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Participatory Plant Breeding Concept as Tool for Creating Adapted Varieties for Local Conditions

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Abstract

Organic farming has been developing worldwide over the last few decades. However, the crucial problem has not been resolved yet – a lack of suitable varieties. It is a serious factor limiting this development. Breeding is a very demanding and expensive process; special varieties are not bred for the organic farming from many crops. A concept called "participatory plant breeding" (PPB) is a possibility for resolving this problem. It is based on a direct involvement and participation of a farmer in the breeding process. Undemanding and cheap breeding methods are chosen there – they do not require any special education or equipment from the farmers involved. Training and professional surveillance are sufficient. One of PPB methods has been used and tested in our climatic conditions – a selection. As far as various wheat species originating from the genetic resources are concerned, the most important production parameters of original seeds and seeds coming from plants selected repeatedly have been studied and evaluated. Production parameters are positive (number of spikes, yield). Some other characteristics (the genetically-conditioned ones) are neutral or of a minimum effect. Considering results of our research, PPB method is highly recommended for improving economic characteristics of less bred or completely inbred crops.

Introduction

A lot of methods have been employed for creating brand new varieties in the agriculture recently. Organic breeders usually use a method of crossbreeding. Not only the method of breeding itself but also a principle of breeding is important. A breeding method called "participatory plant breeding" (PPB) has been introduced in several European countries. It was invented in the early 1980's. It used to make part of a movement supporting a participatory research concept. It was invented in reaction to criticism about a failure of research carried out at trial stations that had aimed at helping poor farmers in developing countries (Ceccarelli *et al.,* 2007).

PPB as a method is based on the idea of farmers and professional breeders having special knowledge and skills they can share with each other. It is defined as a lot of approaches. All of them include a participation of various participants (researchers, breeders and farmers) in the breeding process (GIZ, 2017).

Modern varieties provide higher yield rate in better production areas. However, most of them are not suitable for small farmers or marginal (less favourable) areas, including organic farming. Therefore, PPB may supplement conventional crop breeding, it cannot play the role of alternative breeding system. About eighty PPB programmes exist worldwide nowadays. They include various institutions and crops. Participatory breeding method is mostly followed in tropical countries. It is aimed at acquiring adapted varieties to certain regions. They would be affordable for local farmers and help them be independent on seed supplied from abroad.

There is a different situation in Europe. There is binding legislation on organic farming that requires certified seeds to be used by organic farming system. There is, nevertheless, a shortage of them. A small European market not guaranteeing at least minimum profit to breeding companies is one reason for this organic seed shortage. They do not get their breeding investments back then. Therefore, organic farmers and their associations begin to meet researchers and launch PPB projects. In Germany, for instance, PPB method has been followed in order to grow a specific *Vicia faba* L. variety (Ghaouti *et al.,* 2008). In the Netherlands, a brand new onion variety has been bred with this method (Osman *et al.,* 2008). In Portugal, PPB method has been used for corn breeding since 1984 – the breeding process aims at acquiring traditional technological parameters good or suitable for bread production there (Vatto *et al.,* 2008). In France, cabbage and cauliflower have been bred (Chable *et al,* 2008), and durum wheat as well. They contain enough proteins and are suitable for typical local pasta. Producers of pasta, organic farmers and researchers from the INRA were involved in the selection of suitable materials (Declaux, 2005). In the south-west France, PPB programme has aimed at selecting good-quality varieties of corn and sunflower, resistant against drought (Chable *et al.,* 2014). About thirty species of field crops and vegetables have already been bred with PPB. Since 2009, PPB has been aimed at forage crops and technical crops as well.

Our research and this paper work aim at evaluating PPB method, its effect on inbred land races of various *Triticum L.* (wheat) species. Particular genotypes of spring einkorn, emmer wheat and spelt wheat have been selected and their effect has been evaluated.

Material and Methods

Tested and evaluated genotypes come from the gene bank by the Crop Research Institute in Prague-Ruzyne – six varieties of *Triticum monococcum* L., five varieties of *Triticium dicoccum* Schrank (Schuebl) and seven varieties of *Triticum spelta* L. Two varieties of *Triticum aestivum* L. were used as control varieties in this experiment.

Field trials including the above-mentioned genotypes were carried out at a trial station by the Czech University of Agriculture, Prague-Uhrineves. A method of random blocks was used and repeated twice or three times there. A trial plot – 12 square metres, a seeding rate – 400 germinable caryopses per square metre. Pea was used as a forgoing crop. Impact of selection was studied and evaluated since the project was launched (in 2013). Let us introduce you a list of results we have selected from 2016 yield. They show us how the evaluated parameters of selected materials were changing from 2013 to 2016, and allow us to compare them to the original unselected materials.

The original unselected material and the selected one (the selection) of every single genotype was seeded repeatedly. Since 2013, a negative and a positive selection was made repeatedly (plants of a different habitus, plants affected with diseases, damaged and weak ones were removed during the growing period). The longest and strongest spikes of every single genotype were chosen from a

"selected" trial plot and they were seeded next year in the spring (these spare trial plots were not used for the evaluation of yield parameters).

Results and discussion

All the crop stands grown from the selected material (the "selection") have produced higher yield that the crop stands grown from the original unselected material. All the tested and evaluated wheat species have achieved such a result. The selection has had a positive impact on the yield (see Figure 1), on the number of spikes per square metre before harvest (see Figure 2) and on the field emergence (see Figure 3). On the other hand, it has had a negligible impact on the morphological features (length and width of a flag leaf), on the occurrence of diseases and on the quality indicators as well.

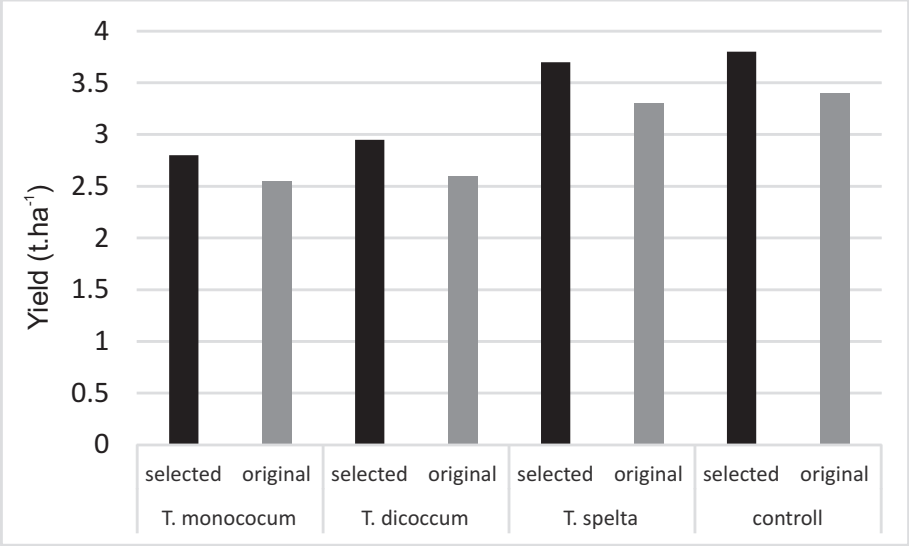

Figure 1. **Impact of selection on yield**

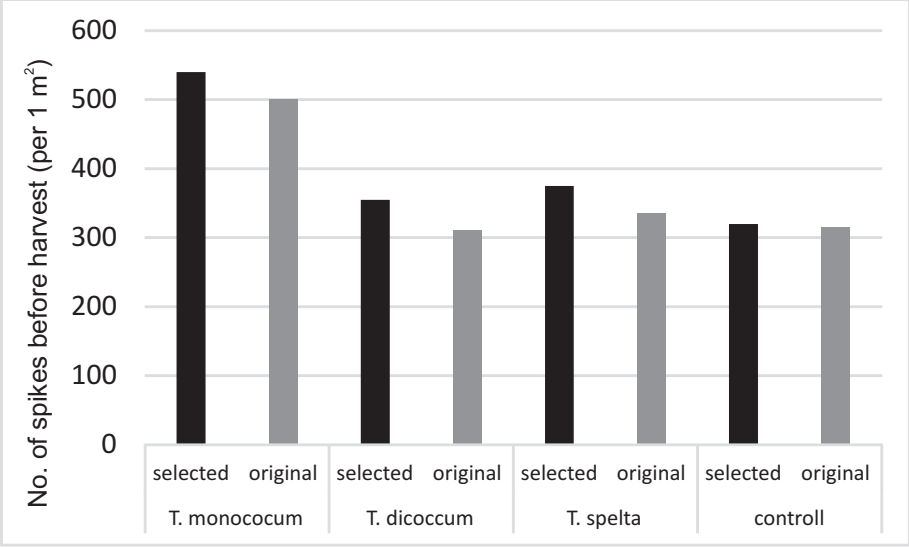

Figure 2. **Impact of selection on number of spikes before harvest**

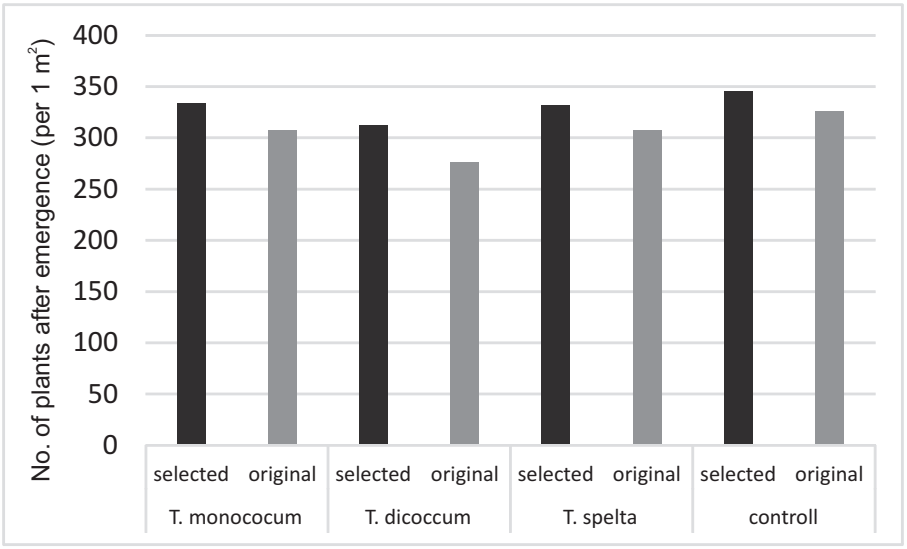

Figure 3. **Impact of selection on field emergence**

Results of our research have shown that the selection may be used for enhancement of various breeding materials (selected genetic resources on einkorn, emmer wheat and spring form of spelt wheat) that have not been crossbred. It has a positive impact on production parameters in particular. The less bred material we use, the stronger impact the selection has (Konvalina *et al.,* 2014). Results of our research have also shown this simple method to be suitable for participatory breeding carried out by farmers. On the other hand, the selection does not usually have any impact on morphological or biological features (e.g. resistance against diseases). They are usually genetically conditioned (Stehno *et al.,* 2010). It is, therefore, important for us to pay attention to the selection of input material (genetic resources) we work with. It is also similar to wheat quality indicators. As far as protein content is concerned (see Figure 4), the selection has a negative impact on it. It is caused by a strong negative correlation between protein content and grain yield (Konvalina *et al.,* 2014 Sedimentation index – Zeleny test (see Figure 5) and falling number are tightly linked to a genotype and the selection does not usually have strong impact on them (Surma *et al.,* 2014).

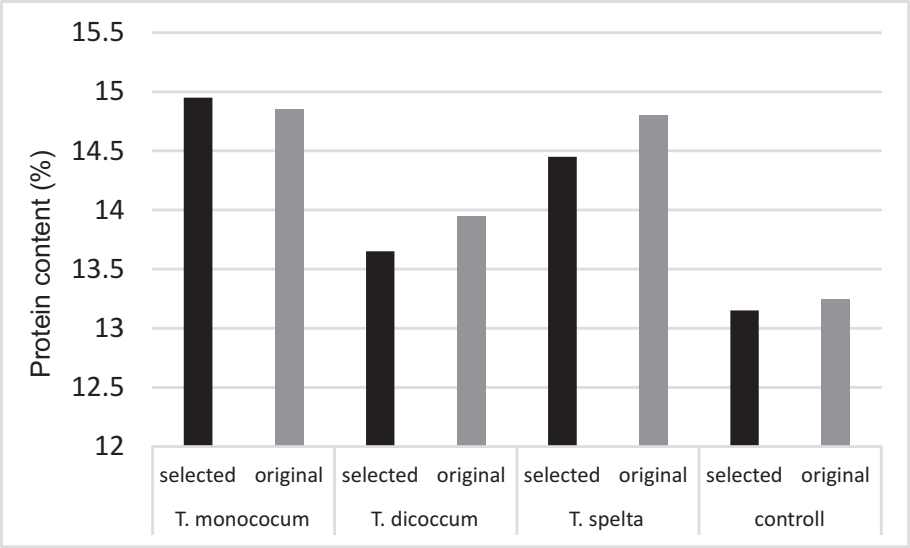

Figure 4. **Vliv selekce na obsah bílkovin v zrnu**

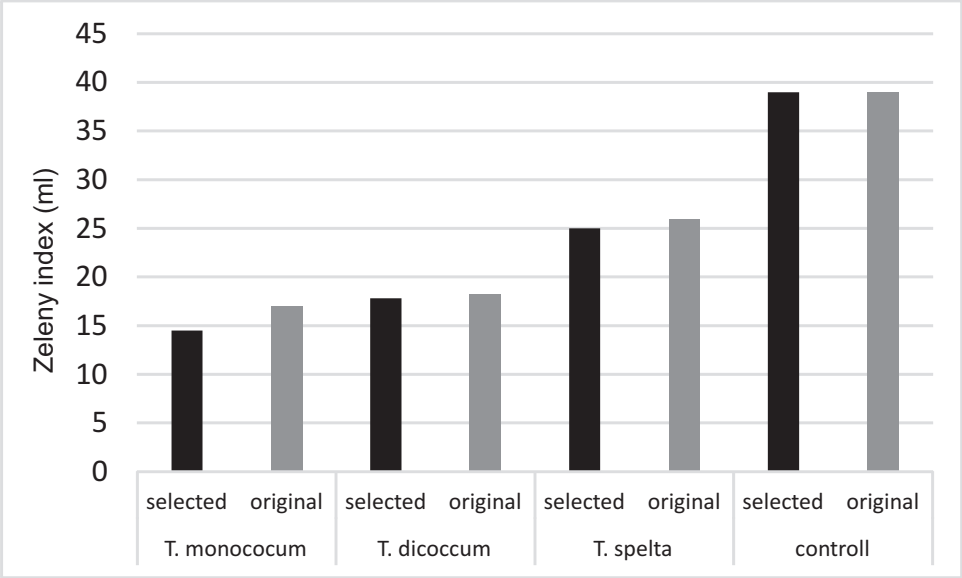

Figure 5. **Vliv selekce na Zeleny index**

Conclusion

Results of our research have shown selection as the simplest and most effective breeding method. It is a method a well-trained farmer can employ. Such a farmer has a big advantage as he knows local conditions well. He can focus the selection on his own needs. As far as financial aspect is concerned, selection is a very cheap method.

PPB may contribute to stronger role of farmers in several ways:

a) it gives farmers with an opportunity to participate in plant breeding process, and influence the development of growing and processing technologies; it takes their specific needs, agro-ecological conditions and cultural preferences into consideration,
b) it gives farmers an opportunity to make a decision, where and how funds and finance will be used for development and external farming services,
c) it allows participating farmers to apply their traditional knowledge and experience,
d) it provides farmers with new contacts, it introduces professional breeders and development workers to them,
e) farmers participate in breeding activities, variety registration process, seed conservation, reproduction and distribution as well.

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