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Composite cross populations: legal considerations and their value for plant breeding

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Abstract

Until recently, it has not been possible to market heterogeneous plant material in the European Union since cultivars have to be distinct, uniform and stable (DUS test) as a prerequisite for official variety registration. The legal basis for the introduction of heterogeneous plant material in the EU has been established in 2014 with decision no. 150 of the European Commission, which demands the organization of a temporary experiment. This experiment will expire at the end of 2018 and is restricted to four cereal species: wheat (*Triticum* spp.), barley (*Hordeum* spp.), oats (*Avena* spp.) and maize (*Zea mays* L.). Note that both composite cross populations (CCPs) of the predominantly self-pollinating species wheat (Figure 1), barley and oats as well as random mating maize populations are referred to as 'populations' in the experiment. According to the regulation a population is defined as a plant grouping which (a) results from heterogeneous source material, (b) can be reproduced unchanged once it has adapted to the specific agro-climatic conditions of a given region of production, and (c) emerges from pairwise crosses of at least five genotypes in all possible combinations or a different crossing protocol, which produces a similarly diverse population. The crossings of the genotypes are followed by bulking of the progeny and exposing the stock to natural selection and supervised selection by breeders in successive generations.

Clause (b) of the new regulation requires a careful interpretation since heterogeneous populations will certainly always change in their composition and characteristics even after they have adapted to a given region of production. What clause (b) really means is that it should be possible to specify certain defining characteristics of a population, which do not change after the stock has adapted to the location. With respect to clause (c) of the regulation, let us note that an example of an alternative crossing protocol to the (full) diallel cross would be, for instance, the so-called MAGIC crossing scheme. The MAGIC scheme has been recently used by the Julius Kühn-Institut (JKI) to produce a barley CCP. Finally, it is important to emphasize that a CCP is something qualitatively different from a mixture of varieties or genotypes. In the case of a variety mixture the seeds are physically mixed, while in a CCP the genotypes are combined using crosses. A beautiful experiment, which illustrates qualitative differences between CCPs and variety mixtures has been published by Allard & Adams (1969). Today, there is a large body of scientific research showing that composite cross as well as random mating populations offer tremendous potential for the improvement of biodiversity in agriculture, which is associated with numerous agronomic and ecological advantages. These advantages include higher yield stability, increased and more durable disease and pest resistances and an ability to adapt to different cultivation sites. Due to their resilience to adverse environmental impacts and changing environmental conditions, populations have been proposed as a strategy for climate change adaptation. Allard & Hansche (1969) have proposed to utilize CCPs as dynamic mass reservoirs for the conservation of genetic diversity. This type of *in situ* conservation offers many advantages including high cost efficiency as well as the ability to adapt the material to changing biotic and abiotic environmental conditions and new locations. From these mass reservoirs breeders may extract individual plants to develop exceptional pure line cultivars. Thus, we expect population breeding programs to supplement pure line and hybrid breeding programs rather than replace them.

Until today, a number of European countries, including Denmark, France, the Netherlands, the United Kingdom and Germany, have implemented the new European legislation at a national level. In Germany, the first populations were approved by the German Federal Plant Variety Office in 2016. The leading German and Swiss organic breeding initiatives, Forschung & Züchtung Dottenfelderhof (FZD) and Getreidezüchtung Peter Kunz (GZPK), have developed 7 winter wheat and 8 summer wheat CCPs. Moreover, the Bavarian State Institute for Agriculture (LfL) and the breeding initiatives FZD and GZPK have released 5 maize populations. In preliminary field trials, these populations have demonstrated their value for agriculture and plant breeding. It is essential that both CCPs as well as maize populations are tested more extensively in field trials and practical agriculture. Constraints to consumer and farmer acceptance of CCPs throughout the value chain are studied in a project of the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-Agri) in the federal state of Hessen. A second important goal of the project is to collect information in order to evaluate the value of the new European regulations for farmers, the whole value chain and end-consumers. It is essential that more funding for projects with a focus on heterogeneous populations is made available. In fact, it seems likely that when the population experiment will expire at the end of 2018, there will not be enough information available for a robust assessment of the legislation. Thus, the leading breeding initiatives and universities involved in the development of populations demand

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Figure 1: Genetic diversity in a winter wheat Composite Cross Population (CCP), Dottenfelderhof, Bad Vilbel, Germany.

that the regulations on heterogeneous plant material should be extended beyond 2018. However, due to legal restrictions, the experiment can be maximally prolonged until 2022. Therefore, the breeding initiatives demand that the scope of the regulations will be extended to more species than the four cereal crops mentioned above and incorporated in national and European seed legislation.

Keywords

Biodiversity · breeding method · climate change · maize · wheat

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