Interrelation of the Effects of Daylength on the Period to Flowering, Flowering Period, and Seed Forming Period, with Special Regards to the Relative Flowering Period and the Relative Growing Period of Soybeans

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As emphasized in the former report (NAGATA 1950), soybeans vary in the relative flowering period and the relative growing period compared with the period from emergence to flowering, and the said properties have intimate relation to the distribution of soybeans in Japan and the world (NAGATA 1959, 1960). Nevertheless, the factors giving rise to these varietal differences have not been clarified to date. PARKER and BORTHWICK (1951) and FUKUI and YARIMIZU (1951, 1952) dealt with the problem of the effects of daylength and temperature on the growths of pod and seed, and maturity. They observed that the daylength was a more marked factor affecting those growing processes than the temperature. Other researchers have also observed the effect of temperature at night on the seed formation or fructification (FURUTANI 1950, TAKESHIMA 1952, TANDA 1952). Above all, FUKUI and YARIMIZU (1951, 1952) suggested that the long seed forming period of soybeans belonging to the summer soybean type or the intermediate type was attributable to their high sensitivity to photoperiod during the seed forming period.

The author carried out several experiments on the relative periods of soybeans mentioned above, and found some correspondence of the determinate vs. indeterminate growth habit, seed size, and photoperiodic perception to the relative periods. The results obtained from the experiments are reported in this paper.

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Materials and Methods

The experiments were conducted in 1953 and 1954, in the Hyōgo Agricultural College. In 1953, nine representative varieties were planted on April 20, and grown under 10-hour daylength till June 15, 7~10 days prior to flowering. Then each variety was divided into the plots of 10-, 12-, 14-, 16-, and 18-hour daylengths. Besides, the same series of materials were planted on June 25, and grown under the same daylengths mentioned above. Each

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plot of the experiment consisted of two earthenware pots of 21-cm diameter having three plants per pot.

In 1954, 49 varieties in total, representatives of the same habits as in the 1953 experiment, were tested as follows:

Planted on May 5:

Plot 1. 10-hour daylength from emergence to maturity.

Plot 2. 10-hour daylength from emergence to a week prior to flowering (June 25), 14.5 hour daylength thereafter.

Planted on June 20:

Plot 3. 10-hour daylength from emergence to flowering.

Plot 4. 14.5-hour daylength from emergence to flowering.

Thus, the experiment was designed to estimate the effects of daylength on the flowering period and the seed forming period from comparisons between plot 1 and 2, and the effect of daylength on the flowering at the same temperature as on the said two periods from plot 3 and plot 4, and then the daylength controls in plot 2, 3, and 4 started on the same day. Each plot also consisted of two earthenware pots of 21-cm diameter, and two or three plants were planted in each pot.

Results

(1) Effects of the daylengths at successive interval on the representative varieties.

As shown in Fig. 1, the flowering period and the seed forming period seem to behave in a similar way to the days to flowering, and the critical daylength for such growing stages was observed to be over 18, 16, and 14 hours for summer, intermediate and autumn soybean types respectively, as presented on the former data (NAGATA 1951). The former two periods, however, have more clear threshold daylength of the effect of the treatment than the latter, that is, they are likely to take a sudden leap being beforehand with the critical daylength.

In a more detailed observation, it is found that some varietal difference on the relation between the effects of daylength at different growing stages is significant. The indeterminate soybeans, Zi-hua No. 1 and Sooty, are more sensitive to daylength in the flowering period and the seed forming period than in the days to flowering, whereas the determinate and small seeded soybeans, Wasedaizu No. 3 and Mizukuguri, respond in the same way in all of the three periods. Such a varietal difference is an expected result from the previous experiments, while the separated group of the determinate and large seeded soybeans, Oyazi No. 2 and Mejiro No. 1, did not behave consistently, that is, the former tends to respond somewhat more sensitively in the seed forming period than in the other two periods, but the latter appears to be more sensitive to daylength in both of the flowering period and the seed forming period than in the days to flowering.

Moreover, the autumn soybean types including the above three types shown in the figure did not show any significant varietal difference and behaved in the same way as in the indeterminate soybeans, that is, they were sensitive to the daylength in the flowering

period and the seed forming period than in the period to flowering.

In spite of the inconsistency in some part discussed above, several conclusions may be made as follows:

i. The differences in the lengths of flowering period and seed forming period between the three groups under the daylength shorter than the critical length were observed to be fairly significant as mentioned previously, that is, the indeterminate soybeans had longer flowering and seed forming periods, and determinate large seeded soybeans had a longer seed forming period than the determinate soybeans of small seed.

ii. Such significant differences were extended to medium long day (16~18 hours) in the summer soybean type, but were limited within a more short daylength in the intermediate and autumn soybean types, in parallel with their critical daylengths.

Hence, the autumn soybean type did not show the varietal differences in the lengths of the periods or relative period suggested by the author under the phenological variation of daylength in the season.

iii. The effects of the daylength on the said periods differed with the varieties, that is, they were more significant on the flowering period and the seed forming period with the indeterminate soybeans; on the seed forming period only with the determinate and large seeded soybean than on the period to flowering; and no difference between them on the three periods with the determinate and small seeded soybean.

iv. Such difference in the daylength effects is

Fig. 1. Comparison between the effects of daylength on the flowering, the flowering period, and the seed forming period.

distinct among the summer soybean types of long critical daylength, and becomes obscure in the autumn soybean types in parallel with their short critical daylength. Such a tendency seems to be a factor of no difference of the relative periods between the autumn soybean types.

Thus, in this series of experiments, the relations between the flowering and the seed forming period, as affected by the daylength, summer vs. autumn soybean habit, determinate vs. indeterminate growth habit, and seed size, were also clarified fairly well.

(2) Effect of definite daylengths on many varieties of soybeans

Some questions, however, remain obscure on such relations in the intermediate soybean types as noted above. Consequently, the experiment using many varieties, 49 in total, was pursued in 1954 under 14-hour daylength, which is near the threshold daylength in the intermediate types, and 10-hour daylength.

In the experiment, the number of days to flowering under 10-hour daylength was limited within the range from 36 to 46 in April planting, and from 21 to 31 in June planting. This number of days did not appear to be different between the determinate and the interminate soybeans or between the large and the small seeded soybeans. While, the varietal associations already shown in Fig. 1, that is, the long flowering period and the long seed forming period with the indeterminate growth habit, and the long seed forming period with the large seed, were ascertained with many varieties under 10-hour daylength as shown in Table 1. From the result, it may be concluded that soybeans with different growth habits and seed sizes have different flowering periods and seed forming periods under short daylength from one another.

Subsequently, the relation between the sensitivity to daylength of the period to flowering and that of the flowering period or the seed forming period are presented in Fig. 2 in comparison between the sensitivities under 14.5- and 10-hour daylengths. As a general rule for all the soybean varieties, the flowering period and the seed forming period vary in parallel with the period to flowering, viz. in positive correlations, according to the daylength. However, the flowering period of indeterminate soybeans (Fig. 2, left) and the seed forming period of the said soybeans and large seeded soybeans of determinate growth habit (Fig. 2, right) tend to be affected more significantly by such daylengths than

Table 1. Varietal differences in the flowering and the seed forming periods under short daylength (10 hours)

Variety	15	20	25	30*	Total	Mean
Determinate						
Small seeded	7	7	1		15	20.18
Large seeded	2	10	4	1	17	21.55
Indeterminate	3	6	7	1	17	24.66
L. S. D. at 5% level						1.65
" 1% level						2.07

* Number of days for flowering period in April planting

Variety	35	40	45	50	55	60	65	70*	Total	Mean
Determinrte										
Small seeded	6	7	2						15	41.15
Large seeded	1	5	3	4	1		1	1	17	49.95
Indeterminate		4	11		1	1			17	47.75
L. S. D. at 5% level										2.53
" 1% level										3.10

* Number of days for seed forming period in April planting

Fig. 2. Relations of the number of reduced days for the period to flowering to those of the flowering period and the seed forming period in comparison between two daylengths (14.5 hours-10 hours)

Fig. 3. Schematic illustration of the effect of daylength on the flowering, the flowering period, and the seed forming period, with special regards to its varietal difference

other soybeans of determinate and small seeded habit.

In a more detailed illustration, it is emphasized in the figure that the flowering period of the indetermined soybean was affected more largely by the daylength than the others belonging to the summer soybean and the intermediate types, viz., early and medium flowering soybeans, and that the seed forming period of indeterminate soybeans and determinate large seeded soybeans was affected more than the determinate small seeded ones belonging to the summer soybean and the intermediate types. Nevertheless, in the autumn soybean type, namely, the very sensitive soybeans to daylength or the soybeans of late flowering, those variations among the three groups did not appear, because, as mentioned previously, the highly sensitive property to daylength of the soybeans masks the attributes of indeterminate growth and large seeded habits.

The diagram in Fig. 3 seems to make easy the understanding of the effect of daylength on the different growing stages of soybean varieties in relation to the varietal difference between the relative flowering period and the relative growing period in fields.

Summary

In order to make it clearer to understand the varietal difference of the relative flowering period and the relative growing period, and the interrelations to other characters, the effects of daylength on the flowering period and the seed forming period were studied in the experiments of 1953 to 1954.

1. The daylengths from 10 to 18 hours appeared to have greater effect on both of the said periods than on the period to flowering at hours of threshold shorter than the critical daylength. Such an effect differed between the varieties in parallel with the lengths of the periods under short daylength, that is, great on the flowering and the seed forming periods of indeterminate soybeans and the seed forming periods of determinate large seeded soybeans, while less on both of the periods of determinate and small seeded soybeans.

2. The difference in the effect of daylength mentioned above was clear between the soybeans of summer soybean type and intermediate type due to the sudden leap of the period at the threshold daylength.

3. Such results seem to make it easy to consider the varietal difference in the relative periods and the interrelations to determinate vs. indeterminate growth habit and seed size under natural daylength in fields, as shown schematically in Fig. 3.

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大豆の開花日数、開花期間、結実日数に及ぼす日長の影響の相互関係、
特に関係開花期間、関係生育日数の品種間差異との関連について

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既報の関係開花期間、関係生育日数の品種間差異、並びに他形質との関連を明らかにするために、1953、1954両年度に亘り、開花日数、開花期間、並びに結実日数に及ぼす日長の影響の相互関係を検討した。

1) 10~18 時間の間の各種の日長は、その品種の閾値の附近では、開花日数より開花期間、結実日数に著しい影響を及ぼした。しかし、その程度は先に述べた短日条件下の開花期間、結実日数の長短と関連が認められた。すなわち、無限伸育性品種は、短日条件下で開花期間、結実日数ともに長い、それらの影響もまた両期間のいずれにも著しい。短日条件下で結実日数のみ長い、

有限伸育性で大粒の品種は上記日長の影響が結実日数にのみ著しかつた。短日条件下で両期間ともに短かい有限伸育性小粒の品種は、開花日数、開花期間、結実日数のすべてにはほぼ同じ程度の日長の影響が認められた。

2) 上記、各種生育段階に及ぼす日長の影響の品種間差異は、夏大豆型及び中間型に顕著であつたが、秋大豆型は、すべての影響が閾値の附近で急に増加するため、明瞭な品種間差異を示さなかつた。

上記の結果は、圃場、すなわち、自然日長の季節的変化の下における関係開花期間、関係生育日数の品種間差異をよく説明することができる。