Observations on plant development (V) Influence of time of sowing on the development of some annual hibernating plants

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Observations performed on some dozen annual hibernating plants (A. Listowski and I. Jackowska 1961 and A. Listowski and A. Jeśmianowicz, 1960) have demonstrated the fundamental importance of the interaction of daylength and light intensity for the growth and development of plants belonging to this biological group.

In order to analyse this influence in detail several series of experiments have been undertaken:

- 1) on the development of several species sown at various dates;
- 2) on the influence of light of lowered intensity on plants sown at the time most favourable to their development.

Experiments concerning dates of sowing were carried out with *Centaurea cyanus*, *Agrostemma githago*, *Delphinium consolida*. The seeds were obtained from plants uprooted in the fields in winter and transferred to the glasshouse. Dates of sowing: May 9, June 6, 20, July 4, 18, August 1, 14, 29, September 12, 26, October 10, 24, November 7, 21. Moreover *Centaurea cyanus* was sown analogously in pots in the glasshouse on August 6, 29, October 24, November 7 and December 12.

Centaurea cyanus

Field series. Plants sown at later dates developed before the winter as follows:

sown on Aug. 29, Sept. 12 attained rosette stage, flowered in the next year

sown on Sept. 26, Oct. 10 the cotyledon stage, flowered in the next year (part of the plants died)

sown on Oct. 24, Nov. 7 germinated in winter in a warmer period at the end of January

sown on Nov. 21 did not germinate before spring (April 10).

Table 1
Centaurea cyanus

Date of sowing	Count of days from sowing to full germination	Count of days from germination to		Average number of flowers on 1 plant*	Average height in cm	Remarks
		beginning of flowering	full bloom			
May 9	5	37	55	203.2	73.0	Budding and coming into flower quite uniform. All plants flowered
May 23	7	40	52	110.8	62.0	
June 6	4	38	45	85.7	57.8	
June 20	5	34	51	37.7	57.0	Marked individual differences in time of budding and of coming into flower between the plants. Most plants flowered
July 4	6	37	75	26.1	50.1	
July 18	5	46	76	—	—	
August 1	7	82	—	—	—	The majority of plants formed buds, a part flowered
August 14	4	o-sp.	—	—	—	Sporadical budding and coming into flower

* To the end of the vegetation period.

The plants of all these series came into flower in June at about the same time.

Glasshouse series. The plants grew in the glasshouse the whole time under natural light without additional illumination. Dates of sowing:
Aug. 6, 29

Most plants formed thin, densely leafed stems. The majority of plants died in the first winter months. The few that survived lost almost all leaves. In February they formed a new rosette at the top of the old stem and the growth of a new stem started. Normal buds formed in April.

Oct. 24 — Nov. 7

Most plants develop only rosettes. Older leaves die while new ones develop continuously, though their growth is very slow. In March the plants form stems with simultaneous intensive development of leaves and lateral shoots also densely leafed. The plants sown on November 7 were particularly well developed vegetatively. In the first half of April budding was general.

Nov. 21 — Dec. 5

Densely leafed rosette develops. In March stems are formed, not high, multiply branched with dense leafage. The own life of the leaves is long. Budding in the beginning of April.

As compared with the plants sown in December under continuous illumination these plants show vigorous vegetative growth and a prolonged growth stage.

The plants of all series began to bud and flowered at the same time.

Agrostemma githago

Field series. The period favourable for sowing, which ensures a quick and uniform development of the plants is relatively short. This is in agreement with the previously established greater sensitivity of the corn cockle to daylength as compared with the cornflower.

Table 2

Agrostemma githago

Date of sowing	Count of day from sowing to germination	Count of day from sowing to			Remarks
		beginning of budding	beginning of flowering	full bloom	
May 9	5	60	65	88	Budding and flowering uniform. All plants flowered
May 23	7	52	62	90	
June 6	4	75	89	116	Budding and coming into flower very slow, part of the plants flowered
June 20	5	67	88	110	

Seeds sown on July 4 did not germinate, those sown later up to November 12 developed rosettes before the winter, when sown at still later dates they germinated, but those sown last on November 21 only managed to develop cotyledons.

All plants sown late hibernated well and flowered between June 20 and 25 independently of the series to which they belonged.

Delphinium consolida

Field series. Series sown on June 20, July 4, 18 did not germinate, those sown on November 7, 21 germinated in spring.

Series sown on August 1, 14, September 12 and October 10 developed before the winter rosettes with a varying number of leaves.

The latest series developed cotyledons.

Table 3

Delphinium consolida

Data of sowing	Count of day from sowing to germination	Count of days from germination to			Remarks
		beginning of budding	beginning of flowering	full bloom	
May 9	16	49	60	98	All plants came into flower
May 23	15	51	59	98	
June 6	10	83	97	—	Part of the plants came into flower. Wide differences in the development rate

The series sown on October 24 germinated in winter. All series hibernated and flowered uniformly in the end of June.

DISCUSSION OF RESULTS

Conditions favourable to harmonious growth and development arise when the plants begin their development cycle with the gradually increasing daylength and light intensity. When sown after mid summer — in the long day period but on its weaning with simultaneous gradual decrease of light intensity — the plants pass through all normal development stages in a continuous manner, nevertheless the delay in passing to the generative stage becomes more and more pronounced (with later date of sowing the growth and differentiation of leaves slows down) and simultaneously the intensity of flowering diminishes. Moreover the differences in the development rhythm of the particular plants become more distinct.

When sown at still later dates the plants develop before winter only rosettes consisting of a large quantity of leaves.

One might think that, beside the light conditions, the influence of decreasing temperature may play a role here. Nonetheless observations

in the glasshouse on various plants (described below in the case of *Centaurea cyanus*) indicate that it is the light conditions that are of greatest importance in plant development.

Centaurea cyanus sown in August passes in the glasshouse from the rosette stage to stem formation, it does not, however form buds. The latter appear only in spring after a secondary stage of growth and differentiation of leaves. Plants sown in autumn develop rosettes exclusively, then their growth ceases, in spite of favourable temperature conditions. The plant starts growing once more in the second half of winter and finally forms stems and buds.

The development has a continuous character when the plant begins its growth at a period close to optimum light conditions or when the curve characterizing changes in these conditions is in ascendance. If however, development occurs (in the considered ecological group) under conditions corresponding to the descending part of the curve, the growth is first retarded, then "intermittent" in the sense of an "arrest" in growth first at the stage of stem and with further decrease of daylength and light intensity — at the stage of rosette; the latter reaction in our conditions would have a distinctly adaptive character.

The minimum height of the threshold of reaction to light conditions in the sense of further developmental differentiation enabling its transgression would be different for the individual stages and also for various biotypes.

Moreover, when the plants are sown at later dates, though still in the summer season, the period between bud formation and their coming into flower is prolonged as confirmed by the data of Went (The Exper. Control of Plant Growth 1957 p. 204) who established that optimum conditions for bud formation are different than those required for their quick development.

The winter hardiness of all three species and particularly of the corn cockle and the cornflower is very high. This feature is characteristic of these plants at various developmental stages as well as of their various organs. Plants which entered into winter in the cotyledon stage hibernated similarly as those which were in the much more advanced rosette stage. The cold tolerance of such generally delicate organs as buds and flowers is most surprising. On October 5 snow fell and the temperature reached -5°C . Some of the *Centaurea* and *Agrostemma* series were then at the flowering stage but neither buds nor flowers were damaged. When warmer weather returned the buds developed into normal flowers.

REFERENCES

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