LENGTH OF DAY RESPONSE OF RANGER AND VERNAL ALFALFA

by

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A Thesis

submitted to the faculty of the

Department of Agronomy

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in the Graduate College, University of Arizona

1956

Approved: D. M. McAlister, May 23, 1956

Director of Thesis — Date

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INTRODUCTION

In the last few years there has been a great increase in alfalfa seed production in the Southwest. Alfalfa seed production in California, Arizona and New Mexico increased from an average of 26,713,000 pounds during 1944 to 1953 to 91,049,000 pounds in 1955. The seed grown in the Southwest in 1955 represented 43 percent of the total production of the 20 alfalfa seed-producing states (5).

In some years, considerable seed is produced in the Middle West, particularly in Wisconsin, Minnesota and Michigan; but, due to wet seasons and poor pollination, the production is undependable (9). This unreliable seed production in the important alfalfa seed consuming states has led to their depending more and more on the Western states for a supply of planting seed.

The high average seed production of California, Arizona and New Mexico is due in part to the more ideal climatic conditions of the Southwest. Seed production is more dependable when the climate is relatively dry. The highest yield regularly occurs in areas where the period from May to September is hot and dry. Such an environment favors seed setting and facilitates harvesting. It also promotes pollination, which in itself is a difficult problem in areas where competitive pollen and nectar plants compete for bee activity. Alfalfa is only a fair producer of nectar and yields but a moderate supply of pollen,

therefore, bees will readily turn to higher nectar and pollen yielding plants (4,6,14,16).

In areas such as the Southwest competitive pollen plants are not a serious factor. High temperature and light intensity with the low relative humidity stimulate and increase the sugar content of nectar, making alfalfa more desirable as a nectar source for honeybees (6, 18). In this area, the use of honeybees for alfalfa pollination is almost universal. The placement of adequate honeybee colonies in or near seed-producing fields increased the seed production from 400 to 1,000 pounds of seed per acre (10). This is quite substantial when compared to the U. S. average of 158 pounds per acre (5).

The value of alfalfa seed to the Southwest is determined mainly by the high production per acre. This high production is dependable and becoming more so as farmers understand the importance of cultural practices and pollination. This area has become the most important source of seed of winter hardy alfalfa varieties. In fact, the major portion of alfalfa seed produced in the Southwest is of cold resistant varieties. During 1955, the Southwest produced over 90 percent of the certified seed of the varieties Ranger and Vernal (8).

There has been some concern expressed by northern states over the possibility of selecting away from winter hardiness when their cold resistant varieties are grown under the warm, short days of the Southwest (15). Such a selection may exist if there is selective seed setting as a result of length-of-day response or if there is a tendency for seed from plants

which are highly productive under short-day conditions to produce less winter-hardy progeny than plants producing seed under long-day conditions. Certain alfalfa research workers believe that such a genetic change may occur even during the first seed generation if seed of hardy varieties is grown in the Southwest and used for establishing hay fields in northern states. No satisfactory proof has been published that this is the case.

The objective of this study is to evaluate the influence of photoperiod on seed production of winter-hardy alfalfa varieties. Such a study will provide basic information toward a final settlement of this problem.

MATERIALS AND METHODS

This study was designed to permit an evaluation of the effects of photoperiod on fruiting and vegetative characteristics of two northern varieties under actual field conditions. Vernal and Ranger, two winter hardy alfalfas were used. Both varieties are winter hardy and resistant to bacterial wilt. The superiority of Ranger and Vernal as northern alfalfas is mainly based on their winter hardiness and capacity for survival on wilt infested soils (9). The terms, "winter hardy" and "wilt resistance" are relative. These varieties are not perfect in survival in intense cold and in wilt infested soils but are much superior to other commercial strains (15).

Ranger alfalfa was developed by H. M. Tysdal and H. L. Westover of the U. S. Department of Agriculture at the Nebraska Agriculture Experiment Station, and released in 1940 (9). It is a multiple strain variety synthesized from wilt-resistant and cold hardy selections out of Cossack, Turkistan and Ladak in the proportion of 45:45:10, respectively (17).

Vernal alfalfa was developed by the University of Wisconsin Plant Geneticist, R. A. Brink, and was released in 1953. Vernal is also a synthetic variety. It has a broad genetic base. All the component lines were resistant to bacterial wilt and winter hardy (3). One of the parents in Vernal is Medicago falcata which is an extremely winter hardy, long-day species.

The parent plants used for establishing the clonal lines of Ranger and Vernal were taken at random from 8-month-old

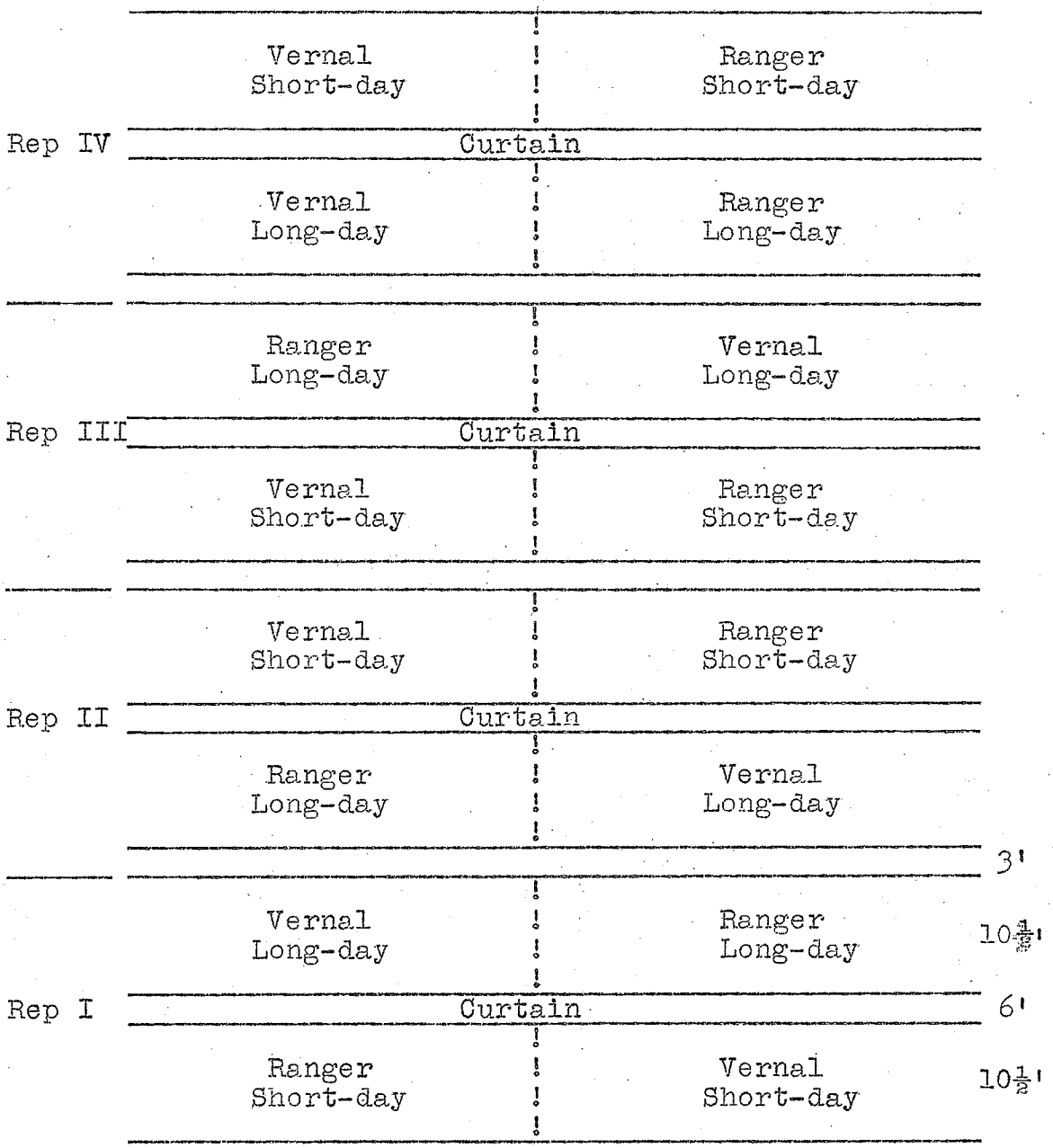
plantings of these varieties. The seed stock of Vernal was obtained from R. A. Brink, University of Wisconsin and the Ranger planting had been established from Idaho Registered Seed.

Twenty stem cuttings of both Ranger and Vernal were rooted from 64 parent plants. From the 20 rooted cuttings, eight of each clonal line were selected on the basis of general plant vigor. The cuttings were rooted and grown under greenhouse conditions prior to transplanting to the field.

On April 15, 1955 the rooted cuttings were planted in the field. Individual plants were set out on 18" centers, a plant of each of the 64 clones was placed in each of four replications of the two light treatment plots. A block of the 64 clones of Ranger was paired with a block of the same number of Vernal clones. The field planting was a split-plot design with varieties constituting the main plots; and clones, the sub-plots. Figure I shows the field layout.

The long day effect was accomplished by mounting 4, No. 2, reflector type photoflood lamps over each long-day plot. The lamps were six feet above the surface of the soil. The lamps were turned on in the middle of the dark (night) period for an interval of 10 minutes. Light exposure treatments began at the time of the last clipping and continued until the end of the seed-setting period. The light exposure essential to produce long-day effects in alfalfa is 60 foot-candle-minutes (13). Light intensity was determined by the use of the plant Photo-

Figure 1. Field Planting Plan



Border 5

South

General view of the field plots on which the study was made. The photograph shows the arrangement of curtains and photoflood lamps used to control the light treatments.

Campbell Avenue Farm, Tucson, Arizona

meter. The minimum light intensity at any point in the long-day plots when the photofloods were on was 28 foot candles. Thus, the minimum light exposure was 280 foot-candle-minutes.

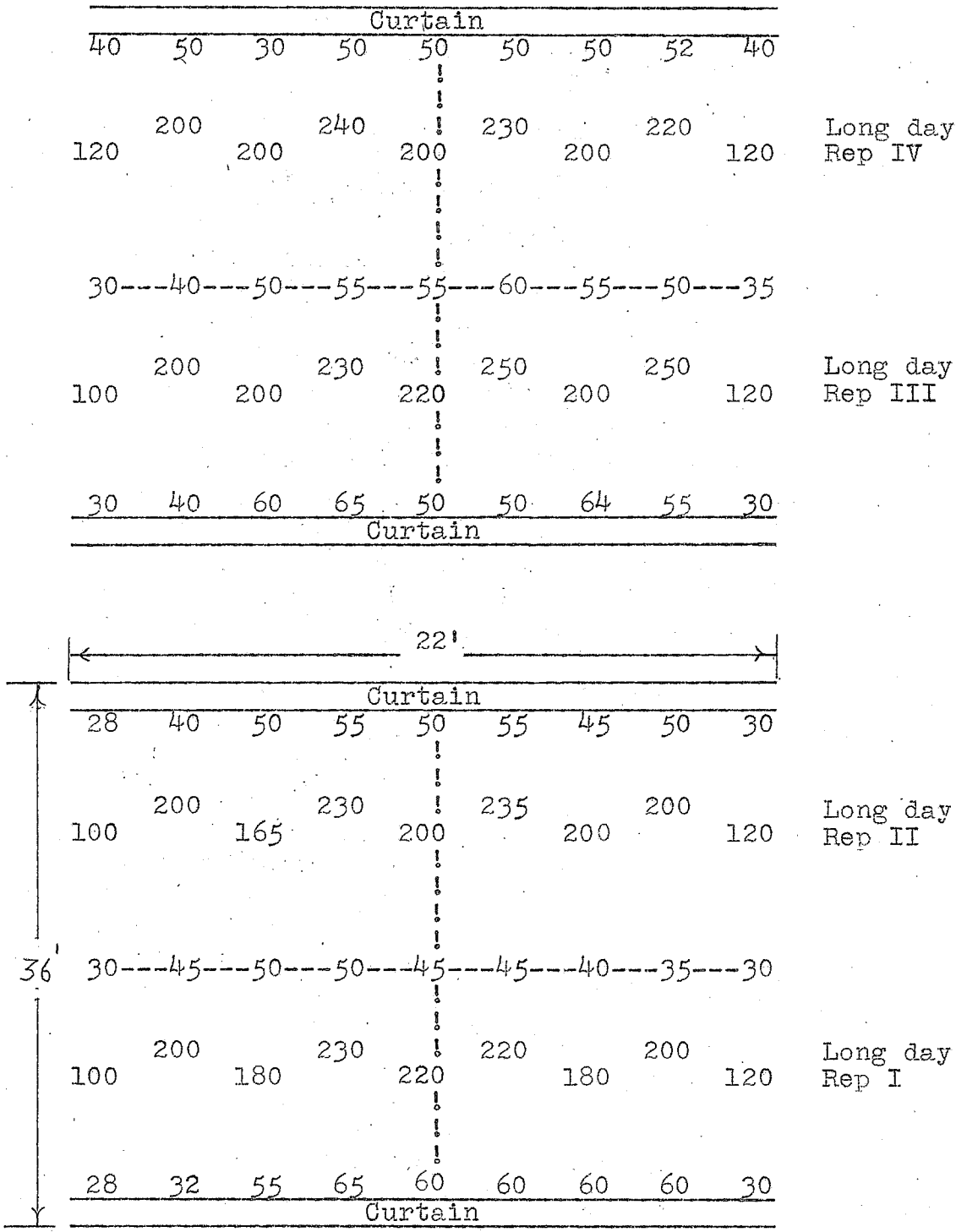
Figure 2 shows the light intensity over the entire long-day plots. Curtains of doubled black sateen 5' by 21' were used to separate the two treatments to prevent any interference with the short day (or natural) photoperiodic conditions. In the mornings, these curtains were drawn back to the sides of the border so as not to shade the clones of alfalfa growing near them. At sunset, they were replaced to separate the day length treatments.

Short or normal day length was accomplished by growing the short day alfalfa plants under normal day length without interference. The mean natural length of day during the period of study was 12 hours (1).

The area was kept free of weeds and irrigated so as to maintain uniform conditions for normal growth. During the latter part of May, the plants were sidedressed with phosphorus at a rate of 100 pounds of P_2O_5 per acre. The plants were clipped on July 1 and again on August just before the light treatments began.

Harmful insects were controlled by dusting with Malathion and Benzene Hexachloride during the vegetative growth. Toxaphene was used during the flowering period so as to prevent damage to the pollinating insects. Two colonies of bees were placed near the border in an attempt to insure adequate polli-

Figure 2. Light distribution pattern in foot candles on long-day plots.



Border 5

South

nation.

Determinations of the effect of photoperiod were made on the basis of the following criteria:

Date of appearance of first flower. As the new growth developed after clipping, the plants were checked for the date of appearance of the first open flower. Such observations were made daily until the first frost.

Plant height at harvest. The height of each plant was measured to the nearest inch at time of harvest.

Weight of air dry plant. After the first killing frost, the individual plants were cut off near the crown and put in a paper bag. The plants were allowed to air dry in the green house and then weighed to the nearest gram.

Length of middle internode of typical stem. During the process of weighing, a typical stem from each plant was chosen and the length of a middle internode was measured.

Weight of seed per plant. After the plant had been weighed and the internode measured, the plants were threshed individually and the weight of clean seed determined.

With the exception of the duration of the flowering period information, all quantitative data were analyzed statistically

using the analysis of variance method. Lack of survival of sufficient plants in certain clonal lines of each variety made it impossible to obtain quantitative data on the original 64 lines in both Ranger and Vernal. When more than one plant was missing in any one of the four replications for a particular clone under a particular photoperiod, all data for this clone were discarded. If only one plant was missing in a series of four clones, the missing value was substituted by using the mean for the remaining three. Statistical analyses were made on the above measurements from 36 Vernal and 52 Ranger clones.

EXPERIMENTAL RESULTS AND DISCUSSION

Time of Flowering

The data on the effects of photoperiod on the number of days between clipping and appearance of the first open flower are presented in Tables 1 and 2 for Vernal and Ranger, respectively.

The mean length of time from clipping to the appearance of first open flower in the Vernal clones was 33.5 days for short days as compared to 29.8 days for the long-day treatment. This represents a difference of 3.7 days less under long days than under short days. The Vernal clones showed a range of 24 to 36 and 27 to 44 days, respectively, when grown under long and short days, between clipping and flowering.

Analysis of variance of these data showed that the mean difference for all clones within this variety was significant at the 5% level of probability. The differences between clones were highly significant, while the interaction between day length and clones showed no significance.

The data for Ranger (Table 2) show the mean number of days between clipping and the appearance of the first open flower to be 34.5 days for short days compared to 32.1 days for long days. When grown under long days, the Ranger clones averaged 2.4 days fewer from clipping to flowering than when grown under short days. The clones showed a

range of from 24 to 45 days under long days and from 27 to 50 days under short days. Analysis of these data showed significant differences between the means for photoperiod treatments. The analysis further showed that the differences between Ranger clones were highly significant. The interaction between day length and clones showed no significance.

Table 3 is a summary table which presents the means for Ranger and Vernal clones under the two day lengths. Although the differences between photoperiods in mean number of days between clipping and the appearance of the first flower within each variety was significant, the difference in both varieties was small in terms of the number of days that the plant continued to flower. Plants of both varieties produced flowers over a period of 60 days. This length of time should be sufficiently long that early flowering clones could furnish pollen to those flowering later. This would tend to minimize selection away from winter hardiness in northern alfalfa varieties grown for seed south of their normal range of adaptation where day length during the seed-setting period is shorter than at northern latitudes.

In synthetic varieties with a diversified genetic base, such as found in Vernal and Ranger, wide differences in physiological behavior would normally be expected. In both varieties there is segregation and recombination of the component lines, which probably aid in maintaining hybrid vigor.

It should be pointed out that Ranger and Vernal alfalfa seed produced in Southwestern states is not eligible for certification unless it is produced in fields established from foundation or registered seed grown above the 40° north parallel. Further, such seed fields may not remain in production for longer than six years. These fields must be adequately isolated from other varieties and volunteer growth removed (2-7-11).

Based on the flowering data in this study, only the small percentage of seed set during the first few days of flowering could possibly be subject to such a risk. Seed produced in the Southwest for northern use under the rules set up by the National Foundation seed project should not lose winter hardiness due to selective flowering under short days.

Table 1. Effect of photoperiod on the number of days between clipping and appearance of the first open flower in Vernal alfalfa clonal lines.

Clone No.	Short Day	Long Day	Mean	Clone No.	Short Day	Long Day	Mean
1	30	26	28	34	28	29	28
4	31	31	31	36	30	32	31
6	39	33	36	37	31	28	30
9	34	28	31	38	32	28	30
10	34	24	29	39	34	29	32
15	28	26	27	41	39	36	38
16	39	32	36	45	31	30	30
18	32	29	30	46	31	30	30
19	39	32	36	47	29	27	28
21	42	36	39	49	38	33	36
23	31	31	31	51	37	33	35
24	39	36	38	53	44	36	40
25	32	29	30	54	44	34	39
26	30	26	28	55	27	28	28
28	32	30	31	59	28	27	28
29	29	27	28	60	32	31	32
30	27	24	26	61	32	28	30
32	35	28	32	62	37	29	33
				Mean	33.5	29.8	31.7

Least significant differences	5%	1%
To compare day length means	3.69	N.S.
To compare any two clone means	4.02	5.30

Analysis of variance of the length to flowering data for Vernal as presented in Table 1.

Source of Variation	Degrees of Freedom	Mean Square	F
Replication	3	13.33	
Day Length	1	983.00	10.13*
Error a	3	97.00	
Clone	35	119.14	7.15**
Clone x day length	35	17.94	1.08
Error b	210	16.66	

Table 2. Effect of photoperiod on the number of days between clipping and appearance of the first open flowers in Ranger alfalfa clonal lines.

Clone No.	Short Day	Long Day	Mean	Clone No.	Short Day	Long Day	Mean
1	38	29	34	26	32	35	34
2	34	38	36	27	29	29	29
3	32	30	31	28	40	40	40
4	40	33	36	29	30	27	28
5	31	30	30	30	42	42	42
6	39	32	36	31	35	28	32
7	31	34	32	32	34	37	36
8	37	38	38	34	33	32	32
11	31	33	32	36	33	32	32
12	36	35	36	37	29	31	30
13	27	31	29	38	30	24	27
14	36	35	36	40	29	25	27
15	36	38	37	41	27	26	26
16	30	31	30	43	28	24	26
17	40	37	38	44	32	32	32
18	50	45	48	45	36	30	33
19	31	31	31	46	38	34	36
20	30	26	28	47	47	44	46
22	32	27	30	48	33	28	30
23	28	25	26	49	40	34	37
24	45	36	40	50	33	31	32

(Continued next page)

(Table 2 Continued)

Clone No.	Short Day	Long Day	Mean	Clone No.	Short Day	Long Day	Mean
51	38	30	34	58	30	25	28
52	34	30	32	59	37	32	34
53	30	31	30	60	47	38	42
55	37	34	36	62	34	34	34
56	36	34	35	63	35	32	34
57	30	27	28	64	30	26	28
				Mean	34.5	32.1	33.3

Least Significant Differences	5%	1%
To compare day length means	1.39	N.S.
To compare any two clone means	4.30	5.66

Analysis of Variance of the length to flowering data for Vernal as presented in Table 2.

Source of Variation	Degrees of Freedom	Mean Square	F
Replication	3	136.67	6.61
Day Length	1	600.00	29.03*
Error a	3	20.67	
Clone	53	183.02	9.58**
Clone x day length	53	22.51	1.18
Error b	318	19.10	

Table 3. Summary of the effect of photoperiod on the number of days between clipping and appearance of the first open flower of Ranger and Vernal.

Variety	Short Day	Long Day	Mean
Vernal	33.5	29.8	31.7
Ranger	34.5	32.1	33.3
Mean	34.0	30.9	

Variance analysis for data presented in Table 3

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	3	1.76	1.02
Day Length	1	42.30	24.41*
Error a	3	1.73	
Varieties	1	6.30	3.02
Varieties x day length	1	2.20	1.06
Error b	6	2.08	

Seed Yield

The data for seed yield as affected by day length are recorded in Tables 4 and 5 for Vernal and Ranger, respectively.

In Vernal, the mean weight of seed per plant was 4.12 grams for short days as compared to 5.74 grams for long days. The range in seed production in 36 clonal lines of this variety was zero to 18.47 grams per plant under short days compared with zero to 23.62 grams for long days. The mean seed production per plant in Vernal was somewhat greater under long than short days but the difference was not statistically significant. The differences between clones were, however, highly significant. Moreover, the interaction between clones and day length was highly significant.

Table 5 shows that the mean seed production in all clonal lines of Ranger was 4.80 grams per plant under short days and 7.20 grams of seed under long days. The clones ranged in mean seed per plant from zero to 26.17 grams under short days and zero to 27.21 grams under long days. Analysis of variance of these data for Ranger seed production showed that the difference between the means for all clonal lines at the two photoperiods was not significant. As in Vernal, the differences in seed production between clones was highly significant. Significance was indicated in the interaction between clones and day length.

A summary of the seed yield data for the two varieties grown under the two photoperiods is presented in Table 6. The variance analysis which accompanies the table supports the following statements. Ranger was superior to Vernal in seed production. The differences in seed yield at the two day lengths were not significant at the 0.05 level of probability. There was no interaction between varieties and day length.

The difference between the mean clonal varieties seed yield due to day length showed no significance although the actual differences in response of several clones were quite substantial. The number of clones which showed differences in seed yield was small when compared to the total number of clones which showed no day length effects. In both varieties, the clones that gave higher seed yields tended to be the ones grown under long days. However, approximately one-eighth of these high seed yielding clones were those under short day periods.

It is quite apparent from this study that there is a wide variability in the germ plasm of these two varieties. The clones fell into 3 seed-producing groups: the largest group showed no photoperiodic effects and may be considered day-neutral; the next largest group showed significantly higher seed yield under long days; and the last group of clones produced significantly higher seed yields under short days. This difference in clonal seed production is probably

inherent within synthesized alfalfa varieties such as Vernal and Ranger, regardless of the region in which the seed is produced.

The number of clones producing higher yields of seed under short days was very small. Such a behavior minimizes the possible danger of greater seed production by short-day plants when a winter hardy variety is grown for seed south of its normal region of adaptation. The high degree of cross-pollination obtained from concentrated bee activity in the Southwest would further tend to reduce the possibility of the loss of winter hardiness by maintaining the original heterogeneity within a synthetic variety.

The difference obtained in seed yield between varieties agrees with commercial seed production experience with Ranger and Vernal in Arizona. Seed yields of Ranger have been high, while the few seed fields of Vernal in this state have been plowed under because of disappointing yields of seed.

Table 4. Effect of photoperiod on the seed yield in Vernal alfalfa clonal lines. (Average of four replications in grams)

Clone No.	Short Day	Long Day	Mean	Clone No.	Short Day	Long Day	Mean
1	4.59	4.63	4.61	34	8.61	2.80	5.70
4	3.68	2.90	3.29	36	6.31	5.07	5.69
6	1.15	4.78	2.96	37	5.62	3.68	4.65
9	1.05	6.62	3.84	38	4.00	7.30	5.65
10	1.74	2.79	2.26	39	2.07	11.52	6.80
15	4.60	7.68	6.14	41	1.82	6.95	4.38
16	0.14	0.77	0.46	45	1.94	8.06	5.00
18	3.50	10.94	7.22	46	7.37	5.98	6.68
19	5.54	12.04	8.79	47	0.22	1.24	0.73
21	4.03	5.61	4.82	49	1.32	6.75	4.04
23	1.30	3.92	2.61	51	3.20	6.78	4.99
24	1.46	5.84	3.65	53	1.60	6.55	4.08
25	0.44	3.34	1.89	54	3.68	6.18	4.93
26	5.34	3.62	4.48	55	4.00	3.05	3.52
28	4.10	4.39	4.24	59	11.41	8.68	10.04
29	10.96	6.82	8.89	60	4.92	5.15	5.04
30	13.73	9.58	11.66	61	2.30	2.24	2.27
32	9.52	9.74	9.63	62	1.18	2.92	2.05
				Mean	4.12	5.74	4.90

Least Significant Differences	5%	1%
To compare two clone means	3.39	4.48
To compare two clone means at the same day length treatment	4.80	6.34

Analysis of variance of the seed yield data for Vernal presented in Table 4.

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	3	120.34	3.49
Day Length	1	190.02	5.52
Error a	3	34.45	
Clones	35	52.07	4.38**
Clones x day length	35	24.19	2.03**
Error b	210	11.90	

Table 5. Effect of photoperiod on the seed yield in Ranger alfalfa clonal lines. (Average of four replications in grams)

Clone No.	Short Day	Long Day	Mean	Clone No.	Short Day	Long Day	Mean
1	2.20	9.59	5.90	29	14.16	15.24	14.70
2	10.25	7.06	8.66	30	1.38	7.64	4.51
3	9.32	9.38	9.35	31	7.14	10.77	8.95
4	4.18	6.24	5.21	32	3.83	6.49	5.16
5	11.18	7.99	9.58	34	1.02	5.04	3.03
6	0.76	6.49	3.62	36	7.18	10.53	8.86
7	5.44	5.88	5.66	37	16.49	9.03	12.76
8	0	0.28	0.14	38	6.84	9.24	8.04
11	5.98	2.59	4.28	40	4.20	9.87	7.04
12	0.13	0.28	0.20	41	9.08	8.16	8.62
13	4.68	3.50	4.09	43	8.13	7.09	7.61
14	0.39	3.46	1.92	44	6.84	6.40	6.62
15	1.38	6.87	4.12	45	8.05	11.49	9.77
17	3.04	3.88	3.46	46	2.86	8.05	5.46
18	0.18	3.67	1.92	47	0.08	3.54	1.81
19	3.89	7.87	5.88	48	1.32	5.27	3.30
20	12.81	8.77	10.79	49	1.77	6.34	4.06
22	3.80	8.46	6.13	51	2.36	5.62	3.99
23	7.54	10.04	8.79	52	5.43	12.04	8.74
24	1.28	7.36	4.32	53	10.29	8.29	9.29
26	3.43	3.73	3.58	55	3.04	7.67	5.36
27	4.58	5.39	4.98	56	2.35	4.27	3.31
28	1.83	5.00	3.42	57	0.84	1.81	1.32

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Clone No.	Short Day	Long Day	Mean	Clone No.	Short Day	Long Day	Mean
58	6.74	16.18	11.45	61	5.04	12.59	8.82
59	5.06	7.63	6.34	63	2.92	7.78	5.35
60	0.20	5.05	2.62	64	11.49	13.74	12.62
				Mean	4.80	7.20	6.00

Least significant differences	5%	1%
To compare two clone means	3.81	5.01
To compare two clones means at the same day length treatment	5.39	N.S.

Analysis of variance of the seed yield data for Ranger presented in Table 5.

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	3	130.87	1.23
Day Length	1	564.98	5.29
Error a	3	106.77	
Clones	51	86.84	5.80**
Clones x day length	51	21.69	1.45*
Error b	306	14.96	

Table 6. Summary of the effect of photoperiod on the seed yield of Ranger and Vernal.

Varieties	Short Day	Long Day	Mean
Ranger	4.91	7.24	6.08
Vernal	4.12	4.75	4.94

Least Significant Difference	5%	1%
To compare variety means	1.12	N.S.

Variance analysis for data presented in Table 6.

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	3	5.35	2.87
Day Length	1	15.68	8.41
Error a	3	1.86	
Varieties	1	5.22	6.29*
Varieties x Day Length	1	0.49	N.S.
Error b	6	0.83	

Forage Yield

The data recorded for dry weight of Vernal alfalfa as affected by length of day are presented in Table 7. The average clonal dry weight for Vernal was 94 grams per plant under short days and 72 grams under long days on a single plant. This represents a difference of 22 grams in favor of short-day photoperiods. Under short days, the clones of Vernal showed a range in dry weight from 6 grams to 322 grams and a range from 14 grams to 238 grams per clone under long days.

The analysis of variance of the data in Table 7 supports the following conclusions on the effect of length of day on the dry weight of plants in Vernal. Short days produced significantly greater amounts of dry forage than long days. The wide differences in plant weight between the clonal lines in this variety far exceeded the amounts necessary for significance at the 0.01 point. Finally, the analysis showed that there was a real difference in reaction of certain clonal lines to long and short days.

Since the differences in dry weight of the Ranger clones were small and did not meet the requirements for significance, the data for individual clonal lines are not presented. The average dry weight for long and short day clones was 163 grams and 155 grams, respectively. The analysis of variance for the dry weight data for Ranger is presented in Table 8. This variance table shows that

the differences due to day length, clones and the interaction between clones and day length were all non-significant.

The summary data for plant weight for both varieties is presented in Table 9. There were no significant differences in dry weight due to day length or variety and there was no significance in the interaction between variety and day length.

Ranger and Vernal alfalfa were affected differently by photoperiod so far as dry weight of plants was concerned. The dry weight of Ranger clones was not significantly affected by day length treatments, Vernal clones proved to be sensitive to day length. This may be assumed to be due to the wild yellow flowered Medicago falcata, which is one of the components of Vernal alfalfa. Medicago falcata is known to have the characteristics of being extremely winter hardy (9), and under short days tends to remain in the vegetative condition. Dry weight is important only as it affects seed production and, as already stated, there was no significant differences between photoperiod treatments and total seed yield.

Table 7. Vernal Alfalfa - Effect of photoperiod on dry weight of individual plants. (Average of four replications in grams)

Clone No.	Short Day	Long Day	Mean	Clone No.	Short Day	Long Day	Mean
1	41	50	46	34	176	84	130
4	37	29	33	36	127	94	110
6	75	66	70	37	61	30	46
9	53	92	72	38	142	71	106
10	54	44	49	39	45	91	68
15	120	94	107	41	124	112	118
16	68	80	74	45	90	86	88
18	61	89	75	46	161	93	127
19	97	91	94	47	34	43	38
21	58	46	52	49	31	55	43
23	153	97	125	51	72	62	67
24	85	78	82	53	126	120	123
25	204	152	178	54	101	62	82
26	97	46	72	55	101	70	86
28	86	40	63	59	138	90	115
29	181	63	122	60	35	35	35
30	95	72	84	61	118	50	84
32	102	56	79	62	45	64	54
				Mean	94	72	83

Least Significant Differences	5%	1%
To compare two day length means	20.9	N.S.
To compare two day length means of the same clone	57.7	N.S.
To compare two clone means	38.9	51.3
To compare two clone means at the same day length treatment	55.0	N.S.

Vernal - Analysis of variance of the dry weight data as presented in Table 7.

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	3	6,779.4	2.17
Day Length	1	35,422.4	11.35*
Error a	3	3,121.8	
Clones	35	8,648.0	5.55**
Clones x Day Length	35	2,654.8	1.70*
Error b	210	1,557.3	

Table 8. Analysis of variance of the dry weight data for Ranger.

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	3	10,866.2	8.60
Day Length	1	1,331.9	1.05
Error a	3	1,263.1	
Clones	51	2,704.7	N.S.
Clones x Day Length	51	3,986.3	N.S.
Error b	306	4,430.6	

Table 9. Summary of the effects of photoperiod on the dry weights of Ranger and Vernal.

Variety	Short Day	Long Day	Mean
Ranger	75	78	76
Vernal	94	72	83
Mean	84	75	

Variance analysis for data presented in Table 9.

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	3	181.87	1.20
Day Length	1	273.90	1.81
Error a	3	151.60	
Varieties	1	172.90	N.S.
Varieties x Day Length	1	735.10	3.72
Error b	6	197.60	

were combined at each day length there was no difference in plant height due to day length effect. The difference between varieties was also too small for significance. Varieties times day length indicates significance. This was due to the response of Vernal to day length rather than any influence of Ranger.

The tables (10 and 11) and analyses of variance show that both Ranger and Vernal follow the same trends in plant height as they do in dry weight. The two measurements are, naturally, closely related. Vernal alfalfa was greatly effected by length of day, showing a highly significant increase in height of short-day clones over long-day clones. Clones and clonal interaction with day length also showed a high significance. This difference in plant height for Vernal alfalfa indicates again that there is a factor within the genetic make-up of Vernal that is highly sensitive to day length. This factor is assumed to be the wild Medicago falcata which is known to be extremely day-length sensitive.

The plant height data for Ranger differed from the data for dry weight in clonal variation only. Whereas Ranger showed no significant differences in clonal dry weight due to photoperiod, it showed highly significant differences in clonal variation in plant height due to photoperiod. This was probably due to the fact that some clones produced a relatively few stems that grew to excessive heights. Such clones would not be outstanding in the statistical analysis for weight but would show significance for plant height.

The interaction between clones and day length was not significant, showing that clones produced this excessive height regardless of the photoperiod. In areas such as the Southwest where Ranger and Vernal seed is produced, this difference in plant height is only as important as it affects the seed production. If day length is not a factor in producing tall plants or short plants as the data indicates, it would matter little where the seed was produced as far as plant height is concerned.

Table 10. Vernal Alfalfa - Effect of photoperiod on plant height. (Average of four replications in inches)

Clone No.	Short Day	Long Day	Mean	Clone No.	Short Day	Long Day	Mean
1	25.5	22.5	24.0	34	27.3	22.5	24.9
4	20.3	17.0	18.7	36	28.0	19.3	23.7
6	22.5	19.8	21.1	37	25.8	21.3	23.6
9	24.3	24.5	24.4	38	28.3	22.5	25.4
10	19.0	18.3	18.7	39	21.8	22.8	22.3
15	22.8	20.3	21.6	41	27.5	25.8	26.7
16	21.0	22.8	21.9	45	23.0	21.0	22.0
18	18.8	17.3	18.1	46	28.0	24.8	26.4
19	26.5	21.5	24.0	47	18.0	12.8	15.4
21	26.0	19.5	22.8	49	16.0	20.0	18.0
23	29.3	27.0	28.2	51	24.8	24.3	24.6
24	30.3	28.3	29.3	53	25.0	22.0	23.5
25	20.3	20.3	20.3	54	24.8	21.3	23.1
26	26.3	21.8	24.1	55	21.8	20.8	21.3
28	25.8	22.3	24.1	59	28.0	25.0	26.5
29	33.0	21.0	27.0	60	22.0	19.0	20.5
30	24.0	21.3	22.7	61	21.8	20.8	21.3
32	25.8	21.0	23.4	62	18.0	18.3	18.2
				Mean	24.21	21.41	22.82

Least Significant Differences	5%	1%
To compare two day length means	1.14	2.10
To compare two day length means of the same clone	4.29	5.76
To compare two clone means	3.02	3.99
To compare two clone means at the same day length treatment	4.26	5.63

Vernal - Analysis of variance of the data for plant height.

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	3	147.51	15.83*
Day Length	1	563.92	60.50**
Error a	3	9.32	
Clones	35	76.26	8.12**
Clones x Day Length	35	16.94	1.80**
Error b	210	9.39	

Table 11. Ranger Alfalfa - Effect of photoperiod on plant height. (Average of four replications in inches)

Clone No.	Short Day	Long Day	Mean	Clone No.	Short Day	Long Day	Mean
1	20.0	25.5	22.7	28	22.0	24.8	23.4
2	21.8	21.5	21.7	29	26.0	27.0	26.5
3	26.5	26.0	26.2	30	21.3	25.0	23.2
4	22.8	21.0	21.9	31	19.8	21.5	20.7
5	26.8	27.0	26.9	32	23.8	24.5	24.2
6	22.0	32.0	27.0	34	22.3	24.0	23.2
7	24.0	25.0	24.5	36	26.0	18.8	27.4
8	24.0	27.3	25.7	37	25.8	25.0	25.4
11	19.5	20.5	20.0	38	23.0	23.5	23.2
12	24.8	28.8	26.8	40	21.0	24.8	22.9
13	19.0	18.3	18.7	41	19.5	26.0	21.2
14	14.3	17.0	15.7	43	21.5	22.5	22.0
15	26.3	26.3	26.3	44	20.5	23.0	21.7
17	26.0	24.8	25.4	45	24.8	31.8	28.3
18	19.0	23.0	21.0	46	28.3	31.5	29.9
19	23.3	21.3	22.3	47	22.8	29.0	25.9
20	23.0	23.8	23.4	48	18.3	25.0	21.7
22	25.0	24.0	24.5	49	17.5	20.5	18.5
23	23.3	26.3	24.3	51	21.5	23.5	22.5
24	14.8	25.3	20.1	52	24.8	26.5	25.7
26	19.8	18.8	19.3	53	26.0	22.5	24.3
27	19.8	21.8	20.8	55	23.3	25.0	24.2

(Continued next page)

(Table 11 Cont'd.)

Clone No.	Short Day	Long Day	Mean	Clone No.	Short Day	Long Day	Mean
56	18.3	20.8	19.6	60	20.3	24.0	20.6
57	17.3	20.3	18.8	61	20.8	23.3	22.1
58	24.8	27.8	26.3	63	24.8	30.0	27.4
59	24.3	23.5	23.9	64	26.7	24.5	26.6
				Mean	22.4	24.3	23.4

Least Significant Differences	5%	1%
To compare two clone means	4.93	6.48

Ranger - Analysis of variance of the data for plant height.

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	3	70.67	N.S.
Day Length	1	366.00	1.97
Error a	3	185.67	
Clones	51	62.18	2.49**
Clones x Day Length	51	17.75	N.S.
Error b	306	25.02	

Table 12. Summary of the effect of photoperiod on plant height of Ranger and Vernal

Varieties	Short Day	Long Day	Mean
Ranger	22.43	24.31	23.37
Vernal	24.18	21.38	22.78
Mean	23.31	22.85	

Least Significant Differences	5%	1%
To compare two day length means of a variety	2.60	N.S.

Variance analysis for data presented in Table 12.

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	3	2.47	2.55
Day Length	1	0.86	N.S.
Error a	3	0.97	
Variety	1	1.40	N.S.
Variety x Day Length	1	21.81	7.44*
Error b	6	2.93	

Length of Internode

Tables 13 and 14 show the analyses of the data on length of internode in centimeters as affected by length of day. The average length of internodes for long and short days for both Ranger and Vernal closely approached the same value, showing no significance for either variety. The difference in clones was highly significant for both Ranger and Vernal. The clonal interaction with day length indicated no significance for either variety.

A summary of the length of internode data is presented in Table 15. The analysis of variance for this data indicates than when Ranger and Vernal means were combined, there was no significant differences for day length treatments. The differences between varieties and varieties times day length also was non-significant. As indicated by the analysis of variance, length of day had no affect on length of internode for either Ranger or Vernal, and the length of internode for both varieties approached the same value. Clones showed highly significant differences. These clonal differences are indicated throughout this study and are assumed to be due to the wide variability that is inherent within these two synthetic varieties.

General Discussion

There has been some alfalfa research done on the performance of regional strains of Ranger alfalfa. Little or no work has been done on the performance of Vernal alfalfa

grown out of its region of adaptation.

The results obtained from long-day photoperiod treatments on Ranger alfalfa agree only in part with those reported by other investigators. Murphy and Kohli report that no significant differences of importance were found among several seed increases of Ranger from Arizona, Nebraska and Montana with respect to yield, disease reaction, recovery, stand and vigor, except for a lot of second generation Arizona seed not eligible for certification (12).

The results of this study are the first of their kind. They possibly show why the above investigators did not get differences in yield, etc., when plants from Arizona grown seed were compared with those from Montana and Nebraska seed. The comparison of Ranger and Vernal clones in this study showed some significance as to plant dry weight and height; but neither Ranger nor Vernal showed an effect as to seed yield as affected by growing seed during a short or long-day period.

Table 13. Vernal Alfalfa - Analysis of variance of the data for the effect of photoperiod on the length of internode.

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	3	0.700	N.S.
Day Length	1	0	N.S.
Error a	3	1.813	
Clones	35	3.074	3.42**
Clones x Day Length	35	1.193	1.33
Error b	210	0.900	

Table 14. Ranger Alfalfa - Analysis of variance of the data for the effect of photoperiod on the length of internode.

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	3	8.840	10.61*
Day Length	1	2.230	2.67
Error a	3	0.833	
Clones	51	1.990	2.36**
Clones x Day Length	51	0.867	1.03
Error b	306	0.842	

Table 15. Summary of the effects of photoperiod on the length of internode for Ranger and Vernal.

Varieties	Short Day	Long Day	Mean
Ranger	4.96	5.11	5.03
Vernal	4.91	4.91	4.91
Mean	4.93	5.01	

Variance analysis for data presented in Table 15.

Source of Variation	Degrees of Freedom	Mean Square	F
Replications	3	0.108	27.00*
Day Length	1	0.035	8.75
Error a	3	0.004	
Varieties	1	0.098	2.13
Varieties x Day Length	1	0.035	N.S.
Error b	6	0.046	

SUMMARY AND CONCLUSIONS

An evaluation was made of the effects of photoperiod on fruiting and vegetative characteristics of Ranger and Vernal alfalfa. Plant material consisted of clonal lines selected at random from these two varieties. The study was carried out under field conditions at Tucson, Arizona. Long days were produced by interruption of the dark period with an exposure to artificial light. The factors studied were the length of time from clipping to the appearance of the first open flower, the weight of seed in grams per plant, the dry weight of plants in grams, the height of plants in inches and the length of internodes in centimeters.

The following statements summarize the results obtained:

1. There were significant differences between flowering dates for long and short days. These differences were 2.4 and 3.7 days less under long days for Ranger and Vernal, respectively.

2. The mean amount of seed produced under long and short days showed no significance for either variety; clonal differences were highly significant in both varieties due to the inherent genetic variability of Ranger and Vernal. The majority of the clones that tended to produce abnormally high seed yields did so under long-day periods. Only one-eighth of the clones

produced significantly high seed yields under short days.

3. Long days resulted in a decrease in both plant height and plant weight in Vernal. Ranger gave no measurable response in plant weight or height due to length of day.

4. Photoperiod had no affect on the length of internode for either variety.

The results of this study show that both Ranger and Vernal alfalfa are long-day varieties since long days decreased the length of time between clipping and flowering. It was also demonstrated that Vernal is more sensitive to day length than Ranger. Although the data obtained show these two varieties to be sensitive to day length, there was no evidence to suggest that seed production under the short days characteristic of the Southwest would result in selective seed production by short-day plants.

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