Empowering farmers' participation: collaborative breeding for climate-resilient durum wheat through BOLD

Summary

Participatory variety selection (PVS) directly engages farmers by providing guidance to plant breeders. It helps ensure breeding decisions and candidate varieties are in line with end-user needs. While PVS is common practice in most breeding programs to assess elites ready for commercialization, it is deemed too costly to evaluate less ready material such as pre-breeding lines. The *Biodiversity for Opportunities, Livelihoods and Development* (BOLD) Project provided the durum wheat program of the International Center for Agriculture in the Dry Areas (ICARDA) with the support needed to conduct PVS for crop wild relative (CWR)-derived lines. Filippo Bassi, principal scientist and BOLD durum wheat project lead at ICARDA, says that with BOLD's support, the CWR-derived lines gained the chance to be directly evaluated by Moroccan farmers under a wide range of local environmental conditions. Farmers identified positive characteristics beyond what breeders could see, such as distinct flavor profiles when baked and a preference for certain spike colors or shapes. This resulted in the commercial release of the Moroccan varieties Nachit, Jabal and Jawahir. By the end of BOLD Phase 1, farmers were actively engaged in shaping and promoting success of the durum wheat varieties within Morocco and beyond.

The Challenges

Developing climate-resilient crop varieties derived from their crop wild relatives (CWR) is a long-term breeding process that is both costly and challenging. Durum wheat breeder Filippo Bassi and his team at ICARDA explained it with an analogy.

"Imagine you have two vehicles in your garage: an old monster truck and a high-performance race car. The monster truck can handle rough terrain with ease, while the race car is fast and efficient, but only on smooth roads. If you wanted the race car to perform better off-road, you could take it apart and try to merge some of the monster truck's parts into it. But that's a risky process.

If you run out of time or money, you could be left with two half-dismantled vehicles and no usable car at all. That is why most people prefer to make small adjustments to the race car and avoid the monster truck all together."

Despite its lengthy process and associated costs, farmers as the end users of CWR-derived material, are seldom engaged in their development. Previous studies have shown a clear mismatch in several countries between the traits breeders prioritize and the traits farmers value (Alary *et al.* 2020), resulting at times in released cultivars that are not adopted by farmers. Partnering with farmers to assess in their fields the future possible varieties (i.e. participatory variety selection, PVS) is a sure strategy to avoid this risk.

PVS is not a new concept, but it is difficult to integrate into the long-term breeding process involving CWR because it is expensive, time-consuming, and often limited by the lack of suitable candidate material to share with farmers. Continuing with his analogy Filippo explained: "Imagine now that you are a dealer that wishes to sell cars to users (i.e. farmers). Would you show them your best race cars (modern cultivars) or your half-working experiments of mixing race cars with monster trucks (CWR-derived lines)? Now add the fact that each time you show your cars there are costs associated with it. That explains why breeders seldom conduct PVS for pre-breeding material."

To address this gap, the International Center for Agricultural Research in the Dry Areas (ICARDA) in collaboration with the Adapting Agriculture to Climate Change: Collecting, Protecting and Preparing Crop Wild Relatives (CWR) project and its continuation, the Biodiversity for Opportunities, Livelihoods and Development (BOLD) project, involved Moroccan farmers directly in the development of climate resilient durum wheat varieties derived from its wild relatives (Kilian *et al.* 2020; El Haddad *et al*. 2021a; El Haddad *et al*. 2021b). Without these resources, the CWR upgrade is almost impossible, and engaging farmers in evaluating them even less likely. This mirrors the durum wheat breeding team's situation after the CWR project ended: they had valuable genetic "parts" from CWR but lacked funding, personnel, and farmer "test drivers" to continue evaluating and improving the lines. Filippo and his colleagues were deeply committed to the work, but without funding support and collaboration opportunities, they could only continue it as a side project.

The solutions

The BOLD Project, building on earlier efforts from the CWR Project, recognized the value of this work and provided the funding needed to give the CWR-derived durum wheat lines a chance. This support allowed the lines to gain priority within ICARDA's breeding program by enabling vast multi-locations trials, large-scale seed multiplications, and early engagement with farmers through PVS.

The BOLD Project

BOLD (Biodiversity for Opportunities, Livelihoods and Development) is a 10-year initiative to strengthen global food and nutrition security through the conservation and use of crop diversity. Funded by the Government of Norway since 2021, BOLD supports national genebanks in Africa, Asia and Latin America to better conserve, manage and share their collections with farmers, breeders and others for resilient, productive food systems.

How can the audience make use of the achievements in your institutions?

Filippo Bassi: We have already provided CWR-derived varieties to over 30 countries. If you are interested, please direct requests through us (icarda-contact@cgiar.org). The process may be complicated if you are not already affiliated with a seed company or research institute. However, get in touch with the nearest one and then send a request to us directly.

Having large quantities of seeds is essential to engage farmers, since these need to be planted in their fields in plots large enough to allow proper farmers evaluation. BOLD funding directly covered costs for field usage, trial monitoring, harvesting, analysis and seed preparation for distribution.

Once enough seed was produced, five focal farms representing a diverse range of environments, from cold highlands to water-limited desert farms, were selected each season to evaluate the candidate pre-varieties. Each growing season, Filippo and his team visited all sites to provide technical support and conduct PVS evaluations.

The preferred method has been named "selection by stone" (Box 1), an informal peer-to-peer reflection engaging the host farmers and their neighbors. Each farmer places a stone to select their preferred candidate, and then a discussion ensues where each farmers tries to convince the others on why their choice is better. This approach allows breeders to grasp the reasons of the preference as these are discussed among peers. This evaluation approach helps to build trust, strengthen community involvement and increase farmers personal connection to the pre-varieties, raising the likelihood to adopt them when released.

This evaluation is repeated annually to assess pre-variety performance consistency over time. After cycles of farmer and breeder assessment, Nachit, Jawahir, and Jabal were repeatedly selected for different zones, due to their drought tolerance, adaptation, grains visual quality, and even their distinctive flavor when used to make home bread or couscous.

This approach allowed farmers and breeders to work collaboratively towards adapted, high-yielding and farmer preferred new cultivars that meet their practical needs, just like involving drivers in designing a car to ensure better driving experience. This collaborative process successfully led to the release of several more varieties that have since been made known to the world through the BOLD project and are now available for direct use by farmers (Box 2). As a successful pilot, the ICARDA-Crop Trust partnership under BOLD serves as a model for the continued development and release of additional genebank-derived varieties adapted to diverse climate uncertainties.

Box 1: Selection by stone

In the "selection by stone" evaluation process, the breeder hands two stones to the host farmers. The neighbor famers receive only one stone. Each farmer is asked to place their stone next to the candidate variety they prefer. Afterwards, the breeder asks the farmers to convince each other why their choice is the best one. The peer-to-peer discussion is often the most valuable part of the PVS process, with the breeders becoming witnesses of the needs and preferences expressed in complete freedom by farmers. For more details see *Selection by Stone*.

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Additional details can be found at https://bold.croptrust.org/

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