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Analysis of genotype by environment interaction in an international winter wheat ring test and consequences for direct and indirect selection strategies for organic agriculture

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Abstract

Within the framework of the EU-COST action 860 SUSVAR (Sustainable low-input cereal production: required varietal characteristics and crop diversity), a ring test with 14 winter wheat genotypes from 5 different countries (AT, CH, DE, FR, RO) was performed in 36 field trials between 2006-2008 in Romania, Switzerland, France and Austria. Based on the observation of about 43 phenotypic traits, the ring test aimed at comparing the performance of wheat genotypes under low and high input cropping practices in many different European environments. Overall, 13 trials were sown under organic conditions (ORG), and out of the conventional trials, 6 were sown without N supply (NI, 'no input'), 8 under 'low input' (LI) conditions using maximum 100 kg N·ha^{-1}, and 9 trials were sown under 'high input' (HI) conditions. All trials were conducted without fungicide or growth regulator application. GGE-Biplots were used for the analysis of genotype stability and differential behavior under ORG, NI, LI and HI. Results were more variable between countries and individual trials than between systems. To represent all countries in each set, environments were re-grouped combining ORG plus NI in N0 and LI plus HI in N, i.e. groups without and with synthetic nitrogen.

Variance components and heritabilities were calculated for N0 and N plus additional groupings of environments (ORG, NI, LI, HI; years and countries). Heritability was 0.85, 0.83, 0.44, and 0.61 for HI, LI, NI, and ORG, respectively. Subsequently, relative selection efficiencies (RE) were calculated in order to compare direct and indirect selection for ORG, N0 and N and for countries and years. The question 'Can 3 years of trialling be replaced by trialling in one year' was answered by comparing sets of 12 trials from 2006 and 2007 with a set comprising 12 trials for 2006-2008 (4 in each year). Using 2006 as test environment gave a poor RE with respect to all 3 years' results, while selection in the year 2007 alone was sufficiently efficient.

Many traits, e.g. plant growth habit or leaf inclination as well as soil coverage were scored at different developmental stages. Data for 13 traits are represented in all 4 intensity groups, 31 traits are represented in both the N0 and N group of trials. Many traits were found to be highly correlated across the four systems HI, NI, LI and ORG.

For specific traits relevant mainly in organic agriculture (e.g. soil coverage) this work gave evidence that direct selection in N0 or ORG can be advantageous due to better differentiation. There seem to be two classes of traits: Those where available nitrogen increases differentiation (e.g. grain yield, plant height) and those where it blurs differentiation (e.g. soil coverage, number of tillers). Therefore, it may be promising to work with both types of environments (N and N0) when varieties are bred being adapted to organic and low input conditions. Conversely, if traits are highly correlated first among each other and second among systems, then it does not matter where selection is performed. Highly correlated traits can replace each other in practical breeding in order to save costs for selection.

The SUSVAR ring test experiment gave evidence that, in order to select suitable lines for organic and low input agriculture, higher selection efficiency at lower cost can be achieved by combining information from organic, conventional low input and high input trials. This enables a commercially more sustainable breeding program for organic and low input agriculture.

Keywords

Genotype by environment interaction, organic breeding, stability, *Triticum aestivum*

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