Stability of variety mixtures of spring barley

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Abstract

Six 3-component variety mixtures of spring barley and their component varieties have been grown in 17 different environments (3 years, 3 locations, 3 different growing systems). For three of the six mixtures, the grain yield was significantly higher than the average yield of its components; in none of the mixtures it was significantly lower. The variation in grain yield over environments of all variety mixtures was compared to the variation of all component varieties. The six mixtures were on average more stable than the 14 component varieties grown in pure stands with respect to actual yield as well as to rank values of yield.

Keywords

Variety mixture, organic growing conditions, yield stability, mixture efficiency.

Introduction

Modern spring barley varieties have been developed with the aim of combining high productivity and standardized product quality under high-input conditions. The organic growing system is a system where pesticides and synthetic fertilizers are generally not allowed. Hence, biotic and abiotic stresses have to be overcome by growing appropriate varieties and by practicing good farm management. An important question is whether modern spring barley varieties possess the right combinations of characteristics, e.g. weed competitiveness and disease resistance and tolerance, to ensure a stable and acceptable yield of good quality when grown under different organic growing conditions. Despite quite intensive testing of varieties, predictions of performance of varieties are known to be very difficult; this especially within organic growing systems, where pesticides and fertilizers cannot help stabilizing yield. Therefore, using mixtures of appropriate varieties might be a way to obtain more stable and acceptable yields.

In Denmark, official regulations for certification of variety mixtures of spring barley have been practiced for several years requiring 3- or 4-component mixtures with equal proportions of component varieties, medium to high grain yield of each component, little difference between ripening dates and culm lengths of components and high average disease resistance of the mixture.

Variety mixtures have so far been studied mostly under conventional farming conditions and with focus on reducing disease severity by combining varieties with different disease resistance genes. In this study, the performance of variety mixtures in organic as well as conventional growing systems is considered with focus on competitive ability of the component varieties in addition to their disease resistance.

Materials and methods

In 2002, six 3-component variety mixtures were constructed based on information from official variety testing (Table 1). The mixtures consisted mostly of high yielding varieties. They were made according to official certification requirements with respect to relative yield, disease resistance, and date of ripening. However, larger differences between component varieties than accepted according to the rules for culm length were introduced. The mixtures were combining malting and fodder varieties, as the purpose was to study the competition between different combinations of varieties. These mixtures as well as their components have been included in large variety trials in the years 2002-2004 (Jensen & Deneken 2002, 2003, 2004).

Each year the mixtures were composed of untreated seeds from conventional multiplication of the component varieties in equal proportions according to expected seed germination. The seed for the pure stands were from the same seed batches. Field trials were conducted on experimental research fields at three Danish locations: Jyndevad, Foulum and Flakkebjerg. Three different growing conditions were studied either resembling organic conditions (i.e. no pesticides, weed harrowing or grass-clover undersown, and low input of organic fertiliser (e.g. slurry)) or conventional conditions (use of herbicides and synthetic fertiliser according to local standards, however, without use of fungicides). All together, data were collected in five to six different environments (system x location) in each year 2002 to 2004. The conventional conditions were only applied on two locations in each of the years 2002 and 2003 constituting all together 4 of the 17 environments. Many different disease- and growth characteristics were assessed; here, we will consider only grain yield.

Table 1. List of component varieties of the six spring barley mixtures studied and of their weed competitiveness.

Component variety	Weed competitiveness	Mix1	Mix2	Mix3	Mix4	Mix5	Mix6
Alabama	Low			x			
Brazil	*Low*		x		x		
Cicero	*Medium*		x				x
Culma	*High*		x				
Danuta	*High*				x		
Fabel	*High*					x	x
Harriot	*High*					x	
Landora	*Medium*	x					
Neruda	*Medium*			x			
Orthega	*High*	x			x		
Otira	*High*	x					
Prestige	*Medium*			x			
Punto	*Medium*						x
Sebastian	*Low*					x	

For each mixture and component variety, mean grain yield for each environment as well as variation between environments was calculated. Further, within each environment rank values of grain yield ('1' the highest yield in the environment and '20' the lowest yield) of the 20 mixtures and varieties were considered and mean and variance over environments was calculated. Two measures of stability were applied: environmental variance for grain yield as well as for rank values. Finally, the mixture effect being the difference between the grain yield of a mixture and the average of its components was calculated for each environment.

Results and discussion

The mixtures performed differently with Mix1 and Mix4 ranking well above the official standard in most environments, in some environments even better than all their component varieties, and Mix1 being among the ten best varieties in all years (data not shown). The grain yield of each mixture was in most cases higher than the average of its components when considering the mean over environments (Table 2). In average, mixtures produced significantly more (0.9 hkg/ha) than the average of their components. Mix1 and Mix4, in addition to Mix5, showed the largest effect. Both Mix1 and Mix4 included two component varieties with high weed competitiveness. The third mixture with this characteristic was Mix5. This mixture showed a significant mixture effect, however, its yield was only medium. One of the component varieties, Fabel, yielded rather low in many environments and this was to some extend compensated by the other components in the mixture. Variety Fabel was also included in Mix6 where the mixture effect was positive but not significant. Based on these results, one may suggest that 3-component mixtures should include more than one good competitor, however, this needs to be confirmed by other studies. For such comparisons of studies, a meta analysis is planned.

Table 2. Mean yield and mean mixture effects over environments for each mixture.

	Mix1	Mix2	Mix3	Mix4	Mix5	Mix6
Mean yield (hkg/ha)	52.9	49.3	48.3	51.6	49.3	47.9
Mean mixture effect (hkg/ha)	1.8*	0.2	-0.3	1.2*	1.4*	0.9

In general, mixtures yielded more than component varieties and also their ranking was better than that of components (Table 3). Further, the environmental variance over these very different environments, measured from either the grain yield or from the rank values, was lowest for the mixtures (Table 3). This is interpreted in the way that the mixtures were more stable than the component varieties. This pattern was found despite the mixtures were composed to demonstrate competition between the component varieties.

Table 3. Comparison between means for 6 mixtures and for 14 component varieties.

	Mean mixtures	Mean components
Mean yield (hkg/ha)	49.9	49.1
Mean environmental variance $(hkg/ha)^2$	5.7	8.3
Mean ranking[a]	9.8	10.7
Mean environmental variance of ranks[a]	19.7	24.1

[a] *highest ranking is 1, lowest is 20*

The final result of natural selection and competition between the components of each mixture will be evaluated from additional data on these six mixtures. Seeds harvested from the mixtures each year have been sown the following year at the same location, resembling farm saved seeds. By means of DNA markers, changes in the proportions of the different components in each mixture will be estimated and related to the characteristics of the different component varieties. These data are waiting to be analysed.

References

Jensen, J. W. & G. Deneken (2002-2004). Results of yield trials with spring barley. Online at www.planteinfo.dk/obsparceller/foj2002.html;www.planteinfo.dk/obsparceller/foj2003.html; www.planteinfo.dk/obsparceller/foj2004.html

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