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VARIABILITY OF YIELD STRUCTURE AND OF PHYSICAL TRAITS DETERMINING LODGING RESISTANCE IN BARLEY MUTANTS

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A b s t r a c t. The paper presents an analysis of the variability of yield structure traits and lodging resistance of 32 spring barley mutants. The mutants were obtained from the DH line HK-119 using a chemomutagen N-nitroso-N-methylurea (MNU) and helium-neon laser.

The mutants were chosen in such a way that they represented a broad spectrum of plant height. The investigation allowed mutants with improved parameters of yield structure in comparison to the initial form HK-119 to be selected. The analysis of morphological and physical traits - stem diameters, wall thickness and stem elasticity (Young's modulus) - made possible the relationship between these traits and lodging grade to be estimated. The lodging grade was assessed in field conditions on a 9 degree scale, where 1 means no lodging and 9 the highest degree of lodging.

Mutants of different plant height, with desirable yield structure and improved lodging resistance, were identified.

K e y w o r d s: barley, lodging resistance, mutants, physical parameters, stem

INTRODUCTION

A very large portion of genes of the genome of higher plants controls the organisation of the shoot system. This becomes obvious from the large number of mutants with alterations in the plant organ which arise in mutation treatment [5]. Many investigators showed that mutagenesis is a very efficient method of obtaining a broad spectrum of plant height [9,10,13].

As a results of the works mentioned above a huge collection of barley mutants was obtained and studied with regard to the genetics, morphology and yield ability of short-stemmed mutants. Short-stemmed and/or lodging-resistant mutants are of particular importance in cereals, but most of them cannot be utilized for breeding purposes because of their strongly reduced seed production. However, the reduction of plant hight results often in an improved lodging resistance and a yield decrease, so it is possible to obtain such forms with equal or even better yielding ability than the control. An example of this is the X-ray induced Swedish short-stem erectoide mutant which was developed into the commercial variety "Pallas". It shows a pronounced lodging resistance and high productivity [6].

The aim of our work was to estimate the relationships between physical parameters of stem, lodging grade and yielding ability if the initial material of mutants derived from a homozygous dihaploid barley line.

MATERIALS

The initial material consisted of the seeds of DH line HK-119 obtained by using the Hordeum bulbosum method [1]. The seeds of HK-119 chosen for the experiment were

*Paper presented at 6 ICA

characterized by uniform 2.4 cm fraction and an intact embryo.

The seeds were soaked in distilled water for 10 h. After that they were treated for 3.0 h with N-nitroso-N-methylurea (MNU) at dose 1.2 mM. Then the seeds were irradiated with laser beams for 2.0 h. For experiment the helium-neon laser (He-Ne) at wave length 6328 Å and power density 1 mW/cm^2 was chosen. Part of seeds, not intended for mutagenic treatment with MNU and laser, constituted a control.

In M_2 generation selection of mutants was started. In M_3 the seeds of selected mutants were propagated and in M_4 generation for field experiment 32 mutants with different plant height and broad morphological diversity of traits (in comparison to initial form) was chosen. The field experiment was established by the method of randomized blocks with three replications. During the vegetation season the growth and development of mutants as well as lodging grade was observed. The degree of lodging was recorded on a 9-grade scale (where 1 means no lodging and 9- highest degree of lodging).

After harvesting the M_4 mutants were analysed for yield-contributing traits: plant height, spike length, seed number per plant and seed weight per plant. Stem characteristics were analysed by stem wall thickness and stem diameter. Physical stem properties were studied by estimating the stem elasticity coefficient, that so-called Young's modulus. The phenomen of ultrasonic flow through the stem was used for that purpose [8].

The obtained results were elaborated statistically and mutants with improved lodging resistance parameters and desirable yielding ability were identified.

RESULTS AND DISCUSSION

The new varieties of cereals, from the genetic point of view, represent a high yielding potential. One of the reasons for not fully utilizing this ability in convenient enviromental conditions is a distinct inclination of cereals to lodge [2,7]. Lodging has a big negative influence on yield, quality of kernels and straw, and it makes mechanical harvesting difficult. This factor markedly increases the cost of cereals production [15]. In years with unfavourable weather conditions the yield losses caused by lodging are particularly high and attain 50-60%. From this point of view obtaining new cultivars with improved lodging resistance is of particular importance.

Table 1 presents statistical characteristics for yield structure and physical traits determining lodging grade. The average plant height of mutants was 73.1 cm, 80.1 cm for initial form. This character ranged in mutants from 51.4 to 92.6 cm. For yield structure traits - seed number and weight per spike, the value of this characters ranged from 10.8 to 26.6 seeds and 0.41-1.59 g in comparison to both traits for initial form attained 25.6 and 1.25 g. The lodging grade variation ranged from 1 to 7 in 1-9 point scala (3 - for initial form). The value of the variation coefficient was particularly high for morphological and physical

Table 1. Statistical characteristics of yield structure traits, lodging grade and physical stem parameters of analysed barley mutants

Character	Statistical characteristics					
	Mean	Min.	Max.	Standard deviation	Coefficient of variation	LSD
Plant height (cm)	73.1	51.4	92.6	9.10	12.4	4.91
Spike length (cm)	9.4	5.7	11.9	1.01	10.8	0.84
Grain number per spike	21.3	10.8	26.6	3.70	17.4	2.71
Grain weight per spike (g)	1.01	0.41	1.59	0.26	25.5	0.20
Stem diameter (mm)	3.44	3.29	3.99	0.10	3.13	0.14
Wall thickness (mm)	0.35	0.28	0.92	0.06	18.7	0.09
Young's modulus (MPa)	37.2	22.4	53.0	6.55	17.6	3.01
Lodging grade (1-9)	2.9	1.0	7.0	1.77	59.4	1.16

traits of stem - wall thickness (18.7) and stem elasticity (17.6). The high value of the variation coefficient for the above mentioned characters was noticed by Jeżowski [7] in work on spring barley.

The relationship between analysed traits were expressed by coefficients of correlation (Table 2). Significant and high values of the correlation coefficient between lodging grade and physical parameters of stem were observed for stem diameter (r=-0.650) and stem elasticity (r=-0.829). This indicates the important influence of these physical parameters on lodging grade. A lower, but also significant relationship was noticed between lodging grade and wall thickness; r=-0.389. Coefficient of correlation between physical parameters of stem - stem diameter and wall thickness (r=0.517) showed a significant relationship. There is also a significant correlation between plant height and lodging grade (r=0.709).

The groups of mutants with significantly lower, lower and higher mean values of analysed traits in comparison to the initial form are presented in Table 3. The largest groups of mutants with values lower than the initial form were created for plant height and yield structure traits (seeds number and weight per spike). This result confirms the earlier works of others investigators who observed a general decline in the productivity of short-stem mutants as compared to the initial forms [10, 13,14]. It was observed that a decrease in plant height is accompanied by an increased density of the spike, reflected in a low 1000-seed weight. This, in combination with a smaller number of seeds per spike, is a basic cause of yield reduction. It is particularly true for semi-dwarf and dwarf mutants [13]. The largest groups of mutants with values higher than the initial form was created for morphological and physical characters of the stem - stem diameter, wall thickness and stem elasticity (Table 3).

Table 2. The correlation coefficients between investigated traits of spring barley mutants

Character	1	2	3	4	5	6	7	8
1. Plant height (cm)	1.00							
2. Spike length (cm)	0.80**	1.00						
3. Grain number per spike	0.52**	0.41**	1.00					
4. Grain weight per spike (g)	0.44**	0.38**	0.92**	1.00				
5. Stem diameter (mm)	-0.62**	-0.35**	-0.40**	-0.43**	1.00			
6. Wall thickness (mm)	-0.15	-0.01	-0.02	-0.03	0.52**	1.00		
7. Young's modulus (MPa)	-0.46**	-0.29*	-0.19	-0.17	0.60**	0.46**	1.00	
8. Lodging grade (1-9)	0.71**	0.52**	0.27*	0.24*	-0.65**	-0.39**	-0.83**	1.00

*Significant at α= 0.05, ** significant at α=0.01.

Table 3. Number of mutants with lower, significantly lower and higher value of analysed characters in comparison to inital form

Groups of mutants	Characters							
	Plant height (cm)	Spike length (cm)	Grain number per spike	Grain weight per spike (g)	Stem diameter (mm)	Wall thickness (mm)	Young's modulus (MPa)	Lodging grade
Mutants with significantly lower value of analysed characters	17	4	18	13	0	0	4	8
Mutants with lower value of analysed characters	26	18	32	29	0	10	9	12
Mutants with higher value of analysed characters	6	14	0	3	32	22	23	20

T a b l e 4. Barley mutants with lower lodging grade, improved parameters affecting lodging grade and different yielding ability

Initial form and mutants	Characters							
	Plant height (cm)	Spike length (cm)	Grain number per spike	Grain weight per spike (g)	Stem diameter (mm)	Wall thickness (mm)	Young's modulus (MPa)	Lodging grade (1-9)
HK-119	80.1	9.5	25.7	1.25	3.26	0.340	33.9	3.0
M-12/4	78.7	9.9	24.9	1.31	3.37	0.366	44.1	2.0
M-2/3	73.4	9.7	24.4	1.39	3.41	0.356	37.7	2.6
M-2/4	72.7	9.0	24.6	1.34	3.46	0.360	37.0	1.6
M-11/5	67.1	9.3	20.8	0.98	3.58	0.380	50.4	1.0
M-2/6	57.9	8.5	21.9	1.07	3.59	0.360	44.3	1.0
M-2/5	55.2	8.3	11.8	0.48	3.57	0.350	47.7	1.0

This is a probable reason of obtaining a higher number of mutants with lower lodging grade. The influence of physical parameters of stem on lodging grade was analysed by many investigators [8,11,12,16]. Particularly important seems to be a relationship between stem elasticity and lodging grade. In the opinion of Dunca [4], Doliński [3] and Jeżowski [8], among all morphological and physical parameters of stem, coefficient of elasticity (Young's modulus) has the most decesive influence on lodging resistance. This opinion confirms a high significant coefficient of correlation for the above mentioned characters obtained in our experiment (r=-0.828).

Generally, the results from Table 3 show, that a lower lodging grade is accompanied by a reduction in plant height, yielding ability and by improved morphological and physical parameters of the stem.

In spite of the observed reduction of yielding ability, it was possible to select mutants with improved lodging resistance and yield structure similar with traits to the initial form (Table 4). It is particularly true for mutants M12/4 and M2/4. The highest decrease of yielding ability was observed for mutants with the most reduced stem length (M2/6 and M2/5) and lowest lodging grade.

CONCLUSIONS

1. N-nitroso-N-methylurea is an efficient tool for obtaining mutants with reduced plant height and broad variation of morphological and physical traits of stem determining lodging resistance.

2. The obtained results showed a positive, highly significant relationship between plant height and lodging grade as well as a negative, significant correlation between lodging grade and physical parameters of stem (stem diameter, wall thickness, stem elasticity).

3. Height reduction of mutants, in comparison to the initial plant form, was accompanied by a decrease of lodging grade, yielding ability as well as by improved morpho-physical parameters of stem.

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