Effects of alleles of dwarfing genes on the morphometric parameters of the kernels of bread wheat

Chebotar Sabina[1], Chebotar Galina[1], Motsnyy Ivan[2], Khokhlov Alexander[2], Sivolap Yuri[1]

[1]South Plant Biotechnology Center UAAS, Ovidiopolskaya dor. 3, 65036 Odessa, Ukraine; e-mail: sabina-chebotar@rambler.ru;

[2]Plant Breeding and Genetic Institute UAAS, Ovidiopolskaya dor. 3, 65036 Odessa, Ukraine

Introduction

The reduction in plant height from the standard to semidwarf levels is known to be associated with significant increasing in kernel number, harvest index and eventually with higher grain yield for bread wheat (Rebetzke, Richards, 2000). The pyramiding of the dwarfing genes *(Rht8c + Rht-D1b, Rht8c + Rht-B1e, Rht8c + Rht-B1d, Rht8c + Rht-D1b+ Rht-B1d)* in the genotypes of modern Ukrainian bread wheat varieties have been detected (Chebotar et al., 2008). In order to investigate possible effects of alleles of dwarfing genes on morphometric parameters of the kernels the nine bread winter wheat analogue lines were tested.

Materials and methods

The analogue lines genetically different in plant height were created by V.V. Khangildin in Plant Breeding and Genetic Institute (Odessa) on the genetic background of historically most popular local varieties.

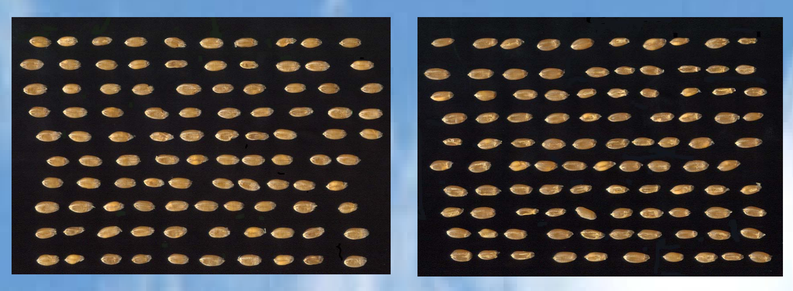
Their allelic composition related to principal dwarfing genes (Rht8, Rht-B1, Rht-D1) have been estimated by using PCR-analysis and test for sensitivity to gibberellic acid: *Kooperatorka (Rht-8a, Rht-B1a, Rht-D1 a)* - Kooperatorka K-90 ***(Rht-8c**, Rht-B1a, Rht-D1a)* and Kooperatorka K-70 ***(Rht-8c**, **Rht-B1e**, Rht-D 1a);* Odesskaya 3 *(Rht-8a, Rht-B1a, Rht-D1a)* - Odesskaya 3 K-75 ***(Rht-8c, Rht-B1b**, Rht-D1a);* Odesskaya 51 ***(Rht-8c**, Rht-B1a, Rht-D1a)* - Odesskaya 51 K-73 ***(Rht-8c**, Rht-B1a, **Rht-D1b**);* Stepnyak *(Rht-8$_{Xgwm261 – 214 bp.}$, Rht-B1a, Rht-D1a)* - Stepnyak 2-K ***(Rht-8c**, Rht-B1a, **Rht-D1b**)* (tabl. 1). As a controls were used lines of Bezostaya 1, Karlik 1, Odesskaya semidwarf.

The one hundred kernels for each line were scanned and the morphometric parameters of the kernels: *l* - major and *d* - minor axes of kernels length, *d / l* - compactness, *P* - perimeter and *S* - square of projection of kernels to a surface area of scanner where calculated using computer program ImageJ 1.41 (NIH, USA) (tabl. 2, fig. 1). Weight of 1000 kernels (WTK) were tested as recommended GSTU 4138 – 2002. Significance of differences was tested by Student's criterion at P=0,05 and P=0,01. Multifactor analysis were done by using Statistic program.

Table 2

Characteristic of analogue-lines by kernel size and WTK parameters

Analogue-lines	$S_з \pm S_{\bar{x}}$, mm^2	$P_з \pm S_{\bar{x}}$, mm	$l_з \pm S_{\bar{x}}$, mm	$d_з \pm S_{\bar{x}}$, mm	$d_з / l_з \pm S_{\bar{x}}$	WTK $\pm S_{\bar{x}}$, g
Kooperatorka	16.08 ± 0.21	17.49 ± 0.19	6.58 ± 0.04	3.13 ± 0.04	0.473 ± 0.003	32.81 ± 0.56
Kooperatorka K-90	17.93 ± 0.24	18.35 ± 0.13	7.09 ± 0.05	3.21 ± 0.03	0.454 ± 0.004	39.70 ± 0.47
Kooperatorka K-70	15.52 ± 0.27	17.05 ± 0.13	6.62 ± 0.05	2.97 ± 0.04	0.449 ± 0.005	30.87 ± 1.71
Odesskaya 3	14.74 ± 0.20	17.13 ± 0.13	7.48 ± 0.27	2.77 ± 0.02	0.411 ± 0.003	33.24 ± 1.52
Odesskaya 3 K-75	13.69 ± 0.29	16.21 ± 0.16	6.38 ± 0.06	2.71 ± 0.04	0.427 ± 0.007	29.92 ± 2.81
Odesskaya 51	18.01 ± 0.19	18.61 ± 0.11	6.98 ± 0.04	3.28 ± 0.02	0.471 ± 0.003	43.17 ± 0.84
Odesskaya 51 K-73	15.88 ± 0.31	17.91 ± 0.16	7.27 ± 0.12	2.96 ± 0.16	0.393 ± 0.005	34.05 ± 3.14
Stepnyak	15.89 ± 0.29	17.63 ± 0.17	6.76 ± 0.06	2.98 ± 0.04	0.442 ± 0.005	23.44 ± 2.67
Stepnyak 2-K	14.99 ± 0.22	17.20 ± 0.13	6.83 ± 0.06	2.79 ± 0.03	0.411± 0.006	24.52 ± 1.16



A B

Fig 1. Definition of kernel size parameters by Image g 1.41 program: A – 100 kernels of variety Kooperatorka K-90; B – 100 kernels of variety Kooperatorka K-70

Table 1

Analogue-lines plant hights and alleles of dwarfing genes

Analogue-line	Plant height in 2008 year, cm	Alleles of dwarfing genes		
		Rht8	*Rht-B1*	*Rht-D1*
Kooperatorka	147.0 ± 4.5	*a*	*a*	*a*
Kooperatorka K-90	116.6 ± 3.9	*c*	*a*	*a*
Kooperatorka K-70	76.3 ± 3.2	*c*	*e*	*a*
Odesskaya 3	135.9 ± 2.7	*a*	*a*	*a*
Odesskaya 3 K-75	102.5 ± 2.5	*c*	*b*	*a*
Odesskaya 51	112.1 ± 1.7	*c*	*a*	*a*
Odesskaya 51 K-73	86.2 ± 8.1	*c*	*a*	*b*
Stepnyak	121.5 ± 0.7	*x**	*a*	*a*
Stepnyak 2-K	94.6 ± 2.7	*c*	*a*	*b*
Odesskaya polukarlikovaya	74.6 ± 2.8	*c*	*e*	*a*
Karlik 1	81.7 ± 1.2	*c*	*b*	*a*

x* - Allele 214 bp by loci *Xgwm261*-2DS

Results

There have been detected increasing of kernels compactness from 4.0 % to 16.5 % for analogue lines comparatively to level of recurrent parental lines (P=0.01) for tested analogue-lines, the line Odesskaya 3 K-75 was an exception (tabl. 3). We consider these differences as side effects of single alleles of dwarfing genes and their combinations.

By *S* parameter all analogue-lines exceeded recurrent parents except line Kooperatorka K-90. This line significantly (P=0.01) surpass analog-lines Kooperatorka and Kooperatorka K-70 by parameters *P*, *l*, by *d* parameter was no significant differences between lines Kooperatorka and Kooperatorka K-90 (tabl. 3). By *P* and *d* parametrs line Stepnyak exceeded its analogue (P=0.05 and P=0.01), by *l* parametr we detected no significant differences. Odesskaya 3 surpass line Odesskaya 3 K-75 by *P* and *l* (P=0.01) parameters, however, there were no difference by *d* (tabl. 3). The line Odesskaya 51 has significantly higher values *P* (P=0.01) and *d* (P=0.05), than Odesskaya 51 K-73, but the line Odesskaya 51 K-73 by the kernel length parameter has significantly higher values than Odesskaya 51 (P=0.05) (tabl. 3).

Table 3

Difference for morphometric parameters of the kernels and WTK between analogue-lines, 2008

Compared analogue-lines	Difference between analogue-lines					
	S, mm	P, mm	l, mm	d, mm	d/l	WTK, g
Kooperatorka - Kooperatorka K-90	-1.85**	-0.86**	-0.51**	-0.08	0.019**	-6.88**
Kooperatorka - Kooperatorka K-70	0.56	0.44	-0.04	0.16**	0.024**	1.94
Kooperatorka K-90 – Kooperatorka K-70	2.41**	1.3**	0.47**	0.24**	0.005	8.83**
Odesskaya 3 - Odesskaya 3 K-75	1.05**	0.92**	1.1**	0.06	-0.016*	3.32
Odesskaya 51 - Odesskaya 51 K-73	2.13**	0.7**	-0.29*	0.32*	0.078**	9.11*
Stepnyak - Stepnyak 2-K	0.9*	0.43*	0.07	0.19**	0.031**	-1.10

* - P=0.05; ** - P=0.01.

In 2008 by WTK between analogue-lines Kooperatorka – Kooperatorka K-90 (P=0.01), Kooperatorka K-90 – Kooperatorka K-70 (P=0.01), Odesskaya 51 – Odesskaya 51 K-73 (P=0.05) have been revealed significant differences (tabl. 3). The analog-line Kooperatorka K-90 surpass it's recurrent parent on 17.33 % and analogue line Kooperatorka K-70 on 22.24 %, also significant difference between Odesskaya 51 and Odesskaya 51 K-73 have been achieved 21.10 %.

These data suggest that substantial decreasing in kernal size is typical for dwarfing forms. Exclusion is analogue-line Kooperatorka K-90. Reduction in the average height of plants to 90 cm, compared to 129 cm of recurrent form, affects the whole complex of features of plants, and, particularly, the size and weight of kernel.

We can see that in the most cases introduction of dwarfing genes decreases kernel size. So it is obviously, that greater yield of dwarfing forms is caused by other elements of productivity.

References

1. Rebetzke *G. J.*, *Richards R. A.* Gibberellic acid-sensitive dwarfing genes reduce plant height to increase kernel number and grain yield of wheat // Australian journal of agricultural research. – 2000.– Vol. 51, № 2. – P. 235 – 245.

2. Chebotar S.V., Fayt V.I., Börner A. Pyramiding of dwarfing genes in the winter bread wheat varieties from the South of Ukraine// European Wheat Aneuploid Co-operative Newsletter -2008- P. 64-68

3. GSTU 4138 – 2002 (ДСТУ 4138-2002) Kernels of agriculture varieties . Methods of determination of quality- Kiev., Gov Standardt UA, 2003. P. 17-18.