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BRIEF COMMUNICATION

Relations between photosynthetic pigment accumulation and microsporogenesis in *Secale*, *Triticale*, and *Secalotriticum*

V.E. SHYMKO*, L.N. KALITUHO**, S.N. KABANOVA**, L.F. KABASHNIKOVA**[,a] and I.A. GORDEÏ*

Institute of Genetics and Cytology, Institute of Photobiology**, National Academy of Sciences of Belarus, Akademicheskaya str. 27, Minsk, 220072, Republic of Belarus*

Abstract

The accumulation of photosynthetic pigments in underflag and flag leaves as well as the process of microsporogenesis in lines of tetraploid *Secale*, hexaploid *Triticale*, and hexaploid *Secalotriticum* were studied. Significant positive correlations were found between the amounts of chlorophyll *a* (Chl *a*), carotenoids (Car), Chl *a/b* ratio, and the normal proceeding of meiosis. High probability of paternal type of inheritance of specifities of meiosis of pollen mother cells and variation in photosynthetic pigments during plant transition from the stalk-shooting to heading stage were demonstrated.

Additional key words: carotenoids, chlorophylls, meiosis, rye, wheat.

The *Secalotriticum*, an intergeneric rye-wheat amphidiploid, produced on the basis of rye cytoplasm, is a valuable material for theoretical research and practical breeding. Complex polygenome functions as well as specific nuclear-cytoplasmic interactions provide the increased adaptive potentialities of *Secalotriticum* and its high resistance to diseases and extreme temperatures. An unique chromosome set of *Triticale*, used as father form, is capable of guaranteeing a wide variation of agronomic characters (Khotyleva 1986, Gordeï *et al.* 1996), that enable to develop and select prospective agricultural material (Bormotov *et al.* 1990, Royo *et al.* 1999).

During evaluation of new cereal crops, an investigation of photosynthetic pigments (PSP) as structural and functional units of photosynthetic apparatus (PSA) is important (Čatský and Šesták 1997, Baker and Ort 1992). Chl content is one of key factors determining crop productivity (Kura-Hotta *et al.* 1987), and therefore should be associated with genetic processes of reproductive system formation. Thus, the goal of present work was to study specifities of microsporogenesis in *Secalotriticum* and its initial parental forms (*Secale* and *Triticale*) and to detect possible correlations between dynamics of PSP accumulation and meiotic division of pollen mother cells during ear formation.

Objects of investigation were tetraploid rye cv. Novosibirskaya, hexaploid *Triticale* L-246 and hexaploid *Secalotriticum* Novosibirskaya × L-246 selected at the Bielorussian Research Institute of Agriculture and Fodder of the Agricultural Academy of Sciences of Belarus, and at the Institute of Genetics and Cytology of the National Academy of Sciences of Belarus (IGC NASB). Plants were grown by the small plot method on the experimental area of IGC NASB using standard agronomy. The content of PSP in underflag (stalk-shooting stage) and flag (heading stage) leaves was determined by the spectrophotometric method in 100 % acetone extracts (Lichtenthaler and Wellburn 1983) using the spectrophotometer *Uvicon-931* (*Kontron Instruments*, Neufahrn, Germany). Leaf discs (0.8 cm^2) were cut from

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Abbreviations: Car - carotenoids; Chl - chlorophyll; PSA - photosynthetic apparatus; PSP - photosynthetic pigments.
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[a] Corresponding author; e-mail: kabash@biobel.bas-net.by

the upper third part of leaf (central parenchyma). For studying microsporogenesis, ears were fixed according to Newcomer (1953) at the stalk-shooting stage, and investigated by light microscopy on the temporary squash acetocarmine samples. Statistical processing was made by *ANOVA* ($P \leq 0.05$) according to Falconer and Douglas (1996) using software designed in the Laboratory of mathematical statistics of IGC NASB. Statistical significance was assessed by the Student's *t*-test. Experiments were performed in 7 - 30 repetitions.

During the period from stalk-shooting to heading the contents of Chl *a*, Chl *b*, and Car in rye leaves increased by 20 to 30 %. In both *Triticale* and *Secalotriticum* a 15 - 20 % increase in Chl *b* content and a less than 8 % decrease in Car content were found, whereas Chl *a* concentration was not changed. The Chl *a/b* ratio declined by 5 - 15 % during this period (Fig. 1, Table 1).

Both the PSP accumulation and curves reflecting the variation in number of disturbances during meiosis between *Triticale* and *Secalotriticum* were similar. An increased value of this variation in *Triticale* and

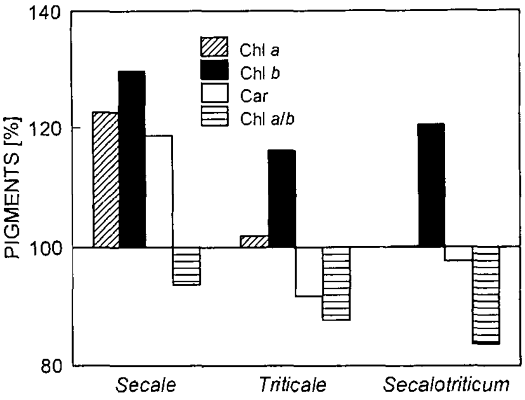

Fig. 1. Differences (at % to stalk-shooting compared to heading) in photosynthetic pigment contents per unit leaf area in *Secale*, *Triticale* and *Secalotriticum*.

Table 1. Content of photosynthetic pigments per unit of leaf area [µg m^{-2}] of *Secale*, *Triticale*, and *Secalotriticum* plants at stalk-shooting and heading stages, and the ratio of pigment contents in % at stalk-shooting compared to heading stage.

		Chl *a*	Chl *b*	Chl (*a*+*b*)	Car	Chl *a/b*
Stalk-shooting stage	*Secale*	26.68 ± 0.90	9.16 ± 0.32	35.84 ± 1.19	8.82 ± 0.25	2.95 ± 0.03
	Triticale	33.84 ± 1.98	10.14 ± 0.60	43.97 ± 2.57	11.85 ± 0.65	3.34 ± 0.03
	Secalotriticum	38.33 ± 0.33	12.76 ± 0.16	51.09 ± 0.42	13.01 ± 0.22	3.01 ± 0.03
Heading stage	*Secale*	32.72 ± 1.24	11.88 ± 0.69	44.61 ± 1.92	10.46 ± 0.34	2.76 ± 0.06
	Triticale	34.46 ± 2.20	11.78 ± 0.93	46.24 ± 3.13	10.87 ± 0.88	2.93 ± 0.05
	Secalotriticum	38.43 ± 1.65	15.38 ± 1.25	53.81 ± 2.90	12.71 ± 0.78	2.52 ± 0.10
Stalk-shooting/ heading stage ratio [%]	*Secale*	122.64 ± 3.67	129.69 ± 3.88	124.47 ± 3.74	118.59 ± 3.56	93.56 ± 2.81
	Triticale	101.83 ± 3.05	116.17 ± 3.49	105.16 ± 3.15	91.73 ± 2.75	87.72 ± 2.63
	Secalotriticum	100.26 ± 3.01	120.53 ± 3.61	105.32 ± 3.11	97.69 ± 2.93	83.72 ± 2.72

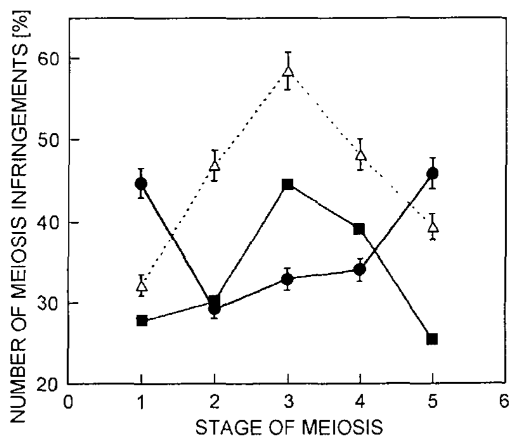

Fig. 2. The number of meiosis infringements at different stages of division of pollen mother cells in *Secale* (*cicles*), *Triticale* (*squares*), and *Secalotriticum* (*triangles*): *1* - metaphase I; *2* - anaphase I; *3* - metaphase II; *4* - anaphase II; *5* - tetrade formation.

Secalotriticum was found at anaphases I and II with amaximum at metaphase II, whereas the maximum meiotic disturbances in *Secale* were observed at metaphase I and at the stage of tetrad formation (Fig. 2).

Our results and the literature data (Shkutina 1982, Hoerlein and Valentine 1995) suggest that similarity of *Triticale* and *Secalotriticum* dynamics of meiotic disturbance can be caused by their interspecific amphidiploid polygenome functions. There is a high probability of paternal (nuclear) type of inheriting PSP accumulation as well as a number of disturbances of meiosis in *Secalotriticum* in the period from stalk-shooting to heading. During this period, plants realise a transition to reproductive phase of development. To the stage of heading, PSA is practically formed (Baker and Ort 1992) and supplies substances and energy to maturing ears where microsporogenesis takes place. We observed significant positive correlations between the number of normal tetrads and the contents of Chl *a* ($r = 0.51$, $P \leq 0.05$), Car ($r = 0.62$, $P \leq 0.01$), and Chl *a/b* ($r = 0.81$, $P \leq 0.01$) in all genotypes studied. A negative correlation coefficient was found between the disturbance number in metaphase I of meiosis and the ratio of Chl *a/b* ($r = -0.70$, $P \leq 0.01$).

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