Performance of wheat composite crosses on-station and on-farm

Diversity, N-uptake, baking qualities, and resilience.

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Summary: The F_{11} of 14 winter wheat composite cross populations (CCPs) were compared in replicated field trials to the mixture of the 20 parents and three commercial wheat cultivars in replicated field trials. In addition, one population was given to farmers for on-farm testing. In 2012 severe frost killed 16 out of the 20 parental varieties of the CCPs. In contrast, the mixture of these varieties and the CCP populations survived well. The CCPs with high yielding parents yielded still highest in the F_{12} and quality in the CCPs with high quality parents was highest. CCPs on-farm were comparable in performance with farmers reference varieties.

Background

In order to be able to adapt to changing environmental conditions, crop plants need a certain degree of diversity (Stevens 1942, Finckh 2008). The development of genetically diverse populations (composite cross populations, CCPs) instead of breeding entirely homogeneous pure line varieties by standard pedigree breeding methods is a strategy that aims at creating flexible varieties.
In 2000, 20 modern wheat varieties were intercrossed in all combinations in the UK to create three composite cross populations (CCPs). These are the intercrosses of 12 high quality varieties (Q) or 9 high yielding parents (Y) and the crosses of the Q by Y parents (All) were used. Since the F_5 the CCPs have been grown under organic (O) and conventional (C) conditions in two parallel sets at the University of Kassel without artificial selection applied. In addition, since the F_8 two A populations have been maintained as broadcast sown populations without mechanical weed control to select for weed suppressiveness.

Materials and Methods

In 2011/12 and 2012/13 the F_{11} of all 14 populations were compared in replicated field trials to the mixture of the 20 parents and three commercial wheat cultivars Achat, Akteur, and Capo in a replicated field trial. N-uptake of the plants was measured at the beginning of stem elongation, at the flowering stage and in the ripe seeds and straw. Samples of fresh plants were cut and dried for 72 hours at 60 °C. Seeds and straw were dried after harvesting and all samples were milled and analyzed for N-content using a CHN analyzer. Nmin in the soil was measured in early spring, at the flowering stage and after harvest. Morphological diversity, Yield and yield components, and raw protein contents were determined in both years, Baking tests were performed in the second year only.
One population (OA) was given to five farmers in 2011 and grown by the farmers since then in comparison to their main variety. Data were collected on yields and where relevant diseases.

Results and Discussion

Resilience of the populations with respect to frost and drought stress
In February 2012 after a very mild winter without severe frosts within one day temperatures dropped to -20 ^{o}C without snow cover for two weeks followed by six weeks of severe drought. The parent varieties that had been grown for seed increase suffered severe damage with only four varieties surviving reasonably well (Figure 1 left). Of these Bezostaya is of Ukrainian origin, Monopol and Renan are German and French, respectively, Herward is an English variety. These varieties were apparently better adapted to harsh winters. In contrast, the populations, the parental mixture and the modern reference varieties survived much better (Figure 1 right). The populations also recovered reasonably well. They all produced low but comparable numbers of head bearing tillers. Despite the relatively poor performance of the mean of the parents the parental mix also recovered although to a lesser extent than the populations. The modern varieties Achat, Akteur, and Capo used in the experiment are well adapted to the potential climatic extremes in Germany and performed well.
In 2012, yields of the populations were 3.77 t/ha for the Y CCPs to4.1 t/ha for the A CCPs 4.17 t/ha for the Q CCPs with the yield of the A and Q significantly higher than Y. In 2013, yields were 6.29 t/ha for the Y and 5.96 and 5.95 t/ha for A and Q, respectively, with no significant differences among populations. In both years, the same seed was used for the experiment. The pattern in 2013 is as it was observed in previous generations with generally highest yields in the Y CCPs and no differences between A and Q CCPs for yield (Finckh et al. 2010). The reason for the poor performance of the Y CCPs in 2012 is most likely due to the higher susceptibility of the Y parents to the freezing damage.

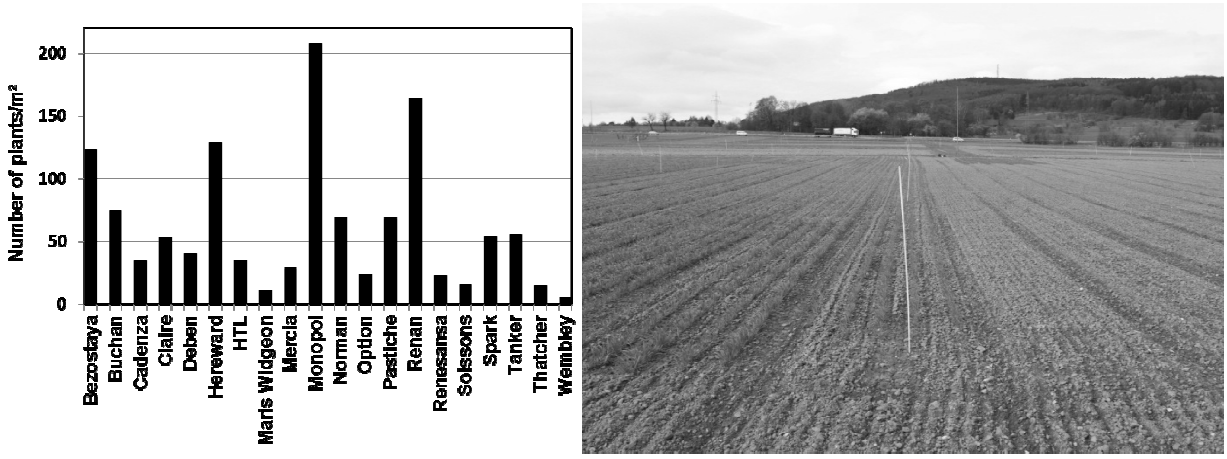

Figure 1. Left: Winter suvival of the parental varieties in 2012. Right: Photograph of the populations on the left side of the field and the parental varieties on the right side on April 16 2012. The surviving plot of Monopol is pointed out.

Overall, the differences among the populations in N-uptake were small. There were no statistically significant differences between the conventionally (C) and organically (O) grown populations. However, in both years at flowering the O-populations had taken up approximately 6% more N than the C-populations. These differences were not visible in early cut samples or in seeds and straw. In contrast, grain N contents of Q populations were in both years significantly higher than in the Y populations (Table 1). Thus, the genetic differences for quality were well conserved into the F11.

Table 1: N-contents (%) in grain in the F11 of three wheat CCPs in two years

	% N-content in grains			Linear contrast		
Year	All (A)	Quality (Q)	Yield (Y)	A vs Q	A vs Y	Q vs Y
2012	2.1	2.2	2.1	*		**
2013	2.0	2.1	1.9			*

* significant at P<0.05 and ** significant at P<0.01

On-farm results

In two of the five participating farms wheat was completely killed in February 2012. In two sites the populations performed as the reference varieties, in one site performance was below. In 2013, all populations did well and performed comparable to the farmers' varieties with good quality properties. By summer 2014 farmers will have saved and regrown seed of their populations for two or three years. These populations will be compared on-station with the population that stayed on-station during that time in 2014/15 in the frame of the Core-Organic II project COBRA.

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