P L A N T   B R E E D I N G   A N D   S E E D   S C I E N C E
Volume 44 Number 1 2000

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INHERITANCE OF SOME MORPHOLOGICAL TRAITS AND YIELD COMPONENTS IN INDUCED MUTANTS OF WINTER WHEAT VARIETY FLEVINA

ABSTRACT

Previously (Grzesik 1980) a number of induced mutants with shortened culm increased loging resistance and changed shape of ear and leaves were obtained from winter wheat var. Flevina. Two of the obtained mutants were crossed with the initial variety to study the mode of inheritance of the mutated traits such as culm length, ear length, grain weight per ear and boat-like leaf shape. The hybrids were sown in experiment with six basic generations: P_1, P_2, F_1, F_2, BC_1, BC_2.

The mode of inheritance of the above traits proved to be very complex. Both additive and nonadditive effects of gene action played a significant role. Basing on genetic analysis it can be concluded that a boat-like shape of leaves is determined by two complementary recessive genes.

Key words: winter wheat, mutants, inheritance, gene effects.

INTRODUCTION

A number of induced mutants of winter wheat varieties with shorter culm, increased lodging resistance, and changed shape of ears and leaves were obtained (Grzesik 1980). Some mutants of variety Wysokolitewka Sztywnosłoma despite shortened culm did not show any reduction of yield components. Genetic analysis of some dwarf and semidwarf mutants of the above-mentioned winter wheat variety showed that both additive and non-additive effects of gene action play an important role in inheritance of culm length and yield structure traits (Grzesik, et al. 1990). On treatment of Flevina variety with N-nitroso-N-ethylurea, among other morphological mutations the boat-like leaf mutants were obtained, i. e. th mutants with rounded leaf tops, with leaf edges bent upwards. The mutation appeared in the M_2 generation and was maintained through out subsequent generations.

So far reports on such change in the shape of leaves are lacking. The most frequently occurring leaf mutation concerned leaf length and

Communicated by Henryk J. Czembor

width, the angle of leaf position, or erectoid leaf (Grzesik and Nalepa 1974, Nalepa and Grzesik 1974, Grzesik 1980, Biyashev et al. 1988, Starzycki and Jabłonka 1989). Also mutants with rolled leaves were described by Bogdanova et al. (1988) while Reddy and Gupta (1989) described the leaf tip blunt mutant.

The aim of this study was to investigate the mode of inheriting boat-like leaves and estimation of gene effects refering to yield components of these induced winter wheat (Flevina variety) mutants.

MATERIAL AND METHODS

Two mutants of Flevina variety with boat-like leaves , the source variety Flevina as control and their hybrids were used. This material was put for the field trials in randomized block design in three replicates. Each replicate consisted of 26 rows: P_1-6, P_2-6, F_1-1, F_2-8, BC_1-1, BC_2-4. The row length was 1 m, the distance between rows 20 cm and grains in each row were spaced 5 cm apart.

During growing season the plants with boat-like leaves and those with normal leaves were counted. The results were analysed using the χ^2 test.

After harvest about 15 plants from parents, F_1, BC_1, BC_2, and 25 plants from F_2 progenies, from each replicate were randomly taken for biometric measurements. The analysis concerned five traits: culm length, ear length, ear number per plant, grain number and weight per ear. The effects of gene action were estimated using the method of Cavalli (1952) for 3-paremeter model and the method of Jinks and Jones (1958), cited by Mather and Jinks (1971) for 6-parameter model .

RESULTS AND DISCUSSION

The results of genetic analysis of boat-like leaves (Table 1) showed that boat-like shape of leaf in the mutants is determined by two complementary recessive genes.

Bogdanova et al. (1988) using monosomic analysis found that trait of the rolled leaves winter wheat was controlled by two dominant genes located to chromosomes 6A and 4D. In case of triticale Reddy and Gupta (1989) analysing the blunt leaf tip mutant, found that this trait was monogenically controlled with recessive inheritance.

Mean values of the analysed traits of the studied parental forms and their hybrids (Table 2) show that the length of culm, number of ears per plant, number of grains per ear and grain weight per ear in both mutants were different than those in control .

Using Mather's scaling test it has been shown that the mode of inheritance of the analyzed traits in both hybrids is complex. To elucidate the effects of gene action a six-parameter model was used since a three-parameter model proved to be inadequate.

Table1

Genetical analysis of the boat-like leaf mutants of winter wheat variety Flevina

Crosses	Number of plants with leaves			Ratio	χ^2	P
	normal	boat-like	total			
P_1 97/717m - boat-like leaf mutant	-	292	292			
P_2 Flevina	243	-	243			
F_1 97/717m×Flevina	66	-	66			
F_2 97/717m×Flevina	455	31	486	15 : 1	0.013	0.95-0.90
BC_1 (97/717m×Flevina) x 97 / 717 m	42	10	52	3 : 1	0.92	0.50-0.30
BC_2 (97/717m×Flevina) x Flevina	184	-	184			
P_1 97/711m - 184 boat-like leaf mutant	-	341	341			
P_2 Flevina	243	-	243			
F_1 97/ 711m-184×Flevina	60	-	60			
F_2 97/ 711m-184×Flevina	344	17	361	15 : 1	1.46	0.30- 0.20
BC_1 (97/711m-184×Flevinal)×97/711m-184	46	12	58	3 : 1	0.57	0.50-0.30
BC_2 (97/ 711m-184 x Flevina) x Flevina	215	-	215			

Table 2

Mean values of the traits of studied hybrids between boat-like leaf mutants and initial (Flevina × Flevina) winter wheat variety

Population	Culm length [cm]	Ear length [cm]	Number of ears per plant	Number of grains per ear	Weight of grains per ear [g]
	$\bar{x} \pm S_{\bar{x}}$	$\bar{x} \pm S_{\bar{x}}$	$\bar{x} \pm S_{\bar{x}}$	$\bar{x} \pm S_{\bar{x}}$	$\bar{x} \pm S_{\bar{x}}$
P_1	108.9 ± 1.01	11.5 ± 0.19	4.2 ± 0.29	27.0 ± 1.15	1.0 ± 0.05
P_2	77.3 ± 0.77	8.0 ± 0.17	2.4 ± 0.2	42.6 ± 1.25	1.7 ± 0.06
F_1	88.1 ± 0.87	8.9 ± 0.17	2.7 ± 0.23	44.2 ± 1.38	1.7 ± 0.07
F_2	87.0 ± 1.12	7.8 ± 0.14	2.2 ± 0.15	42.2 ±1.56	1.7 ± 0.07
BC_1	91.6 ± 1.24	9.5 ± 0.17	2.4 ± 0.22	37.1 ± 1.79	1.4 ± 0.09
BC_2	94.7 ± 0.89	9.2 ± 0.20	3.5 ± 0.25	52.4 ± 1.33	2.1 ± 0.05
P_1	88.7 ± 1.58	8.8 ± 0.21	2.1 ± 0.20	24.5 ± 1.49	0.8 ± 0.07
P_2	77.3 ± 0.77	8.0 ± 0.17	2.4 ± 0.20	42.6 ± 1.25	1.7 ± 0.06
F_1	93.7 ± 0.74	10.1 ± 0.17	3.6 ± 0.25	45.5 ± 1.22	1.8 ± 0.06
F_2	90.3 ± 0.94	8.9 ± 0.14	2.4 ± 0.14	44.1 ± 1.11	1.7 ± 0.06
BC_1	104.9 ± 1.42	10.7 ± 0.17	4.1 ± 0.25	45.1 ± 1.55	1.7 ± 0.07
BC_2	109.8 ± 1.35	10.3 ± 0.24	5.1 ± 0.32	42.1 ± 1.41	1.3 ± 0.06

The length of culm both in the crosses 97/717m × Flevina and 97/711m-184 × Flevina was determined mainly by a dominant gene and to a lesser degree resulted from the additive gene action. Of importance were also all the types of epistases: epistasis resulting from interaction of additive with additive genes-aa, additive with dominant-ad, as well as dominant with dominant genes-dd (Table 3). In selection for this trait it would be rather difficult to obtain homozygous forms in early hybrid generations.

In inheriting ear length in 97/717m × Flevina cross both additive and nonadditive effects of gene action were significant with the dominance effects prevailing (Table 3). In cross 97/711m-184 × Flevina the mode of

Table 3

Effects of gene action for some traits of hybrids between boat-like leaf mutants 97/717m and 97/711-184m × Flevina

Model	Culm length [cm]	Ear length [cm]	Number of ears per plant	Number of grains per ear	Weight of grains per ear
			97/ 717m × Flevina		
			3-parametric		
m	93.19 ± 0.59	9.27 ± 0.11	2.99 ± 0.15	36.21 ± 0.79	1.47 ± 0.04
a	12.74 ± 0.58	1.24 ± 0.11	0.44 ± 0.15	9.13 ± 0.79	0.44 ± 0.04
d	-3.37 ± 1.05	-0.73 ± 0.21	-0.59 ± 0.28	11.35 ± 1.55	0.45 ± 0.07
χ^2	183.3	90.86	41.81	30.56	31.95
P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
			6-parametric		
m	68.40 ± 5.49	3.15 ± 0.86	1.76 ± 0.38	34.85 ± 0.85	1.48 ± 0.04
a	15.78 ± 0.64	1.46 ± 0.13	0.95 ± 0.18	7.79 ± 0.85	0.37 ± 0.04
d	54.68 ± 13.05	12.87 ± 2.03	1.11 ± 0.56	27.01 ± 4.66	1.23 ± 0.22
aa	24.76 ± 5.45	6.37 ± 0.78	1.65 ± 0.42	-	-
ad	- 37.66 ± 3.31	-2.27 ± 0.60	-3.86 ± 0.76	15.91 ± 4.73	0.72 ± 0.22
dd	- 34.92 ± 7.90	-7.07 ± 1.30	-	- 17.61 ± 4.88	-0.88 ± 0.23
			97/ 711m-184 × Flevina		
			3-parametric		
m	86.90 ± 0.75	8.65 ± 0.12	2.33 ± 0.13	35.48 ± 0.87	1.32 ± 0.04
a	6.41 ± 0.77	0.52 ± 0.12	0.16 ± 0.13	6.73 ± 0.88	0.30 ± 0.04
d	10.74 ± 1.13	1.76 ± 0.22	1.54 ± 0.27	12.50 ± 1.54	0.53 ± 0.08
χ^2	334.81	72.27	76.27	40.36	73.99
P	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
			6-parametric		
m	15.00 ± 5.53	1.92 ± 0.82	6.11 ± 1.00	35.29 ± 0.87	2.14 ± 0.31
a	5.70 ± 0.88	0.37 ± 0.12	0.24 ± 0.13	8.76 ± 0.97	0.48 ± 0.04
d	222.71 ± 14.29	19.71 ± 2.12	24.60 ± 2.71	12.96 ± 1.54	-1.39 ± 0.78
aa	68.08 ± 5.48	6.52 ± 0.81	8.37 ± 0.99	-	- 0.84 ± 0.31
ad	- 21.18 ± 4.36	-	-	-22.94 ± 4.61	-1.70 ± 0.22
dd	-143.95 ± 9.03	-11.52 ± 1.36	-14.86 ± 1.80	-	1.13 ± 0.49

inheritance of ear length is similar, however, epistasis resulting from the interaction of additive and dominant genes - ad - was noted.

Ear number per plant in case of 97/717m × Flevina cross is determined by both dominant and additive gene as well as by epistasis resulting from the interaction of additive × additive genes - aa - and additive × dominant genes - ad (Table 3). In 97/711m-184 × Flevina cross the effects of additive gene action proved to be insignificant. The most important were the dominance effects of gene action - d - and epistatsis resulting from the dominant ×dominant gene action - dd.

Grain number per ear is controlled by both additive and dominant gene as well as by epistasis resulting from the interaction of additive × dominant genes - ad, and dominant × dominant - dd (Table 3). Epistasis and dominance effects exceeded those of additive gene action.

In inheritance of grain weight per ear in case of the cross 97/717m × Flevina the effects of almost all types of gene action, allelic and nonallelic, proved to be significant, however, epistasis resulting from theinteraction of additive × additive gene action did not occur (Table 3). In case of the hybrid 97/711m-184 × Flevina all three types of epistasis - aa, ad and dd - played an important role. The effects of additive and dominant gene action were insignificant.

The mode of gene action, determining inheritance of grain number per ear and grain weight per ear, is more or less the same. In both cases epistasis had a great share. It causes difficulties in selection of homozygotic material with respect to these traits in early generations.

In general these results are in agreement with the results obtained with the mutants of winter wheat Wysokolitewka Sztywnosłoma (Grzesik et al. 1990) and with the results reported by other authors: Ketata et al. (1976), Węgrzyn and Pochaba (1981), Jedyński and Lonc (1983), (Drozd 1989) and Lonc et al. (1993), on wheat nontreated with mutagens.

A very important problem in the breeding program is the interrelationship between yield structure traits. In the crosses studied in reported experiment in all analysed generations the highest were the correlations between grain weight and grain number per ear with r ranging from 0.71 to 0.95 (Table 4). A similar correlation coefficient was also reported by Masłowski and Milczak (1989).

From the breeding point of view many important data on relations between traits can be obtained by means of a path coefficients analysis. Basing on this analysis it can by stated that grain number per ear has the greatest direct influence on grain weight per ear (Table 5) viz. p=0.821 and 0.783, respectively, being similar to the phenotypic correlation coefficient in F_2 generation. Direct effects of other traits are insiginificant. Grain weight per ear can be modified by culm length and ear length since indirect effects of grain number per ear in these traits are significant at p = 0.157 and 0.177, respectively for culm length and 0.443 for ear length. Similar results were obtained by Larik (1979) and Kadłubiec et al. (1989). The result of the above analysis of path coefficients suggests that a great number of grain per ear may serve as a criterion of selection for high grain weight per ear.

Table 4

Phenotypic correlation coefficients between the analyzed traits of parental forms, F_1, F_2, BC_1, BC_2 generations of hybrids 97/717m x Flevina (1) and 97/ 711m-184 x Flevina (2)

Generations	Cculm length [cm]		Ear length [cm]		Number of ears per plant		Number of grains per ear	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Ear lenght								
P_1	0.16	0.26						
P_2	-0.63**	-0.64**						
F_1	0.35*	0.52**						
F_2	0.30*	0.24*						
BC_1	0.22	0.19						
BC_2	0.28	0.12						
Number of ears per plant								
P_1	0.15	0.32*	0.36*	0.41*				
P_2	0.38*	0.38*	0.27	0.27				
F_1	0.47*	0.37*	0.47*	0.23				
F_2	0.81**	0.82**	0.32*	0.19				
BC_1	0.37*	0.70**	0.59**	0.61**				
BC_2	0.31*	0.55**	0.48**	0.30				
Number of grains per ear								
P_1	0.41*	0.21	0.18	0.51**	0.84**	0.49**		
P_2	0.40*	0.40*	0.43*	0.43**	0.32*	0.32*		
F_1	0.40*	-0.46*	0.60**	0.52**	0.49*	0.29*		
F_2	0.19	0.23	0.59**	0.57**	0.16	0.18		
BC_1	0.36*	-0.92**	0.12	0.37*	0.28	0.23		
BC_2	0.48*	0.27	0.44*	0.37*	0.12	0.48**		
Weight of grains per ear								
P_1	0.39*	0.24	0.17	0.48*	0.42*	0.51**	0.92**	0.95**
P_2	0.73**	0.73**	0.35*	0.35*	-0.26	-0.26	0.90**	0.90**
F_1	0.29*	0.20	0.33*	0.37*	0.37*	0.28	0.77**	0.88**
F_2	0.28*	0.29*	0.61**	0.55**	0.13	0.21	0.90**	0.85**
BC_1	0.33*	-0.14	0.10	0.25	0.29*	0.15	0.93**	0.90**
BC_2	0.13	0.16	0.45*	0.34*	0.18	0.35*	0.71**	0.91**

*,** - significant at P=0,05 and P=0,01, respectively

Table 5
Path coefficients analysis of traits affecting grain weight per ear of hybrids 97/ 717m x Flevina (1) and 97/ 711m-184 x Flevina (2) in F_2 generation.

Traits	Direct effect		Indirect effect		Phenotypic correlation coefficient	
	(1)	(2)	(1)	(2)	(1)	(2)
Grain weight per ear vs culm length						
Direct effect	0.098	0.098				
Indirect effect via ear length			0.032	0.017		
Indirect effect via ear number per plant			-0.004	0.004		
Indirect effect via grain number per ear			0.157	0.177		
Phenotypic correlation coefficient in F_2					0.284	0.295
Grain weight per ear vs ear length						
Direct effect	0.111	0.071				
Indirect effect via culm length			0.029	0.023		
Indirect effect via ear number per plant			0.015	0.008		
Indirect effect via grain number per ear			0.485	0.444		
Phenotypic correlation coefficient in F_2					0.610	0.546
Grain weight per ear vs ear number per plant						
Direct effect	-0.046	0.045				
Indirect effect via culm length			0.008	0.008		
Indirect effect via ear length			0.036	0.013		
Indirect effect via grain number per ear			0.131	0.141		
Phenotypic correlation coefficient in F_2					0.129	0.207
Grain weight per ear vs grain number per ear						
Direct effect	0.821	0.783				
Indirect effect via culm length			0.019	0.022		
Indirect effect via ear length			0.066	0.040		
Indirect effect via ear number per plant			0.007	0.008		
Phenotypic correlation coefficient in F_2					0.898	0.853

The traits under observation determined grain weight per ear in 82,85% of cross 1 and in 74,58% of cross 2. vs - versus

CONCLUSIONS

1. The boat-like shape of leaves in the mutants of Flevina variety is determined by two complementary recessive genes.
2. The mode of inheritance of yield traits proved to be very complex. Both additive and nonadditive effects of gene action were significant.
3. In all analysed generations the highest was the correlation between grain weight and grain number per ear.

4. Grain number per ear has the greatest direct influence on grain weight per ear.

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