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VARIABILITY OF ALKYLRESORCINOL CONTENT IN RYE (*SECALE CEREALE* L.) GRAINS. A COMPARATIVE ANALYSIS WITH SEVERAL SPECIES OF THE GENUS *TRITICUM*[1]

JAN KACZMAREK, FRANCISZEK TŁUŚCIK[2]

Chair of Plant Breeding and Seed Production, Academy of Agriculture, Wroclaw
Institute of Biochemistry, Wroclaw University, Wroclaw

Summary. Variability in alkylresorcinol content in grain was studied in inbred lines and clones of rye. The estimated genetic factor of variability appeared to be relatively high ($h^2=0.81$ for the lines and $h^2=0.62$ for the clones). The alkylresorcinol content in a developing grain increases proportionally to the area increase of the outer cuticle. Alkylresorcinols were chromatographically separated into homologs with the chain length of C_{15}, C_{17}, C_{19}, C_{21}, C_{23}, C_{25} and into saturated and unsaturated compounds and compared to alkylresorcinols contained in the grain of *Triticum* species. The principal difference between rye and wheat species was about twofold lower alkylresorcinol content in wheat grain than in rye. The upper level of unsaturated alkylresorcinols percentage in wheat grain is similar to the lower level in rye. The intraspecific pattern of homolog composition in wheat and in rye is stable. Rye grains contain the largest amounts of C_{15} and C_{17} homologs, diploid and tetraploid wheats C_{21} and C_{25} (except *T. timopheevi*), but hexaploid wheats C_{19} and C_{21}. The grain of diploid and tetraploid wheats was found to have trace amounts of C_{15} and C_{17} homologs, whereas the grain of hexaploid forms contained only trace amounts of C_{15} homolog.

Cuticular layers of grass grain display a specific chemical composition in the form of hydrocarbons, phenols, sterols or alkylresorcinols (Morrison 1975). The last group of compounds is considerably more abundant in *Secale cereale* than in *Triticum vulgare*. In rye, 40% of the outer cuticle volume are filled with alkylresorcinols (Tłuścik 1978).

An interest to alkylresorcinols is associated with the reports of Wiering (1967), who displayed that they are the cause of certain diseases in pigs fed with rye grain. As a result of feeding chicks with rye grain, inhibition of their growth was observed, however Fernandez et al. (1973) do not assign this negative action to alkylresorcinols, but to other water-soluble factors. Kozubek and Demel (1981) found that the toxic action of unsaturated alkylresorcinols consists in the induction of an increased leakage of potassium and divalent ions from erythrocytes and then their hemolysis. Alkylresorcinols fulfil protective functions in plants during anabiosis and

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[2] First and Second Authors: Dr. Present address: ul. Cybulskiego 34, 50-205 Wrocław, Poland.

germination and in view of that it is not reasonable to create species with a too low alkylresorcinol content. No diseases in animals fed with rye grain were observed in the case of wheat grain.

The purpose of the present studies was to analyse variability of alkylresorcinol content in rye grain of inbred lines and the cv. Dańkowskie Złote and to compare their chemical composition, particularly the presence of saturated, unsaturated compounds and alkylresorcinol homologs with the chemical composition of grain of some *Triticum* species.

MATERIAL AND METHODS

The field experiment was performed at the Experimental Agricultural Department in Swojec near Wrocław. The material of the studies consisted of 44 inbred rye lines with the inbreeding degree from S_2 to S_{20}.

From the population of Dańkowskie Złote 13 clones consisting of three plants were derived. Each plant consisted of half-sisters, i.e. clones originating from single grains of the same spike. The grain originating from plants of two clones of the same plant was studied for accumulation of alkylresorcinols during its development. Material for analyses was collected 13, 15, 16, 20 and 21 days after the outset of flowering and at the stage of full maturity of the grain.

The alkylresorcinol content was determined by colorimetric micromethod using diazonium salt Fast Blue B (Tłuścik et al. 1981). In the studies of the alkylresorcinol content in the course of grain development various number of seeds from individual spikes was used (45 to 91) because samples after weighing were extracted by a calculated acetone volume (0.1 ml acetone per seed).

DETERMINATION METHODS OF ALKYLRESORCINOL HOMOLOGS

A plate covered with silica gel was impregnated through immersion for 30 min. in 5% paraffin oil soluble in hexane. When the plate was dried up condensed acetone extract was put on it in the form of a dot 3 cm long (seeds were extracted by acetone at a room temperature for 24 hours and the extract was condensed by partial evaporation of acetone on boiling water bath).

10 µl samples containing 30 - 100 µg alkylresorcinols were brought. A chromatogram was made for the length of 15 cm using methanol: water — 100:13. After separation and vaporation of solvents the plates were submerged into 0.1% freshly prepared solution of Fast Red B in 0.05 N HCl for 15 min. After several minute rinsing in 0.05 N HCl the water excess was filtered off by filter paper and gel with different, obtained alkylresorcinol homologs was scraped off still moist plates into separate tubes. The dye was extracted by acetone volume resulting from the contents of a given homolog (2 - 6 ml). After 20 minutes of extraction and gel falling on the bottom a clear fluid above the sediment was taken and extinction was determined at 470 nm and the contents of individual homologs was calculated. A reference sample

was a fragment of gel scraped from unstained places extracted by methanol. Localization of individual homologs was made on the basis of simultaneously developed in chromatogram 5-n-pentadecyloresorcin. Each next homolog in the direction of the start line, beginning with C_{15} has the lateral chain longer by two carbon atoms (therefore, C_{17}, C_{19}, C_{21}, C_{23}, C_{25}).

DETERMINATION METHODS OF SATURATED AND UNSATURATED ALKYLRESORCINOLS

A plate covered with silica gel was impregnated by submerging it for 30 min. in 20% silver nitrate in 75% methanol. After impregnation, condensed acetone extract was put on dry plates in the form of a dot 2 - 3 cm long. The extract volume put on the plates contained 20 - 50 μg alkylresorcinols.The chromatogram was developed using chloroform: acetone — 95:5 on the length of 15 cm. After taking out the plates and evaporation of solvents, they were washed out of silver nitrate by a threefold rinsing for 5 min. each time in 0.05 N HCl (silver nitrate keeps from dyeing). After rinsing, still moist plates were submerged for 20 min. in 0.1% solution of Fast Red B in 0.05 N HCl (a staining solution was prepared immediately before the use). After dyeing the plates were rinsed of the excess of a dye in three baths in 0.05 N HCl (each bath for about 5 min.). After rinsing and filtering off on a filter paper, the upper and lower fractions of the moist gel — containing saturated and unsaturated alkylresorcinols, respectively, were scraped off into separate tubes. The dye was extracted from acetone gel (2 - 6 ml) for 20 min. After clarification, the fluid above the sediment was taken and extinction was determined at 470 nm, and the percentage of saturated and unsaturated alkylresorcinols was calculated. The extinction was read to the reference sample, represented by a gel fragment containing no alkylresorcinol.

Data obtained from the analyses of alkylresorcinol composition and content were statistically treated. Heritability of saturated and unsaturated alkylresorcinol content for inbred lines was calculated on the basis of the analysis of variance from the model $h^2=\frac{\sigma_c^2}{\sigma_c^2+\sigma_e^2}$, where: σ_c^2 — genotypic variance, σ_e^2 — environmental variance. Regarding rye clones calculations were made according to the model of the analysis of variance for a two-staged hierarchical classification. Hypotheses about the lack of differences in homolog composition were tested with the X^2-test.

RESULTS

Results of the performed analysis of variability in the alkylresorcinol contents in grain of 44 inbred rye lines are presented in Table 1. It gives the picture of differences between and inside the lines. Using Duncan's test, 25 groups significantly differing in alkylresorcinol content were separated. Variability coefficients indicate large intralinear variability. Different proportions of the contents of saturated and unsaturated alkylresorcinols were detected within 44 lines. The per cent of unsaturated alkylre-

Table 1. Variability in the alkylresorcinol content in grain of 44 inbred rye lines and division into homogeneous groups

Origin and inbreeding degree	Alkylresorcinol content in µg/g dr. wt.	% of unsaturated alkylresorcinol in total content	Variability coefficient	Homogeneous groups
Kazimierskie — $S_{11/1}$	554	16.3	32.6	1
Dańkowskie Sel. — $S_{11/1}$	715	28.0	23.0	2
Imperial — $S_{18/1}$	766	29.8	30.2	3
Dańkowskie Sel. — $S_{9/2}$	884	20.5	22.0	4
Wierzbieńskie — $S_{18/1}$	845	19.1	39.5	
Dańkowskie Zł. — $S_{4/1}$	854	21.5	13.9	5
Zeelandzkie — $S_{7/1}$	860	49.5	9.5	
Dańkowskie Sr. — $S_{2/1}$	874	19.8	30.7	6
Zeelandzkie — $S_{7/2}$	881	28.8	27.6	
Dańkowskie Sel. × Dańkowskie. Zł. — S_2	899	—	15.5	7
Zeelandzkie — $S_{18/3}$	947	—	20.9	8
Węgierskie — S_{18}	948	18.6	29.6	
Wierzbieńskie — $S_{20/2}$	956	28.7	31.9	
Populacja N — S_3	957	25.8	17.4	
Dańkowskie Zł. — $S_{2/2}$	992	24.1	12.9	9
Zeelandzkie — $S_{18/4}$	1022	31.7	15.5	10
Zeelandzkie — $S_{18/5}$	1026	21.0	8.6	
Kazimierskie — $S_{11/2}$	1033	28.8	18.8	
Zeelandzkie — $S_{18/6}$	1035	21.2	14.2	
Mikulickie Wcz. — $S_{17/1}$	1075	19.1	36.4	11
Wielkopolskie — S_{17}	1078	—	33.1	
Wojcieszyckie — S_2	1079	23.3	18.9	
Dańkowskie Sr. — $S_{2/2}$	1096	19.2	24.1	12
Wierzbieńskie — $S_{18/3}$	1098	23.2	20.2	
Horton — S_{18}	1114	—	23.8	
(Dańkowskie Zł. × Wierzbieńskie) — S_6	1146	27.3	28.9	13
Dańkowskie Sel. — $S_{10/3}$	1147	—	12.1	
Garczyńskie — S_{18}	1170	27.4	28.7	14
Lubelskie — S_2	1177	—	19.6	
Zeelandzkie — $S_{9/7}$	1225	31.1	26.6	15
Rogalińskie — S_{16}	1288	—	20.3	
Imperial — $S_{15/2}$	1243	23.4	26.7	16
(Imperial × Włoszanowskie) — S_7	1254	25.7	16.1	
Włoszanowskie — $S_{20/1}$	1259	16.7	45.8	17
Wierzbieńskie — $S_{18/4}$	1265	23.5	44.3	18
Kazimierskie — $S_{9/3}$	1276	31.5	19.1	19
Ludowe — S_{20}	1286	38.2	14.7	
Mikulickie Wcz. — $S_{7/2}$	1310	27.5	21.2	20
Dańkowskie Zł. — $S_{2/3}$	1311	—	22.6	
Kazimierskie — $S_{19/4}$	1481	17.8	36.5	21
Włoszanowskie — $S_{16/1}$	1606	26.5	37.0	22
Dacold — S_{19}	1678	34.0	14.3	23
Kazimierskie — $S_{9/5}$	1733	29.2	25.3	24
Dańkowskie Zł. — $S_{4/4}$	2051	15.6	24.8	25

Remark: Vertical lines mean homogeneous groups and numerical value — its number.

sorcinols ranged from 15.6% to 49.5%. The heritability coefficient calculated for inbred lines was high and amounted to 0.81. It proves a high degree of genetic differentiation of inbred lines. h^2 coefficients were also used for estimation of the variability in alkylresorcinol content within the clones of Dańkowskie Złote.

The mean contents of alkylresorcinols including the percentage of unsaturated ones and the composition of homologs are presented in Table 2. Using the χ^2 test it was found that the percentage composition of homologs in different clones was

stable and that the observed deviations were accidental. This is indicated by the value of $\chi^2=5.91$ which is smaller than the limiting values of $\chi^2_{1;\ 0.05}=16.30$ and $\chi^2_{2;\ 0.05}=59.70$. Using the F test (for $P=0.05$) significant differentiation was found

Table 2. Alkylresorcinol content in grain of 11 clones of the rye cv. Dańkowskie Złote

Clone	Alkylresorcinol content		% composition of alkylresorcinol homologs					
	total µg/g	including unsaturated	C_{15}	C_{17}	C_{19}	C_{21}	C_{23}	C_{25}
47/1	750	19.8	7.0	31.3	29.8	18.4	8.2	5.3
47/2	867	21.4	6.6	38.2	31.1	12.9	7.1	4.1
47/3	750	29.0	6.4	34.5	29.9	16.5	7.4	5.3
47/4	1293	32.3	9.3	33.9	30.1	14.4	7.9	4.4
47/5	1175	24.5	6.1	31.3	31.4	17.4	9.2	4.6
47/6	859	26.4	6.0	33.1	29.9	17.7	8.7	4.6
50/1	907	17.6	6.0	39.5	30.9	13.7	6.7	3.2
50/2	772	43.2	7.0	30.2	29.6	17.6	10.1	5.5
50/3	916	30.1	7.9	33.8	28.5	16.8	8.9	4.1
51/1	931	31.0	7.7	31.9	29.9	16.9	9.3	4.3
51/2	1053	31.1	9.8	32.2	28.0	16.7	8.4	4.9
Expected F			40.9		29.9	16.3	12.9	

$\chi^2_{0.05;\ 1}=16.306$ $\chi^2_{calc.}=5.91$ $\chi^2_{0.05;\ 2}=59.703$

between 3 families (clones in groups) and half-sisters (clones in subgroups). The estimated variances are given in Table 3. The variance S_d is of genetic importance. The correlation coefficient inside the class for clones was 0.16 and for the contents of unsaturated alkylresorcinols — 0.76. The heritability coefficient of alkylresorcinol content was equal to 0.62. Like in the collection of inbred lines it is indicative of a significant share of genetic factor in variability of alkylresorcinols.

Table 3. Estimates of variance components expressing the influence of father and mother forms and variability inside subgroups for saturated and unsaturated alkylresorcinols

Components of variance	No. of freedom degrees	Estimates of variance components	
		saturated alkylresorcinols	unsaturated alkylresorcinols
Paternal (S_s)	8	1531	51.4
Maternal (S_d)	2	2599	−6.1
inside subgroups (S_e)	22	5724	10.9

In order to elucidate some other causes of variability an analysis of alkylresorcinol content in a developing grain was performed with reference to the grain position on particular fragments of spike.

Table 4 presents the dynamics of alkylresorcinol accumulation in the course of grain development in two clones of rye. The total quantity of alkylresorcinols is presented in per µg of dry weight and in µg per developing grain. It was observed that the alkylresorcinol content per grain increases with the increase of grain weight, whereas the alkylresorcinol content per gram of grain dry weight at the initial stages of growth is significantly higher and decreases already in mature grain.

This difference is an expression of changes in the relation of the grain surface to its weight during the development and maturity. More stable results are obtained in analyses, where the basis of calculations is the grain weight, not the number of grains. The percentage composition of individual homologs of alkylresorcinols did not change at different stages of the grain development. The correlation coefficients

Table 4. Saturated and unsaturated alkylresorcinol contents and homolog composition in developing grain of 2 clones of the rye cv. Dańkowskie Złote

Developing grain weight in mg	No. of clone	Alkylresorcinols			Homolog composition (%)					
		mg/g dr. wt.	per grain	including % of unsaturated	C_{15}	C_{17}	C_{19}	C_{21}	C_{23}	C_{25}
2.5 – 3.5	1	1054	3.34	29.3	5.2	33.6	32.2	16.8	8.5	3.7
	2									
3.6 – 4.5	1	1202	4.74	28.4	6.6	35.1	31.0	16.4	7.6	3.3
	2	1050	3.88	25.6	7.3	28.7	30.5	18.9	10.4	4.2
4.6 – 5.5	1	1281	6.49	24.3	8.1	32.5	29.7	16.7	8.6	4.3
	2	1201	5.24	24.1	5.5	29.3	32.4	21.2	8.1	3.5
5.6 – 6.5	1	1477	8.57	19.3	7.4	27.4	28.9	16.3	11.9	8.1
	2	1471	8.42	26.1	7.8	33.8	34.8	29.5	9.5	4.6
6.6 – 7.5	1	1051	7.14	19.0	4.7	32.7	32.2	16.4	9.3	4.7
	2	1618	11.33	26.0	6.5	29.5	30.2	17.6	10.4	5.8
Mature grain 30	1	771	19.00							
	2	1095	28.47							
31 – 35	1	768	25.30	29.1	8.5	37.6	29.2	13.4	7.7	3.6
	2	1079	36.80	31.9	7.8	32.3	29.2	17.2	9.2	4.3
36 – 40	1	886	32.40							
41 – 43	1	961	44.10							

Table 5. A comparative analysis of alkylresorcinol composition in the grain of rye and wheat

	Genome formula	Total alkylresorcinol content				Homolog composition in %					
		µg/g of dr. wt.	µg/30 grains	including % of saturated	including % of unsaturated	C_{15}	C_{17}	C_{19}	C_{21}	C_{23}	C_{25}
Secale cereale L.) Cultivar Dańkowskie Złote (11 clones)	R	934	1034	56.8 – 82.4	17.6 – 43.2	7.2	33.6	29.9	16.2	8.4	4.7
T. monococcum L.	A	482	468	82.1	17.9	0.0+	0.0+	10.8	56.3	29.3	3.6
T. turgidum L. var. *dicoccum*	AB	529	482	93.8	6.2	0.0+	0.0+	14.6	54.8	22.2	8.4
T. turgidum L. var. *durum*	AB	565	508	93.1	6.9	0.0+	0.0+	16.7	54.2	22.5	6.6
T. turgidum L. var. *polonicum*	AB	685	493	91.4	8.6	0.0+	0.0+	12.3	56.9	23.1	7.7
T. timopheevi (Zhuk) var. *timopheevi*	AS	722	630	87.7	12.3	0.0+	0.0+	25.1	50.6	18.6	5.7
T. aestivum L. var. *spelta*	ABD	439	539	83.6	16.4	0.0+	10.1	28.8	41.9	13.9	5.3
var. *compactum*	ABD	453	565	91.0	9.0	0.0+	10.7	28.4	42.2	12.5	6.2
var. *vulgare*	ABD										
cv. Kaspar		339	519	86.0	14.0	0.0+	11.5	33.5	41.3	10.4	3.3
cv. Kolibri		359	495	88.7	11.3	0.0+	9.8	33.1	42.2	11.9	3.0

Explanation: + = trace homolog content

between the alkylresorcinol content and the weight of developing grain were insignificant in the case of the first clone ($r=0.25$) and significant for the second clone ($r=0.48$). In mature grain these relationships were insignificant in the first clone ($r=0.22$) and negative in the second clone ($r=0.62$).

The share of unsaturated alkylresorcinols in developing rye grains was also subjected to changes. A gradual decrease of their quantity together with an increase of the grain weight was observed in clone No. 1 (Table 4).

Grains in different portions of spike differed by the alkylresorcinol content. On the other hand, no significant differences were found in the alkylresorcinol content between the clones of the same plant (Mejbaum-Katzenellenbogen et al. 1975).

Differences in the chemical composition of alkylresorcinols in rye grain and in several wheat species are shown in Table 5. Rye is characterized by about twofold higher alkylresorcinol content than hexaploid wheats. The upper limit of the percentage share of unsaturated alkylresorcinols in wheat is similar to the lower limit of that in rye. The model for the percentage composition of wheat homologs in relation to rye is shifted towards homologs with longer carbon chain. Diploid and tetraploid wheat species contain trace amount of homologs C_{15} and C_{17}, but hexaploid wheats contain homolog C_{17} in determinable amounts (about 10%). Homologs with a shorter carbon chain have in their composition a larger portion of unsaturated compounds and for that reason rye possesses considerably more these compounds than wheat.

DISCUSSION

Alkylresorcinols accumulating in the outer cuticle of rye and wheat grains are related with the protective mechanism of plants. Their bactericidal action, first of all on Gram-bacteria is positive and plays a definite role in natural selection of bacterial flora in the alimentary duct of animals (Ratcliffe 1929).

Variability in the alkylresorcinol content observed in inbred lines is an information with a possible variation in a population. The heritability coefficient in the lines and clones of the cv. Dańkowskie Złote was high (0.81 and 0.62). Genetic factor of alkylresorcinol content estimated by Musehold (1974) in interlinear crosses and by Becker and Geiger (1977) in the cv. Carocurz and Kustro and Morgenstern was high. The intralinear variability expressed by the variability coefficient (Table 1) is to a great extent a result of environmental modification. Studies of variability within a single plant revealed no significant differences in the alkylresorcinol content between spikes. Differences within the spike were found by Mejbaum-Katzenellenbogen et al. (1975). Variability of the percentage share of unsaturated compounds in rye is very large.

Ruebenbauer (1977) reports about the relation of self-incompatibility genes with alkylresorcinol content. No such relationships were detected in the studied material. Differences in the composition of homologs between rye and hexaploid wheat were studied also by Musehold (1979). Results obtained by that author are

in agreement with those of our studies. From these studies it may be inferred that the specific composition of homologs is stable.

The presented results of the studies as well as studies of other authors (Becker et al. 1977, Walther, and Seibold 1981) show to a possibility of decreasing the alkylresorcinol content in grain. The analysis of the composition of saturated and unsaturated alkylresorcinols of rye and wheat and the analysis of variability in rye suggest a possibility and need to decrease the contents of first of all unsaturated alkylresorcinols, which are considered to be more toxic.

CONCLUSIONS

1. The grain of inbred rye lines was found to have different proportions of saturated and unsaturated alkylresorcinols. The percentage of unsaturated alkylresorcinols ranged from 15.6% to 49.5%. The observed phenotypic variability to a high degree coincides with the genotypic variability. The heritability coefficient calculated for the lines was 0.81 and for the clones — 0.62.

2. The dynamics of alkylresorcinol accumulation is related with the grain development. The chemical composition of accumulating alkylresorcinols during grain development is stable.

3. The rye grain contains about twice as much alkylresorcinols as the wheat grain. The upper limit of the percentage share of unsaturated compounds in alkylresorcinols in wheat grains is similar to the lower one of the compounds share in rye grains.

4. The intraspecific pattern of homologs in the grain of wheat and rye is stable. Rye contains the largest number of homologs C_{17} and C_{19}, diploid and tetraploid wheats — C_{21} and C_{23} (except *T. timopheevi*), whereas hexaploid wheats — C_{19} and C_{21}. Trace amounts of homologs C_{15} and C_{17} occur in the grain of diploid and tetraploid wheats, while hexaploid wheats have only trace amounts of C_{15}.

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ZMIENNOŚĆ ZAWARTOŚCI ALKILOREZORCYNOLI W ZIARNIE ŻYTA (*SECALE CEREALE* L.) ORAZ PORÓWNANIE Z NIEKTÓRYMI GATUNKAMI RODZAJU *TRITICUM*

Streszczenie

Badano zmienność obecności alkilorezorcynoli w ziarnie linii wsobnych i klonów żyta. Całkowitą zmienność rozdzielono na części uzależnione od działania genotypu i wpływu środowiska. Oszacowany czynnik genetyczny zmienności okazał się stosunkowo wysoki (dla linii $h^2=0{,}81$ a klonów $h^2=0{,}62$). W rozwijającym się ziarnie zawartość alkilorezorcynoli wzrasta proporcjonalnie do przyrostu powierzchni kutikuli zewnętrznej. Alkilorezorcynole rozdzielono chromatograficznie na homologi o długości łańcucha C_{15}, C_{17}, C_{19}, C_{21}, C_{23}, C_{25} oraz na związki nasycone i nienasycone, a także wykonano porównanie z alkilorezorcynolami zawartymi w ziarnie gatunków rodzaju *Triticum*. Zasadniczą różnicą między żytem a gatunkami pszenicy jest około dwukrotnie niższa niż u żyta zawartość alkilorezorcynoli w ziarnie pszenicy. Górny poziom procentowego udziału związków nienasyconych w ziarnie u pszenicy zbliżony jest do dolnego poziomu u żyta. Wewnątrzgatunkowy wzór składu homologów w ziarnie pszenicy i żyta jest stały. Ziarno żyta zawiera najwięcej homologów C_{15}, C_{17}, pszenic diploidalnych i tetraploidalnych C_{21} i C_{23} (z wyjątkiem *T. timopheevi*), natomiast pszenic heksaploidalnych C_{19}, C_{21}. Śladowe ilości homologów C_{15}, C_{17} stwierdzono w ziarnie pszenic diploidalnych i tetraploidalnych, natomiast u form heksaploidalnych jedynie śladowe ilości homologa C_{15}.

ИЗМЕНЧИВОСТЬ И СОДЕРЖИМОЕ АЛКИЛОРЕЗАРЦИНОЛОВ В ЗЕРНЕ РЖИ (*SECALE CEREALE* L.) СО СРАВНИТЕЛЬНЫМ АНАЛИЗОМ И ИХ СТРУКТУРЫ С НЕСКОЛЬКИМИ ВИДАМИ РОДА *TRITICUM*

Резюме

Исследовалось изменчивость алкилорезорцинолов в родственных линиях и клёнах ржи. Полную изменчивость поделено на часть зависимую от действия генотипа и влияния среды. Определенный генетический фактор изменчивости оказался относительно высоким (для линии $h^2=0{,}81$

а кленов $h^2=0{,}62$). В развивающемся зерне содержимое алкилорезорцинолов повышается пропорционально к приросту поверхности внешней кутикулы. Полное содержимое алкилорезорцинолов поделено хроматографически на гомологи длинной цепи C_{15}, C_{17}, C_{19}, C_{21}, C_{23}, C_{25} и на соединения насыщенные и ненасыщенные и произведено сравнения с алкилорезорцинолами находящимися в видах рода *Triticum*. Основной разницей между рожью а видами пшениц является около двукратно более низкое содержимое алкилорезорцинолов в пшенице. Верхний уровень % участия ненасыщенных соединений у пшениц приближен к нижнему уровню у ржи. Внутривидовый образец состава гомологов в пшенице и ржи постоянный. Рожь содержит больше всего гомологов C_{15}, C_{17}, пшеница диплоидальная и тетраплоидальная C_{21} и C_{23} (за исключением *T. timopheevi*), гексаплоидальные пшеницы C_{19}, C_{21}. Следовые количества гомологов C_{15}, C_{17} обнаружено у диплоидальных и тетраплоидальных пшениц, зато у гексаплоидальных следовые количества C_{15}.