Genetically diverse populations of self-pollinating cereals for organic farming: agronomic performance, effect of environment, and improvement techniques

Latvian Council of Science project (2018-2021)

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Background

CCPs (composite cross populations) include diallel crosses between usually 5-10 parental genotypes with desirable traits and maintain genetic diversity ensuring adaptability to changing environmental conditions (Raggi et al., 2015). Only little research on CCPs has been done; it was started in 1920-ties with barley (Harlan and Martini, 1929), but due to dominating high-input agriculture was not introduced in production. The first step in it is the currently going on Temporary Experiment on marketing of populations (EC Implementing Decision of 18 March 2014).

In this century three winter wheat populations created in UK (Haigh et al., 2007) are being widely investigated. Our first results on spring barley CCPs initiated in 2013 show that it is possible to obtain populations with equal agronomic performance to commercial varieties (Ločmele et al., 2017; Fig.1.). Soliman and Allard (1991) suggested CCP approach as an effective breeding method in case if disease resistance and yield stability are the main breeding goals; the yield of CCPs was found to be more stable than that of uniform commercial varieties (Döring et al., 2015; Raggi et al., 2017). Population yield level is not always satisfactory in comparison to commercial varieties, however, it was found to be better in the presence of abiotic stress factors (Danquah and Barrett, 2002). Growing of CCP in different environments in the same time can lead to distinctive locally adapted populations (Döring et al., 2011).

Aim and objectives

The research aim is to investigate agronomic performance, effective improvement techniques and changes due to environmental effects in genetically diverse populations, which are a potentially significant alternative to traditional varieties for self-pollinating cereals in environmentally friendly agriculture.

Hypothesis: it is possible to create barley and wheat CCPs that are able to adapt to specific growing environments and with yield comparable to traditional varieties and surpass them according to specific traits important in sustainable agriculture; breeding techniques for CCPs can be improved.

Research objectives:

WP 1. To evaluate agronomic traits of CCPs and compare to commercial varieties and identify superior CCPs according to specific traits

WP 2. To determine trends for genetic, morphological and agronomic changes in CCPs as a result of environmental effect and identify traits affected by natural selection

WP 3. To apply improved breeding techniques in CCP creation and test their efficiency

WP 4. To disseminate obtained results by promoting establishment of registration and marketing system and introduction in production of CCPs and by organizing international scientific conference.

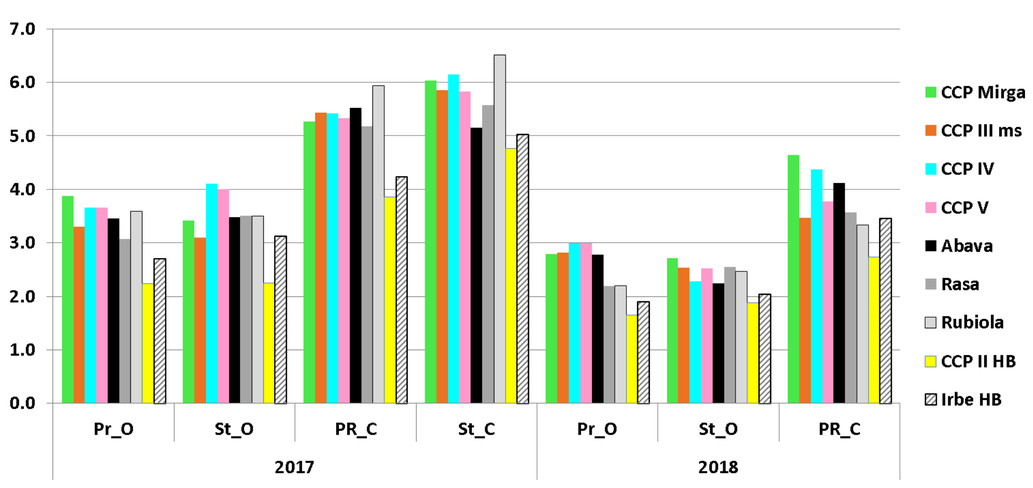

Fig.1. Grain yield (t/ha) of five spring barley CCPs in two locations (Pr, St) under organic (O) and conventional (C) crop management, 2017-2018 (F5-F6), compared to four check varieties (HB – hulless barley, ms-male sterile crosses)

Phenotypic variability in spring barley CCP 'MIRGA' applied for Temporary Experiment on marketing of populations

Research approach

Field experiments will be performed in two meteorologically different locations in Latvia: Priekuļi (NE part) and Stende (NW part), in organic and conventional crop management systems in Priekuļi and two different organic sites in Stende (including organic farm).

1. Agronomic performance of 9 local and 2 Danish covered and hulless spring barley CCPs (previous data of 5 CCPs in Fig.1.) will be assessed and compared to mixtures of parental genotypes and commercial varieties for 3 field seasons. Similarly several spring wheat CCPs from Denmark and Germany will be tested and at least 2 CCPs created in the project added for 3rd field season. The main evaluated traits will be related to yield and its stability, competitive ability against weeds, nutrient use efficiency and disease severity.

2. Sub-populations of 3 barley CCPs cultivated in parallel under organic and conventional; management systems for 7 years will be compared for agronomic performance and morphological traits in 4 environments in the 3rd season. Early generation (F4) stored at gene bank will be included in the comparison. In the same sub-populations genetic diversity will be assessed with neutral molecular markers (SSR, preliminary results in Fig.2.) and frequency of some major disease resistance genes (*mlo11, Mla18, Un8*) screened using CAPS and SCAR markers and change dynamics during cultivation analyzed. In addition parental genotype mixtures will be used as model populations in order to assess genotype proportion changes by SSR molecular markers as a result of several year cultivation and relate those changes to particular traits.

3. Techniques potentially useful in population breeding will be developed/tested:

(a) improved molecular marker linked to *Un8* barley loose smut resistance gene adapted/elaborated and tested;

(b) application of negative mass selection to improve resistance/tolerance to seed borne diseases, leaf diseases and Fusarium head blight;

(c) usefulness of male sterility application;

(d) building of mixtures from lines selected from CCPs;

(e) hybridization of CCPs to selected perspective genotypes for improvement of particular traits;

(f) choice of parental genotypes and setup of CCP breeding for spring and winter wheat.

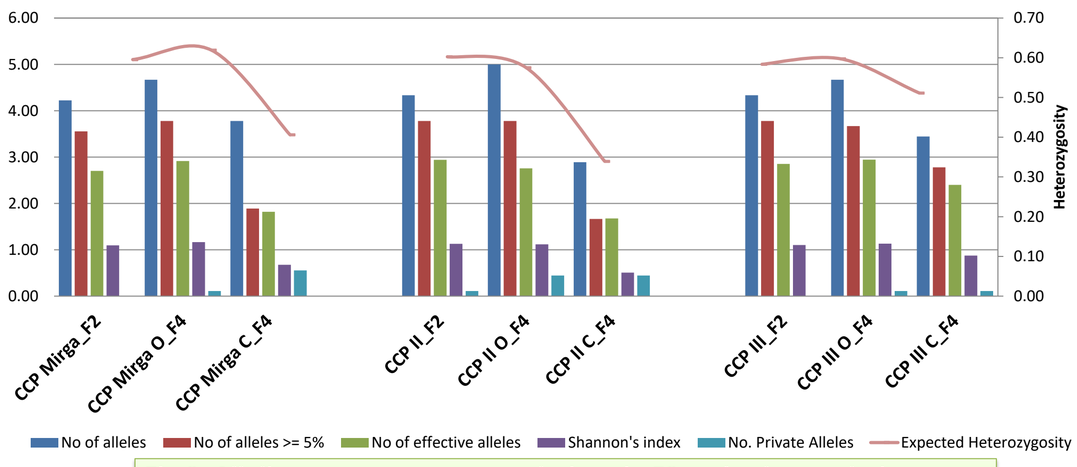

Fig.2. Allelic patterns across populations in F2 and sub-populations cultivated under organic (O) and conventional (C) environments in F4

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