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Dynamics of growth and development of spring rye

Dynamika wzrostu i rozwoju żyta jarego

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The present work is part of a larger investigation on growth and development in Spring cereals. Results of two years experiments with Spring rye are reported.

The methods used are similar to those reported earlier (Strebeyko, Wisłocka, Krzywacka 1963). The variety of spring rye used was „Puławskie".

1960 Experiments

The dates forming a division between different phases in the developmental sequence were as follws:

Sowing — April 23 rd.
Emergence — May 1st.
Going into ear — June 6th.
Flowering — June 13th.
Milky stage of grain — June 29 th.
Doughy stage of grain — July 8th.
Full maturity — August 2nd.

Vegetation lasted 101 days from the date of sowing and 93 days from the date of emergence. Samples for growth and development analysis were taken in 17 successive harvests in the period from May 6th to August 2nd.

Total leaf weight (Fig. 1) increased from sowing up to June 4th. which is almost the time of earing. Lower leaves started going yellow and drying some time before this date. The first yellowing leaves were observed on May 31st. and leaf dry weight and green-leaf area begun decreasing rapidly from this date onwards. Stem dry-weight increases rapidly as the leaf dry-weight and leaf area drops. The stem dry-weight increase lasts four weeks from May 31st. to the milky stage of grain June 29 th. Root growth stopped some days after flowering i.e. June 17th. or June 21st. The increase in the dry-weight of grain is attributable to pho-

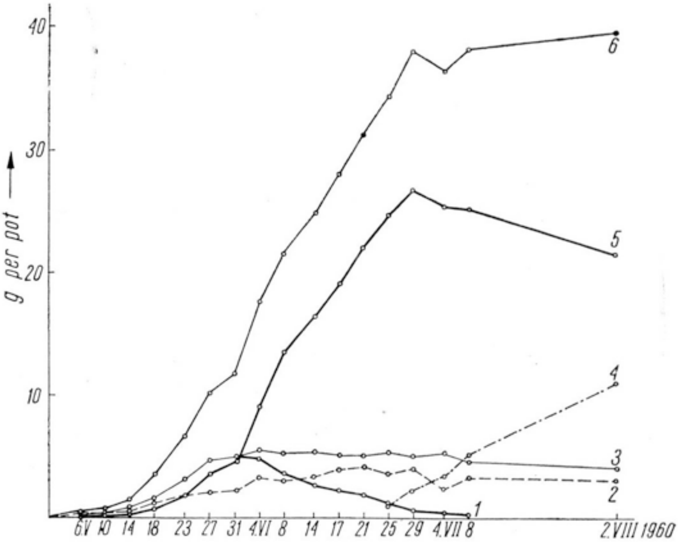


Fig. 1. Increase of plant dry weight in 1960
1 — green leaves; *2* — roots; *3* — total leaves; *4* — grains; *5* — stems; *6* — total

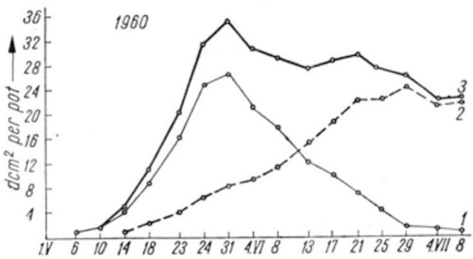


Fig. 2. Increase of assimilation (green) area in 1960
1 — leaves; *2* — stems; *3* — total area

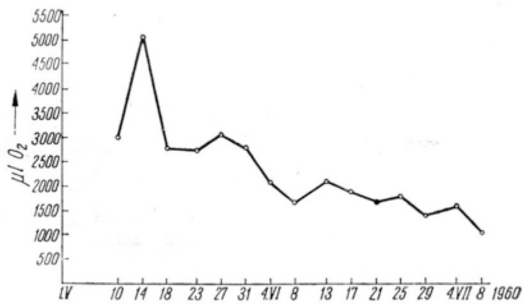


Fig. 3. Intensity of leaves respiration expressed by oxygen absorbed per 1 g of dry weight per hour

tosynthesis and partially to the translocation of organic substances from stems and leaves to the ears. Total growth of plants stopped with the growth of stems at the milky stage of the grain (June 29th.).

Green leaf area reached the maximum value on May 31st. (Fig. 2). The stem area maximum was attained on June 29th. It was nearly as great as the leaf area. The assimilation area of the stems is equal to the decreasing green leaf area at the time of flowering, but later exceeds it more and more. The plants reach the highest total assimilation area value on May 31st. The photosynthetic area of the ears was not measured.

The final average dry matter value attained for the whole vegetative phase was 39 g and consisted of 11 g grain, 25 g straw, 3 g roots.

Respiratory rates in detached leaves were measured using the Warburg apparatus (Fig. 3). Oxygen taken up decreased from 3 to 1 ml O_2 per 1 g dry weight per hour.

In a separate experimental variant, growth in normal plants was compared with growth in plants in which the leaves had been removed. This experiment begun immediately after earing June 8th. and continued until the end of vegetation period. Only shoot growth was measured since from June 4th. onwards roots grew very slowly (1 g dry weight increase in 17 days). It may be seen from Table 1 that stem photosynthetic intensity was 60% of the leaf photosynthesis figure. Leaves produced ca. 50 mg dry matter per 1 dcm^2 assimilating surface per day while the figure for stems was ca. 30 mg dry matter.

Table 1

Date of leaf removal	Dry-weight of shoots			Increase in dry-weight	Extra dry weight due to leawes	Sum of products: average assimilation area by the time of its activity (dcm^2 × × days)		Intensity of photosynthesis per 1 dcm^2 per day	
		On the day of leaf removal	At the end of vegetation					in mg	%
8.VI. 1960	Control plants	19.2 g	36.4 g	17.2 g	7.5	leaves	192	39	100
	Leafless plants	13.5 g	23.2 g	9.7 g		stems (and ears)	404	24	62
13.VI. 1960	Control plants	21.6 g	36.4 g	14.8 g	4.9	leaves	117	42	100
	Leafles plants	16.4 g	26.3 g	9.9 g		stems (and ears)	341	29	69
17.VI. 1960	Control plants	24.1 g	36.4 g	12.3 g	4.2	leaves	72	58	100
	Leafless plants	19.1 g	27.2 g	8.1 g		stems (and ears)	261	31	58

1961 Experiments

Dates marking the transitions between the different phases of the developmental sequence were:

Sowing — April 6th.
Emergence — April 13 th.
Begining of the generative phase — April 21st.
Earing — June 2nd.
Flowering — June 10th.
Milky stage of grain — June 23rd.
Doughy stage of grain — July 3rd.
Full maturity — July 24th.

Vegetation lasted 112 days from the date of sowing and 105 days from the date of emergence. There were 19 successive harvests within the period April 17th. until July 27th. Growing point and ear development is shown in Plate I. The total dry weight of leaves increased over a 6 week period, from emergence to May 29th. (Fig. 4). Lower leaves begun yellowing and drying from May 20th. onwards. A rapid increase in stem dry weight starts concurrently with the degeneration of the lower leaves and lasts 6 weeks until the milky stage of the grain.

Root growth stopped at the time of flowering (June 9th.). The dry weight of grain increased until the end of the vegetation period. This increase is partially attributable to photosynthesis. From the milky stage

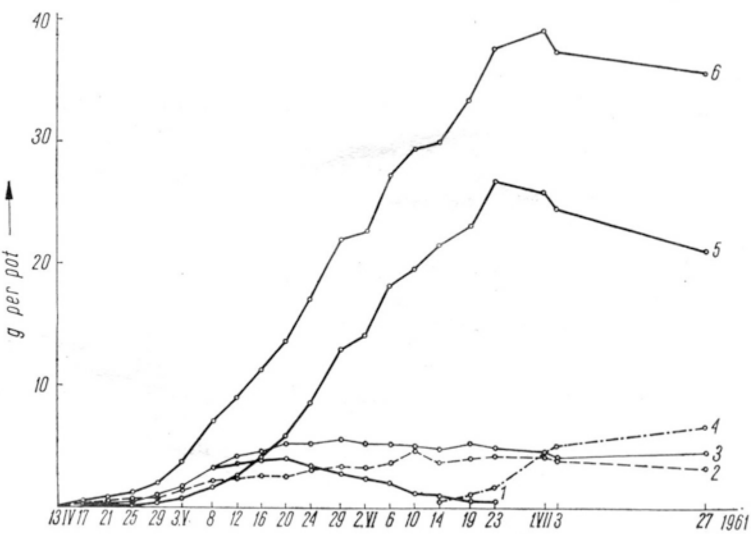


Fig. 4. Increase of plant dry weight in 1961
1 — green leaves; 2 — roots; 3 — total leaves; 4 — grains; 5 — stems; 6 — total

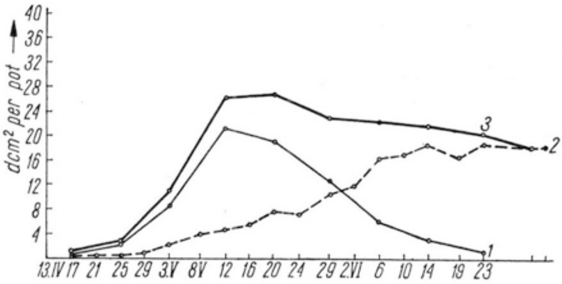


Fig. 5. Increase of assimilation (green) area in 1961
1 — leaves; 2 — stems; 3 — total area

onwards it is partially attributable to the translocation of organic compounds from the stem and leaves to the ear.

All growth ended at the doughy stage (July 1st.). The average dry weight per pot for the vegetative period was 36g and consisted of 6g grain, 26g straw and 4g roots.

The green leaf area (Fig. 5) reached a maximum value on May 12th. which was the time of flower formation. Stem area was nearly equal to leaf-area by June 14th.

The highest values for total plant assimilation area were attained in the period from May 12th. to May 20th. Thereafter the total assimi-

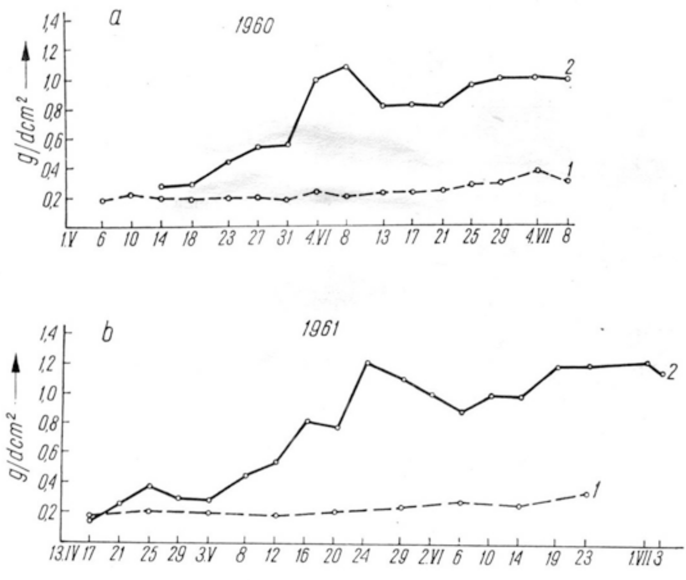


Fig. 6. Ratio between the area and dry weight of green leaves (*1*) and stems (*2*) in 1960 and 1961

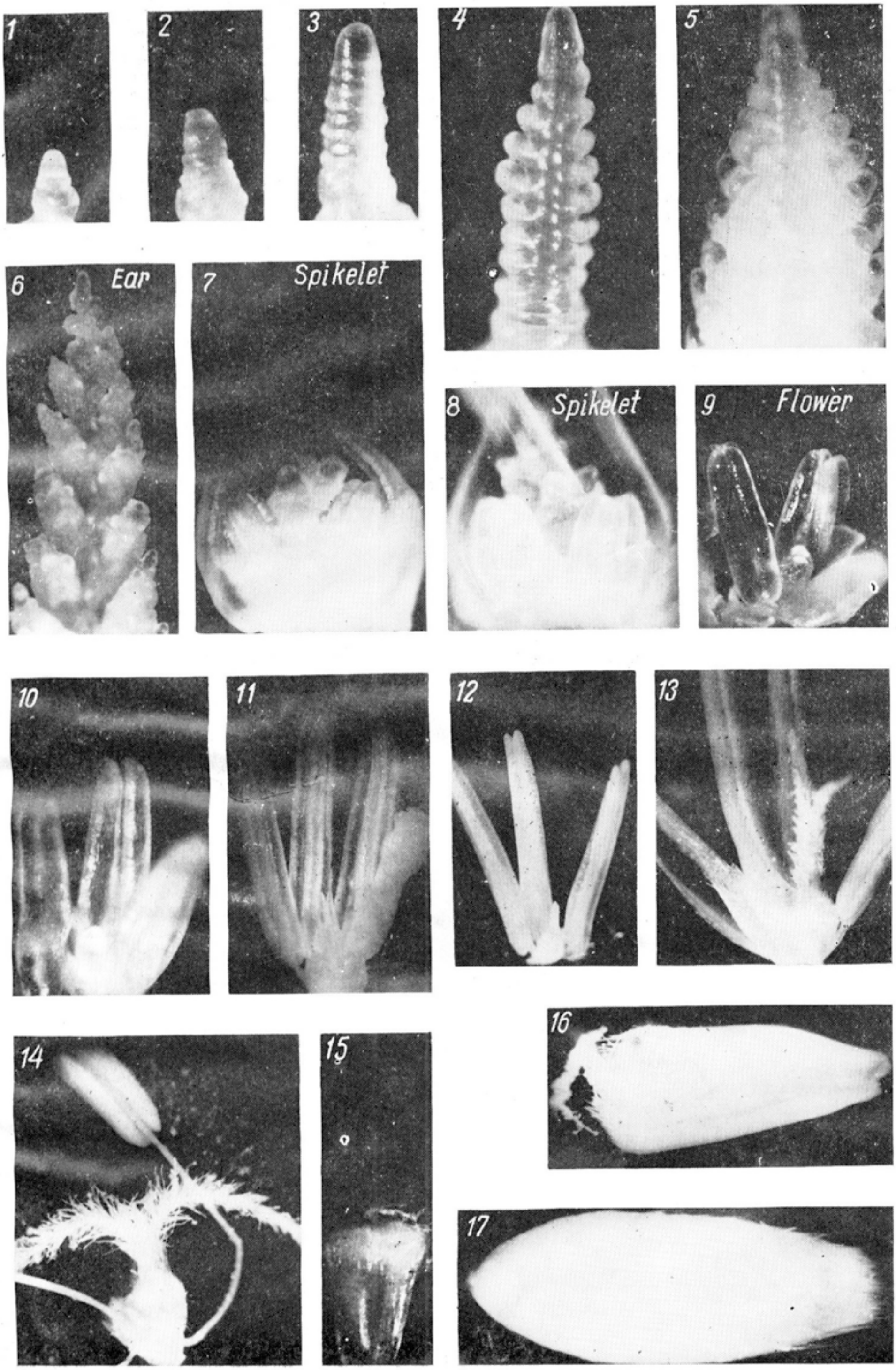
PLATE I

Explanations of Plate I

Development of plants in 1961

Harvest (figure)	Date	Days from emergence	Numbers of leaves	Dry weight attained (per cent of final yield)	
	5.IV				Seeding
	13.IV				Emergence of seedlings
1	17.IV	4	2	0,8	Leaf initials are produced by the growing point (x55)
2	21.IV	8	3	2	Growing point elongation (x55)
3	25.IV	12	3	3	Beginning of spikelet differentiation shown by double ridges on a young spike (x55)
4	29.IV	16	4	5	Spikelet formation (x55)
5	3.V	20	5	10	Glume formation. Beginning of flower differentiation
6	8.V	25	6	20	Beginning of the elongation of spike rachis internodes (x55). Finished stamen differentiation in 1-st, 2-nd flower (x30)
7	12.V	29	7	25	Flower formation and growth continued (x55)
8	16.V	33	7	32	Beginning of the differentiation of stigma branches (x55)
9	20.V	37	8	38	Stamen, pistil and stigma growth continued. Pollen mother cells differentiation (x55)
10	24.V	41	8	48	Beginning of pollen formation. The rapid growth of stigma (x30)
11	29.V	46	9	62	Pollen formation finished (x10)
12	2.VI	50	9	64	Beginning of earing (x10)
13	6.VI	54	9	76	Full earing. Stigma formation finished (x10)
14	10.VI	58	9	83	Anthesis (x10)
15	14.VI	62	9	84	Beginning of grain formation (x10)
16	19.VI	67		94	Beginning of milky stage (x10)
17	23.VI	71		106	Milky stage of grain (x10)
18	1.VII	79		110	Milky stage of grain
19	3.VII	81		108	Doughy stage of grain
20	27.VII	105		100	Full maturity of grain

PLATE I



Phot. T. Krzywacka

lation area value showed a gradual decrease due to the high stem assimilation area values.

Due to limited space, only the 1961 photographs of growing point development are shown. Data concerning the number of leaves and plant dry weight expressed in percent of the final leaf weight is given in Plate I. The increase in dry weight of unit leaf area, and in stem area is shown in Fig. 6.

CONCLUSIONS

1. Total leaf weight of the tested Spring rye variety increased almost up to the time of earing. The lower leaves started turning yellow and drying sooner.

2. A rapid increase in stem weight begun at the time when yellowing was first recorded in the lower leaves and lasted up to the milky stage of the grain.

3. The maximum value for the assimilation area in leaves 1.5 dcm^2 per plant, was close to the figure for stem area. The maximum for leaf area was attained a month earlier than the maximum for stem area. Since the stem area is rather large the value for the total assimilating surface area of the plant was kept high for a long time.

4. The stem photosynthesis value was 60% of the value for leaves. Leaves produced ca. 50 mg dry matter per 1 dcm^2 per day while the figure for stems was 30 mg.

5. Leaf dry weight per unit area increased from 0.2 g to 0.35 g with age while that of stems rose 0.2 g to 1.2 g. Assimilation per unit stem area was slower and several times more organic compounds than in leaves were used for its production. Leaves were more efficient in plant weight production.

6. In detached leaves the rate of respiration decreased with age from 3 ml to 1 ml O_2 taken up per 1 g dry weight per hour.

7. Root growth stopped at the time of flowering but total increase in plant weight did not end until the milky stage (1960) or even the doughy stage (1961).

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SUMMARY

A variety of spring rye „Puławskie" was sown in pots. Two years experiments were carried out.

The course of growth and development was studied during the whole vegetation period. Dry weight increase in roots, leaves, stems and grain was measured. The assimilation area in plants was recorded and measurements of rate of respiration were taken. Phases of growing point and ear development were photographed.

The assimilating surface area of the stems is of greater importance in rye in which the plants are taller than in either wheat or barley.

Acknowledgments.

The authors are greatly indebted to Mrs. T. Krzywacka for photographic records of growing point and ear development.

STRESZCZENIE

W dwuletnich doświadczeniach wazonowych (1960 i 1961) badano dynamikę wzrostu i rozwoju żyta jarego (Puławskie). Rośliny sprzątano co 4—5 dni i oznaczano suchą masę liści, łodyg i korzeni, a w późniejszych okresach — również suchą masę nasion. Poza tym mierzono powierzchnię zielonych liści i łodyg oraz intensywność oddychania liści. Wykonano wiele obserwacji i zdjęć fotograficznych rozwijającego się stożka wzrostu i kłosa. Wyniki przedstawiono w tabeli i 6 wykresach. Obliczono szybkość przyrostu suchej masy na decymetr kwadratowy powierzchni asymilacyjnej w ciągu dnia.

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