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RECOMBINATIVE VARIABILITY OF SOLUBLE PENTOSAN CONTENT AMONG INTROGRESSIVE TRITICALE LINES DERIVED FROM HYBRIDIZATION OF HEXAPLOID TRITICALE WITH THE SYNTHETIC AMPHITETRAPLOID *T. MONOCOCCUM*/*S. CEREALE* (A^mA^mRR)

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Abstract. In animal feeding soluble dietary fibres have been considered as the main anti-nutritive factor. High level of soluble pentosan content (SPC) in grains of triticale, which is used greatly as a feeding cereal, decreases feed intake in chickens and piglets, hampers digestion and makes droppings very sticky resulting in inhibition of growth. Variability of SPC was assessed spectrophotometrically within the recombinants of hexaploid triticale with synthetic amphitetraploid *Triticum monococcum/Secale cereale* to evaluate the possibilities of selection in respect of low soluble pentosan content. Standard triticale lines LT 176/10 and LT 522/6 used in crosses as a gene recipient parents had 125% and 128% of SPC in wheat check cultivars. Surprisingly high variation in SPC of grain was found within the set of introgressive triticale lines resulting from recombination with amphitetraploids. The coefficient of variation (CV%) amounted to 24.7. Some of the studied introgressive lines of triticale had the grain SPC lower than wheat. Theses results make the breeding of low SPC triticale promising.

Key words: triticale, soluble pentosans, *T. monococcum*, introgressive lines

INTRODUCTION

The dietary fraction which is resistant to hydrolysis by the digestive enzymes of monogastrics is named dietary fibre (DF). This term refers to the heterogeneous group of polysaccharides interlinked with cellulose and lignin in plant cells walls and includes also intracellular matrices. Dietary fibre may be divided into soluble and insoluble fractions. Their beneficial role in the intestinal regulation and metabolism in man stimulate

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the development of high-fibre food products. In opposite to this in animal feeding, especially soluble DF have been considered as the main antinutritive factor diminishing the efficiency of feed utilisation [Rakowska et al. 1985, Ward and Marquardt 1987, Fengler and Marquardt 1988, Rakowska 1994]. These caused the importance of soluble DF content in kernels of triticale, which is used greatly as a feeding cereal. Arabinoxylans are the main constituents of soluble DF responsive for decrease of kernels protein digestibility due to their possibility to form of pentosan-protein conjugates. Because of this, the assessment of soluble pentosan content in genetically differentiated stocks can give information valuable for improving of triticale kernel quality.

The aim of this work was to analyse the variability of soluble pentosan content (SPC) in recombinants of hexaploid triticale with amphitetraploid *Triticum monococcum*/*Secale cereale* and to evaluate how are the possibilities to select introgressive triticale lines distinguished by advantageous content of this antinutritive factor.

MATERIALS AND METHODS

The studying material consisted of the accession of diploid wheat *Triticum monococcum ssp. monococcum* (var. *macedonicum)* [= *Tm* 16] and diploid rye *Secale cereale cv.* Dańkowskie Złote [= *Sc.* DZ] – two stocks representing parental genomes A^mA^m and RR which were used to develop *Triticum monococcum*/*Secale cerea*le amphiploid (A^mA^mRR), and also of two winter hexaploid triticales [=*Tcl* LT176/10 and LT 522/6] applied as a gene recipients in crosses with this synthetic A^mA^mRR-amphitetraploid.

Pentaploid F_1-hybrids (2n = 35) obtained as a result of this crossing were backcrossed with parental triticale and BC_1-plants were propagated until BC_1/F_3 generation. BC_1/F_4-plants were analysed in respect of the somatic chromosome number. All of this plants developed with participation of recombination between triticale A-genome and A^m-genome of *T. monococcum*/*S. cereale* amphiploid and showing hexaploid chromosome number were propagated by selfing into the set of introgressive lines (Tcl/Tm).

Soluble pentosan content (SPC) of grain was measured in 54 developed introgressive lines of BC_1/F_7 generation. Among the lines, 22 were products of recombination within the genome of triticale LT 176/10, and 32 lines were products of recombination within triticale LT 522/6. Additionally, 2 winter cultivars of hexaploid wheat were included in the analysis, to compare the SPC of diploid wheat *T. monococcum* with cultivated forms of a higher ploidy. The studied cultivars of hexaploid wheat (*cvs*. Izolda and Kobra) were also objects of reference for comparison of variation among introgressive lines of triticale (Tcl/Tm) to related cereal species with a low pentosan content (wheat) and with a high pentosan content (rye).

The SPC of the studied samples was assessed by extraction from ground material, followed by hydrolysis in 4 N HCl in submerged phials for 2 h at 100°C, according to the method of Czarnecki et al. [1993].

A small amount of the hydrolysate was subjected to staining (0.1% $FeCl_3$ in concentrated HCl + 1% orcein) and absorption of the resulting solution at 670 nm was measured spectrophotometrically. Calibration curve was prepared with xylose. Each line/cultivar was analysed in at least 2 replications of 1-gram grain samples.

Analysis of variance was performed according to MSTAT (microcomputer statistical program: Michigan State University) by ANOVA software, and means were subjected to grouping according to multiple-range Duncan's test.

RESULTS AND DISCUSSION

Among the studied standard stocks of hexaploid wheat, triticale and rye, the lowest SPC was found in both hexaploid wheat cultivars (*cvs*. Kobra and Izolda). According to the classification of technological value, those cultivars represent group B (bread wheat) and group C (fodder wheat) respectively [COBORU 2001]. Rye *cv*. Dańkowskie Złote had a high SPC (about 184% of mean content of wheat grain), while in triticale LT 176/10 and LT 522/6 these values were lower than in rye, but significantly higher than in wheat (125% and 128%, respectively). Such relations of SPC are typical, observed many times in comparative analyses with rye and wheat of other lines and cultivars of hexaploid triticale [Drews et al. 1976, Biskupski et al. 1982, 1984, Rakowska et al. 1985, Boros 1988, Cyran et al. 1994, Boros and Rek-Ciepły 1997]. Thus the maternal triticale lines used in the process of hybridization with *T. monococcum*/*S. cereale* amphiploid represented the middle level of SPC typical for this cereal. In comparison with those three cereals, the diploid wheat *Triticum monococcum* showed high SPC value, closer to that of rye than to that of hexaploid wheat (Table 1).

Table 1. The soluble pentosan content in grain of triticale introgressive lines Tcl/Tm developed from recombinantes triticale x *T. monococcum*/*S. cereale* amphiploid comparatively with grains of parental wheat, rye and triticale stocks
Tabela 1. Zawartość rozpuszczalnych pentozanów w ziarniakach linii introgresywnych pszenżyta wytworzonych z rekombinantów *Triticale* x amfiploid *T. monococcum/S. cereale* w porównaniu z ziarniakami form rodzicielskich i wzorcowych pszenicy, żyta i pszenżyta

Line/variety Linia/odmiana	Mean values of soluble pentosan content % d.m. × 10^3 Średnia zawartość pentozanów rozpuszczalnych % s.m. × 10^3	Significance in multiple-range Duncan's test* Istotność różnic według testu Duncana*
1	2	3
B20/1	838.0	A
B15/2	813.0	AB
A5/2	801.0	B
Sc. Dańk. Złote	799.5	B
B15/5	798.0	B
A6/3	778.5	BC
A10/2	750.0	CD
A6/2-2	746.0	CD
Tm 16	736.5	DE
A13/1-4	724.0	DE
A17/1	720.0	DE
A5/3	717.5	DEF
A18/1	704.0	EF
A9/1	682.0	FG
A9/2	659.0	GH
A8/1-7	646.0	HI
A6/2	644.5	HI
B7/4	640.0	HI
B40/3-1	628.0	HIJ
A17/2	625.5	HIJK
B24/1	614.5	IJKL
B15/4	596.0	JKLM

1	2	3
A6/1	594.5	JKLMN
B11/4-1	590.5	JKLMNO
B9/1	588.5	KLMNO
A5/1	586.5	LMNOP
A9/2-1	574.0	MNOPQ
Tcl LT522/6	557.0	NOPQR
B10/2-3	554.0	OPQR
A4/1-1	549.5	PQRS
B39/1-1	548.5	PQRS
Tcl LT176/10	543.5	QRST
A10/2-2	542.5	QRST
A16/1-1	541.5	QRST
A8/1-2	530.5	RSTU
B11/1	526.0	RSTU
B22/1-1	524.0	RSTU
B20/4	520.5	RSTU
B5/3	519.5	RSTU
B28/1	513.5	STUV
A6/2	512.0	STUV
B36/1-1	503.5	TUV
B29/1	503.5	TUV
A13/1	500.5	UV
B38/1	480.0	VW
B39/2	446.5	VW
B10/1-1	446.5	WX
Ta cv. Izolda	444.0	WXY
B5/1	436.0	XY
B11/2	432.0	XYZ
Ta cv. Kobra	425.5	XYZ
B29/2	411.5	XYZ
B43/1-1	406.0	YZA'
B29/4	396.5	ZA'B'
B39/3	370.5	A'B'C'
B47/1-1	364.0	B'C'D'
B46/2-1	336.0	C'D'
B36/4	333.5	D'
B36/2-1	291.5	E'
B19/1	260.0	F'

*Means signed with different letter showed significant difference at P = 0.05.
*Średnie oznaczone różnymi literami różnią się istotnie na poziomie P = 0,05.

Our results attest to a surprisingly high variation in SPC within the set of introgressive lines resulting from recombination in hybrids of triticale with the amphiploid *T. monococcum/S cereale*. Among introgressive lines Tcl/Tm derived from such recombinants, the line with the highest SPC had a three times higher value in relation to the line from the opposite limit of variation. The coefficient of SPC variation (CV%) assessed for all the 54 lines Tcl/Tm reached 24.7%. It is very interesting that in some of the studied introgressive lines of triticale the grain SPC was significantly lower than in wheat (Table 1).

All lines with such a low SPC originated from crossings where triticale LT 522/6 was the recipient parent. The recombinants of this triticale with the amphitetraploid *T. monococcum/S. cereale* were characterized by a great variation in SPC. Beside the forms with a low value of this trait (lower than in wheat), there were also forms with

values higher than that of rye grain (Fig. 1). Generally, a decreasing trend in SPC can be observed among lines derived from LT 522/6. The number of lines with values lower than that of the parental triticale compared with the number of lines with values higher than that give a ratio of 23:7. Among lines Tcl/Tm derived from recombination in triticale LT 176/10, this ratio was 5:17, i.e. recombinants with higher values prevailed (Fig. 2). Thus, results of recombination of triticale with the amphiploid *T. monococcum/S. cereale* depended mainly on the triticale stock used as the genes recipient parent.

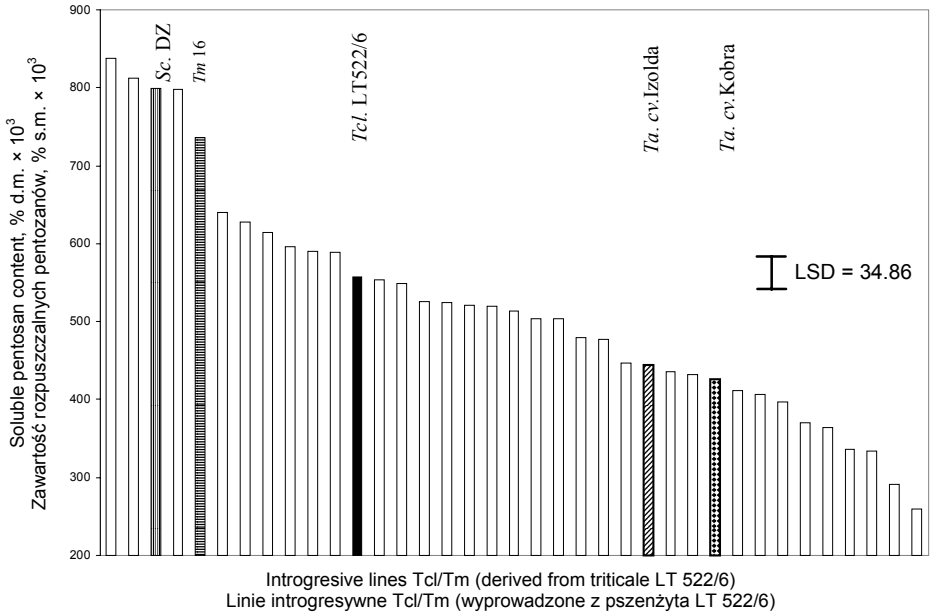

Fig. 1. Variability of soluble pentosan content among introgressive lines derived from triticale LT 522/6 in result of recombination with synthetic amphitetraploid *T. monococcum/S. cereale* (A^mA^mRR)
Rys. 1. Zmienność zawartości rozpuszczalnych pentozanów w liniach introgresywnych powstałych z pszenżyta LT522/6 w procesie rekombinacji z syntetycznym amfitetraploidem *T. monococcum/S. cereale* (A^mA^mRR)

Rye (*Secale cereale*) as a species is distinguished by a high pentosan content of grain, as compared with other cereals. Thus it is rather unlikely that the rye *cv.* Dańkowskie Złote involved in the recombination process differs considerably in this respect from the rye genome present in triticale LT 176/10 and LT 522/6. The higher SPC in both parental triticale stock as compared with wheat, is in fact a result of the influence of the rye genome. In such a situation, the appearance of recombinants with a lower SPC than that of the hexaploid wheat cultivars should probably be attributed to recombination with the genome of *T. monococcum* within the wheat genome present in the triticale recipient parent. The high SPC found in grain samples of *T. monococcum* does not have to be evidence of genetic predisposition, but may result from the small size of seeds of this species. Pentosan compounds are not evenly distributed within the

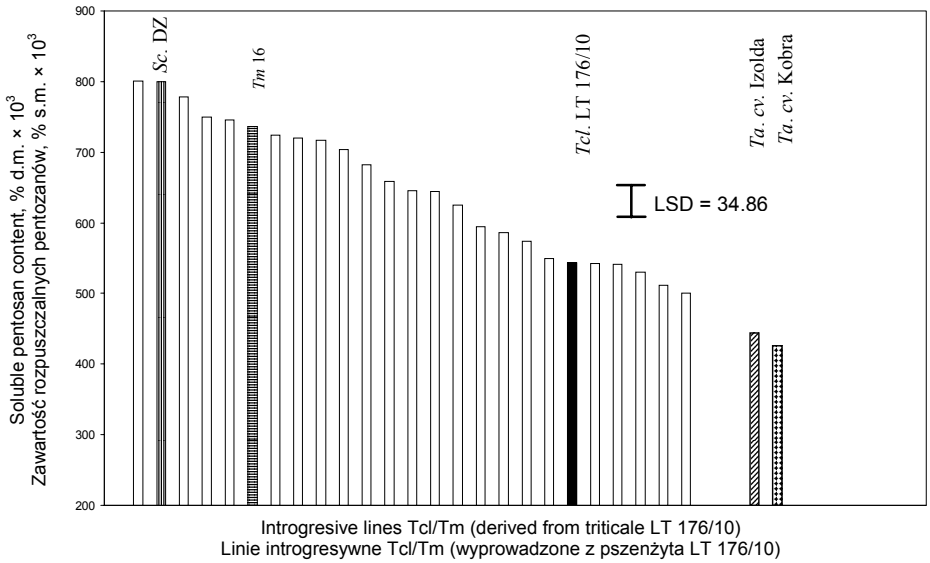

Fig. 2. Variability of soluble pentosan content among introgressive lines derived from triticale LT 176/10 in result of recombination with synthetic amphitetraploid *T. monococcum/S. cereale* (A^mA^mRR)

Rys. 2. Zmienność zawartości rozpuszczalnych pentozanów w liniach introgresywnych powstałych z pszenżyta LT176/10 w procesie rekombinacji z syntetycznym amfitetraploidem *T. monococcum/S. cereale* (A^mA^mRR)

kernel. Their concentration is the highest in the seed coat and outer layers of cells [Michniewicz 1994]. Consequently, the proportion of those parts of kernels in grain samples of small-seeded species is higher than in the case of large-seeded cereals, which may have a significant effect on the measured values of SPC. Further research is needed to verify this hypothesis. Nevertheless, the introgressive lines Tcl/Tm derived from LT 522/6 that are distinguished by a low grain SPC attest to the possibility of obtaining a new variation in this trait by introducing genes from the amphiploid *T. monococcum/ S. cereale*. Selection in respect of low SPC has practical importance because greater amounts in food of this polysaccharides decrease feed intake in chicken and piglets, hamper digestion and make droppings very sticky, resulting in inhibition of growth [Schlegel 1996]. The decrease of the SPC obtained in some of introgressive triticale lines makes it possible to improve grain quality and increase its value as a fodder cereal.

CONCLUSIONS

1. Hybridization of triticale with synthetic amphiploid *T. monococcum*/*S. cereale* given origination of new variation in SPC with some introgressive lines distinguishing of low SPC values.

2. These genetic stocks, together with spectrophotometric evaluation of soluble pentosan content make promising the breeding of low SPC triticale and increase its value as fodder crop.

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REKOMBINACYJNA ZMIENNOŚĆ ZAWARTOŚCI ROZPUSZCZALNYCH PENTOZANÓW W LINIACH INTROGRESYWNYCH PSZENŻYTA POWSTAŁYCH W PROCESIE KRZYŻOWANIA PSZENŻYTA HEKSAPLOIDALNEGO Z SYNTETYCZNYM AMFITETRAPLOIDEM *T. MONOCOCCUM*/*S. CEREALE* (A^mA^mRR)

Streszczenie. W żywieniu zwierząt, błonnik pokarmowy, a zwłaszcza jego rozpuszczalne frakcje, uważane są za główne związki antyżywieniowe. Wysoki poziom zawartości roz-

puszczalnego błonnika pokarmowego (SPC) w ziarniakach pszenżyta, używanego w gospodarce głównie jako zboże paszowe, obniża przyswajalność pokarmu u kurczaków i prosiąt, utrudnia trawienie i powoduje kleistość odchodów dając w rezultacie spowolnienie wzrostu. Zmienność SPC analizowano spektrofotometrycznie, w grupie rekombinantów heksaploidalnego pszenżyta z amfitetraploidem *T. monococcum*/*S. cereale*, stwarzając w ten sposób możliwość selekcji linii z niską zawartością rozpuszczalnych pentozanów. Żyto wykazywało wysoką zawartość SPC, osiągającą około 184% średniej zawartości w ziarniakach pszenicy, a linie pszenżyta (wykorzystywane w krzyżowaniach w charakterze biorców genów) osiągały odpowiednio 125% i 128% SPC w porównaniu z dwoma odmianami pszenicy ('Izolda' i 'Kobra'). Zaskakująco wysoką zmienność w zawartości SPC stwierdzono w ziarniakach linii introgresywnych pszenżyta powstałych w wyniku rekombinacji z amfitetraploidem. Współczynnik zmienności cechy (CV) wynosił 24,7%. Wśród badanych linii introgresywnych pszenżyta wystąpiły takie, u których zawartość SPC w ziarniakach okazała się niższa niż u pszenicy.

Słowa kluczowe: pszenżyto, rozpuszczalne pentozany, *T. monococcum*, linie introgresywne

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