T1966PRO02

SUNFLOWER DEVELOPMENT AT LATITUDES RANGING FROM 31 TO 49 DEGREES

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The objective of this cooperative study among nine experiment stations was to determine whether there is a relationship between geographical latitude and size of sunflower plant, time of bloom, and growing degree-days from planting until bloom.

Five to eight varieties* of commercial or breeding importance were planted May 14, 1965, at the nine locations in Table 1. Another planting was made at practical dates for the latitude at four locations. Seed was soaked 24 to 48 hours before planting so that imbibition of water was similar at all locations. Where necessary, fertilizer and irrigation were used to give normal growth from planting until flowering.

Table 1 Latitude and daylight duration at nine locations

Location	Latitude°	Daylight, hrs. 4/21	Daylight, hrs. 6/21
Tex.	31	13.1	14.2
Okla.	36	13.3	14.6
Kans.	39	13.5	14.9
Neb.	41	13.6	15.1
S. D.	44	13.7	15.5
So. Minn.	45	13.8	15.6
N. D.	47	13.9	15.9
No. Minn.	48	14.0	16.1
Morden	49	14.1	16.2

With fertilizer and water in adequate supply, effects of latitude on sunflowers might be attributed to photoperiod and temperature differences associated with latitude.

Daylight duration differences among latitudes appear relatively small -- 2 hours June 21 and 1 hour April 21. However at normal planting dates, daylight duration when photoperiod effects occur may be over 3 hours longer in the north than in the south. Growing degree-days using bases from 35 to 45F by 1 degree increments were calculated daily for each variety at each location for the planting to ray flower period.

* The term, variety, is used as defined in the International Code. Six inbreds, one hybrid, and one open-pollinated variety were included.

Obviously growing degree-days and days to ray flower appearance were highly correlated by variety and had a correlation coefficient of .999 at all temperature bases. However when correlated by location in Table 2, the correlation coefficient was -.85 (P .01) at 45F base, declined to -.78 (P .05) at 43F, became non-significant but still negative at 41F, and though still non-significant was positive at 36F. Therefore whether growing degree-days decreased, varied about an average, or possibly increased from south to north was dependent upon the temperature base chosen.

Table 2. Effect of various base temperatures on number of growing degree-days from planting May 14 to ray flowers appearance

	Growing degree-days			
Latitude°	45F	43F	41F	36F
31	1741	1849	1957	2227
36	1831	1947	2063	2353
39	1806	1938	2070	2400
41	1706	1840	1974	2309
44	1675	1823	1971	2341
45	1586	1738	1890	2270
47	1492	1652	1812	2212
48	1583	1751	1919	2339
49	1541	1721	1901	2351
r (GDD and rays, days)	-.85**	-.78*	-.65	+.09

Growing degree-days are frequently used to predict various stages of crop growth. Based on experience with sunflowers and knowing that bases of about 40F for peas and some small grains and about 50F for corn are commonly used, 45F was considered a reasonable base temperature. For varietal comparison or descriptive data at a location, any reasonable base temperature was satisfactory. However, for comparisons involving locations differing in latitude, conclusions based on growing degree-days to sunflower bloom were unsatisfactory because they could be altered by changing the base temperature.

Analyses of variance indicated that locations differed significantly for days from planting to emergence, days from emergence to ray flowers, days from planting to ray flowers, plant heights, and leaves per plant. The three periods -- planting to emergence, emergence to ray flowers, and planting to ray flowers-- increased greatly from south to north. Data for the planting to ray flower period are shown in Table 3. The regression equation of days from planting to ray flowers on location latitude indicated that days to ray flowers on the average tended to increase nearly 2 days for each degree latitude northward, and the correlation coefficient was .97 (P .01).

To study the association among latitude, days to ray flowers, and growing degree-days, partial correlation coefficients were calculated. The partial correlation coefficient between location latitude and days from planting to ray flowers was .92 (P .01) eliminating effect of growing degree-days (45F base).

Whereas the partial correlation coefficient between growing degree-days and days from planting ray flowers was -.36 (NS) when effect of location latitude was eliminated. Thus even using 45F base, differences in growing degree-days among locations did not conyribute to the differences in number of days to ray appearance above that accounted for by location latitude.

Table 3. Relationships between latitudes, days to ray flower appearance, growing degree-days (45F base), heights, and number of leaves

Latitude°	Planting to rays, days	GDD	Height inches	Leaves/plant
31	54	1741	52	32
36	58	1831	43	30
39	66	1806	43	25
41	67	1706	64	30
44	74	1675	35	30
45	76	1586	51	29
47	80	1492	67	33
48	84	1583	55	30
49	90	1541	52	30

Height and leaves per plant data in Table 3 reveal no trend associated with location latitude. This is quite significant when compared with the trend of the days to ray flower data in the table. Morphologically, photoperiod influences changes in the terminal bud. Foliage leaf differentiation is replaced by differentiation of inflorescence and reproductive organs. Therefore differences in photoperiod response might be reflected in leaf numbers per stem. For the May 14 plantings, the June 21 daylight duration column in Table 1 exemplifies the photoperiod differences among locations. Within this 2-hr range of photoperiod and differing environments, all varities reacted morphologically as day neutral, since there was no latitudinal trend for differences in leaves per stem, and no significant varieties x locations interaction was shown. The lengthening of the three periods of growth studied from south to north may have been due to temperature gradient.

When practical dates of planting among locations were compared, the range of daylight duration differences was over 3 hours. Under this range of photoperiod, three related varieties (inbreds)-- HA6, HA7, HA43 -- tended toward a "short day reaction". Data from the April 5 planting in Texas and the May 14 planting at Morden are shown in Table 4 as these locations represent extremes in latitude.

All varieties took more time from planting to ray flowers at Morden. However HA6, HA7, and HA43 were earlier than T56002 and S-37-388T2 and about the same as S-37-388T1 and Arrowhead in Texas, but they were the latest varieties in the north. Similarly, leaves per plant were higher in Texas for all varieties except HA6, HA7, HA43, and CM95. CM95 varied little in leaf number and fit no consistent latitudinal pattern.

The "short day reaction" of HA6, HA7, and HA43 is further supported by the leaves per plant analysis of early and later dates of planting in Texas, Minnesota and the Dakotas. The varieties x locations interaction was highly significant because HA6, HA7, and HA43 had fewer leaves in Texas, relative to the other varieties, than at the northern locations.

Table 4 Comparative growth of sunflower varieties planted April 5 in Texas and May 14 at Morden

	Planting to rays, days		Leaves/plant	
	Texas	Morden	Texas	Morden
HA6	62	105	31	33
HA43	58	102	25	37
HA7	59	99	28	37
T56002	64	88	40	32
S37-388RRT1	62	85	31	23
S37-388T2	67	86	36	29
Arrowhead	58	81	35	29
CM95	47	73	20	21

It is recognized that the varieties x locations interaction in leaves per plant might be attributed to differential response to temperature, photoperiod, or a temperature-photoperiod relationship. Hence the term "short day reaction" is used to describe morphological response and does not imply physiological classification.

In using these inbreds for hybrid seed production, latitude and planting date are important considerations. Unusual planting dates are sometimes used for commercial sunflower production such as July planting to escape diseases and insects in some southern and central states. Seed increases are sometimes made in the winter in Florida. Investigation of photoperiod-temperature response of other sunflower germplasm might reveal more variation than has previously been suspected and lead to useful application.

Grateful acknowledgment is made to L. A. Bernat, H. A. Geise, F. K. Johnson, M. L. Kinman, E. L. Mader, R. M. Oswalt, E. D. Putt, C. M. Swallers, and J. H. Williams for their contributions to this study. A paper under joint authorship is being submitted for publication.

DISCUSSION

Robinson: May I bring one thing up. This is not on the program but I think this conference could settle it in a few minutes. Is this crop we are talking about a singular or a plural? Now we avoid the situation many times by saying sunflower crop. I noticed that Mme. Pustovoit in her talk used the plural form. That seems to be fairly commonly used. I wrote an article once on sunflowers and safflower. I used the singular form sunflower and safflower. One of the reviewers insisted it be changed to sunflowers and safflower. This is confusing - just what is correct? It would be much simpler in writing to use the singular. Then the question of plurality would never arise. With oats and soybeans we always have the question of "oats is", or "oats are". Using sunflower we would be in a similar situation to using wheat. I'd like to know what the group thinks on this.

Putt: I won't try to say which is correct but in our usage in Canada it is "sunflower crop", or if the word stands along the plural form "sunflowers". You speak of the oat crop but when the word "oats" stands alone it is never thought of as the singular in my recollection. I think you have a precedent with respect to "oats" and "oat crop" or "soybeans" and "soybean crop".

Robinson: What about safflower and wheat.

Putt: These are things that have been established over the years. I am not saying that they are correct but I think that we have precedents - that we should follow within crops and admit that there is variation between crops.

Kinman: I do have one comment on Dr. Johnson's report and it plays a little bit into Dr. Heiser's field. Dr. Heiser has inferred, at times at least, that the Texas Wild sunflower carries some genes or fragments of chromosomes from the Helianthus argophyllus. The H. argophyllus as known in Texas is very definitely photoperiodic. It does not flower until after September 21st. I understand there is a different form in Florida but the one that would most likely be introgressed in Texas Wild annuus is definitely photoperiodic. Now these three lines that Robinson mentioned that look like they might be photoperiodic or short-day types do trace to the Texas Wild and a few generations of open pollination at Morden. The rest of the material except for the hybridsthat involve these three lines are mostly from western Europe and was later carried to Russia and has had many years to get away from the photoperiodic response. This may play into your hand on the evolutionary standpoint, Charlie.

Panchenko: Concerning the influence of day length on the sunflowers, it must be recognized that every commercial variety of sunflower is very complex and consists of many biotypes, e.g., if we take the variety Peredovik in natural conditions the length of flowering is approximately 10 days; the first plant begins to flower 15 July, the last plants will flower 25 July. When you put many plants in short days, 9 hours daylight and they rest at night flowering period will be 30 maybe 35 days. If you take the first flowering plants and last flowering plants from this variety and study their requirement for length of day you may find that the first will be short-day plant and the last will be long-day plant. It is very important to judge your results on the basis of when you started the influence of long day on the sunflower.

Robinson: I should say that this study was conducted on individual plants, and the extremes of the variety were not used. This was the average response of the variety to answer this practical question. The second point I would like to make is that I pointed out the range of photoperiod or daylight duration at planting was about two hours at the extreme. Physiologic studies do not apply to this, to the practical problem because we do not get a 9-hour day - a 9-hour day is outside of our growing season. So the typical physiological study where they use a short-day plant, i.e.

below a 12- or 14-hour photoperiod really does not apply here because all of the day lengths we encountered were really in the long-day range. I recognize your point but this was a practical study to answer the practical question and we were operating in the long-day range not in the short-day range.

Panchenko: I made my remark from the point of view of plant physiology only. It may be useful for your next studies.

Robinson: Correct. I appreciate the comment and I wanted to be sure that I understood that the short-day range as used by physiologists quite often applies to these 9- or 10-hour days which do not apply to our field conditions. The next step would be interesting, namely - to try some laboratory trials using these very short days.

Kinman: I would like to make a little explanation for Dr. Panchenko. Almost all of the materials in this study were inbred lines, not varieties. There was one hybrid, an F_1 hybrid between inbred lines and one variety but I do not think you showed the variety on there did you, Bob? There was actually only one variety in the sense that you think of varieties and, a much more narrowly based variety at that, than the ones you, Dr. Panchenko, think of as varieties. Actually we do not consider the Russian varieties as varieties but as populations. They do not fit our concept of a variety or at least our past concept of varieties. We are probably changing this concept.

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