Research on heterogeneous populations of self-pollinating cereals

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Plant diversity plays a significant role in sustainable and in particular organic farming. Composite cross populations (CCPs), composed of bi-parental crosses between around 10 parental genotypes can provide a large diversity within a crop. They are able to evolve and adapt to particular growing environments.
Creation of barley and wheat CCPs in Latvia was initiated, and testing of agronomical performance for traits essential in organic farming performed. Three-year agronomic data from 12 environments were summarized for spring barley CCPs compared to mixtures and homogeneous varieties. Spring and winter wheat populations from abroad, as well as first local CCPs, were tested. Genotypic and phenotypic data on three barley CCPs were obtained in order to detect the effect of growing environment and duration on trait expression and diversity parameters. Research on several population improvement techniques was initiated.
When comparing heterogeneous spring barley materials to homogeneous varieties, we found significant advantages for yield in organic and conventional stress environments, yield stability across contrasting environments, nitrogen utilization efficiency, protein content, 1000-grain weight, and net blotch (*Pyrenophora teres*) severity as well as some positive trends for nitrogen use efficiency (NUE), and competitiveness against weeds. We found significant differences between CCPs and mixtures of their parents, indicating advantages for CCPs in protein content and 1000-grain weight. In addition, there was a non-significant yield gain mainly in low-yield and stress environments, higher yield stability in most cases, and some other minor positive trends (Legzdina et al., 2022). For spring wheat, grain yield and most other investigated traits of populations were comparable to local varieties. Some significant advantages for grain quality characteristics and trends for better weed competitiveness and NUE over homogeneous varieties were found.
No clear difference in genetic diversity parameters between sub-populations cultivated under either organic or conventional conditions for seven generations were identified. The proportion of powdery mildew (*Blumeria graminis*) resistant plants was in most cases higher in conventionally cultivated sub-populations than in organic ones and decreased over time. Diversity index (H') for morphological traits was comparatively higher for organic sub-populations in most cases. Organic sub-populations were less infected with net blotch than conventional ones indicating positive effect of natural selection in organic conditions, where the disease pressure was on average significantly higher. To compare F_4/F_5 and F_9 generation sub-populations of three CCPs, the observed heterozygosity was decreased; slight improvement of grain yield in organic sites, and positive trends for powdery mildew and grain volume weight were found. H' for plant height was slightly reduced in two out of three CCPs.
First results on breeding methods indicated successful mass selection by molecular marker for loose smut (*Ustilago nuda*) resistance within CCPs, negative effects of male-sterile parents on yield, positive effects of CCP crossing to advanced lines. Line selection within CCPs, when mixture of 10 best performing lines was compared to initial populations, provided yield advantage only in case of male-sterile cross derived CCP.
We suggest heterogeneous populations as valuable alternative to traditional uniform varieties for organic as well as poor and stress cultivation environments.

Reference

Legzdiņa, L.; Bleidere, M.; Piliksere, D.; Ločmele, I. Agronomic Performance of Heterogeneous Spring Barley Populations Compared with Mixtures of Their Parents and Homogeneous Varieties. Sustainability 2022, 14, 9697. https://doi.org/10.3390/su14159697