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Observations on the development of plants XVI

Developmental rhythm and flowering of Setaria glauca

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Setaria glauca, an annual plant flowering in natural conditions in July—August is a common weed in cereal and root crops.

Observations were made of the developmental rhythm of this plant under various light conditions:

a) in chambers with continuous daylength of 8 and 19 hrs (fluorescent tubes, 4000 Lux, chamber temperature 22—26°);

b) in a glasshouse under natural waning (seeding date Sept. 23) and rising daylight (seeding Jan. 13), ambient temperature not less than 14°.

The plants grew under natural (N) varying light, short 8-hr day (N_8) and daylight prolonged by means of 500 W lamps to 16 hrs N_{16} as well as under continuous daylight (N_{24}).

The plants sown in January sprouted rapidly and uniformly, those seeded in autumn were retarded (up to one month) and sprouted unevenly. It was therefore difficult to select plants in the same development phase.

The observations comprised: the date of appearance of the successive leaves one the main culm, the rhythm and intensity of development of the axillary shoots, the date of heading of the main and lateral shoots, analysis of the ear structure.

The results are compiled in the tables and graphs.

The habitus of the plants is shown in photos 1—4.

The light conditions exert a marked influence on the whole course and character of development, producing wide differences in the habitus of plants from various combinations (photos 1—5).

Under short day the transition of the plant to the generative phase is greatly accelerated and most uniform (with small individual differences). The intensity of growth is low and the length of the growth period greatly diminishes. The plants are small with short and thin culms bearing few small leaves. The lateral shoots are not numerous and develop late. The ear is reduced to some dozen flowers (and seeds). In extreme cases underdevelopment of the ear was also observed.

Photo 1. Plants seeded in autumn (Sept. 23) growing in glasshouse under various light conditions (from left to right N, N_8, N_{16}, N_{24} photo taken on Jan 8)

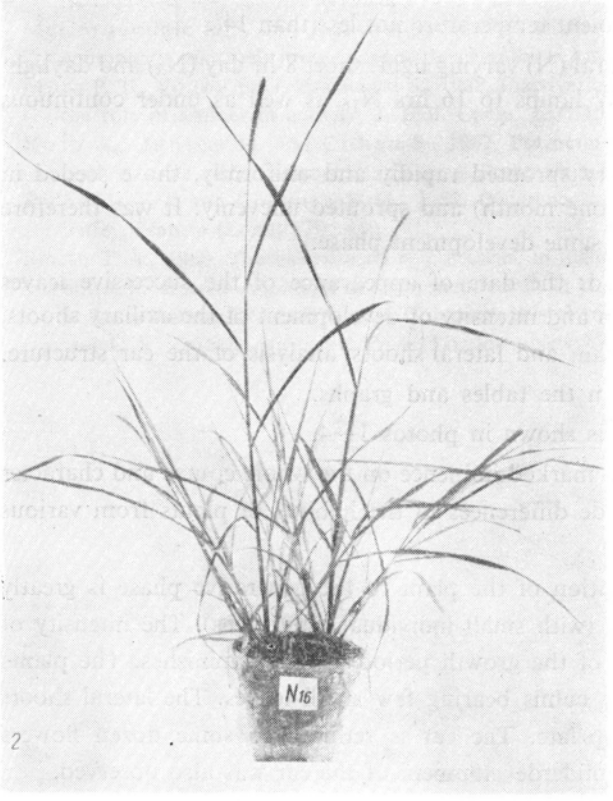


Photo 2. Plant from second (winter) seeding growing in glasshouse under daylight prolonged to 16 hrs (after heading)

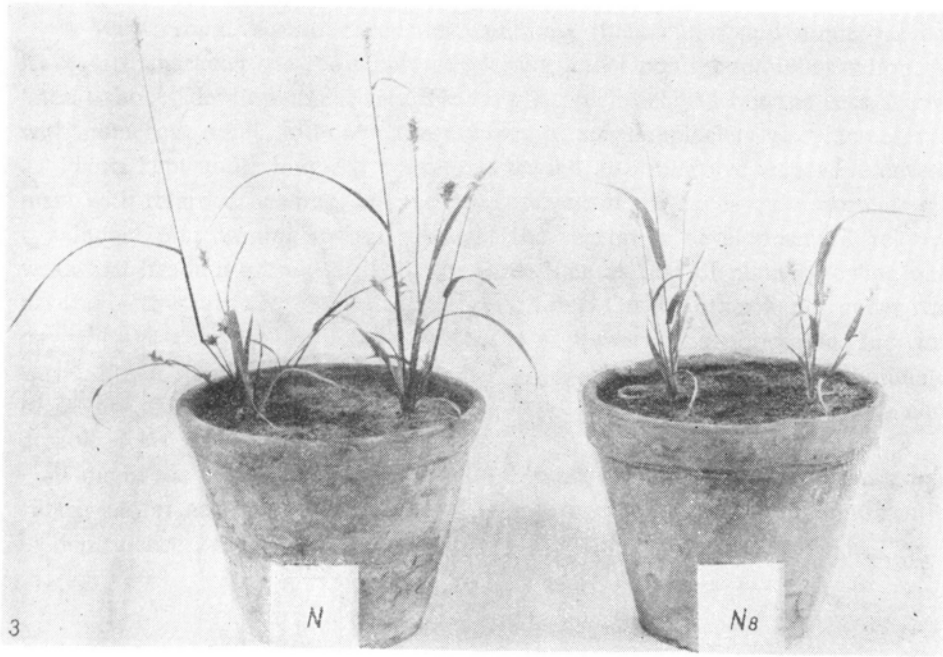


Photo 3. Plants of N and N_8 combination from winter seeding after heading

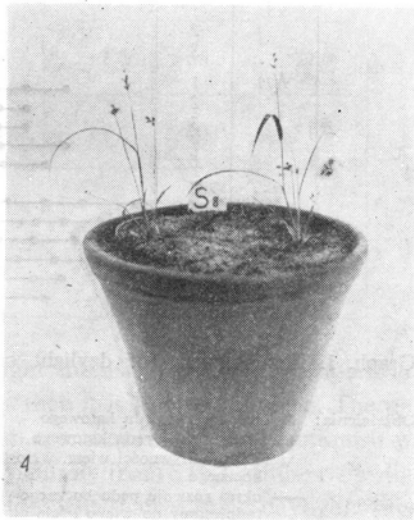
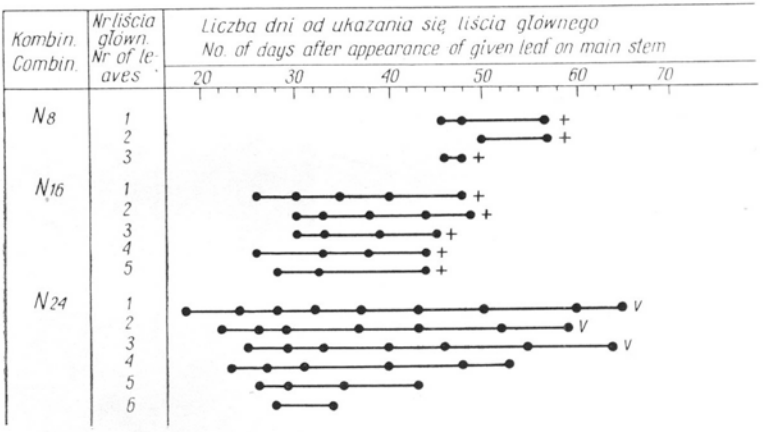


Photo 4. Plant growing under S_8 in light chamber

Photo 5. Plant growing under L_{19} in light chamber



Graph. 1. The influence of daylight on the number of leaves, axillary shoot growth and heading

Objaśnienia:
- kolejny liść pędu kątowego
- \+ kłoszenie się pędu kątowego
- V Zanik aktywności wierz. wzrostu pędu bocznego
- —— okres rozwoju pędu bocznego (odniesiony do wieku liścia głównego)

Legend:
- successiwe leaf of axillary shoot
- \+ Heading of axillary shoot
- V Cessation of apex activity of axillary shoot
- —— Period of development of axilary shoot versus age of leaf on main clum

A very strong vegetative development, long thick culms and numerous large leaves are characteristic for plants developing under continuous illumination. The lateral shoots develop intensively. Heading is much delayed but the ears are long with numerous seeds, although the number of sterile spikelets also increases.

Plants kept under long-day conditions exhibit also intensive vegatative development with retarded heading, but the development of the ear is quite normal.

Under 16-hr waning natural daylight the vegetative development is relatively weak and heading occurs at about the same time as that of plants growing under natural — thus already short daylight conditions. On the other hand, under rising daylight the delay in the time and course of flowering is noticeable. Individual variations in the time of heading are more frequent. Prolongation of illumination to 19 hrs daily with light of low intensity produces vigorous growth and a considerable delay in heading.

Thus in the long-day combination the character of the reaction of plants, particularly as far and heading is concerned, undergoes most important modifications in dependence on the light intensity and length of exposure to daylight.

Table 1

Time of heading of main culm

Combination		No. of days from appearance of lst leaf to heading (usually)		No. of leaves developed to heading (usually)		Mean length of main culm cm	
Seeding date		autumn	winter	autumn	winter	autumn	winter
glasshouse	N_8	31	47	5	6	9,8	8,1
	N	38	44	5	6	10,4	19,5
	N_{16}	38	75	8	12	55.5	77.0
	N_{24}	62	82	$\geqslant 12$	14	60.0	81.0
light chamber	S_8	42		5		9.3	
	L_{19}	104		14		47.1	

The interaction between daylength and light intensity is, however, noted also under short and continuous illumination, only then it is less pronounced. The photoperiodic factor is dominant here and plays an essential role in the reaction. It was also demonstrated that varying daylength, particularly from S to L, thus, rising light conditions are more favourable to plant development than waning daylight.

Table 2

Ear and seed setting (main culm)

Group	Comb.	Ear length	No. of spikelets	
autumn seeding glasshouse	N_8	1.1	5.2	No. of seeds does not exceed 4—5*
	N_{16}	4.7	64.4	Ears develop normally and are normally fertile
	N_{24}	9.5	158.0	One third of ear from below with underdeveloped sterile spikelets
winter seeding glasshouse	N_8	2.0	11.0	6—8 seeds
	N	2.1	12.0	some dozen seeds or so
	N_{16}	9.1	25.2	almost all spikelets fertile
	N_{24}	10.4	130.0	90% of spikelets fertile
light chamber	S_8	1.5	6.0	5—6 seeds in one ear,
	L_{19}	7.0	147.0	1/3 of length of the ear sterile

* In some plants under short day (autumn seeding) only a rudimentary ear was set.

1) From the point of view of the generative photoperiodic reaction *Setaria glauca* is a typical quantitative short-day plant. The photoperiodic reaction of various *Setaria* species (*S. glauca*, *S. italica*, *S. viridis*) has already been analysed. All these species, in dependence on their origin and experimental conditions have been classified to plants with a „weak" or with a „strong" short-day reaction (Chouard 1950, Mathon 1967, manuscript). *Setaria verticillata* which, according to Chouard (1950), is a „weakly" reacting short-day plant, has been described by Mathon and Stroun (1961) as the example of a plant with an ambiphotoperiodic type of reaction. All the above enumerated species have a wide area and are classified to thermocosmopolites.

2) The vegetative modifications due to daylength are strong and pronounced. Elongation growth becomes more intensive, the number and size of leaves and the degree of development of tillers increase with rising daylength. As seen on graph 1 the rate of differentiation of the successive leaves is accelerated. This increasing intensity of development of the axillary buds is manifested in two directions:

a) the axillary buds of an increasing number of leaves become active;

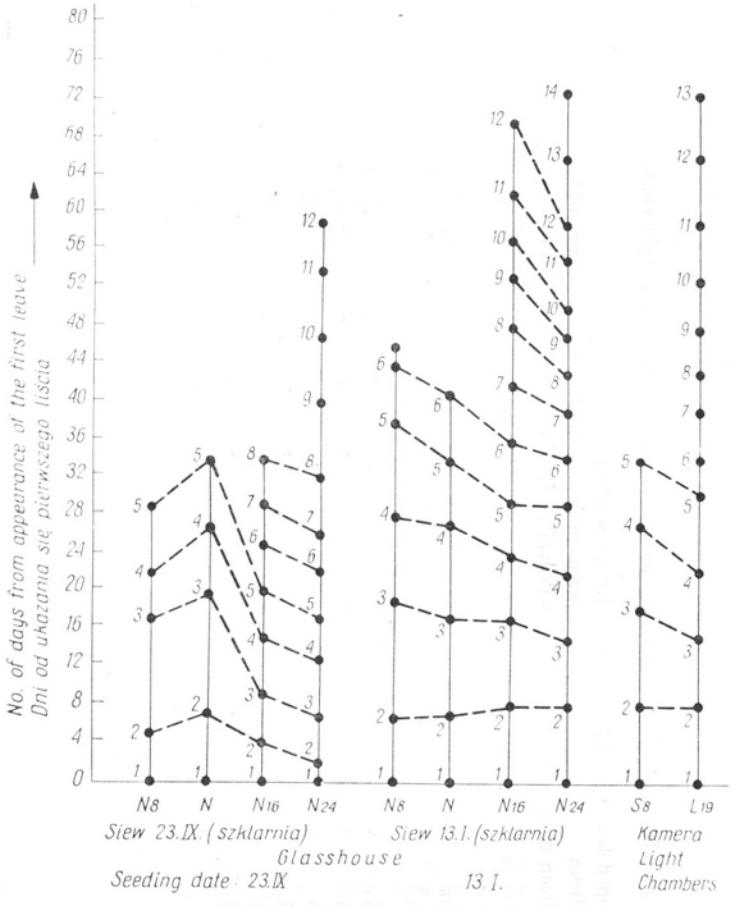
b) the developing tillers are long and profusely foliated.

3) The number of spikelets and seeds under short day is greatly reduced. Thus, short day promotes shooting and simultaneously inhibits spikelets differentiation and the growth of the ear.

4) The differences in the development of tillers in dependence on their position on the main axis, that is on the age of the plant are distinct in plants growing

under continuous daylight and long-day conditions and disappear under short day (see Graph 2, Tables 3 and 4).

These differences involve the intensity and duration of elongation growth, the number of leaf differentiations, the time of heading and the characters of the ear: its length, number of spikelets and the ratio of fertile to sterile spikelets.



Graph. 2. The influence of light conditions on the development of tillers

As we move upwards along the shoot, a decline of vegetative and an intensification of the generative activity is observed this appearing in a diminished number of leaves on the axillary shoot, and thus in an accelerated differentiation of the ear.

On the other hand, the length of the culm and ear development are most advanced in the shoots developed from the axils on the middle part of the main culm, whereas they decrease in size both in the acro- and basipetal direction.

Table 3

Development of axillary shoots (winter seeding and plants in light chambers)

A — No. of developed leaves on axillary shoot up to heading
B — No. of days from date of development of given main leaf to date of appearance of last leaf on axillary shoot
C — No. of days from development of given main leaf to heading of axillary shoot

No of main leaf	A						B						C					
	N	N_8	N_{16}	N_{24}	L_{19}	S_8	N	N_8	N_{16}	N_{24}	L_{19}	S_8	N	N_8	N_{16}	N_{24}	L_{19}	S_8
1	2	—	6	8	—	—	37	—	63	65	—	—	43	43	79	80	—	48
2	2	—	6	9	9	1	32	—	52	64	68	32	36	35	65	70	94	35
3	1	—	6	8	8	—	25	—	47	55	60				57	61	84	
4			5	7	7				47	52	52				55	57	80	
5			5	6	6				44	48	50				50	55	75	
6			4	5	6				43	44	50				48	49	71	
7				4	5					41	46					48	71	
8				4	5						46						64	
9					4						46						63	
10					4						40						62	
11																		

Table 4

Variability of certain characters of axillary shoots

No. of main leaf and axillary shoot	N_{16}					N_{24}					N				
	Culm length	No. of leaves	Ear length	No. of fertile spikelets	No. of sterile spikelets	Culm length	No. of leaves	Ear length	No. of fertile spikelets	No. of sterile spikelets	Culm length	No. of leaves	Ear length	No. of fertile spikelets	No. of sterile spikelets
1	24,8	6	5,5	85	16	15,5	8	5.0	38	12	2,1	—	1,0	4	—
2	47,4	7	7,6	194	16	42.5	8—10	6,7	110	26	11,8	1	1,6	12	—
3	49,2	6—7	7,6	205	6	67,2	9—11	9,0	204	20	11,7	1	1,7	19	—
4	45,5	5	7,4	188	15	64,2	9—10	8,8	197	22	8,5	—	1,9	13	—
5	35,2	5	6,9	134	35	64,9	7—8	8,7	191	23					
6	24,6	4	6,6	84	46	59,4	6	8,0	159	19					
7	13,4	3—4	5,0	47	25	49,6	5	7,0	127	15					
8						25,5	4	5,4	82	20					
9						18,7	3—4	4,4	45	28					
10						12.0	1—2	4,4	45	30					

The variability along the main axis which is an expression of the ontogenetic variability associated with the plant's age has been analysed by Krenke (1950) on woody plants and by Listowski (1968, in press) on various annual plants.

The results of various restitution experiments also indicate an intensification of the generative tonus in upward direction. In tobacco for instance the restituting specimens grown from explants taken from various parts of the stem of a flowering plant come into flower the quicker, their time of growth and differentiation are the shorter, and they have the less leaves as they originate from higher parts of the stem (Aghion-Prat 1965).

In *Setaria glauca* the ontogenetic variability is distinct in plants growing „under long and continuous daylight".

This variability cannot be observed in short-day conditions owing to a strong reduction of the growth processes and the general acceleration of development.

The ontogenetic variability on the main axis is unidirectional, thus expressing the intensification of the generative „tonus" and reduction of the number of leaves.

On the other hand, elongation growth and ear development are strongest in shoots from the middle part of the plant. Analogous facts frequently observed in trees have been analysed by Krenke (1950). This author explains this intensification by a better supply of water and nutrient substances to the middle part. These facts do not contradict the hypothesis of the unidirectional character of ontogenetic variability. The intensification of growth processes in the middle part is not a general observation. Differences in this respect may be found in species belonging to the same family (as for instance observed in the case of *Chenopodium*).

SUMMARY

The course of development of *Setaria glauca* was investigated under various light conditions: waning (autumn) and rising (winter—spring) with varying daylength.

1. *Setaria* is a quantitative short-day plant as regards flowering initiation, whereas its growth and differentiation of the ear as well as the number of seeds are greatly reduced in these conditions (tables 1 and 2).

2. The elongation growth of the culm is intensified, and the number and size of leaves, and rate of axillary shoots growth increase with rising daylight (graph 1, table 1; graph 2, tables 3 and 4).

3. The interaction between daylength and light intensity is most pronounced under long-day conditions (table 1).

4. Varying daylength of rising character is more favourable to plant development than waning light conditions (table 1 and graph 1).

5. The ontogenetic variability in axillary shoot development along the main axis in very distinct under long and continuous daylight (graph 2, tables 3 and 4).

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Obserwacje nad rozwojem roślin

XVI, Rytm rozwojowy i kwitnienie *Setaria glauca*

STRESZCZENIE

Badano rozwój *Setaria glauca* w różnych warunkach świetlnych zarówno przy malejącej (jesień — zima), jak i wzrastającej (wiosna — lato) intensywności oświetlenia i przy różnych długościach dnia.

Setaria glauca, jeśli chodzi o inicjację kwitnienia, jest rośliną krótkiego dnia, podczas gdy jej wzrost, różnicowanie kłosów, jak i liczba nasion w tych warunkach są znacznie obniżone (tab. 1 i 2).

Przy wzrastającej intensywności światła następuje wydłużenie pędów, wzrasta liczba i wielkość liści oraz tempo wzrostu pędów bocznych.

Interakcja między długością dnia a intensywnością światła zaznacza się najbardziej w warunkach długiego dnia.