

Breeding *mlo* resistant spring barley (*Hordeum vulgare* L.) lines for organic cultivation

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This study was carried out in the 2009 and 2010 seasons in Fleischmann Rudolf Research Institute, Kompolt, Hungary to screen 12 *mlo* resistant barley lines and two susceptible cultivars for grain yield (GY), hectoliter weight (HLW) and thousand grain weight (TGW) in field trials. The pleiotropic effect of *mlo* gene on TWG, HLW and yield potential depended on the genetic background. Water stress affected the expression of *mlo* resistance of three barley lines in 2010.

Keywords: spring barley, powdery mildew, *mlo* resistance, grain yield, hectoliter weight, thousand grain weight.

Powdery mildew (*Blumeria graminis* f.sp. *hordei*) is the most important pathogen of spring barley in Hungary affecting the foliage and heads. The windborn, biotrophic, fungal pathogen of cultivated barley and wild barley is particularly prevalent under cool conditions when the maximum daily temperature does not exceed 25°C (Dreiseitl et al., 2006). Severe infection not only reduces yield but also lowers the quality and grade of the grain produced. Systematic foliar fungicides are registered for control of powdery mildew. However, breeding resistant cultivars is an economical and environmentally safe way of protecting barley against powdery mildew, and they have benefit under organic growing conditions.

Resistance provided by *Mlo* genes is a unique form of monogenic resistance that is not classically race specific and is conferred by a series of recessive alleles (Jørgensen, 1992).

The objective of this study was to screen our 12 *mlo* resistant barley lines for grain yield, thousand grain weight and hectoliter weight in field trials at one location and in two years.

Materials and Methods

Plant material

The experiments were carried out in Fleischmann Rudolf Research Institute, Kompolt, Hungary on brown forest soil. High yielding good quality spring barley lines/varieties were crossed with powdery mildew resistant lines/varieties of different origin, and then twelve *mlo* resistant spring barley lines were produced. The lines were: M-03/24-13, M-03/24-2, M-03/27-12, M-03/27-27, M-03/21-11, M-03/21-4, M-03/27-17, M-03/66-1, M-03/66-12, M-03/71-16, M-03/71-17, M-03/96-2. The cultivars 'Pasadena' and 'Scarlett' were used as susceptible controls.

Disease assessment

The leaves of greenhouse-grown plants were inoculated with Hungarian *B. graminis* f.sp. *hordei* populations by shaking conidia from diseased plants when the plants had one leaf. After seven days incubation, the infection types were scored according to a 1-9 scale developed by Dreiseitl et al., (2007) with some modification. Scoring was done on the basis of incidence of leaf spotting and conidial growth. Plants scoring 1 were included in the susceptible group and plants scoring 9 in the resistant one.

The experiment was conducted in a Randomized Block design with four replications. Plot size was 10 m². Sowing was done by a Wintersteiger drill on 18 and 23 March in 2009 and 2010, respectively. The basic presowing fertilization rates for all plots were 60 kg N ha⁻¹ and 60 kg P ha⁻¹; a top dressing of 40 kg N ha⁻¹ was applied to plots at early stem elongation. Harvest was done using Wintersteiger Nursery Master. Yield was recorded in kg per hectare (kg ha⁻¹) after combine harvesting. TGW and HLW were determined according to the ICC standard method. The weather conditions during the crop years are presented in Table 1.

One-way analysis of variance (ANOVA) was used to determine the effects of genotype and year for the data on yield, thousand grain weight and hectoliter weight. Least significance difference (LSD) tests were performed to determine the significant differences between individual means. All statistical analyses were performed using the Excel program.

Table 1. Precipitation and average temperatures in the growing seasons of the investigated crop years

		February	March	April	May	June	July	Total
2009	mm	40	43	3	36	97	37	256
	°C	1,0	5,4	14,8	20,1	22,5	22,5	
2010	mm	55	22	74	160	97	164	572
	°C	0,7	5,2	14,4	17,8	19,5	22,8	

Results

Grain yield

In 2009 the growing season was dry, and the yield ranged between 4130 kg ha⁻¹ and 5800 kg ha⁻¹ with an average of 4920 kg ha⁻¹. Six resistant barley lines significantly over yielded the average of susceptible standards (Table 2).

In 2010 the spring was extremely rainy, and there was water stress. The yields were by 72.8% lower than in the previous year (Table 2). The average yield was only 1340 kg ha⁻¹. In this wet year the seed production of seven resistant barley lines was significantly higher than the average of susceptible varieties. Spring barley lines M-03/24-13, M-03/24-2, M-03/27-17 and M-03/96-2 showed a significantly higher yield potential in both two seasons when compared to the average of susceptible cultivars (Table 2).

Thousand grain weight

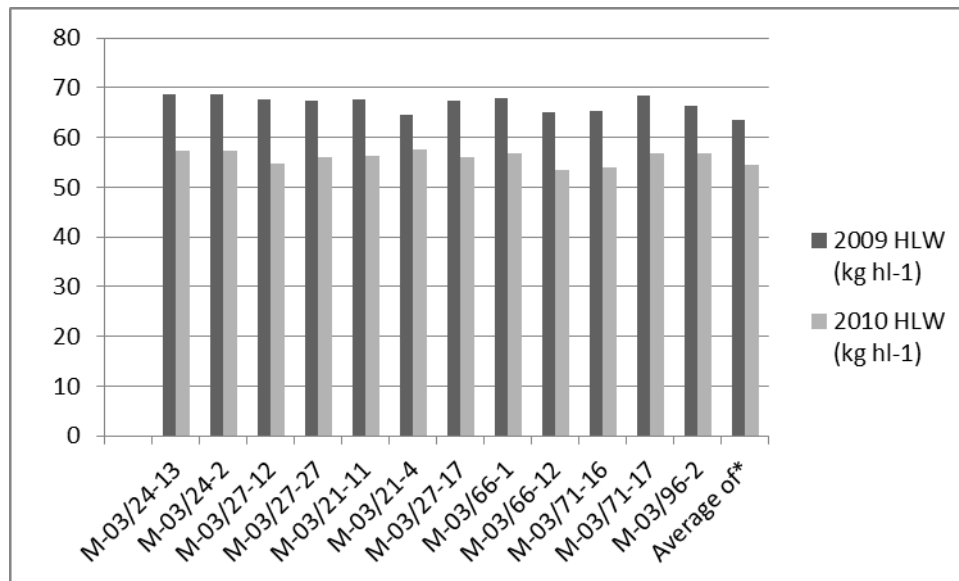
The TGW ranged between 43.6 and 50.9 g in 2009, and between 30.3 and 41.0 g in 2010. The average TGW was 47.6 g and 35.8 g, respectively. Nine spring barley lines such as M-03/24-2, M-03/24-13, M-03/27-12, M-03/27-17, M-03/27-27, M-03/66-1, M-03/71-16, M-03/71-17, M-03/96-2) had significantly higher TGW in both years when compared to the average of susceptible check varieties (Table 2). Line M-03/21-4 was the same TGW over two seasons than both 'Pasadena' and 'Scarlett'. The TGW of the *mlo* resistant lines was by 10,02 g significantly higher in the first year than in the second one. Significant differences between the resistant lines in TWG were also found in both years.

Hectoliter weight

HLW of the resistant lines were significantly influenced by the year. The main values of the resistant lines and the susceptible cultivars were higher in the first year (66.6 kg hl⁻¹) than in the second one (55.9 kg hl⁻¹) while their average grain yield was also higher due to the favourable weather conditions in 2009. The average of HLW over the years varied between *mlo* resistant barley lines from 53.5 to 68.7 kg hl⁻¹, and between susceptible cultivars from 54.5 and 64.1 kg hl⁻¹ (Figure 1). M-03/24-13, M-03/24-2, M-03/27-17 and M-03/96-2 had the highest HLW in 2009.

Table 2. Yield per plot (t ha⁻¹), Thousand Grain Weight (g⁻¹) and Hectoliter Weight (kg hl⁻¹) of the *mlo* resistant spring barley lines and the susceptible 'Pasaden' and 'Scarlett' cultivars in 2009 and 2010

Lines	2009		2010	
	Yield/plot (t ha ⁻¹)	TGW (g ⁻¹)	Yield/plot (t ha ⁻¹)	TGW (g ⁻¹)
M-03/24-13	5.28*	49.00*	1.41*	33.98**
M-03/24-2	5.23*	49.20*	1.81**	40.98***
M-03/27-12	4.73	47.80***	1.50*	35.98***
M-03/27-27	4.95	47.40***	1.50*	35.95***
M-03/21-11	5.71***	46.20**	1.05	30.98
M-03/21-4	5.82**	44.70	1.24	32.03
M-03/27-17	5.26*	47.30**	1.69**	37.95***
M-03/66-1	4.52	49.00***	1.08	36.03***
M-03/66-12	4.13	45.00	1.23	37.95***
M-03/71-16	4.61	45.90*	1.12	34.03**
M-03/71-17	4.34	50.90***	1.69***	38.95***
M-03/96-2	5.49*	48.30***	1.50*	34.98**
Average of susceptible cultivars	4.82	43,93	1.20	31,25
*LSD 5%	0.66	1.18	0.30	1.47
**LSD 1%	0.89		0.40	
***LSD 0.1%	1.16		0.53	



*Average of susceptible cultivars

Figure 1. The hectoliter weight (kg/hl) of the *mlo* resistant spring barley lines and the average of susceptible cultivars in 2009 and 2010



Conclusions

According to Baker et al. (1998) specific environmental conditions like water stress affecting the expression of *mlo* resistance. The pleiotropic effect of *mlo* gene could not be observed at *mlo* resistant spring barley lines M-03/24-13, M-03/24-2, M-03/27-17 and M-03/96-2 because their yield potential and TWG were significantly higher in both years than that of the susceptible cultivars. M-03/66-1, M-03/66-12 and M-03/71-16 May be that the low yield potential of the M-03/21-11 and M-03/21-4 furthermore their significantly lower TGW in 2010 were due to a breakdown effect of their *mlo* resistance. On the basis of our results we suppose that M-03/66-1, M-03/66-12 and M-03/71-17 lines have no *mlo* resistance. So it will be important to test the resistance of all our spring barley lines with isolates having virulence to the major resistance genes currently found in Hungary and Europe, as well.

The pleiotropic effect of *mlo* gene on TWG, HLW and yield potential depends on the genetic background. This effect could be observed in 2009 which was favourable for barley production. By growing *mlo* resistant lines yield losses can be decreased under stress conditions.

Literature

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