Genetic potential for grain yield in spring barley varieties and variety mixtures in variable organic environments

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***Abstract* - For organic crop production, well-characterised varieties increase the possibilities for controlling diseases and weeds and compensating for deficits in nutrients. Variation in grain yield was studied in about 150 spring barley varieties and variety mixtures and 20 combinations of location, growing system and year. Choice of variety was found to be as important a factor for grain yield as other factors in the management. Some variety mixtures out yielded even the best variety in the mixture, when this was grown in pure stand. Finally, a concept for organic variety testing of spring barley was developed. This Danish project is part of a European COST Network on sustainable low-input cereal production (SUSVAR) which coordinates studies in different countries on variety mixtures, composite crosses and variety testing.[1]**

INTRODUCTION

Most modern spring barley varieties have been developed with the aim of combining high productivity and standardised product quality under high-input conditions. In organic growing systems, biotic and abiotic stresses have to be controlled entirely by growing appropriate varieties and by good farm management practices.

Organic varieties

An important question is whether modern spring barley varieties possess the right combinations of traits to ensure a stable and acceptable yield and quality, when grown under different organic growing conditions. The genetic resources in spring barley available for farmers for organic farming may be categorised into three groups: i) conventionally bred varieties which may be suitable for organic production, ii) conventionally bred which have been developed specifically for low-input environments and iii) organically bred varieties. In the latter group, organic breeding techniques would be applied, selection would take place in organic environments and socioeconomic aspects may also be considered (Lammerts van Bueren et al., 2003).

Yield stability and variety mixtures

When a farmer chooses a specific variety for a specific field, he may consider information from variety testing trials the previous years. However, often the highest yielding varieties differ from year to year, due to interaction with annual fluctuations in weather. Therefore, by growing a seed mixture of good varieties, the farmer will get a crop with potential better yield stability (Finckh et al., 2000; Østergård and Jensen, 2005). Certified variety mixtures of spring barley have been grown in Denmark since 1979. At present, seed of certified variety mixtures constitute about 6% of available conventional spring barley seed and 12% of organic seed. In other European countries the use of spring barley variety mixtures is not registered but presumably less.

Organic variety testing

We know that varieties often yield differently in different environments due to genotype-environment interactions. Therefore, it may be important to evaluate characteristics of varieties under organic as well as under conventional conditions. However, to date it remains unclear whether the differences between conventional and organic growing systems are large enough to justify an official testing of varieties in both environments, or rather to include additional characteristics of relevance only for organic farmers into the conventional testing.

Danish study

To illustrate the genetic potential for grain yield in spring barley and its interactions with the growing conditions, results from a project on characteristics of spring barley varieties for organic farming (BAR-OF: *www.darcof.dk/research/darcofii/vi2.html*) considering varieties as well as variety mixtures will be presented.

MATERIALS AND METHODS

Field trials were carried out in years 2002-2005 mainly on three Danish Research Stations (different soil type and weather condition) with 1-2 mainly organic growing systems per year per location. The systems were divided according to input: 'org' = reduced application of organic manure and weed harrowing; 'org-' = undersown clover grass without application of manure and without weed harrowing; and 'con' = application of fertilizer and chemical

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weed control (conventional). No disease control was applied. All together, about 150 varieties (mainly modern conventional varieties of group i) and ii)) and mixtures were grown and 20 combinations of year, location and growing system were studied. Many different disease - and growth characteristics were assessed; here, only grain yield is considered.

RESULTS AND DISCUSSION

The importance of choice of variety was apparent from the amount of variation in grain yield explained by the variation among varieties: e.g., within the 'org' group of environments nearly 40% of the total variation in grain yields was explained by varieties and by their interaction with environments (Table 1). Within the group of 'conv' environments, the variation among varieties was similar to that in the 'org' group but the variation among environments was less. In the group of environments without application of manure, 'org-', only the 24 best varieties were grown. For these extreme environments, the variation among varieties was very little, and the variation among environments was large. As the interaction between varieties and environments was about the same for all groups, these results implied a higher influence of varieties in the 'conv' group and a lower contribution in the 'org-' group.

Table 1. Variance components ($(hkg/ha)^2$) for variation in grain yield in different groups of environments.

Variance component	**'org'** 10 environments (2002-2005) 72 varieties	**'conv'** 4 environments (2002-2003) 72 varieties	**'org-'** 3 environments (2004-2005) 24 varieties
Environment	33.01	17.77	90.87
Variety	12.73	15.16	1.60
Variety x Environment	6.54	8.32	6.95
Variety + Variety x Environment	37%	57%	9%

When considering six 3-component variety mixtures composed for this project, the mean environmental variance in grain yield was lower for the mixtures than for their 14 component varieties (Østergård and Jensen, 2005). This may be interpreted in the way that the mixtures were more stable over environments than component varieties. Further, mixtures yielded, in general, more than the component varieties and had a higher ranking (Østergård and Jensen, 2005). In fact, one mixture out yielded the best component in half of the organic environments (data not shown).

The genetic potential of single varieties and the interaction between varieties and environments were analysed using regression with environmental variables as covariates. Disease load of powdery mildew, leaf rust and net blotch and total weed infestation had a significant influence on grain yield. The slopes of the regression lines varied between groups of varieties, based on varietal characteristics from official variety testing trials (data not shown). All together, these factors explained more than 60% of the variation among varieties and about 15% of the interaction among varieties and environments.

This kind of regression analysis was also used to investigate to which extend disease and growth characteristics from conventional official variety testing may predict grain yield as observed in organic compared to conventional trials. Data from 'org 1' and 'con' growing systems from two years and two locations were analysed (Østergård et al., 2005). In conclusion, the official variety testing results predicted the observed grain yield slightly better in the conventional systems than in the organic systems.

CONCLUSIONS

In any analysis of genotype-environment interactions, the results obtained depend on the varieties and growing systems chosen. In the Danish study, a broad spectrum of varieties were included, however, these were mainly conventional varieties bred for high-input conditions. Further, the growing systems chosen may not be fully representative for neither certified organic nor conventional farms. Therefore, the actual genetic potentials and genotype-environment interactions may be even bigger than demonstrated here.

The Danish results are included in the European COST Network 'Sustainable low-input cereal production: required varietal characteristics and crop diversity', SUSVAR (www.cost860.dk). Data from variety testing in several countries are being collected for a combined statistical analysis of potential differences between ranging of varieties in conventional and organic growing systems. Furthermore, common protocols for organic variety testing are discussed. Also data on cereal variety mixtures will be collected for a combined meta analysis aiming at clarifying principles for how to combine varieties in variety mixtures in the best way.

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