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Genetic and environmental variation of grain yield of oat varieties

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Abstract. Both variety genotype and climatic conditions influence the grain yield of oat. The field experiments were carried out in 1998–2002 at the Jõgeva Plant Breeding Institute (PBI) in Estonia to investigate the genetic and environmental variation of oat grain yield. 101 oat varieties from Germany, Sweden, Russia, Canada, USA, and other countries were included in the trial.

As a result of the trial, the climatic conditions proved to have considerable influence on the grain yield of oat. Oat grain yield was decreased by drought and high temperatures in 1999 and 2002. Heavy winds and rains caused lodging of oat crop and lowered the grain yield in 1998 and 2001. The oat grain yield was highest in 2000, in rainy vegetaton period with moderate temperature. The coefficients of variation and differences between minimum and maximum values indicate the wide range of genetic variability of grain yield.

Key words: oat varieties, grain yield, genetic variation, environmental variation

INTRODUCTION

High grain yield potential is the most important trait for an oat variety in Estonian conditions. Producing high yields of high quality oats involves interactions among numerous biological factors, climate conditions, and management strategies. Biological factors, including disease resistance, straw length, leaf area, photosynthetic capasity, source–sink relationships, and mineral uptake are controlled by the unique combination of genes assembled in the genotype (variety) being grown (Forsberg, 1986).

Meteorological situation is one of the main environmental factors, which either promotes or limits the realisation of variety yield potential (Peltonen-Sainio, 1991). Among climatic factors, temperature and moisture are the most important. Cool and moist climates are considered best for oat (Forsberg & Reeves, 1995). Oat requires more moisture to produce a given unit of dry matter than any other cereal except rice (Coffman & Frey, 1961; Downes, 1969). Based on several studies, temperatures from approximately 13 to 19°C are optimal for oat plants to produce high grain and straw yields (Sorrells & Simmons, 1992).

MATERIALS AND METHODS

The field experiment was carried out at the Jõgeva PBI in 1998–2002 to estimate the variation of oat grain yield. 101 oat varieties from Germany, Sweden, Russia, Canada, USA, and other countries were included in the trial. The Estonian variety

'Jaak' was used as a standard. The plot size was 5 m², each with 3 replications. The seeding rate for oat was 600 seeds/m². The precrop was potato. Fertilisers N70 P12 K35 kg/ha were applied before sowing.

The trial was organised by NNA method. Data processing was carried out in Agrobase. To estimate the variation of grain yield, the minimum and maximum values, averages and coefficients of variation were calculated.

The climatic conditions were quite different in the testing years. Heavy rains and winds caused lodging of oat already at heading time in 1998. The growth of oat was inhibited by heavy drought in 1999 and 2002. The vegetation period was very rainy with moderate temperature in 2000. The summer was hot and rainy with heavy thunderstorms in 2001.

RESULTS AND DISCUSSION

The average grain yield of oat varieties varied from 3,288 to 5,824 kg/ha in the testing years (Table 1). The great difference between the minimum and maximum levels of yield indicates considerable influence of climatic conditions on the oat grain yield in the trial. The average grain yield was lowest (3,288 kg/ha) in 1999, when the development of oat was inhibited by high temperatures and heavy drought starting from heading time. Shortage of water can cause serious loss of the grain yield of oat (Sandhu & Horton, 1977). There may appear a decrease in the number of panicles per plant and florets per panicle, coupled with an increase in floret sterility by drought (Sandhu & Horton, 1977). Yield levels of oat varieties are closely connected with the average daily temperatures, especially in the period of seedling growth – anthesis. The higher the air temperature, the lower the grain yield (Zute, 2002).

The relatively low average levels of grain yields in 1998 (3,531 kg/ha) and 2001 (3,701 kg/ha) were caused mainly by heavy lodging at the heading time. Lodging can result in severe yield losses. The most severe lodging of oat occurs within 25 days after anthesis (Burrows, 1986). The average grain yield was highest (5,824 kg/ha) in rainy summer in 2000. To produce high grain yield, oat must be supplied with optimal moisture during the whole vegetation period (Rodionova et al., 1994). Higher oat yields were obtained in trials in Latvia when there was more rainfall in vegetation period (Zute, 2002).

Table 1. Variation of grain yield (kg/ha) of oat varieties at the Jõgeva PBI in Estonia in 1998–2002.

Year	Min–max	Mean ± SE	Coefficient of variation
1998	767–5,227	3,531 ± 82	23
1999	1,507–4,300	3,228 ± 57	18
2000	2,468–7,680	5,824 ± 92	16
2001	1,238–5,204	3,701 ± 68	18
2002	2,329–5,004	3,744 ± 46	12
Average	1,776–4,993	4,005 ± 53	13

Table 2. Grain yield (kg/ha) of oat varieties at the Jõgeva PBI in Estonia 1998–2002.

Variety	State of origin	1998	1999	2000	2001	2002	Average
Adamo	Germany	5,093	4,047	6,994	5,029	3,802	4,993
Revisor	Germany	3,770	3,567	7,680	4,032	5,004	4,811
Bruno	Germany	4,413	3,593	7,035	4,232	4,676	4,790
Lorenz	Germany	5,227	3,240	6,667	5,030	3,410	4,715
Klaus	Germany	4,213	4,240	7,022	4,368	3,730	4,715
Kompleks 1	Russia	5,060	3,353	6,191	4,730	4,159	4,699
Sirene	France	4,927	3,433	6,448	4,768	3,850	4,685
Fuchs	Germany	4,233	3,327	7,015	4,720	4,090	4,677
Villu	Estonia	4,130	4,172	6,481	3,677	4,499	4,592
Tomba	Germany	5,173	3,227	6,137	5,204	3,181	4,584
Kosõr	Russia	4,980	3,693	6,265	4,212	3,637	4,557
Bonus	Germany	3,947	3,560	7,011	4,222	4,006	4,549
Komes	Poland	4,787	2,753	6,448	4,404	4,233	4,525
Jaak	Estonia	**4,264**	**3,820**	**5,819**	**4,761**	**3,904**	**4,514**
LSD (0,05)		375	279	371	373	310	209

Table 3. Ranking of oat varieties by grain yield and yield at the Jõgeva PBI in Estonia 1998–2002.

Variety	1998	1999	2000	2001	2002	Average	Coefficient of variation
Adamo	3	9	7	3	45	1	25
Revisor	36	30	1	34	1	2	35
Bruno	13	26	3	23	2	3	27
Lorenz	1	53	14	2	79	4	30
Klaus	21	3	4	17	54	5	28
Kompleks 1	4	45	45	8	20	6	22
Sirene	6	38	28	6	41	7	25
Fuchs	20	47	5	9	23	8	30
Villu	26	7	24	48	5	9	24
Tomba	2	54	48	1	88	10	29
Kosõr	5	21	40	25	61	11	24
Bonus	29	31	6	24	29	12	31
Komes	8	76	29	13	17	13	29
Jaak	**18**	**17**	**60**	**7**	**34**	**14**	**18**

The variation coefficients of grain yield were between 12 and 23% in single testing years and reached 13% for the average results. It indicates the considerable genetic variability of this character. The differences between minimum and maximum values of grain yield varied in a wide range in single testing years and were 1,776–4,993 kg/ha for average results. It indicates the presence in the trial of varieties with a very different yield potential compared to the trial average. The grain yield of 13 varieties was superior to the standard variety 'Jaak' (Table 2). Among these, the grain yields of 'Adamo', 'Revisor' and 'Bruno' from Germany were statistically higher compared to that of 'Jaak'. The ranking of varieties by grain yield in single testing years referred to the different reaction of individual varieties to variable climatic conditions (Table 3). The variation coefficients of oat varieties varied between 18–50% in the trial. It indicates great influence of climatic conditions on the yield level of each variety. The standard variety 'Jaak' proved to produce a more stable grain yield in the trial.

CONCLUSIONS

There was considerable influence of climatic conditions on the oat grain yield in the trial carried out in 1998–2002. Drought and high temperatures caused a decrease in oat grain yields in 1999 and 2002. Heavy lodging caused a loss of grain yield in 1998 and 2001. The average grain yield of oat varieties was high in 2000 when the vegetation period was very rainy and with moderate temperature.

The coefficients of variation for average trial results (13%) and each testing year (12–23%) showed considerable genetic variability of grain yield. The trial included varieties with very low and high yield potential compared to the average trial results. Varieties 'Adamo', 'Revisor' and 'Bruno' from Germany appeared to have the highest level of grain yield.

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