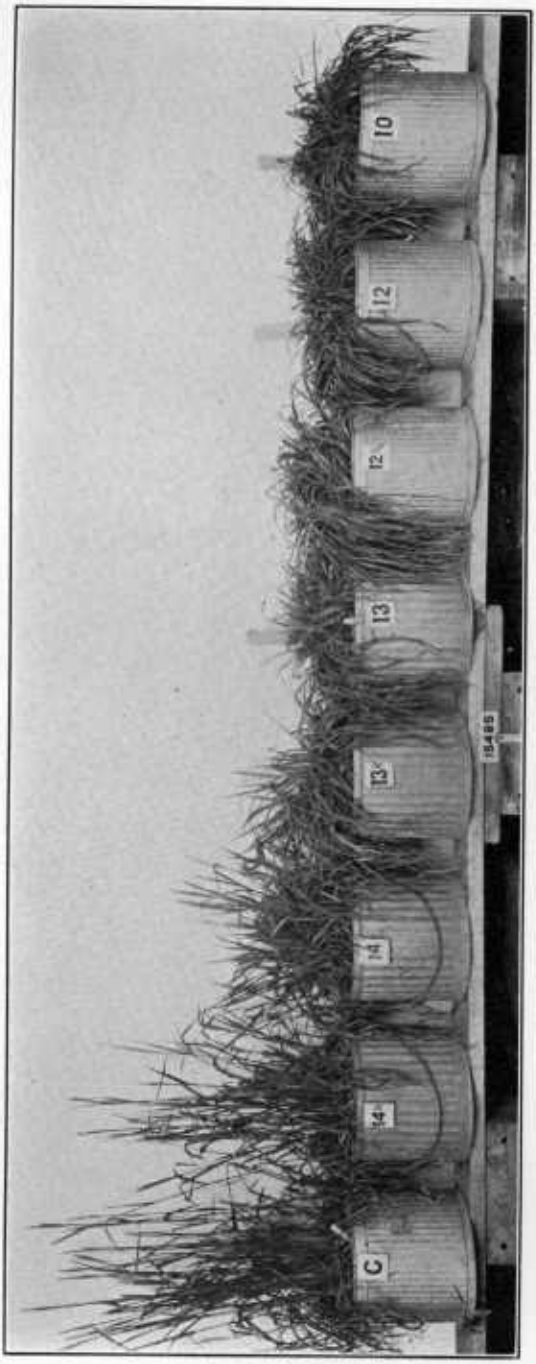

FIGURE 5.—Plants of timothy strain no. 15485, grown under different lengths of day, as indicated by number of hours on containers. The control plant (*C*) was grown under natural length of day. Photographed July 1, 1931.

Characteristics of Stems

The stems of plants which are grown with sufficiently long periods of illumination each day to enable the inflorescences to develop in a normal manner and on which the florets bloom at a normal time usually grow upright. In this experiment the plants that were grown under days too short for normal development of the inflorescences were commonly characterized by stems which were declined or which were more or less procumbent at the base, sometimes bearing inflorescences with proliferations. Figures 3 and 4 show that the plant of strain no. 15092 grown with 12.5 hours of illumination and the plant of strain no. 6127 grown with 13.5 hours of illumination daily had a tendency to a spreading habit of growth owing to the declined position of the stems.

On plants of all strains except those that were earliest under natural conditions, no elongation of the stems occurred under the shortest periods of illumination. Thus, on the plants of no. 6127 (fig. 4), there was no elongation of stems under 10 to 13 hours of illumination daily; under 13.5 hours of illumination, elongation occurred although the stems were somewhat declined; on the plants grown under 14 and 14.5 hours of light each day and those grown under natural illumination, the stems grew in an upright position.

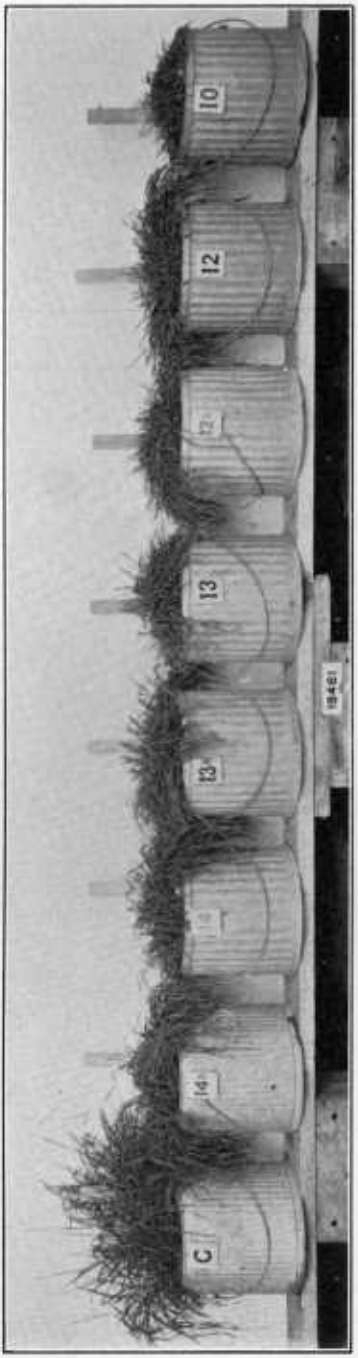

FIGURE 6.—Plants of timothy strain no. 1946, grown under different lengths of day, as indicated by number of hours on containers. The control plant (*C*) was grown under natural length of day. Photographed July 1, 1931.

Length of Stems

At the time of the first blooming of the florets of a timothy plant, the stems on which the inflorescences are borne have attained only a part of their final length.[7]

The data obtained in this experiment show that when the first florets bloomed the actual length of the stems varied according to the number of hours of daily illumination under which the plants had been grown. The records show

[7] EVANS, M. W. Pp. 10–13. (See footnote 4.)

that generally, as the length of day increased, the length of the stems of the plants of any strain on the date when the first florets bloomed gradually increased to the maximum. After this maximum had been reached, the length of the stems was not essentially changed by continued increase in the length of day. For example, when the plants of timothy no. 11902 were grown with 12 hours of light, the longest stem was 16 inches at the time the florets began to bloom; as the length of day increased, the length of stem at the time the first florets bloomed also increased by fairly uniform steps to a maximum length of 41 inches on the plant grown with 15 hours of light each day. On the plants grown with 16, 17, and 18 hours of illumination daily, the length of the longest stem at the time the first florets bloomed was either 40 or 41 inches, practically the same length as on the plant illuminated for 15 hours each day. Table 4 and figure 8

FIGURE 7.—Plants of timothy strain no. 19461 grown under natural length of day (*C*) and with days longer than normal, as indicated by number of hours on containers. This strain of timothy is the latest one (when grown under natural conditions) that was used in this experiment. Photographed June 25, 1931.

show the average length of the longest stems of the plants in groups of early, medium, and late strains of timothy grown under different lengths of day.

RESULTS OF CONTINUED GROWTH UNDER DAYS TOO SHORT FOR DEVELOPMENT OF CULMS AND INFLORESCENCES

In relation to those plants which were grown under days of short lengths and on which only vegetative growth had taken place prior to July 1, the question arises as to whether continued growth for a longer time under the same conditions would have resulted in the development of culms and inflorescences. The results obtained with the plants of strain no. 15485 are fairly typical and may be used to illustrate the general behavior, in this respect, of the plants of all the strains of timothy studied. Figure 9 shows the condition of the plants

of this strain on August 10, 6 weeks after the plants in figure 5 were photographed. On plants upon which partial development of culms occurred before July 1, there was a somewhat more advanced development on August 10. On plants that were grown with 10, 12, 12.5, and 13 hours of light each day, and on which only vegetative growth had taken place prior to July 1, no further development occurred as a result of 6 weeks of added growth. If timothy plants are grown, therefore, under days too short for the formation of culms and inflorescences these will not be formed even though the period of growth under the same light conditions is extended.

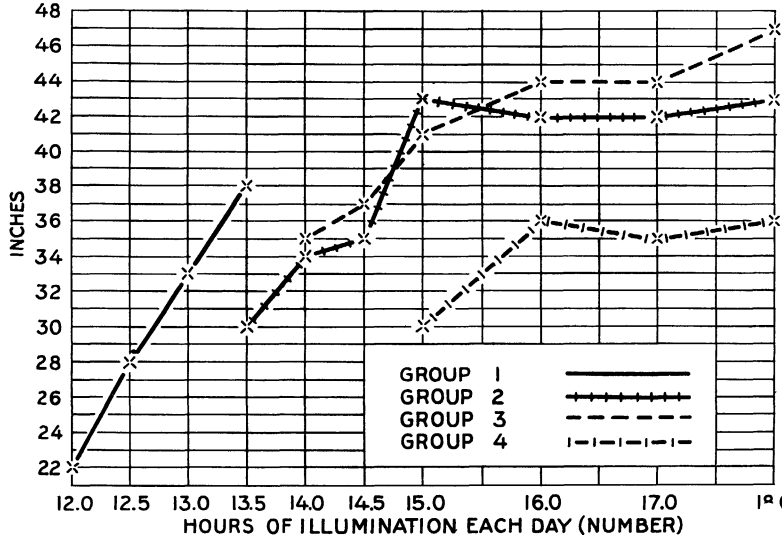

FIGURE 8.—Average length of the longest stem (in inches) of early (group 1), medium (groups 2 and 3) and late (group 4) timothy plants grown under various constant daily periods of illumination.

TABLE 4.—*Average length (inches), on the date when the first florets bloomed, of the longest stem of timothy plants grown under various constant daily periods of illumination and grouped according to relative earliness* [a]

Group	Average length (inches) of the longest stem grown under indicated hours of illumination daily [b]											
	Natural	10	12	12.5	13	13.5	14	14.5	15	16	17	18
1	38	------	22	28	33	38	[c]	[c]	[c]	[c]	[c]	[c]
2	34	------	------	------	------	30	34	35	43	42	42	43
3	39	------	------	------	------	------	35	37	41	44	44	47
4	27	------	------	------	------	------	------	------	30	36	35	36

[a] When grown under normal conditions, plants of group 1 (nos. 19457 and 15092) were the earliest strains of timothy used in this experiment; those of group 2 (nos. 11902, 6127, and 11966) were the next earliest, those of group 3 (nos. 9220, 12421, and 15485) were next, and those of group 4 (nos. 15445, 19459, 19460, and 19461) were the latest.

[b] Leaders indicate that no average was available, because flowering either did not take place or some of the strains failed to flower under the indicated period of illumination.

[c] No average given because there were no plants of no. 19457.

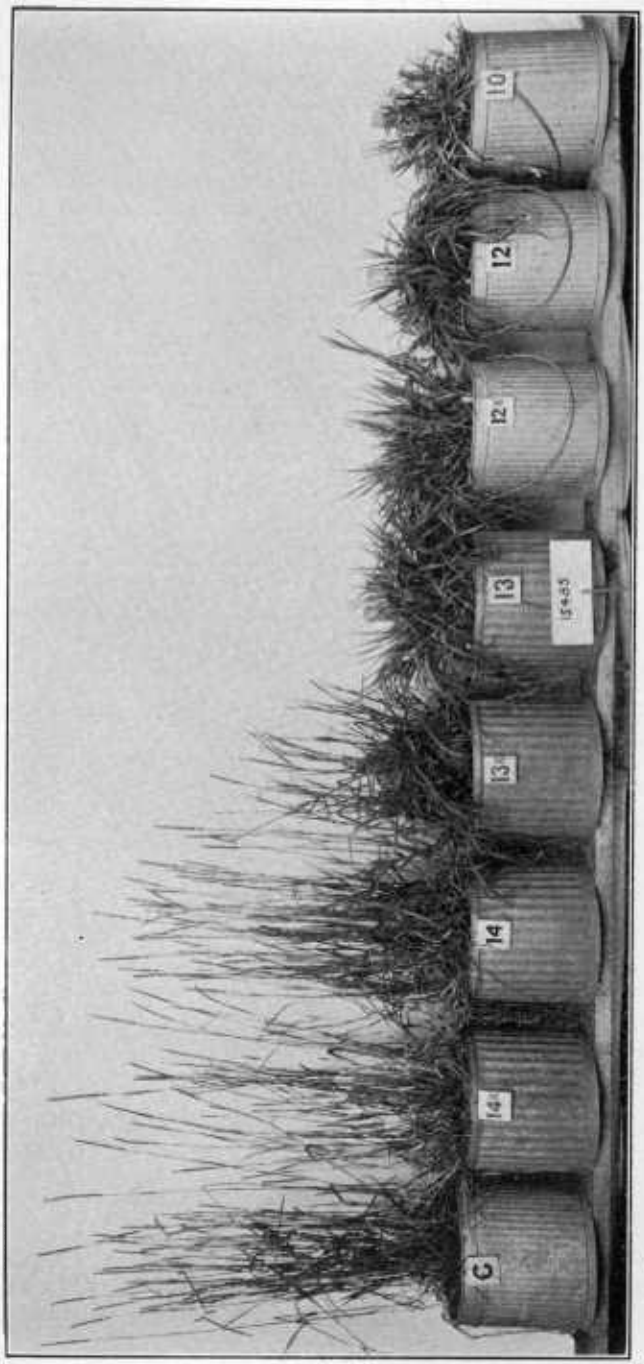

FIGURE 9.—Plants of timothy strain no. 1585, grown under different lengths of day, as indicated by number of hours on containers. The control plant (*C*) was grown under natural length of day. Photographed August 10, 1931. Some increase in the length of the stems on plants illuminated for 13.5 hours or more each day since July 1 may be observed by comparing this photograph with figure 5. Under 13 hours or less of light each day, no growth in length of the stems had taken place.

COMPARISON OF EFFECTS OF NATURAL AND ARTIFICIAL ILLUMINATION

The length of the longest day at Rosslyn, Va., where this experiment was conducted, is 14 hours and 54 minutes, or 14.9 hours. Tables 2 and 3 show that in most strains of timothy the heads appeared and the florets bloomed at approximately the same time on plants illuminated for 14.5 hours each day as on the control plants; on the plants grown under days 15 hours long, the heads appeared and the florets bloomed earlier than on the plants grown with natural illumination.

EARLINESS AND LATENESS IN TIMOTHY AN ADJUSTMENT TO DIFFERENT LENGTHS OF DAY OCCURRING AT DIFFERENT TIMES

In timothy, as in some other plants,[8] the earliness or lateness of different strains is evidently a matter of the adjustment of the plants to length of day. In figure 10 the strains of timothy are arranged according to the dates when the first florets bloomed on the plants grown with natural illumination; the first heads had appeared on these plants in practically the same order. Figure 10 also shows the dates on which the first heads appeared and the first florets bloomed on plants of most of these strains when grown with 18 hours of light each day, the maximum length of day employed. When the length of day was increased to 18 hours, plants of those strains that are late under natural conditions produced heads and florets in bloom almost as early as plants of those strains that are early under natural conditions (fig. 10).

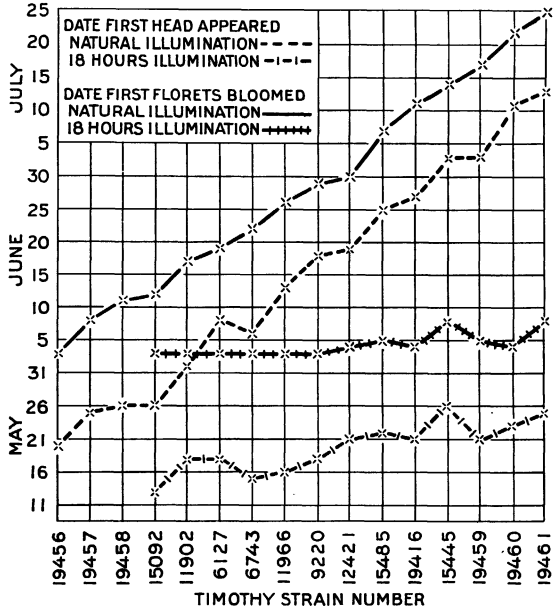

FIGURE 10.—Dates when the first head appeared and the first florets bloomed on timothy plants grown near Washington, D.C., under natural illumination and under 18 hours of illumination each day. Note that plants of those strains that are late under natural conditions in the latitude of Washington, D.C., when grown under 18 hours of daily illumination produced heads and florets in bloom nearly as early as plants of those strains that are early under natural conditions in the same locality.

The results of this experiment indicate that in any locality some timothy plants produce inflorescences and florets in bloom earlier than other plants because they are adapted to relatively short days. On those plants that are adapted to longer days, the appearance of the heads and the flowering process are delayed until the days lengthen.

[8] GARNER, W. W., and ALLARD, H. A. PHOTOPERIODIC RESPONSE OF SOYBEANS IN RELATION TO TEMPERATURE AND OTHER ENVIRONMENTAL FACTORS. Jour. Agr. Research 41: 719–735, illus. 1930.

SUMMARY

At the Arlington Experiment Farm, Rosslyn, Va. (near Washington, D.C.) there were grown under days of different lengths strains of timothy plants that when grown under natural conditions constitute a series ranging by fairly uniform gradations from very early to very late in the time their inflorescences appear, florets bloom, and seeds mature. In addition to the control plants grown under natural illumination, plants were grown with the periods of illumination artificially regulated by means of dark houses and electric lights to days 10, 12, 12.5, 13, 13.5, 14, 14.5, 15, 16, 17, and 18 hours long.

Insofar as vegetative growth is concerned, the plants grew well under all lengths of day within the range used in this experiment. There were great variations, however, with respect to the time of emergence of the heads from the enclosing leaf sheaths, the flowering process, and the characteristics and development of the stems.

The later the plants of different strains of timothy produce inflorescences and florets in bloom when grown under natural conditions, the greater is the length of day required for normal development when the plants are grown under days of different uniform lengths.

As the length of day is gradually increased above the minimum under which development of culms with inflorescences occurs, the stems lengthen and the time of the appearance of the inflorescences and the blooming of the florets gradually is shortened up to an optimum length of day. If the length of day is increased above this optimum, there is little added effect—at least up to 18 hours, the greatest length of day under which plants were grown in this experiment.

If the length of day is too short for the development of culms and inflorescences within the time that these processes ordinarily occur, continued growth of the plants for a longer time under the same length of day will not induce their development.

With a day of 14.5 hours, the timothy plants developed at about the same time as plants grown under the natural lengths of days occurring at Washington, D.C., which gradually increase up to a maximum of 14.9 hours at the summer solstice and then gradually decrease. When plants were grown under a day 15 hours long, they developed earlier than the control plants.

In timothy the earliness or lateness of different strains is evidently chiefly a matter of the adjustment of the plants to the lengths of day. The results of this investigation indicate that, in any locality, some timothy plants produce inflorescences and florets earlier than others because they are adapted to relatively short days. On those plants that are adapted to longer days, the appearance of the heads and the flowering process are delayed until, with the advancement of the season, the days increase to the lengths which these plants require for development.