# Variety and Environment Effects on Quality Traits in Latvian - Grown Winter Wheat

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## Abstract

Field experiments with 13 winter wheat (*Triticum aestivum. L*) varieties of different origin were conducted on brown lessive soils of the Study and Research farm “Peterlauki” of the Latvia University of Agriculture from 2000 to 2001.

Split nitrogen (rate $N_{150}$) dressing for all the studied winter wheat varieties was applied in the following way: $N_{60}$ early in spring at the beginning of vegetation period for the first time, $N_{30}$ at the end of tillering the second time and $N_{60}$ at the end of shooting into stems. Improvement of end use quality in winter wheat depends on thorough understanding of the influences of environment, variety, and their interaction. Wet gluten content (WG), sedimentation value (SED), grain protein content (GPC), test weight (TW), thousand kernel weight (TKW) and Hagberg falling number (HFN) were measured. Highly significant differences were detected among the environments and varieties for each of the quality variables. Both variety (V) and environment (E) had a significant effect on quality traits. Significant V x E interactions indicated that quality trait evaluations must be undertaken for environments. Close positive correlation was determined between the grain protein content and wet gluten content as well as between sedimentation value and grain protein content.

## Media summary

Latvian researchers have investigated winter wheat varieties and determined quality traits, however statistical analyses indicates that for quality traits there is an interaction between variety and environment.

## Key words

winter wheat, grain quality, variety x environment interaction

## Introduction

Wheat is the major field crop grown in Latvia. High - quality wheat grains are required for the milling and baking industries.

The quality of wheat is mainly determined by management techniques and environmental conditions, however it can be influenced by genetics (Grausgruber et al., 2000).

A wheat variety’s quality depends not only on its genetic potential for particular characters but also on its ability to realize this potential in actual production and under different environmental conditions (Dotlacil and Toman 1991; Mladenov, Misics et al., 2001). Wheat varieties differ significantly as to their grain quality. Nonetheless, environmental factors play a major role in the expression of genotype characteristics (Ruza, 2002; Bassett et al., 1989; Lucov and McVetty, 1991). Their impact, however, is rarely optimal; one or more of them will always limit the yield and quality of the product. For this reason, it is very important to determine the variation of environmental factors and their effects on the processes that determine wheat quality. Addition of nitrogen fertilizer in accordance with the plant requirement is necessary to attain high yields and quality of winter wheat (Ruza and Linina, 2001; Masauskiene et al., 2001).

Our objectives were to determine relative contributions of variety, environment, and V x E interaction to variation in quality characteristic of winter wheat.

## Material and Methods

Field experiments with 13 winter wheat *(Triticum aestivum L.)* varieties: 'Donskaja polukarlikovaja' (Russia), 'Sakta' (Latvia), 'Krista' (Latvia), 'Pamjati Fedina' (Russia), 'Moda' (Latvia), 'Kobra' (Poland), 'Kosack' (Sweden), 'Bussard' (Germany), 'Ibis' (Germany), 'Portal' (Germany), 'Kontrast' (Germany), 'Zentos' (Sweden) were conducted at the Study and Research farm "Peterlauki" of the Latvia University of Agriculture (LUA) from 2000 to 2001. The soil at the site was brown lessive medium loam with medium phosphorus and potassium sufficiency levels, pH $_{KCl}$-6.9 to 7.1, humus content 19 to 21 mg/kg of soil. Previous crop – full fallow - oil radish for green manure. Plots were sown to winter wheat inhe first half of September. The seeding rate was 500 germinating seeds per $m^2$.

Conventional measures of agrotechnics were applied in growing, NPK (6:26:30) 200 kg/ha was used. Split nitrogen (rate $N_{150}$) dressing for all the studied winter wheat varieties was applied in the following way: $N_{60}$ early in spring at the beginning of vegetation period for the first time, $N_{30}$ at the end of tillering the second time and $N_{60}$ at the end of shooting into stems.

During the study years the meteorological conditions were significantly different. In 2000, comparatively dry and warm weather conditions prevailed during the first half of the growth period, however there set in the rainy season from mid - June up to the end of the harvest period. In 2001,excessive rainfall and hot weather prevailed during growing season.

Quality tests were performed on the harvested grain of each variety for each year. Quality traits were calculated at 14% moisture level and 100% purity.

The following baking quality indices were determined: wet gluten content according to Perten, grain protein content by Kjeldahl procedure (N x 5,7; moisture basis), Sedimentation value (according to Zeleny) as an approximate measure of baking quality, Hagberg falling number according to Hagberg - Perten as measure of the degree of alpha-amylase activity in grain and flour, and test weight by determination of kernel test weight and thousand kernel weight according to standard methods used in Latvia.

Analysis of variance (ANOVA) and estimates of the component of variance to variety ($\sigma^2_V$), variety by environment ($\sigma^2_{V \times E}$) and error ($\sigma^2_e$) were calculated according to Comstock and Moll (1963). The year was treated as separate environments for statistical analyses. Using mean squares for variety x year and pooled error, respectively, tested the significance of mean squares for varieties, years, and variety x year interaction. The percentage contribution of each variance component was estimated by summing the appropriate terms to give an estimate of total variance and then dividing the specific variance component by the total variance (Singh et al., 1993). The ratios of variance components ($\sigma^2_V / \sigma^2_{V \times E}$) were calculated by Peterson et al. (1986). Coefficient of variation was determined using formulae of Arhipova et al. (1997). Correlation was calculated according Arhipova et al. (1997).

## Results and discussion

Based on the pooled ANOVA (Table 1), all sources of variation for each of the 6 qualitative traits were highly significant ($P < 0.01$). In general, V x E interactions were significant ($P < 0.01$) yet relatively small. The significant V x E interaction for all quality traits resulted from the different abilities of cultivars to adjust quality to the environment as a consequence of genetic differences. For GPC, HFN, TW and TKW variances due to cultivars were greater that V x E variances. These results are in agreement with the findings for winter wheats (Mladenov et al 2001), soft and hard red winter wheats (Baenziger et al., 1985; Peterson et al., 1992), semi dwarf spring wheats (Lukow and Mc Vetty 1991), and soft white winter wheats (Basset et al., 1989).

**Table 1. Mean Square for Analysis of Variance Across Environments in 2000 – 2001**

| Source | | Quality traits[b] | | | | | |
|---|---|---|---|---|---|---|---|
| of variation [a] | df | WG | SED | GPC | HFN | TW | TKW |
| Environment (E) | 1 | 85.68** | 3672.48** | 15.72** | 99443.77** | 1776.10** | 47.39** |
| Variety (V) | 12 | 3.58** | 106.50** | 2.36** | 7347.98** | 1473.44** | 55.74** |
| V x E | 12 | 20.70** | 171.65** | 1.56** | 0,269** | 338.92** | 9.74** |
| Pooled error | 51 | 0.079 | 0.028 | 0.002 | 0.269 | 0.877 | 0.623 |
| $\sigma^2_V$ | | 11.3 | 18.2 | 35.5 | 45.1 | 75,1 | 18.8 |
| $\sigma^2_{V x E}$ | | 65.3 | 29.4 | 24.5 | 29.8 | 17,3 | 13.8 |
| $\sigma^2_e$ | | 0,53 | 0,10 | 0,10 | 0,08 | 0,09 | 1,91 |
| $\sigma^2_V / \sigma^2_{V x E}$ | | 0.17 | 0.61 | 1.45 | 1,51 | 4.34 | 5.71 |

[a] Total variance for each source of variation ($\sigma^2_{V;}$ $\sigma^2_{V x E}$; $\sigma^2_e$ ), ratios of variances estimated for cultivar main effect and interaction ($\sigma^2_V / \sigma^2_{V x E}$ ).
[b] WG - wet gluten, SED - sedimentation value, GPC - grain protein content,
HFN - Hagberg falling number, TW - test weight, TKW- thousand kernel weight.
** Significant at P < 0.01.

Component of variance for each qualitative trait expressed as percentage illustrates the relative contribution of each source to total variance (Table 1). The variance component due to variety explained most of the total variation, ranging from 11.3 to 75.1 % of the variability associated with each quality parameter. Effects of V x E interaction ranged from a low of 13.8 of total variance for TKW to a high of 65.3 % of total variance for WG. The relatively large V x E interaction for WG, SED, GPC and HFN multiple years testing to accurately assess the genetic potential.

The importance of the V x E interaction in relation to genetic effects can be shown through the ratio of the variance component $\sigma^2_V / \sigma^2_{V x E}$ (Table 1). The ratio of variety to V x E effects differed among the quality parameters measured. A ratio > 1.0 indicates greater influence and stability of genetic factors relative to the variability associated with the interactions V x E (Peterson et al., 1992). The ratios for all the quantitative traits ranged from 0.17 to 5.71. The ratios for GPC (1.45), HFN (1.51), TW (4.34) and TKW (5.75) showed a larger influence on variability by the variety than the V x E interaction. The ratios for WG (0.17) and SED (0.61) were <1.0, indicating the important influence of the V X E interaction on these quality traits. Variances associated with the V x E interaction were of similar magnitude as genetic components for SED and GPC. Grain quality is a complex character that depends on a number of traits, and the individual contribution of each trait varies depending on the specific reaction to environmental conditions. The significant variety variance component indicated that the cultivars differed in their genetic potential for quality. A wide range for all quality parameters was observed in Table 2.

**Table 2.Variety and Environment Mean Values for 6 Quality Traits of 13 Wheats Grown in 2000-2001**

| ? | Range | | | | | |
|---|---|---|---|---|---|---|
| Trait | Variety | CV (%) | Environment | CV (%) | Mean | CV (%) |
| ? | (n=13) | ? | (n=2) | ? | (n=26) | ? |
| Wet gluten (%) | 26.8 - 29.3 | 3.2 | 22.5 - 36.1 | 6.6 | 28.0 | 9.8 |
| Sedimentation value (ml) | 38.5 - 56.5 | 10.6 | 39.9 - 56.8 | 24.8 | 48.3 | 24.5 |
| Grain protein content (%) | 13.1 - 16.2 | 5.6 | 13.4 - 14.5 | 5.6 | 14 | 8.0 |
| Falling number (s) | 183.5 - 331.0 | 15.5 | 233.2 - 320.5 | 22.3 | 276.9 | 25.4 |
| Test weight (g/l ) | 740.4 - 819.0 | 2.4 | 780.9 - 792.2 | 1.0 | 786.5 | 2.7 |
| Thousand kernel weight (g) | 40.2 - 52.2 | 8 | 44.5 - 46.6 | 3.3 | 45.5 | 8.9 |

Ranges in TW and TKW across variety were notably larger than those established across environments. Range in GPC was similar for cultivars and environments. Some cultivars were stable for one trait and unstable for another, suggesting that the genetic factors involved in V x E differed between traits.

There was a significant V x E interaction for all the quality traits studied. The relatively large contributions (>20 %) (Lukow and McVetty, 1991) of variety variance and V x E interactions for some traits WG and HFN (Table 1) also suggest that these quality parameters may require multiple environment testing to accurately assess the genetic potential of wheat lines.

Correlations between the traits depend on genetic and environmental factors. Pleiotropic gene effects and gene linkage are the main reasons for the existence of genetic correlations between traits (Falkoner and Mackay, 1996). When several traits are involved in evaluation of quality, it is desirable to determine correlations among them. In the present study, 15 possible pairs of traits were examined for interrelationships. The correlations among the various traits are presented in Table 3.

**Table 3. Correlations among 6 quality traits[a] in grain of different wheat varieties**

| Traits | WG | SED | GPC | TW | TKW |
|---|---|---|---|---|---|
| WG | | | | | |
| SED | 0.58**[b] | | | | |
| GPC | 0.77** | 0.52** | | | |

| | | | | | |
|---|---|---|---|---|---|
| TW | -0.16 | -0.24 | 0.06 | | |
| TCW | 0.01 | -0.16 | 0.27 | 0.01 | |
| HFN | 0.18 | 0.15 | 0.02 | 0.28 | -0.26 |

[a] WG - wet gluten, SED - sedimentation value, GPC -grain protein content, HFN – Hadberg falling number, TW - test weight, TKW- thousand kernel weight.
[b]** - Significant at $P < 0.01$.

The significant high positive correlation among WG, SED and GPC are in agreement with the findings of most other researchers (Grausgruber et al., 2000; Mladenov et al., 2001). The high positive correlation between SED and GPC that was established in our study is in close agreement with that reported by Mladenov et al. (2001), and Gaile and Kopmanis (2002).

## Conclusion

The responsiveness of diverse winter wheat to growth conditions was significantly different.

Highly significant differences were detected among the environments and varieties for each of the quality variables. Significant V x E interactions indicated that quality trait evaluations must be undertaken for environments. Close positive correlation was determined between the grain protein content and wet gluten content as well as between sedimentation value and grain protein content.

Stability of wheat quality characteristic over environment is important to the milling and baking industry, the processing technology of which requires consistent raw materials in order to produce a quality end product. Grain quality is increasingly becoming an important factor in cereal trading, both nationally and internationally. Only cultivars with well balanced and stable indicators of quality can defy the unfavourable conditions of growing.

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