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SIGNIFICANCE OF GEOMETRICAL AND PHYSICAL FEATURES FOR GENETIC ANALYSIS OF TRIALS DETERMINING LODGING RESISTANCE

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A b s t r a c t. In the paper 28 lines of doubled haploids (DH) produced from F_1 hybrids Aramir x EP79 were investigated under field conditions. Lodging degree was estimated in the field applying a 9-grade scale (where 1 means no lodging and 9 the highest degree of lodging). The geometrical stalk features evaluated in the experiment included: stalk length its external diameter and wall thickness. However, some physical stalk features were judged employing ultrasound method and are described as values of elasticity index (Young's modulus). The data presented in the paper have showed that stalk elasticity seems to be the most variable feature of DH lines populations. A genetic analysis showed the significance of the additive gene action effects for all the studied geometrical and physical treits of stalk.

K e y w o r d s: *Hordeum vulgare* L., genetic parameters, lodging resistance, Young's modulus

INTRODUCTION

Cereal lodging is mostly associated with a damage of the stem or root system as a result of unfavourable conditions during their vegetation. These are most frequently weather conditions: rainfalls, winds and temperature.

Losses of grain and straw yield caused by lodging may reach 60%. In this connection it seems that all the works in the field of genetics, breeding and agrophysics aimed consequently at creating cultures which increased lodging resistance may reduce these losses to a significant degree.

This paper presents results of an experiment with DH barley lines carried out to estimate some geometrical and physical properties of stem which determine lodging resistance.

MATERIAL AND METHODS

The studying material consisted of 28 doubled haploid lines of spring barley obtained from F1 Aramir x EP 79 hybrids by *Hordeum bulbosum* methods [1,7]. The lines and parental forms were examined in a field trial established in a randomized block design with three replications. Seeds at the rate of 330 g/m^2 were sown out on 4 m^2 plots. The degree of lodging was estimated at full maturity using a 1-9 scale, where 1 means no lodging and 9- the largest lodging. After harvest, geometrical stem measurements were taken for the length, the length of the first and second internodes (counting from stem base), diameter of internodes and their wall thickness. In addition, stem elasticity (Young's modulus) was estimated on the basis of the speed of ultrasonic wave flow through a 5 cm stem section of the third internode by the method described by Gawda and Haman [4].

The data obtained from the measurements were statistically calculated. An analysis of variance was carried out, and using Dunnet's test groups of lines with maximal and minimal values of a given trait were separated. The

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lines within each of these groups did not differ significantly from one another, but differed significantly from the remaining forms. On the basis of means for extreme lines, the effects of additive gene action [d] and effects of interaction of loci in a homozygous state [i] were estimated. Results of the analysis of variance made it possible to estimate also heritability coefficients.

RESULTS AND DISCUSSION

The analysis of variance showed that the examined DH lines significantly differed from one another in all analysed traits, due to this it was possible to separate groups of lines with maximal and minimal values. Table 1 gives mean values for the both groups of lines as well as general means for the studied DH line population and for initial forms. It can be noticed here that the cv. Aramir was markedly more resistant to lodging than the form EP79. This cultivar, as compared to the from EP 79, had a shorter stem and definitely larger diameters and thicker walls of the first two internodes. However, the most pronounced were differences in the values of stem elasticity (Young's modulus). The value of this index for the cv. Aramir was twice as high as that of the more lodging form EP79. Estimates of parameters for the studied geometrical traits of the DH lines presented in Table 2 showed, that the effects of additive gene action [d] were significant for the lenght of both the stem and lower internodes as well as for the diameter and wall thickness of internodes. Non-allelic interaction [i], however, appeared to be significant only for the internode length and for the wall thickness of the first and second internodes. The "m" parameter in Table 2 means the value of trait independent of the action of segregation loci, in the case of doubled haploids the "m" parameter is equal to the mean of all the lines Surma *et al.* [9]. This table also gives the value of genetic parameters for stem elasticity and lodging degree. The value of the parameter [d] significantly differend from 0 for the both considered traits. Effects of the interaction of genes in a homozygous state [i] appeared to be also significant for these traits.

From the values of the heritability coefficients presented in Table 3 follows that the portion of additive variance in phenotypic variation of the analysed geometrical traits was comparatively small - from 44.6% for the diameter to 65.5% for the wall thickness of the first internode. However, in the case of stem elasticity (84.5 and 80.2%, respetively) these coefficients were already considerably higher. It may, however, be noticed, that the heritability coefficients for the stem length and for the lenght of the first two internodes were similar and ranged within 50-54%. In the case of the

Table 1. Mean values of the studied geometrical and physical stem traits of doubled haploid lines (DH) of barley obtained from F_1 Aramir × EP 79 hybrids

Character	Lines DH			Parental forms	
	max.	min.	mean	Aramir	EP 79
Length (cm)					
stem	78.21	55.21	65.22	60.43	68.70
internode I	7.32	5.81	6.61	5.89	6.93
internode II	12.09	9.11	10.91	10.05	11.32
Diameter (mm)					
internode I	3.51	2.99	3.11	3.36	3.00
internode II	3.54	3.11	3.33	3.44	3.29
Wall thickness (mm)					
internode I	0.38	0.32	0.35	0.43	0.36
internode II	0.31	0.27	0.30	0.36	0.30
Young's modulus (MPa)	29.11	18.91	23.11	45.25	22.11
Lodging grade (1-9)	5.05	3.11	4.21	2.44	5.00

Table 2. Estimation of genetic parameters for the studied traied traits of barley DH lines

Character	m	[d]	[i]
Length (cm)			
stem	65.22±3.610	11.05±0.614	0.91±1.511
internode I	6.61±0.151	0.92±0.123	0.55±0.121
internode II	10.91±0.801	0.69±0.322	0.84±0.192
Diameter (mm)			
internode I	3.11±0.012	0.64±0.053	0.06±0.051
internode II	3.38±0.081	0.59±0.082	0.02±0.056
Wall thickness (mm)			
internode I	0.35±0.012	0.16±0.049	0.08±0.036
internode II	0.27±0.002	0.05±0.001	-0.02±0.005
Young's modulus (MPa)	23.11±0.583	8.11±0.592	0.22±0.061
Lodging grade (1-9)	4.21±0.163	1.04±0.111	0.12±0.090

Table 3. Estimation of the heritability ceofficients studied traits of barley lines

Character	Heritability coefficients (%)
Length (cm)	
stem	51.1
internode I	54.1
internode II	50.8
Diameter (mm)	
internode I	41.6
internode II	46.1
Wall thickness (mm)	
internode I	65.5
internode II	52.8
Young's modulus (MPa)	84.5
Lodging grade	80.2

internode diameter the situation was similar (44.6-46.1%). The obtained values of genetic parameters and heritability coefficients show, that in the studied set of genotypes the largest breeding advance can be obtained by selection for high stem elasticity, and among geometrical traits - for the wall thickness of the first and second internodes. The mentioned traits, particularly the index of stem elasticity (Young's modulus), largely determine lodging resistance [3,5,6].

The suggestions made should first of all be referred to the studied population of doubled haploids, since the values of both geometrical parameters and heritability coefficients depend on the environmental conditions and analysed cross combination [2,8]. As metioned before, on the basis of DH lines it is possible to estimate only effects of the action of genes in a homozygous state. In self-pollinating plant breeding these are the most significant information as they concern those effects, which can become stable in the process of selection and determine breeding advance.

CONCLUSION

Stalk elasticity seems to be the most variable feature of DH lines populations. A genetic analysis showed the significance of the additive gene action effects for all the studied geometrical and physical treits of stalk.

REFERENCES

1. **Adamski T.:** The obtaining of autoploid barley lines using haploids from the cross *Hordeum vulgare* L. × *Hordeum bulbosum* L. Genet. Pol., 20, 31-42, 1979.
2. **Doliński R.:** The inheritance of elastic properties of the stem schlerenchyma in winter wheat hybrids (*Triticum aestivum* L.). Genet. Pol., 31, 199-204, 1990.
3. **Doliński R.:** Variation, heritability and correlation of machanical and morphological characters determining lodging of wheat (*Triticum aestivum* L.) (in Polish). WAR Lublin. Rozprawy Naukowe 177, 1-68,1995.
4. **Gawda H., Haman J.:** An ultrasonic method of determining Youngs modulus in cereal plants. ASAE, 26, 250-254, 1983.
5. **Jeżowski S.:** Variation, correlation and heritability of characters determining lodging of spring barley (*Hordeum vulgare* L.). II. Analysis of relationship between lodging grade and some morphological characters of sping barley varieties. Genet. Pol., 22, 45-61, 1981a.

6. **Jeżowski S.:** Variation, correlation and heritability of characters determining lodging of spring barley (*Hor*deum vulgare L.). III. Analysis of relationship between lodging grade and selected morphological and physical indices of the stem. Genet. Pol., 22, 149-162, 1981b.
7. **Kasha K.J., Kao K.N.:** High frequency haploid production in barley. Nature, 225, 874-876, 1970.
8. **Rybiński W.:** Short-straw forms of spring barley (*Hordeum vulgare* L.) obtained as a result of MNUA-induced mutations. Genet. Pol., 22, 271-287, 1981.
9. **Surma M., Adamski T., Kaczmarek Z.:** The use of doubled haploid lines for estimation of genetics parameters. Genet. Pol., 25, 27-32, 1984.