PROCEEDINGS OF THE LATVIAN ACADEMY OF SCIENCES. Section B, Vol. 68 (2014), No. 3/4 (690/691), pp. 119–132.
DOI: 10.2478/prolas-2014-0014

CHARACTERISATION OF AGRONOMIC PERFORMANCE OF BALTIC SPRING BARLEY MATERIAL

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Spring barley breeding has been carried out for almost a century in all three Baltic countries. The efforts of breeders have resulted in many new improved varieties released. The goal of our project was to survey the effect of these efforts throughout the century on this crop. The material included in this study consisted of 64 accessions originating from Latvia, Estonia and Lithuania, representing landraces, varieties released from 1927 to 2001, and breeding lines. Six agronomic traits (days to heading, days to maturing, plant height, harvest index, volumetric weight and thousand kernel weight) were recorded during two years (2002 and 2003) at three locations — Priekuļi (Latvia), Landskrona (Sweden) and Bjørke (Norway). The differences between spring barley materials of different origin and from different breeding periods were assessed, and variation of their performance in different environments was discussed.

Key words: Hordeum vulgare *L., Baltic region, plant height, days to heading, days to ripening (maturing), harvest index, volumetric weight, thousand kernel weight, phenotypic variation.*

INTRODUCTION

Man has been improving the agronomic properties of crops since their domestication. There have been studies that have described these changes, e.g. increased grain weight in modern cereals as compared to archaeological grains (Ferrio, *et al*., 2006). The intensification of agriculture in the beginning of the 20th century led also to focus on genetic enhancement of varieties via professional plant breeding. In many countries, the founding of plant breeding institutes and companies correspond to this period of time. The Baltic countries were not an exception and also here, in the period from the 1920s to the 1940s, institutes dealing with crop improvement and plant breeding were founded (Gaike, 1992). Breeding for barley has been carried out in all of the Baltic countries, since this is an economically important species in the region. Initially breeding was based on selection from locally adapted landraces, as well as from selections from other European materials. Later the varieties resulted from crosses between local varieties and foreign material. The yields of spring barley have more than doubled during the last century due to improvements in mechanization and plant breeding efforts (http://www.stat.ee; http://www.zm.gov.lv; http://wwwstd.lt). During the 20 th century, the area of planted barley has been increasing, which reached its maximum at the end of 1970, followed by a decrease due to more area planted with wheat (Anonymous, 2012). Currently about 10% of the total crop area in Latvia and Lithuania, and 20% in Estonia is planted with barley (Anonymous, 2012).

The objectives of this study were to characterise the agronomic properties of spring barley, comparing material from all three countries, different breeding periods and different types (six-rowed vs. two-rowed). The accessions discussed in this paper were also included together with accessions from Sweden, Denmark, Finland and Norway in a larger study to investigate genetic erosion in barley over the last century (Kolodinska Brantestam, 2005). This paper is focused on Baltic material only, to assess trait variation and trait stability of Baltic varieties in different environments. The same set of accessions has been characterised using simple sequence repeat (SSR) and isozyme markers (Kolodinska Brantestam *et al*., 2010).

MATERIALS AND METHODS

Materials. The material analysed consisted of 64 accessions of spring barley from Estonia, Latvia and Lithuania, including landraces, varieties and breeding lines (Table 1). Material was obtained from gene banks in the Baltic countries (Commission on Plant Genetic Resources for Food and Agriculture in Estonia; Genetic Resource Centre in Latvia and Plant Gene Bank in Lithuania) and plant breeding companies (Jõgeva Plant Breeding Institute, State Priekuļi Plant Breeding Institute, and State Stende Cereal Breeding Institute in Latvia and Lithuanian Institute of Agriculture in Lithuania). Both six-rowed (seven accessions) and two-rowed (57 accessions) types were included in this study.

Trial sites and plot size. The trials were performed during two years, 2002 and 2003, at three locations: Bjørke (south-

Table 1

BARLEY ACCESSIONS, THEIR ORIGIN, TYPE AND YEAR OF RELEASE

Field Nr.*	Accession name	Gene bank number	Origin country	Year of release	Accession type	Pedigree	Spike type	Breeding Inst.
133	Latvijas vietējie	LVA00018	Latvia	-	landrace	-	two-rowed	-
134	Vairogs	LVA00017	Latvia	1930	variety	(S) local material from Priekuļi	six-rowed	Priekuļi Pl.Br.Inst.
135	Kombainieris	LVA00009	Latvia	1950	variety	Maja x Talsu local material	two-rowed	Stende Cer.Br.Inst.
136	Priekuļu 1	LVA00011	Latvia	1959	variety	(S) Norwegian local	six-rowed	Priekuļi Pl.Br.Inst.
137	Priekuļu 60	LVA00012	Latvia	1972	variety	Talsu local material x Maja x Tammi	two-rowed	Priekuļi Pl.Br.Inst.
138	Stendes	LVA00016	Latvia	1972	variety	Drost x Maja	two-rowed	Stende Cer.Br.Inst.
139	Abava	LVA00001	Latvia	1978	variety	Mari x Elsa x Domen	two-rowed	Stende Cer.Br.Inst.
140	Ilga	LVA00006	Latvia	1983	variety	KM 1192 x Hadmersleben 70179/70	two-rowed	Priekuļi Pl.Br.Inst.
141	Agra	LVA00002	Latvia	1984	variety	Priekuļu 1 x Otra	six-rowed	Stende Cer.Br.Inst.
142	Imula	LVA00007	Latvia	1985	variety	Abava x Akka	two-rowed	Stende Cer.Br.Inst.
143	Balga	LVA00004	Latvia	1990	variety	Gunilla x KM 1192	two-rowed	Priekuļi Pl.Br.Inst.
144	Rasa	LVA00013	Latvia	1991	variety	France gold x HE-R-54	two-rowed	Stende Cer.Br.Inst.
145	Klinta	LVA00008	Latvia	1992	variety	Torkel x CF-42	two-rowed	Latvia University of Agriculture
146	Ruja	LVA00014	Latvia	1992	variety	(Kombainieris x Triumph) x Abava	two-rowed	Priekuļi Pl.Br.Inst.
147	Sencis	LVA00015	Latvia	1994	variety	Rupal x Ofir x Torkel	two-rowed	Stende Cer.Br.Inst.
148	Ansis	LVA00003	Latvia	1995	variety	KM 246-3-78 x Taifun	two-rowed	Stende Cer.Br.Inst.
149	Gate	LVA00005	Latvia	1995	variety	H 497 x Hadmersleben x Nadja*2 x Emir	two-rowed	Priekuļi Pl.Br.Inst.
150	Malva	LVA00166	Latvia	1998	variety	STN8142 x STN7542	two-rowed	Latvia University of Agriculture
151	L-1879	LVA01393	Latvia	-	breeding line	unknown	two-rowed	Priekuļi Pl.Br.Inst.
152	L-1883	LVA01394	Latvia	-	breeding line	Ida x (Mazurka x KM 1192)	two-rowed	Priekuļi Pl.Br.Inst.
153	L-1885	LVA01396	Latvia	-	breeding line	unknown	two-rowed	Priekuļi Pl.Br.Inst.
154	8154	-	Latvia	-	breeding line	Athos x Ving	two-rowed	Stendes Cer.Br.Inst.
155	7978	-	Latvia	-	breeding line	Nadja x Ofir*2	two-rowed	Stendes Cer.Br.Inst.
156	8993	-	Latvia	-	breeding line	7233 x Belfor	two-rowed	Stendes Cer.Br.Inst.
157	Jogeva	EST17	Estonia	1931	variety	(S) Binder	six-rowed	Jõgeva Pl.Br.Inst.
158	Jogeva 1104	EST18	Estonia	1953	variety	Maja x Rimpau Hanna	two-rowed	Jõgeva Pl. Br.Inst.
159	Toomas	EST23	Estonia	1976	variety	(S) local population	six-rowed	Jõgeva Pl.Br.Inst.
160	Liisa	EST20	Estonia	1981	variety	Hylkema x Diamant	two-rowed	Jõgeva Pl.Br.Inst.
161	Miina	EST21	Estonia	1981	variety	Jogeva x Hylkema	two-rowed	Jõgeva Pl.Br.Inst.
162	Esme	EST16	Estonia	1982	variety	Foma x Hylkema	two-rowed	Jõgeva Pl.Br.Inst.
163	Elo	EST15	Estonia	1989	variety	Triumph x Lofa	two-rowed	Jõgeva Pl.Br.Inst.
164	Teele	EST22	Estonia	1991	variety	(M) Otra	six-rowed	Jõgeva Pl.Br.Inst.
165	Anni	EST14	Estonia	1993	variety	Lola x Lisa	two-rowed	Jõgeva Pl.Br.Inst.
166	Leelo	EST19	Estonia	1995	variety	Ansgar x Sv 2552 x Elo	two-rowed	Jõgeva Pl.Br.Inst.
167	Roosi	EST240	Estonia	1999	variety	Abava x Nadja x Piggi	two-rowed	Jõgeva Pl.Br.Inst.
168	2686.10.1.6	EST575	Estonia	-	breeding line	1338.3.4 x Moskva 2	two-rowed	Jõgeva Pl.Br.Inst.
169	2734.2.5.5	EST576	Estonia	-	breeding line	Sv 86298 x Digger	two-rowed	Jõgeva Pl.Br.Inst.
170	2867.14.3.3	-	Estonia	-	breeding line	546.11.27 x Ellinor	two-rowed	Jõgeva Pl.Br.Inst.

Table 1 (continued)

Field Nr.*	Accession name	Gene bank number	Origin country	Year of release	Accession type	Pedigree	Spike type	Breeding Inst.
171	2878.1.6.4	-	Estonia	-	breeding line	546.11.27 x KM 1192	two-rowed	Jõgeva Pl.Br.Inst.
172	2928.10.9.9	-	Estonia	-	breeding line	Elo x Ultra	two-rowed	Jõgeva Pl.Br.Inst.
173	2951.6.9.3	-	Estonia	-	breeding line	Roland x Defra	two-rowed	Jõgeva Pl.Br.Inst.
174	2975.4.1.2	-	Estonia	-	breeding line	Corgi x Ilka	two-rowed	Jõgeva Pl.Br.Inst.
175	2987.1.2.1	-	Estonia	-	breeding line	1338.3.4 x Corgi	two-rowed	Jõgeva Pl.Br.Inst.
176	3038.3.7.4	-	Estonia	-	breeding line	546.11.27 x Maresi	two-rowed	Jõgeva Pl.Br.Inst.
177	Auksiniai	AGB00255	Lithuania	1927	variety	(S) Gul	two-rowed	Lithuanian Institute of Agriculture
178	DotnuvosKeturei liai	AGB00256	Lithuania	1930	variety	(S) local material	six-rowed	Lithuanian Institute of Agriculture
179	Auksiniai II	AGB00258	Lithuania	1947	variety	Abed Kenia x AkermanIsaria	two-rowed	Lithuanian Institute of Agriculture
180	Dziugiai	AGB0257	Lithuania	1947	variety	(S) local material	two-rowed	Lithuanian Institute of Agriculture
181	Gintariniai	AGB00260	Lithuania	1973	variety	KM 1081252 x Pallas	two-rowed	Lithuanian Institute of Agriculture
182	Dainiai	AGB00261	Lithuania	1981	variety	1561-12 x Abed 3371	two-rowed	Lithuanian Institute of Agriculture
183	Vilnieciai	AGB002263	Lithuania	1982	variety	(M) Pallas	two-rowed	Lithuanian Institute of Agriculture
184	Gausiai	AGB00255	Lithuania	1998	variety	Auksiniai II x (MIX) Viner+Bingo+Abed+Archer	two-rowed	Lithuanian Institute of Agriculture
185	Auksiniai III	AGB00262	Lithuania	1983	variety	Carina x Tarra 26	two-rowed	Lithuanian Institute of Agriculture
186	Aidas	AGB00264	Lithuania	1990	variety	(KM 1192 x Ofir) x Effendi	two-rowed	Lithuanian Institute of Agriculture
187	Ūla	AGB002265	Lithuania	1992	variety	Roland x Ca 33787	two-rowed	Lithuanian Institute of Agriculture
188	Alsa	AGB002266	Lithuania	1993	variety	(Minera x (M)Gintariniai) x (Abava x Emir)	two-rowed	Lithuanian Institute of Agriculture
189	Aura	AGB00267	Lithuania	1996	variety	(Mirena x (M)Gintariniai) x Lina	two-rowed	Lithuanian Institute of Agriculture
190	LIA 6107-26	AGB00541	Lithuania	-	breeding line	Roland x Ca 53102	two-rowed	Lithuanian Institute of Agriculture
191	LIA 6700-28	AGB00544	Lithuania	-	breeding line	[Vega x (Sv 73608 x WW 6405)] x [HVS 929/77 x (Chellas x Mirena)]	two-rowed	Lithuanian Institute of Agriculture
192	LIA 6782-33	AGB00546	Lithuania	-	breeding line	[Vega x (Ofir x Berenice)] x Liisa	two-rowed	Lithuanian Institute of Agriculture
193	Luokė	AGB00268	Lithuania	2001	variety	[Vega x (Ofir x Berenice)] x Flare	two-rowed	Lithuanian Institute of Agriculture
194	LIA 6804-62	AGB00545	Lithuani a	-	breeding line	Ūla x Korru	two-rowed	Lithuanian Institute of Agriculture
195	LIA 6121-02	AGB00543	Lithuania	-	breeding line	Krinichnij x [(KM 1192 x Ofir) xDeba x KM 1192)]	two-rowed	Lithuanian Institute of Agriculture
196	LIA 6186-03-01	AGB00542	Lithuania	-	breeding line	[(KM 1192 x Ofir) x (KM 1192 x Mami)] x [(KM 1192 x Ofir) x (Maris Mink x Nadia)]	two-rowed	Lithuanian Institute of Agriculture

* These numbers are used in the figures to identify accessions. Priekuļi Pl.Br.Inst, State Priekuļi Plant Breeding Institute; Stende Cer.Br.Inst., State Stende Cereal Breeding Institute; Jõgeva Pl.Br.Inst., Jõgeva

ern Norway 60°47' N, 11°13' E), Landskrona (southern Sweden 55°52' N, 12°51' E) and Priekuļi (Latvia 57°19' N, 24°20' E). The size of each plot was ~1.5 m^2 with ~200 seeds per plot (six rows) — both in Bjørke and Landskrona and ~2.3 m^2 with ~400 seeds per plot (seven rows) in Priekuļi.

Agronomic traits. Days to heading, days to maturing, plant height, harvest index, volumetric weigh and thousand kernel weight were recorded for the accessions studied. Days to heading was scored as the number of days from June 1 until 50% of inflorescence emerged in a plot. Days to maturing were scored as the number of days from July 1 until 50% of spikes were mature in a plot. Plant height was measured in centimetres from the soil surface to the tip of the inflorescence of the most typical individual per plot (excluding awns). Harvest index was calculated as the ratio between the total grain yield from the plot (excluding the border plants) and the above ground biomass yield after plants had dried. Volumetric weight was measured as the weight of grain contained in a 0.25 l cylinder and converted to kilograms per hectolitre. The thousand kernel weight was estimated by weighing two samples of 400 seeds harvested from each sample plot and converting the average value of these into thousand kernel weight. The moisture content of grain was on average 8% (2002) and 9% (2003) in Bjørke, 10% in Priekuļi and 12% in Landskrona. The moisture content of the straw was 5% in Bjørke, 10% in Priekuļi and in Landskrona.

Statistical analysis. The Square Lattice design was used in order to reduce the experimental error within each trial (Cochran and Cox, 1957; Yau, 1997; Sarker *et al.*, 2001). Two replications for each accession at each experimental site and year were included. The adjusted means for the Lattice design were calculated using MATLAB (version 5.3. MATHWORKS Inc, 1999) and the adjusted treatment means were used in further calculations (Koltz and Johnson, 1983). For comparison of means of groups with different size, t-criteria was used. Least significant difference (LSD) for pair comparison was calculated as follows:

$$LSD = t_{0.01}\sqrt{\left(\frac{1}{G_1}+\frac{1}{G_2}\right)\frac{ms_e}{n \times l}}$$

where $t_{0.01}$ – value of Student criteria at $p < 0.01$, ms_e – interaction mean square, n – number of replications, l – number of trials, G_1 and G_2 – size of compared groups.

Parameter stability for environment interaction was estimated by calculating the ecovalence (SQ) for each accession (Wricke, 1962). Experimental sites were compared by regression analysis (Baetz, 1984).

Multivariate data analysis (based on normalised data) including heat map and principal component analysis, carried out using R statistical software (Anonymous, 2013). In heat map plots, the relationships between accessions and traits on two axes were examined. The plotted grid shows a box for each factor combination, which is encoded with a different colour depending on the size of the dependent variable — the dissimilarity index. A cluster analysis dendrogram is included on the side of side of plots to show hierarchy of values.

The conditions of the field trials varied between years and sites (Table 2). Since mean values represent the behaviour of the entries under a single set of the many possible environmental conditions, they have limited descriptive value (Lasa *et al.*, 2001). For these reasons, we chose to present results also for traits of varieties in each site and year (Annex 1).

RESULTS

ANOVA analysis on data from all trial locations and years showed that agronomic trait values varied significantly ($p < 0.0001$) between accessions. There were also significant effects of location and year of experiment, as well as a significant effect of interaction between variety and location, and variety and year ($p < 0.0001$). The ANOVA demonstrated a significant effect of the year of experiment and interaction between variety and year on each trait also when each trial site was analysed separately (data are not shown). There was only a few exceptions at the Norwegian site, where no significant effect of interaction between year of experiment and variety was observed for plant height ($p = 0.073$) and harvest index ($p = 0.082$).

Overall ANOVA based on all trial data showed that interaction genotype (accession) × environment was statistically significant for all tested traits (Table 3) allowing further to analyse trait stability. The minimum and maximum values per trait for each accession and eco variance for each accession are presented in the Table 4, demonstrating both variation between accessions and amplitude of responses for the given environments, as well as stability of accession for the studied traits.

Trait performance. Days to heading between accessions reached 13 days at Latvian site in 2002, whereas in 2003 the differences were not more than seven days at the same site. Variety 'Teele' had the lowest number of days to heading, compared to that of other varieties at the Latvian site in 2002 and during both trial years in Norway and Sweden, but in 2003 in Latvia, Estonian breeding line 8154 had the lowest value. Latvian landrace 'Latvijas vietējie' had the highest number of days to heading in Sweden and Latvia in 2002 and in Norway in 2003. In 2003, at the Latvian site, the latest heading variety was a Lithuanian breeding line LIA-6782-33, while at the Swedish site in the same year, the latest maturing variety was Latvian variety 'Ruja' and in

Table 2

METEOROLOGICAL CHARACTERISTICS OF LOCATIONS AND YEARS OF TRIALS

Location	Year	Sowing week	Rainfall (mm)				Average temperature (°C)			
			May	June	July	August	May	June	July	August
Priekuļi (Latvia)	2002	17	38.2	111.1	67.0	11.3	13.5	16.3	19.5	18.9
	2003	19	88.0	59.2	87.8	175.8	11.9	14.0	19.7	15.7
Bjørke (Norway)	2002	17	82.9	67.4	128.5	136.5	11.7	15.2	16.0	18.4
	2003	21	75.1	85.7	67.1	53.2	9.1	14.9	17.6	15.1
Landskrona (Sweden)	2002	13	53.5	75.3	76.4	68.9	13.1	16.0	17.8	20.0
	2003	15	70.7	40.4	76.0	45.7	12.2	16.3	18.6	18

Table 3

ANALYSIS OF VARIANCE (ANOVA) OF TRIALS IN 6 ENVIRONMENTAL CONDITIONS (3 TRIAL SITES X 2 YEARS) OF 64 ACCESSIONS OF BALTIC ORIGIN

Source of variation	SS	df	ms	F	SS	df	ms	F
	Heading days				Harvest index			
Total	41275.79	383			1.5774	383		
Accessions	1572.57	63	24.96	7.98*	0.3680	63	0.0058	5.77*
Environments	38717.97	5	7743.59	2475.74*	0.8903	5	0.1781	175.79*
Interaction G x E	985.25	315	3.13	4.35*	0.3191	315	0.0010	2.90*
Error		378	0.72			378	0.0003	
	Ripening days				Volumetric weight			
Total	26289.28	383			3633.42	383		
Genotypes	2594.06	63	41.18	19.32*	1184.19	63	18.80	6.10*
Environments	23023.88	5	4604.78	2160.62*	1479.34	5	295.87	96.09*
Interaction G x E	671.34	315	2.13	2.15*	969.89	315	3.08	2.49*
Error		378	0.99			378	1.24	
	Length of plant				1000 kernel weight			
Total	93752.44	383			13960.87	383		
Genotypes	41098.23	63	652.35	20.53*	5775.54	63	91.67	19.39*
Environments	42646.53	5	8529.31	268.47*	6695.68	5	1339.14	283.17 *
Interaction G x E	10007.68	315	31.77	2.14*	1489.64	315	4.73	3.30*
Error		378	14.85			378	1.43	

2002 in Norway Latvian variety ‘Ruja’. Estonian variety ‘Teele’ was the earliest maturing accession in Latvia in both years and in Sweden in 2003. Landrace ‘Latvijas vietējie’ matured last in the Latvian trial site during both years and at the Swedish site in 2002. The Latvian six-rowed varieties ‘Vairogs’ and ‘Agra’ matured earliest at the Norwegian site in 2002 and 2003, respectively, and the Lithuanian variety ‘Luoke’ in 2002 and Estonian breeding line 2686.10.1.6 in 2003 were the latest maturing in Norway. The earliest maturing variety in 2002 at the Swedish site was Latvian variety ‘Priekuļu 1’, while the latest maturing variety in 2003 was Latvian variety ‘Stendes’. The differences between accessions for plant height varied from 57 cm (trial in Sweden in 2002) up to 74 cm (trial in Norway 2002). At all sites and years the tallest accession was landrace ‘Latvijas vietējie’, and the shortest was either Estonian breeding line 2734.2.5.5 (Latvia 2002, Norway both years) or Estonian variety ‘Leelo’ (Latvia 2003 and Sweden both years). Old varieties and landraces generally had lower values for harvest index, compared to those of modern ones. The lowest values for harvest index were scored for ‘Latvijas vietējie’ (2002 Latvian and Swedish site); ‘Dotnuvos Ketureiliai’ (Norwegian site both years); ‘Kombainieris’ (Latvian site 2003) and L-1879 (Swedish site 2003). The highest harvest value index values were found for variety ‘Teele’ (2002 Latvian and Swedish sites); Estonian breeding line 2734.2.5.5 (Norwegian site both years), variety ‘Agra’ (Swedish site 2003) and Latvian breeding line 8154 (Latvian site 2003). Latvian variety ‘Priekuļu 1’ had the lowest values at the Latvian site in 2003, Norwegian site in 2002 and Swedish site both years, while Estonian variety ‘Miina’ had the lowest value at the Latvian site in 2002 and Latvian variety ‘Vairogs’ at the Norwegian site in 2003. The maximal values for thousand kernel weight were observed for different varieties in each trial site and year: ‘Klinta’ in Latvia 2002, LIA6700-28 in Latvia 2003, ‘Ula’ in Norway 2002, L-1879 in Norway 2003, ‘Latvijas vietējie’ in Sweden 2002, and LIA6804-62 in Sweden 2003. Variety Tele had the lowest values at the Latvian and Norwegian sites in 2003. For other trial sites and years, different varieties ranked lowest for this trait. The highest values were scored for LIA6186-03-01 (Latvia 2002); ‘Ilga’ (Latvia 2003); ‘Abava’ (Norway 2002), 2951.6.9.3 (Norway 2003), ‘Auksiniai II’ (Sweden 2002) and 2987.1.2.1 (Sweden 2003).

Comparison of accessions with different row numbers showed that six-row barleys had shorter time to heading and to maturity, they were shorter, and had significantly lower thousand kernel weight, volumetric weight and harvest index, in comparison values for two-row types (Table 5).

Significant differences were found among accessions of origin from different countries in all analysed traits (Table 6). The number of days to heading in Estonian accessions was significantly higher than those of Latvian and Lithuanian origin. Days to maturity was earliest for Latvian, was latest for Lithuanian accessions. The Estonian accessions were shorter in comparison to material from both other countries. This might explain why Estonian accessions on average had higher harvest index than Latvian and Estonian accessions. Lithuanian accessions had on average bigger grains (higher values for thousand kernel weight and volumetric weight), while Estonian accessions had the smallest.

Comparison of accessions from different breeding periods showed (Table 7) that varieties from the 1st period, created till 1931, are characterised first of all by longer length of plant, and, as a consequence, less harvest index. Modern va-

Table 4

THE MINIMUM AND MAXIMUM VALUES OF AGRONOMIC TRAITS AND ESTIMATE OF ECO VALENCE VALUE (SQ) AND STANDARD DEVIATION OF ECO VALENCE (S%) FOR EACH BARLEY ACCESSION

Accession name	Thousand kernel weight (g)				Harvest index				Days to heading				Plant height (cm)				Days to maturing				Volumetric weight (kg/HL)			
	max	min	SQ(EV)	S%(EV)	max	min	SQ(EV)	S%(EV)	max	min	SQ(EV)	S%(EV)	max	min	SQ(EV)	S%(EV)	max	min	SQ(EV)	S%(EV)	max	min	SQ(EV)	S%(EV)
Latvijas vietējie	57.5	43.1	9.1	2.7	0.494	0.302	0.00	6.45	44	17.5	18.97	6.72	135.5	106	213.85	5.54	49	29.5	18.92	5.11	70.8	66.75	1.24	0.72
Vairogs	38.9	28.6	55.8	9.7	0.543	0.259	0.01	11.56	37.5	15.0	40.53	13.72	106.5	76.0	349.39	8.82	37.5	19.5	26.92	8.54	72.38	62.58	18.54	2.87
Kombainieris	54.7	42.6	13.1	3.3	0.542	0.395	0.00	4.02	42.5	1w5.5	4.45	3.56	115.5	80.0	190.07	6.29	44.5	26.0	9.63	3.88	71.85	71.55	18.37	2.72
Priekuļu 1	37.0	25.2	59.2	10.4	0.581	0.297	0.02	12.09	40.5	14.0	4.75	4.30	112.0	86.5	285.89	8.15	38.5	21.0	28.48	8.30	73.70	61.75	43.10	4.29
Priekuļu 60	46.2	31.8	13.9	4.1	0.582	0.379	0.00	6.22	44.0	14.5	13.91	6.33	97.0	64.5	76.62	4.97	41.0	28.0	8.50	3.69	74.33	70.30	9.44	1.93
Stendes	51.5	33.9	63.1	8.0	0.551	0.442	0.00	4.90	43.5	14.5	17.32	6.83	106.0	77.5	66.21	3.98	43.5	30.0	5.05	2.75	71.28	72.38	24.14	3.08
Abava	53.0	39.3	20.8	4.4	0.540	0.393	0.00	3.13	43.0	17.5	14.16	6.08	102.5	73.5	64.98	3.93	46.5	29.5	5.12	2.69	72.88	70.70	12.56	2.20
Ilga	49.1	38.2	26.3	5.1	0.564	0.457	0.00	3.83	43.5	18.5	14.58	6.25	85.0	72.0	162.48	6.99	47.0	27.0	13.74	4.52	71.50	74.48	39.83	3.94
Agra	41.3	30.5	19.7	5.4	0.600	0.384	0.01	7.71	38.0	13.0	30.25	12.15	106.0	83.0	111.04	4.97	35.0	20.0	7.34	4.42	70.80	64.68	3.81	1.29
Imula	52.2	41.5	6.6	2.4	0.586	0.496	0.00	5.43	40.5	15.0	16.91	8.24	104.0	76.0	90.29	4.93	38.5	22.5	10.83	4.72	70.20	70.70	33.31	3.73
Balga	46.8	34.9	8.5	3.1	0.571	0.513	0.01	6.80	41.0	15.5	4.76	4.06	77.0	75.0	333.38	11.01	40.5	25.0	1.18	1.48	72.13	72.18	18.74	2.70
Rasa	48.7	36.5	15.5	4.1	0.569	0.482	0.00	5.20	40.5	16.0	3.55	3.52	100.0	68.5	105.29	5.39	42.5	25.5	6.62	3.49	72.30	66.75	0.48	0.44
Klinta	53.0	44.2	24.3	4.4	0.557	0.448	0.00	4.08	41.5	17.5	11.11	6.08	110.5	85.5	202.48	6.74	43.0	23.5	12.79	4.69	75.28	71.75	5.29	1.40
Ruja	56.0	44.5	15.0	3.5	0.559	0.471	0.00	4.59	43.5	18.0	6.28	3.98	102.5	76.0	73.63	4.35	48.0	29.5	24.58	6.01	73.08	65.93	7.44	1.74
Sencis	50.1	34.1	27.6	5.3	0.563	0.434	0.00	3.46	39.5	13.0	1.60	2.46	95.0	76.0	117.89	5.89	38.5	26.5	6.38	3.47	71.95	66.75	12.49	2.22
Ansis	50.8	34. 6	22.6	4.8	0.583	0.470	0.00	5.04	43.0	14.5	41.99	10.51	77.0	61.5	49.04	4.46	44.5	29.0	2.37	1.90	72.23	65.73	16.90	2.65
Gate	49.1	38.3	22.4	4.9	0.564	0.369	0.01	6.35	41.0	18.0	15.90	6.56	87.0	69.5	151.82	6.66	45.5	29.0	3.02	2.12	73.43	69.05	11.58	2.13
Malva	49.2	34.9	21.2	4.7	0.542	0.409	0.00	1.82	42.5	13.5	30.64	9.49	95.5	73.5	17.08	2.18	41.5	27.5	10.17	4.07	74.05	68.20	3.15	1.11
L-1879	55.6	40.0	46.0	6.3	0.549	0.460	0.01	9.45	41.5	13.5	4.98	4.06	95.5	83.0	121.53	5.39	39.0	29.0	19.60	5.71	74.05	66.33	16.46	2.60
L-1883	50.6	36.1	26.9	5.3	0.576	0.424	0.00	2.24	38.0	16.5	15.79	7.81	105.0	74.0	42.24	3.13	39.0	24.5	2.93	2.39	72.88	67.38	5.18	1.43
L-1885	54.7	43.0	13.4	3.4	0.544	0.472	0.00	5.27	37.5	17.5	51.68	14.56	95.5	69.5	91.90	5.20	40.5	23.5	25.21	7.04	72.95	69.03	14.53	2.44
8154	50.7	34.4	11.6	3.5	0.548	0.400	0.00	3.72	41.5	12.0	15.34	7.05	86.0	61.5	74.82	5.27	41.0	26.5	6.94	3.51	69.78	66.13	4.65	1.40
7978	54.8	37.1	35.8	5.8	0.556	0.398	0.00	2.56	42.0	13.5	7.17	4.85	96.0	79.5	128.35	5.78	40.0	26.0	1.66	1.74	73.48	68.83	3.77	1.21
8993	53.7	40.5	2.6	1.5	0.540	0.433	0.00	3.88	39.0	14.5	11.08	6.54	98.0	62.5	82.34	4.89	38.5	24.0	9.48	4.37	71.00	63.20	26.15	3.48
Jogeva	38.2	28.1	39.4	8.2	0.514	0.252	0.02	14.13	38.5	14.0	25.32	10.93	101.0	75.5	283.05	8.03	35.0	19.5	17.27	6.72	70.60	62.15	14.32	2.53
Jogeva1104	48.0	35.6	14.0	4.0	0.575	0.328	0.01	8.15	42.0	16.5	3.79	3.37	100.0	78.5	35.83	3.00	44.0	29.5	7.53	3.45	73.23	72.18	20.82	2.86
Toomas	41.6	27.1	40.6	8.0	0.589	0.376	0.00	5.20	39.5	14.5	7.59	5.52	107.5	66.5	422.87	10.28	38.5	21.0	19.53	6.93	72.15	60.28	35.84	3.97
Liisa	46.2	32.4	9.5	3.4	0.551	0.397	0.01	7.41	41.5	17.0	4.02	3.54	105.0	60.5	343.20	9.80	44.0	27.0	4.75	2.81	71.33	60.90	40.10	4.14
Miina	48.0	29.9	55.7	8.3	0.565	0.428	0.00	4.76	43.0	13.5	13.25	6.24	102.5	71.0	78.37	4.46	41.5	27.5	8.24	3.60	71.55	65.73	2.05	0.93
Esme	49.3	37.0	20.8	4.7	0.547	0.462	0.01	7.06	41.5	16.0	6.29	4.25	100.5	71.0	67.12	4.23	43.5	24.5	9.28	3.97	73.65	70.08	6.68	1.63
Elo	44.9	34.6	4.4	2.3	0.569	0.474	0.00	4.85	42.5	15.0	4.86	3.83	72.0	60.0	117.40	7.13	42.5	26.5	1.31	1.48	72.83	68.83	3.55	1.19
Teele	40.1	28.1	33.9	7.3	0.635	0.339	0.02	10.52	36.0	15.0	52.12	17.14	113.5	65.5	493.29	10.86	34.0	17.5	12.88	6.10	71.10	57.15	57.77	5.26
Anni	52.1	37.4	32.6	5.9	0.593	0.471	0.00	3.44	42.0	14.5	17.62	7.02	75.0	57.5	43.02	4.32	42.5	27.5	2.43	1.97	73.63	66.95	7.32	1.72
Leelo	48.2	37.0	19.6	4.5	0.576	0.468	0.00	4.10	41.5	15.0	4.27	3.79	76.5	54.5	126.24	8.04	41.0	25.0	20.92	5.89	73.33	66.33	8.53	1.86

Table 4 (continued)

Accession name	Thousand kernel weight (g)				Harvest index				Days to heading				Plant height (cm)				Days to maturing				Volumetric weight (kg/HL)			
	max	min	SQ(EV)	S%(EV)	max	min	SQ(EV)	S%(EV)	max	min	SQ(EV)	S%(EV)	max	min	SQ(EV)	S%(EV)	max	min	SQ(EV)	S%(EV)	max	min	SQ(EV)	S%(EV)
Roosi	49.7	33.0	37.2	6.3	0.591	0.445	0.00	4.00	43.5	14.0	26.65	8.50	80.0	64.5	125.51	7.15	43.0	28.5	0.45	0.84	74.48	63.00	23.68	3.17
2686.10.1.6	48.7	34.4	20.6	4.8	0.566	0.455	0.00	4.18	43.5	15.0	23.62	8.03	68.5	55.5	110.90	7.11	45.0	29.0	6.89	3.16	71.60	69.45	9.60	1.97
2734.2.5.5	50.2	33.0	20.0	4.8	0.590	0.460	0.01	6.07	40.0	13.5	6.03	4.54	62.0	46.5	154.78	9.11	40.0	26.5	17.82	5.53	72.60	67.38	1.87	0.87
2867.14.3.3	50.5	39.1	17.5	4.1	0.519	0.450	0.00	5.34	43.0	14.5	17.63	6.91	81.5	65.5	45.38	4.02	44.0	29.5	2.69	2.00	73.15	71.55	9.06	1.88
2878.1.6.4	48.5	35.5	24.4	5.1	0.590	0.400	0.00	4.64	43.0	16.5	12.20	5.80	71.0	65.0	191.02	8.81	45.0	29.5	2.50	1.92	72.63	70.93	15.40	2.50
2928.10.9.9	47.2	32.6	22.7	5.3	0.595	0.434	0.00	3.30	43.0	13.5	27.54	8.91	67.0	56.5	170.74	8.84	42.0	26.0	8.97	3.79	74.05	64.88	11.82	2.22
2951.6.9.3	45.9	31.3	12.4	4.0	0.578	0.481	0.00	4.06	42.0	14.5	9.72	5.33	72.5	63.5	195.89	9.00	42.0	29.5	8.04	3.62	74.45	68.00	6.81	1.62
2975.4.1.2	47.7	33.7	5.9	2.6	0.594	0.431	0.00	4.20	42.0	15.5	12.62	5.88	77.0	63.5	87.49	6.00	45.5	29.5	6.93	3.21	69.53	68.63	12.52	2.27
2987.1.2.1	47.3	32.3	19.2	4.8	0.598	0.432	0.00	3.05	44.0	14.0	24.57	8.14	77.5	59.5	60.73	5.11	43.5	27.5	2.22	1.84	70.85	67.60	18.51	2.71
3038.3.7.4	50.5	36.4	4.6	2.1	0.571	0.451	0.00	2.55	41.5	17.5	5.53	4.21	83.0	64.5	59.50	4.71	43.5	27.0	4.35	2.66	73.98	71.75	4.80	1.35
Auksiniai	49.7	33.4	86.2	10.4	0.535	0.382	0.00	5.54	40.5	17.0	149.89	24.33	75.5	48.0	1375.30	19.70	43.0	28.5	70.07	11.01	69.60	68.63	110.96	6.79
Dotnuvos Ketureiliai	47.0	35.7	49.6	7.4	0.517	0.152	0.06	26.67	40.5	15.0	5.72	4.67	108.5	87.5	74.62	3.84	39.0	24.5	7.99	4.03	72.33	62.80	13.18	2.39
Auksiniai II	49.1	38.7	7.4	2.8	0.551	0.480	0.01	7.02	40.5	14.0	3.21	3.26	108.0	74.0	78.24	4.27	40.0	28.0	18.49	5.47	73.28	71.35	14.26	2.32
Dziugiai	51.6	32.4	40.9	6.6	0.503	0.217	0.02	13.49	40.0	16.0	2.39	2.87	113.5	90.5	429.63	9.31	41.5	27.0	12.58	4.71	74.43	64.05	30.54	3.46
Gintariniai	46.6	34.6	88.9	10.0	0.551	0.357	0.00	3.88	40.5	15.5	0.73	1.55	92.0	71.5	87.38	4.88	41.0	27.5	6.73	3.42	73.53	68.63	5.47	1.49
Dainiai	49.0	35.9	3.4	1.9	0.553	0.367	0.00	4.16	42.0	15.5	1.04	1.77	105.5	69.0	321.57	8.92	43.0	28.5	2.02	1.79	73.65	67.78	1.37	0.74
Vilnieciai	52.7	39.2	7.1	2.6	0.571	0.435	0.00	2.45	41.5	16.5	4.55	3.73	104.0	66.5	133.28	5.86	42.5	28.5	1.88	1.71	74.25	69.88	4.24	1.28
Gausiai	49.9	37.6	2.3	1.6	0.533	0.426	0.00	5.06	41.5	16.5	1.15	1.89	100.5	77.5	42.48	3.33	42.0	27.0	8.56	3.89	72.78	67.80	0.85	0.58
Auksiniai III	47.5	35.9	5.6	2.5	0.529	0.393	0.00	1.18	41.0	14.5	2.59	2.90	97.5	65.0	122.38	5.85	40.5	28.0	11.64	4.42	73.83	71.55	10.81	2.02
Aidas	49.4	40.5	11.2	3.2	0.567	0.427	0.00	2.06	41.0	13.5	11.10	6.27	101.5	68.0	92.37	5.20	39.5	27.5	13.08	4.75	72.30	70.50	10.38	2.00
Ula	55.3	42.9	20.5	4.0	0.557	0.400	0.00	2.04	40.5	17.5	12.70	6.66	98.5	65.5	123.00	5.85	42.0	27.5	7.65	3.55	72.75	69.88	8.99	1.87
Alsa	52.4	40.0	15.0	3.8	0.558	0.489	0.00	4.80	41.5	17.0	3.14	3.15	89.0	70.5	97.24	5.35	44.5	27.0	11.09	4.27	73.93	70.93	8.91	1.87
Aura	51.3	42.0	14.0	3.6	0.568	0.509	0.01	6.08	42.0	14.5	6.56	4.58	89.5	71.5	60.39	4.39	40.5	27.0	4.52	2.78	73.78	69.48	2.58	1.01
LIA6107-26	51.5	40.0	16.3	4.0	0.559	0.492	0.00	5.11	41.0	15.5	2.39	2.87	88.0	64.0	49.75	3.99	40.0	26.5	11.17	4.31	74.10	74.25	22.85	2.93
LIA6700-28	54.9	43.2	16.5	3.6	0.563	0.419	0.00	2.17	39.5	18.5	31.78	10.80	97.0	73.0	128.54	5.82	42.0	27.5	1.72	1.66	72.20	65.73	14.61	2.40
LIA6782-33	50.2	35.4	21.9	4.8	0.559	0.395	0.00	4.18	41.5	19.0	14.02	6.63	92.0	64.0	96.28	5.44	44.5	28.0	7.98	3.49	72.35	65.10	14.23	2.39
LIA6791-35 (Luoke)	51.9	38.6	9.8	3.0	0.57	0.42	0.00	3.53	41.5	16.0	3.52	3.41	86.5	74.0	79.61	4.95	40.5	29.0	16.28	5.00	72.33	68.20	4.86	1.41
LIA6804-62	537	43.0	13.3	3.3	0.564	0.470	0.00	3.44	40.5	17.0	6.89	4.81	92.5	63.0	76.93	4.85	42.0	29.0	9.66	3.90	72.60	64.68	17.13	2.64
LIA6121-02	49.6	39.1	8.2	2.8	0.590	0.457	0.00	3.84	43.0	17.0	13.603	6.35	99.0	72.0	77.21	4.74	45.5	28.5	10.70	4.04	75.38	69.48	4.55	1.30
LIA6186-03-01	52.4	39.8	15.7	3.8	0.576	0.426	0.00	2.41	42.0	14.5	5.28	4.04	94.0	67.5	46.42	3.76	41.5	29.0	5.04	2.81	75.70	69.03	6.91	1.62

Table 5

COMPARISON OF MEAN VALUES OF TWO- AND SIX-BARLEY ACCESSIONS FOR ALL TRIALS

Type	Days to heading	Days to maturing	Lenght of plant	Harvest index	Volumetric weight (kg/HL)	1000 kernel weight
Two-row	25.36[b]	34.97[b]	81.92[a]	0.51[b]	70.75[b]	44.44[b]
Six-row	21.19[a]	28.17[a]	93.94[b]	0.48[a]	67.15[a]	35.96[a]

Mean values indexed with the same letters do not differ significantly according to Student criteria at $p < 0.01$.

Table 6

COMPARISON OF MEAN VALUES OF BARLEYS OF DIFFERENT ORIGIN

Country of origin	Days to heading	Days to maturing	Lenght of plant	Harvest index	Volumetric weight (kg/HL)	1000 kernel weight
Latvia	24.8[a]	33.6[a]	87.5[c]	0.505[a]	70.11[ab]	44.3[b]
Estona	25.3[b]	34.3[b]	75.6[a]	0.524[b]	69.80[a]	41.1[a]
Lithuania	24.6[a]	34.8[c]	85.7[b]	0.503[a]	71.23[b]	45.1[c]

Mean values indexed with the same letters do not differ significantly according to Student criteria at $p < 0.01$.

Table 7

COMPARISON OF MEAN VALUES OF BARLEYS IN DIFFERENT BREEDING PERIODS

Breeding period	Days to heading	Days to maturing	Lenght of plant	Harvest index	Volumetric weight (kg/HL)	1000 kernel weight
1st	23.8[a]	32.6[a]	99.4[c]	0.4463[a]	68.35[a]	41.6[a]
2nd	24.0[a]	32.8[a]	94.3[b]	0.4747[b]	70.25[b]	40.8[a]
3rd	25.1[b]	34.5[b]	80.8[a]	0.5191[c]	70.52[b]	44.0[b]

Mean values indexed with the same letters do not differ significantly according to Student criteria at $p < 0.01$.

rieties and breeding lines are, in general, later ripening, shorter, and with bigger grains.

The heat map plot (Fig. 1) visualizes the relationship between accessions and agronomic traits. The plotted grid shows a box for each factor combination which is encoded with a colour depending on the value of the dissimilarity index. Plant height is grouping most close with harvest index, nevertheless that both of these traits are not always correlated. Two pairs of traits are related: days to heading and days to maturity as well thousand kernel weight and volumetric weight. Differences in value combinations for these traits in several accessions pointed out that this similarity is not due to identical genetic systems for mentioned traits but since common selection direction in the process of breeding in different locations.

Genotype-environment interaction. The majority of the accessions (about 80%) demonstrated stable eco-response for days to heading and days to maturity. The highest values and hence lowest eco-stability for days to heading and days to maturity was found for the old Lithuanian variety 'Auksiniai' (Table 3). The majority of accessions showing high eco-stability for days to heading also had stable response to days to maturing, but there were some exceptions, e.g. 'Priekuļi 1' was eco stabile for days to heading, but had low stability for the days to maturity, while varieties 'Agra', 'Imula', 'Roosi' and breeding lines 2686.10.1.6, 2928.10.9.9, 2987.1.2.1 and LIA6700-28 had high eco-stability for days to maturity and low stability for days to heading.

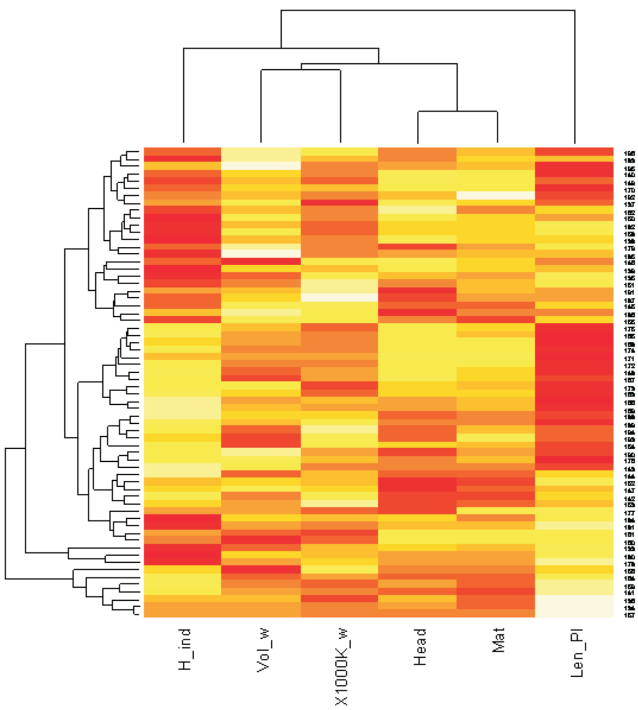

Fig. 1. Heat map demonstrating relationships between accessions and harvest index (H_ind), volumetric weight (Vol_w), thousand kernel weight (X1000K_w), days to heading (Head), days to maturity (Mat) and plant height (Len_pl)

The plotted grid shows a box for each factor combination which is encoded with a color and color intensity depending on the value of the dissimilarity index.

Among the varieties released before the 1970s, five accessions had low eco-stability for plant height, two had a moderate response and three accessions ('Dotnuvos Ketureiliai', 'Auksiniai II' and 'Jogeva 1104') showed high eco-stability. For the more modern varieties, the majority of accessions either had high eco-stability for plant height (23 accessions) or moderate response (21 accessions), and only ten could be classified as varieties with low eco stability of plant height. The varieties released before 1970s and landraces had low eco-stability (six accessions) or moderate response three accessions) for harvest index, except the variety 'Kombainieris', which demonstrated high eco-stability of harvest index (Table 3). Among the varieties released after 1970 and breeding lines, only three accessions had low eco-stability for harvest index trait, 15 accessions had moderate and as many as 36 were eco-stable. Among the varieties released before 1970, three accessions ('Kombainieris', 'Priekuļu 1' and 'Auksiniai') had high eco-stability for thousand kernel weight, whereas and the remaining accessions had moderate response or low eco-stability. Among accessions released after the 1970s, only four accessions had low eco-stability, while the majority of material (39 accessions) had high eco-stability and 11 had moderate eco-response for thousand kernel weight (six Latvian and five Estonian varieties/breeding lines). For volumetric weight, the majority of material showed high eco-stability, and only two six-rowed varieties ('Teele' and 'Auksiniai') showed moderate response. The eco-stability of thousand kernel weight and volumetric weigh were not correlated.

Evaluation of trial sites. In addition to evaluation of the stability of varieties, regression analysis can be used for detection of the optimal experimental site for variety comparison. This allows to identify particular trials in which results are most close to results of the entire set of trials and to evaluate particular locations for regarding ability of differentiation of accessions.

Value of the coefficient of adequacy (B) of regression of means in the trial site on the means of varieties allows to assess the level of coincidence of results in the particular site and in the whole set of trials: $B_j > 0.8$ – very good, $0.6 < B_j \leq 0.8$ – good, $0.4 < B_j \leq 0.6$ – medium, $B_j \leq 0.4$ – bad. The regression coefficient (b) of means in the trial site on the means of varieties estimated the level of differentiation of the varieties: $b_j > 1.2$ – good, $0.8 \leq b_j \leq 1.2$ – differentiation is close to those in the set of trials, $b_j < 0.8$ – weak differentiation (Baetz, 1984).

The results of regression analysis of trial sites are presented in Table 8. The trial in Bjørke, 2002, showed best coinci-

Table 8

EVALUATION OF TRIAL SITES BY REGRESSION ANALYSIS

Trial	Coefficient of adequacy B	Coincidence of trials	Regression coefficient (b_j ± error)	Differentiation of accessions
		Harvest index		
Bjørke, 2002	0.84	Very good	1.35 ± 0.07	High
Landskrona, 2002	0.57	Medium	0.60 ± 0.07	Week
Priekuļi, 2002	0.47	Medium	0.66 ± 0.09	Week
Bjørke, 2003	0.78	Good	1.05 ± 0.07	Middle
Landskrona, 2003	0.21	Bad	0.49 ± 0.12	Week
Priekuļi, 2003	0.67	Good	1.84 ± 0.16	High
		1000 kernels weight		
Bjørke, 2002	0.90	Very good	1.22 ± 0.05	High
Landskrona, 2002	0.87	Very good	1.01 ± 0.05	Week
Priekuļi, 2002	0.49	Medium	0.67± 0.09	Week
Bjørke, 2003	0.84	Very good	1.15 ± 0.06	Middle
Landskrona, 2003	0.83	Very good	0.87 ± 0.05	Middle
Priekuļi, 2003	0.86	Very good	1.07 ± 0.05	Middle
		Volumetric weight		
Bjørke, 2002	0.69	Good	1.30 ± 0.11	High
Landskrona, 2002	0.57	Medium	0.91 ± 0.10	Middle
Priekuļi, 2002	0.29	Bad	0.44 ± 0.08	Week
Bjørke, 2003	0.62	Good	0.81 ± 0.08	Middle
Landskrona, 2003	0.60	Good	0.94 ± 0.09	Middle
Priekuļi, 2003	0.65	Good	1.60 ± 0.15	Hard
		Plant height		
Bjørke, 2002	0.87	Very good	1.27 ± 0.06	Hard
Landskrona, 2002	0.88	Very good	0.83 ± 0.04	Middle
Priekuļi, 2002	0.68	Good	0.79 ± 0.07	Week
Bjørke, 2003	0.86	Very good	1.17 ± 0.06	Middle
Landskrona, 2003	0.88	Very good	1.01 ± 0.05	Middle
Priekuļi, 2003	0.74	Good	0.93 ± 0.07	Middle

dence with the whole set of trials for all evaluated traits. In this site, good results were obtained also in 2003. In Priekuļi, the results were opposite among years — in 2002 there was poor accession differentiation for all traits, whereas in 2003 good differentiation was observed.

DISCUSSION

Differences in photoperiod can lead to different variety response in various traits. Guitard (1959) reported that increases in photoperiod, among other traits, reduces the number of days to heading, but increases the number of days from heading to maturity and reduces plant height. However, in our study, plant height was more influenced by the annual variation, as compared to the geographical location of the trial, likely due to the differences in precipitation between the trial years (Fig. 2, Table 2). For example, at the Latvian trial, there were very dry conditions in spring 2002, when the plants were significantly shorter than those in following trial year 2003. Also, the differences in days between heading and maturing were influenced by other environmental factors to a larger extent than differences in length of photoperiod. The days between heading and maturing were about two weeks longer in the Latvian location during 2003, compared to those in other locations and in the Latvian trial in 2002, due to high precipitation in combination with lower temperatures late in the season. The differences of harvest index values between locations and years also were significant (Fig. 2). This observation is in accordance with those of other authors who demonstrated a large effect of environmental factors on the expression of this trait, hence showing the low heritability properties of harvest index (Madic *et al*., 2002).

The agronomic performance of accessions studied was grouped in four larger clusters that separated the majority of six-rowed accessions from two-rowed accessions. Most Baltic six-rowed accessions had earlier heading and maturing, compared to these traits for two-rowed accessions, as previously observed for other spring barley materials in Northern Europe (e.g. study by Äyräväinen (1976) on Finnish varieties and Nurminiemi (2002) on Nordic material. Marquez-Cedillo *et al.* (2001) showed that the *vrs1* locus on chromosome 2H, which determines inflorescence row type, is coincident with the largest effect of QTL on determining traits like yield, kernel plumpness, test weight and plant height. Also in Baltic barley, thousand kernel weigh and volumetric weight differentiated between the two-row types. Our previous study on isozyme and simple sequence repeat (SSR) variation revealed clear separation of two-rowed and six-rowed Baltic accessions, suggesting that the genetic differences between these two groups of barley involve also other DNA regions. This agreement of molecular and agronomical data results can be explained by the history of barley introduction and cultivation in Northern Europe. The six-rowed barleys were grown here as early as from the third and fourth millennia B.C. (Körber-Grohne, 1987), whereas two-rowed barleys were introduced in the region much later, dating to the 17^{th} and 18^{th} century (Hjelmqvist, 1955). Comparing relationships between accessions based on agronomical data and marker data separately for two-rowed and six-rowed accession data, however, demonstrated no correlation.

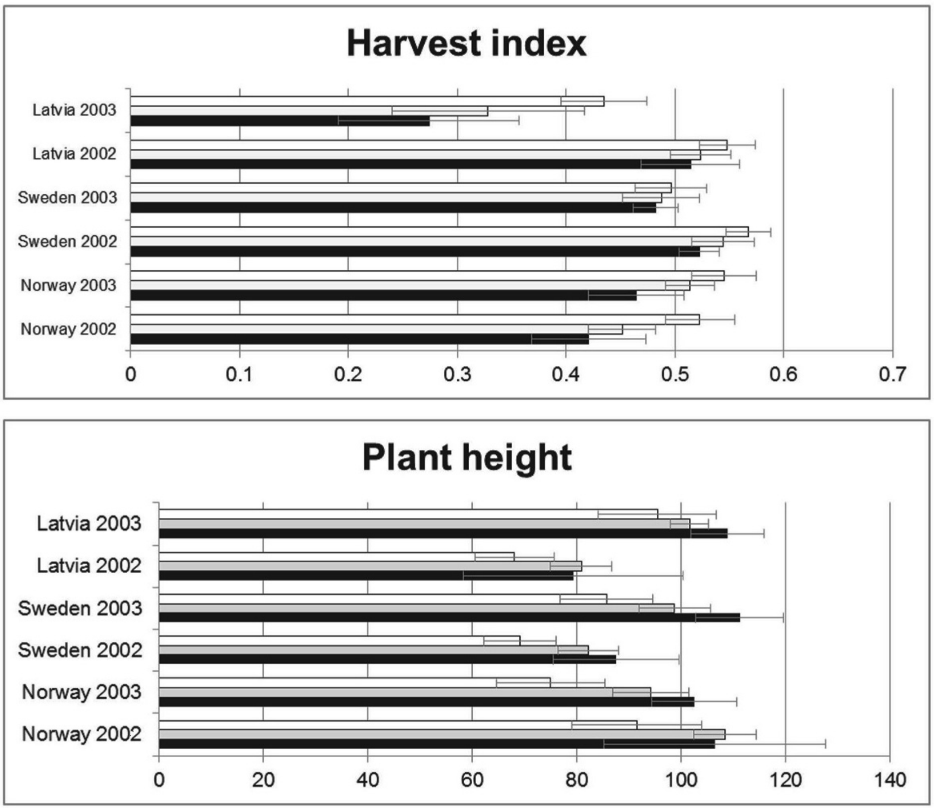

Fig. 2. Differences in harvest index and plant height of accessions in relation to the breeding period in different locations and years of trial. ■ – landraces and varieties before accessions before 1930; ▨ – varieties 1931-1970; □ – varieties after 1971 and breeding lines.

Nurminiemi and Rognli (1996) reported that six-rowed barley lines are more responsive than two-rowed for grain yield trait. However, Moral *et al.* (2003) observed the opposite — that two-rowed varieties were more responsive to environmental changes than for six-rowed varieties, which consistently showed a more stable behaviour. Based on our trial data, we could not demonstrate differences between two-rowed and six-rowed accessions for their eco-stability of any traits studied. However, differences could be found between old and newer varieties. For example, regarding harvest index, the majority of old varieties showed low eco-stability, with the exception for variety 'Kombainieris'. The eco-stability of this variety was recognized already soon after this variety was released from the early Latvian breeding programme. It was grown in various parts of former USSR, and its cultivation reached as far as Central Asia (Usubaliev, personal communication). The modern Baltic barley material not only demonstrated the increase of harvest index (Table 7), but most showed stable eco-response for this trait, revealing the potential of this material for growing also in other regions (Table 3). Increased harvest index has been shown to be associated with increase in grain yield (Jedel and Helm, 1994). Nurminiemi *et al.* (1996) found that newest varieties of Nordic barleys were more unstable for grain yield than the oldest varieties. The correlation of the stability of harvest index and grain yield needs to be investigated in Baltic barley. Not only harvest index, but also other traits are considered as yield components, such as thousand kernel weight, which was eco-stabile in many of the modern accessions. This indicates a useful link for further breeding.

ACKNOWLEDGEMENTS

We thank the Baltic breeding companies and gene banks for providing accessions included in this study. We thank staff members at the breeding companies — Graminor AB, Lantmännen AB (former Svalöf Weibull AB) and State Priekuļi Plant Breeding Institute helping with setting up and carrying out these field trials. This study was part of the project "Genetic diversity in Nordic-Baltic crops — a model study of genetic erosion in barley" supported by the Royal Academy of Agriculture and Forestry.

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Received 30 September 2014

BALTIJAS VASARAS MIEŽU AGRONOMISKO ĪPAŠĪBU RAKSTUROJUMS

Vasaras miežu selekcija ir veikta visās trīs Baltijas valstīs jau gandrīz gadsimta garumā. Selekcionāru centieni atspoguļojas šī kultūrauga izmaiņās. Šajā pētījumā tika iekļauti 64 miežu paraugi no Latvijas, Igaunijas and Lietuvas, kas pārstāv gan vietējās (tautas) šķirnes (*land-races*), šķirnes, kuras reģistrētas no 1927. gada līdz 2001. gadam, kā arī selekcijas līnijas. Sešas pazīmes – dienu skaits līdz vārpošanai, dienu skaits līdz nobriešanai, augu garums, ražas indekss, graudu tilpummasa un tūkstoš graudu masa, tika uzskaitītas divus gadus (2002. un 2003. g.) trijās izmēģinājuma vietās — Priekuļos (Latvijā), Landskronā (Zviedrijā) un Bjorkē (Norvēģijā). Tika noteiktas atšķirības starp dažādu valstu paraugiem un starp paraugiem no dažādiem selekcijas periodiem, kā arī analizēta pazīmju izpausmes daudzveidība atkarībā no izmēģinājuma vides.

Annex 1

The average values for accessions for given traits for each trial site and year

Accession name	Days to heading						Days to maturing						Plant height					
	Bjørke		Landskrona		Priekuļi		Bjørke		Landskrona		Priekuļi		Bjørke		Landskrona		Priekuļi	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Latvijas vietējie	41.5	44.0	23.5	24.5	23.0	17.5	46.0	43.0	30.0	29.5	31.0	49.0	135.5	115.0	107.5	125.0	106.0	119.0
Vairogs	27.5	37.5	16.0	15.5	13.0	15.0	32.0	37.0	17.0	19.5	20.0	37.5	106.5	100.0	76.0	110.0	76.0	100.0
Kombainieris	37.5	42.5	20.5	24.0	19.0	15.5	43.0	43.0	28.0	26.0	30.0	44.5	115.5	97.5	92.0	97.5	80.0	105.5
Priekuļu1	33.0	40.5	16.0	18.5	14.0	14.0	35.5	38.0	16.5	21.0	23.0	38.5	112.0	92.5	78.0	90.0	86.5	98.0
Priekuļu60	36.5	44.0	19.0	25.0	19.0	14.5	42.5	44.5	27.0	28.0	29.0	41.0	97.0	72.5	67.5	80.0	64.5	91.5
Stendes	40.5	43.5	21.0	25.5	18.5	14.5	43.0	44.5	28.5	30.0	30.0	43.5	106.0	85.0	74.0	97.5	77.5	109.0
Abava	41.5	43.0	20.0	26.0	18.0	17.5	46.0	44.5	28.0	29.5	31.0	46.5	102.5	87.5	78.5	97.5	73.5	111.5
Ilga	41.5	43.5	20.0	23.0	17.5	18.5	43.5	44.0	28.5	27.0	30.0	47.0	85.0	77.5	73.5	80.0	72.0	101.0
Agra	27.5	38.0	16.0	15.0	12.0	13.0	34.5	36.5	17.5	20.0	21.0	35.0	106.0	97.5	78.0	95.0	83.0	109.5
Imula	32.0	40.5	17.0	17.0	12.5	15.0	41.5	40.0	21.5	22.5	23.0	38.5	104.0	80.0	73.0	87.5	76.0	96.5
Balga	34.5	41.0	18.0	21.5	13.5	15.5	40.0	40.5	24.5	25.0	26.0	40.5	77.0	62.5	66.0	80.0	75.0	84.5
Rasa	34.5	40.5	17.5	20.0	15.0	16.0	41.5	40.0	24.5	25.5	24.0	42.5	100.0	80.0	72.0	85.0	68.5	105.5
Klinta	33.5	41.5	17.5	21.5	15.5	17.5	42.0	41.5	26.5	23.5	28.0	43.0	110.5	82.5	74.0	105.0	85.5	109.0
Ruja	39.5	43.5	21.0	27.0	20.0	18.0	44.5	41.0	28.5	29.5	30.0	48.0	102.5	77.5	78.0	90.0	76.0	105.0
Sencis	33.5	39.5	17.0	21.0	14.0	13.0	41.5	39.5	24.5	26.5	25.0	38.5	95.0	70.0	71.5	85.0	76.0	97.0
Ansis	43.5	43.0	20.0	26.0	18.5	14.5	44.5	44.0	27.0	29.0	28.0	44.5	77.0	65.0	59.0	77.5	61.5	81.0
Gate	40.5	41.0	19.5	25.5	18.5	18.0	44.5	43.0	28.5	29.0	29.0	45.5	87.0	75.0	69.0	90.0	69.5	106.0
Malva	41.5	42.5	19.0	23.5	16.5	13.5	45.5	42.5	27.5	27.5	26.0	41.5	95.5	77.5	71.5	90.0	73.5	100.5
L-1879	35.5	41.5	18.0	23.0	16.0	13.5	44.5	42.5	27.0	29.0	26.0	39.0	95.5	90.0	80.5	100.0	83.0	99.5
L-1883	33.0	38.0	17.5	18.5	13.0	16.5	41.5	39.5	23.5	24.5	24.0	39.0	105.0	90.0	81.0	100.0	74.0	108.0
L-1885	32.5	37.5	18.0	14.5	12.5	17.5	41.0	41.0	19.5	23.5	26.0	40.5	95.5	72.5	73.5	82.5	69.5	101.0
8154	36.5	41.5	19.5	23.5	16.0	12.0	41.5	42.0	26.5	26.5	24.0	41.0	86.0	67.5	67.5	75.0	61.5	82.5
7978	37.0	42.0	17.5	22.5	15.5	13.5	41.0	40.0	25.5	26.0	26.0	40.0	96.0	80.0	71.5	90.0	79.5	109.0
8993	32.0	39.0	17.5	18.0	15.5	14.5	42.0	39.5	22.0	24.0	23.0	38.5	98.0	77.5	74.0	87.5	62.5	98.5
Jogeva	30.5	38.5	15.0	14.0	11.5	14.0	36.5	38.5	17.5	19.5	19.0	35.0	101.0	100.0	88.0	100.0	75.5	98.0
Jogeva1104	36.0	42.0	19.5	24.5	16.5	16.5	41.5	43.0	27.5	29.5	28.0	44.0	100.0	80.0	76.0	95.0	78.5	105.5
Toomas	31.5	39.5	16.0	18.5	14.0	14.5	35.5	37.0	17.0	21.0	22.0	38.5	107.5	97.5	77.5	95.0	66.5	92.5
Liisa	35.5	41.5	18.5	23.5	16.0	17.0	41.5	42.0	27.0	27.0	27.0	44.0	105.0	90.0	68.5	87.5	60.5	96.0
Miina	38.5	43.0	20.5	24.0	17.0	13.5	44.0	42.5	28.5	27.5	30.0	41.5	102.5	80.0	76.0	95.0	71.0	108.0
Esme	38.5	41.5	20.0	25.0	17.5	16.0	43.0	41.0	27.0	24.5	27.0	43.5	100.5	77.5	73.5	97.5	71.0	100.0
Elo	38.0	42.5	18.5	23.5	17.0	15.0	42.5	43.0	27.0	26.5	27.0	42.5	72.0	62.5	62.0	72.5	60.0	78.5
Teele	26.5	36.0	13.0	13.0	9.5	15.0	34.0	36.5	19.0	17.5	17.0	34.0	113.5	97.5	72.5	100.0	65.5	100.0
Anni	39.5	42.0	20.0	26.0	18.5	14.5	43.0	42.5	28.0	27.5	29.0	42.5	75.0	60.0	59.0	75.0	57.5	81.0
Leelo	35.0	41.5	19.0	22.0	14.0	15.0	42.5	43.0	26.0	25.0	31.0	41.0	76.5	60.0	51.5	65.0	54.5	67.5
Roosi	41.5	43.5	20.0	25.0	19.0	14.0	44.0	43.5	27.5	28.5	28.0	43.0	80.0	62.5	59.5	77.5	64.5	76.5
2686.10.1.6	42.0	43.5	20.0	24.5	17.5	15.0	45.0	46.5	29.5	29.0	28.0	45.0	68.5	65.0	56.0	75.0	55.5	77.5
2734.2.5.5	34.5	40.0	19.0	21.0	17.0	13.5	41.0	40.5	27.0	26.5	30.0	40.0	62.0	55.0	53.0	70.0	46.5	80.0
2867.14.3.3	40.0	43.0	21.5	26.0	18.0	14.5	43.5	45.0	29.0	29.5	29.0	44.0	81.5	67.5	64.0	82.5	65.5	89.0
2878.1.6.4	41.0	43.0	20.0	24.0	17.0	16.5	45.0	44.5	29.0	29.5	28.0	45.0	71.0	62.5	62.5	75.0	65.0	85.0
2928.10.9.9	41.0	43.0	20.0	22.0	18.5	13.5	42.5	44.0	28.5	26.0	29.0	42.0	67.0	57.5	60.0	75.0	56.5	80.5
2951.6.9.3	39.0	42.0	19.5	24.0	18.0	14.5	42.5	42.5	27.5	29.5	26.0	42.0	72.5	57.5	62.5	77.5	63.5	84.0
2975.4.1.2	38.5	42.0	21.0	26.5	18.5	15.5	43.5	42.5	29.0	29.5	30.0	45.5	77.0	60.0	59.0	75.0	63.5	83.5
2987.1.2.1	41.0	44.0	20.0	25.0	19.5	14.0	44.0	44.5	28.5	27.5	29.0	43.5	77.5	62.5	60.0	72.5	59.5	77.0
3038.3.7.4	35.0	41.5	18.0	22.0	16.0	17.5	44.0	42.5	27.0	27.0	26.0	43.5	83.0	67.5	65.0	77.5	64.5	82.0
Auksiniai	22.5	40.5	18.0	21.0	16.0	17.0	35.0	41.0	29.5	28.5	27.0	43.0	75.5	92.5	80.5	102.5	48.0	106.0
Dotnuvos Ketureiliai	33.5	40.5	16.0	19.0	13.5	15.0	38.5	41.0	22.0	24.5	23.0	39.0	108.5	102.5	86.5	107.5	87.5	110.5
AuksiniaiII	36.5	40.5	18.5	22.5	15.5	14.0	45.5	41.0	28.5	28.0	28.0	40.0	108.0	92.5	79.0	97.5	74.0	104.5
Dziugiai	35.0	40.0	17.5	21.0	15.0	16.0	44.0	39.0	25.5	27.0	25.0	41.5	113.5	102.5	80.5	112.5	90.5	98.0
Gintariniai	36.0	40.5	18.0	21.5	16.0	15.5	41.0	42.0	27.0	27.5	25.0	41.0	92.0	77.5	77.0	90.0	71.5	106.0
Dainiai	37.0	42.0	19.5	23.0	17.5	15.5	44.0	42.5	27.5	28.5	27.0	43.0	105.5	75.0	76.0	100.0	69.0	114.0
Vilnieciai	35.5	41.5	18.5	23.5	18.0	16.5	44.5	43.0	27.5	28.5	29.0	42.5	104.0	85.0	77.0	90.0	66.5	106.5
Gausiai	36.5	41.5	19.0	23.0	16.0	16.5	43.0	40.5	25.5	27.0	24.0	42.0	100.5	80.0	73.0	95.0	77.5	98.5
AuksiniaiIII	36.0	41.0	19.0	23.0	15.5	14.5	44.0	42.0	27.5	28.0	25.0	40.5	97.5	80.0	71.0	87.5	65.0	106.5
Aidas	32.5	41.0	19.5	21.5	14.5	13.5	43.5	41.5	27.5	27.5	25.0	39.5	101.5	77.5	66.0	87.5	68.0	95.5
Ula	34.0	40.5	17.5	19.5	14.5	17.5	45.0	42.5	25.0	27.5	27.0	42.0	98.5	85.0	68.5	87.5	65.5	103.5
Alsa	35.0	41.5	19.0	22.0	16.5	17.0	41.0	41.5	26.5	27.0	29.0	44.5	89.0	75.0	71.0	85.0	70.5	104.0
Aura	34.5	42.0	18.5	23.5	17.0	14.5	41.5	42.5	26.0	27.0	28.0	40.5	89.5	75.0	67.0	85.0	71.5	87.5
LIA6107-26	35.0	41.0	18.0	20.0	15.0	15.5	45.0	42.5	27.0	26.5	27.0	40.0	88.0	75.0	73.0	85.0	64.0	89.5
LIA6700-28	33.0	39.5	18.0	18.5	12.5	18.5	43.5	43.0	28.0	27.5	28.0	42.0	97.0	77.5	72.5	92.5	73.0	110.5
LIA6782-33	36.5	41.5	18.0	21.0	15.5	19.0	45.5	42.0	27.0	28.0	30.0	44.5	92.0	70.0	68.0	90.0	64.0	100.0
LIA6791-35(Luoke)	35.5	41.5	19.0	21.0	14.5	16.0	46.5	43.5	28.0	29.0	29.0	40.5	86.5	77.5	69.5	85.0	74.0	91.5
LIA6804-62	35.5	40.5	18.5	20.0	15.0	17.0	44.5	41.0	28.5	29.0	29.0	42.0	92.5	80.0	68.0	82.5	63.0	99.5
LIA6121-02	34.0	43.0	20.5	22.5	19.0	17.0	43.5	41.5	29.5	28.5	29.0	45.5	99.0	72.5	71.5	85.0	72.0	97.5
LIA6186-03-01	35.5	42.0	19.5	23.0	18.0	14.5	44.5	43.5	28.0	29.0	28.0	41.5	94.0	75.0	68.0	82.5	67.5	99.5

Annex 1

The average values for accessions for given traits for each trial site and year

Harvest index						Volumetric weigh						Thousand kernel weight					
Bjørke		Landskrona		Priekuļi		Bjørke		Landskrona		Priekuļi		Bjørke		Landskrona		Priekuļi	
2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
0.440	0.457	0.494	0.469	0.459	0.302	70.5	69.9	68.4	67.0	70.8	66.8	49.2	53.9	57.5	50.1	44.4	43.1
0.436	0.497	0.543	0.482	0.488	0.259	67.1	67.8	67.2	65.7	72.4	62.6	32.9	33.9	38.9	36.3	36.0	28.6
0.475	0.530	0.542	0.519	0.533	0.395	70.8	72.4	68.5	68.3	71.9	71.6	48.3	54.4	54.8	47.6	42.8	42.6
0.433	0.535	0.581	0.527	0.520	0.297	67.1	70.8	68.6	68.5	73.7	61.8	29.5	36.5	37.0	35.7	34.6	25.2
0.505	0.538	0.582	0.453	0.583	0.379	73.3	71.3	71.3	67.6	74.3	70.3	43.5	45.7	46.3	39.2	36.9	31.8
0.485	0.509	0.551	0.484	0.499	0.442	72.3	71.5	71.7	68.9	71.3	72.4	44.3	51.5	49.8	45.6	33.9	39.5
0.466	0.484	0.540	0.440	0.512	0.393	76.0	74.0	71.6	68.1	72.9	70.7	48.6	51.9	53.1	45.7	39.3	41.5
0.512	0.519	0.564	0.495	0.544	0.457	72.6	73.2	68.7	69.6	71.5	74.5	45.0	49.2	49.0	47.6	38.2	41.0
0.533	0.511	0.600	0.563	0.527	0.384	68.6	68.2	66.4	66.9	70.8	64.7	37.7	37.1	41.4	39.5	34.5	30.5
0.514	0.542	0.586	0.532	0.558	0.496	72.7	67.2	67.0	67.8	70.2	70.7	50.1	51.0	52.3	47.1	42.2	41.5
0.547	0.576	0.571	0.538	0.533	0.513	74.2	71.4	69.3	70.8	72.1	72.2	42.7	46.8	46.3	43.9	37.0	34.9
0.527	0.576	0.569	0.491	0.543	0.482	71.5	70.9	68.0	68.1	72.3	66.8	46.3	47.0	48.8	43.2	36.5	38.0
0.487	0.516	0.557	0.495	0.528	0.448	75.9	74.1	70.4	72.0	75.3	71.8	50.2	53.0	51.9	50.0	49.0	44.3
0.515	0.545	0.559	0.485	0.542	0.471	73.6	72.1	67.9	67.2	73.1	65.9	50.7	52.3	56.1	46.4	46.1	44.5
0.522	0.549	0.563	0.498	0.513	0.434	74.5	73.3	69.2	71.2	72.0	66.8	46.7	49.0	50.2	46.7	37.8	34.1
0.591	0.611	0.583	0.508	0.580	0.470	72.7	72.9	65.2	67.1	72.2	65.7	45.6	50.8	49.4	42.8	41.2	34.6
0.542	0.554	0.564	0.449	0.534	0.369	75.5	73.4	69.2	67.2	73.4	69.1	44.7	46.5	49.1	39.1	39.8	38.3
0.498	0.532	0.542	0.472	0.517	0.409	74.7	71.7	70.0	69.4	74.1	68.2	46.1	49.1	49.3	40.9	41.0	34.9
0.506	0.491	0.549	0.402	0.511	0.460	72.7	72.1	69.4	64.8	74.1	66.3	49.4	55.6	55.2	43.2	44.2	40.0
0.505	0.553	0.576	0.503	0.530	0.424	73.0	71.7	70.9	70.6	72.9	67.4	44.5	43.7	50.6	47.5	40.8	36.2
0.508	0.524	0.544	0.497	0.544	0.472	73.1	69.1	68.5	65.7	73.0	69.0	51.5	49.2	54.7	48.1	44.7	43.0
0.536	0.559	0.548	0.516	0.538	0.400	71.5	70.2	66.7	68.1	69.8	66.1	45.4	47.9	50.8	45.5	40.3	34.4
0.489	0.528	0.556	0.494	0.507	0.398	73.7	71.6	71.4	70.5	73.5	68.8	46.0	46.8	54.8	45.3	45.8	37.1
0.511	0.541	0.540	0.464	0.557	0.433	68.1	68.8	61.3	61.9	71.0	63.2	48.6	50.9	53.8	47.6	42.1	40.5
0.411	0.507	0.514	0.519	0.483	0.252	66.9	69.6	67.0	65.7	70.6	62.2	32.8	34.7	38.2	35.7	34.9	28.1
0.492	0.499	0.575	0.450	0.564	0.328	74.3	72.5	69.8	66.7	73.2	72.2	44.0	46.5	48.0	41.0	35.4	36.8
0.493	0.549	0.589	0.527	0.546	0.376	67.5	69.8	68.3	66.2	72.2	60.3	33.3	37.1	41.6	36.3	36.6	27.1
0.497	0.541	0.551	0.407	0.561	0.397	72.6	72.0	68.8	64.6	71.3	60.9	41.7	43.1	46.3	40.4	39.2	32.4
0.485	0.536	0.565	0.449	0.560	0.428	71.8	71.0	68.6	66.7	71.6	65.7	40.8	46.6	48.0	41.0	29.9	34.4
0.465	0.549	0.547	0.450	0.546	0.462	73.2	71.8	68.1	68.5	73.7	70.1	46.5	46.7	49.3	43.1	37.0	39.8
0.557	0.541	0.569	0.490	0.569	0.474	73.1	72.9	68.4	67.9	72.8	68.8	41.2	44.6	44.9	39.3	36.6	34.6
0.520	0.558	0.635	0.556	0.613	0.339	63.9	65.3	66.2	64.0	71.1	57.2	35.5	36.1	40.1	38.4	35.7	28.1
0.576	0.564	0.593	0.514	0.570	0.471	71.6	73.6	69.2	67.1	73.6	67.0	42.2	42.3	52.1	43.8	39.5	37.4
0.586	0.578	0.576	0.516	0.583	0.468	73.6	72.4	67.3	67.5	73.3	66.3	48.2	48.0	48.1	43.5	37.8	37.0
0.560	0.593	0.591	0.490	0.585	0.445	70.4	71.2	67.3	65.8	74.5	63.0	41.9	47.5	49.8	42.1	43.5	33.0
0.570	0.563	0.566	0.522	0.544	0.455	73.2	72.0	67.2	69.4	71.6	69.5	43.7	46.7	48.7	42.2	34.4	37.2
0.592	0.641	0.590	0.506	0.598	0.460	73.6	71.7	68.9	68.8	72.6	67.4	43.0	43.2	50.2	44.1	37.6	33.0
0.517	0.521	0.519	0.482	0.524	0.450	73.5	72.4	69.2	70.1	73.2	71.6	47.1	50.5	49.4	45.6	39.1	40.9
0.552	0.551	0.590	0.481	0.535	0.400	71.5	71.8	67.2	67.7	72.6	70.9	46.2	48.5	48.3	43.1	35.5	37.5
0.552	0.553	0.595	0.489	0.551	0.434	69.7	71.0	68.0	67.7	74.1	64.9	38.4	47.2	46.3	41.1	37.7	32.6
0.532	0.569	0.578	0.532	0.546	0.481	72.6	75.0	70.7	70.5	74.5	68.0	37.9	42.6	45.9	38.7	37.6	31.3
0.576	0.593	0.594	0.512	0.556	0.431	71.2	71.7	70.3	67.8	69.5	68.6	43.2	47.2	47.8	41.7	38.3	33.7
0.551	0.553	0.598	0.556	0.582	0.432	73.0	72.2	70.3	72.5	70.9	67.6	41.5	42.3	47.3	42.2	40.2	32.3
0.545	0.575	0.571	0.504	0.569	0.451	74.6	73.6	70.6	70.4	74.0	71.8	45.8	48.4	50.5	45.1	42.2	36.4
0.474	0.508	0.535	0.463	0.578	0.382	62.7	73.6	71.7	70.2	69.6	68.6	33.4	44.6	49.7	40.1	34.8	36.7
0.333	0.396	0.517	0.515	0.530	0.152	70.2	68.3	68.0	66.6	72.3	62.8	43.9	41.7	47.0	41.7	44.1	35.7
0.478	0.537	0.551	0.465	0.546	0.480	75.1	73.5	74.1	69.2	73.3	71.4	45.7	47.0	49.1	44.6	38.7	39.3
0.420	0.474	0.503	0.444	0.495	0.217	73.6	72.7	72.6	70.8	74.4	64.1	44.0	44.3	51.6	45.4	42.2	32.4
0.482	0.516	0.551	0.487	0.535	0.357	71.8	70.6	67.4	67.7	73.5	68.6	41.4	42.4	45.4	42.5	46.6	34.6
0.505	0.517	0.553	0.475	0.558	0.367	73.5	71.5	69.7	69.3	73.7	67.8	45.1	47.4	49.0	43.0	38.2	35.9
0.502	0.526	0.571	0.488	0.536	0.435	75.1	73.9	69.8	69.0	74.3	69.9	46.9	47.9	52.7	43.8	41.9	39.2
0.458	0.496	0.533	0.477	0.491	0.426	73.1	72.0	70.0	68.3	72.8	67.8	44.5	46.3	49.9	44.2	41.1	37.6
0.474	0.503	0.529	0.459	0.514	0.393	75.5	73.6	73.6	69.4	73.8	71.6	45.2	46.6	47.6	41.6	38.2	35.9
0.513	0.537	0.567	0.525	0.552	0.427	74.9	73.2	70.0	72.0	72.3	70.5	48.4	49.2	49.4	48.0	42.8	40.5
0.515	0.529	0.557	0.506	0.531	0.400	74.6	73.3	69.0	71.7	72.8	69.9	53.6	55.3	54.7	51.4	43.4	42.9
0.545	0.580	0.558	0.525	0.563	0.489	73.0	70.8	69.9	69.8	73.9	70.9	46.0	47.2	52.4	48.0	40.0	40.5
0.527	0.562	0.568	0.505	0.567	0.509	72.7	71.3	69.5	68.9	73.8	69.5	47.8	47.9	51.3	46.2	44.7	42.0
0.532	0.564	0.559	0.523	0.553	0.492	73.7	72.2	71.8	71.5	74.1	74.3	43.7	47.7	51.5	43.6	40.1	41.0
0.532	0.533	0.563	0.518	0.551	0.419	75.0	73.1	70.8	69.9	72.2	65.7	52.5	54.9	54.6	50.0	43.2	44.6
0.515	0.512	0.559	0.499	0.578	0.395	73.9	71.8	70.8	70.1	72.4	65.1	44.7	47.8	50.3	45.0	35.4	36.6
0.519	0.525	0.571	0.512	0.589	0.422	72.5	71.1	66.8	68.0	72.3	68.2	47.6	51.9	50.7	47.8	41.7	38.6
0.543	0.575	0.564	0.513	0.567	0.470	71.3	73.6	68.2	70.0	72.6	64.7	50.0	53.7	53.3	51.4	43.1	43.0
0.526	0.547	0.590	0.543	0.537	0.457	75.9	73.4	73.1	71.9	75.4	69.5	47.9	47.3	49.6	45.1	42.5	39.1
0.524	0.520	0.576	0.499	0.538	0.426	75.6	72.9	72.6	69.3	75.7	69.0	50.8	51.4	52.4	45.1	41.9	39.8