Evolutionary populations: Living gene banks in farmers' fields in Iran

Efforts to rapidly increase on-farm biodiversity are a matter of urgency in an era of climate change. To do so, farmers need better access to the genetic material of research stations and gene banks. Collaboration with scientists who are willing and able to work together with farmers is crucial. The Evolutionary Plant Breeding programme in Iran is one example of how this can be done.

Maryam Rahmanian, Maede Salimi, Khadija Razavi, Reza Haghparast, Salvatore Ceccarelli and Ali Razmkhah

Photo: Maede Salimi

Access to genetic resources and genuine collaboration between farmers and scientists is lacking in most parts of the world. A model in Iran that has given a large number of farmers access to a great amount of biodiversity in a relatively short time is evolutionary plant breeding (EPB). A dynamic and inexpensive strategy, EPB rapidly enhances the adaptation of farmers' crops to climate change. It was developed by the Centre for Sustainable Development (CENESTA) in Iran. It builds on experience with participatory variety selection, in which farmers plant a number of different varieties of the same crop and, after several years of selection, choose a small number of varieties for multiplication and use.

In EPB, farmers begin by planting a large mixture of hundreds or thousands of different varieties, and do not necessarily aim to arrive at the selection of a few varieties. EPB instead relies on mixing as many different types of a particular crop as possible, leaving them to cross freely between each other. Genetically, the seed which is harvested is never exactly the same as the seed which was planted. Several farmers in different regions plant and harvest a small sample of seed (4-5 kg) in the same 250 m^2 plot for successive years. These plant populations then evolve under different types of agronomic management and in the face of specific combinations of stress from diseases, insects, weeds, drought, extreme temperatures and salinity. In this way, the frequency of genotypes that have adapted to local conditions gradually increases.

The idea of EPB is not new, although it wasn't until 2008 that EPB was implemented as a formal project. As early as 1929, methods were developed for generating heterogeneous populations of barley where locally adapted varieties were needed. In 1956, this was labelled as the 'evolutionary plant breeding method'. Yet there was already a strong demand for uniformity in the most important food and feed crops. This was driven by the growing use of chemical inputs, which require uniformity to give a consistent response. In addition, emerging seed companies attempted to protect their breeding programmes and associated products by promoting this uniformity.

Farmers at the centre

Before CENESTA launched participatory breeding projects, all the breeding programmes in Iran had excluded farmers from the most important stages of the breeding process, and farmers often did not adopt the products of these programmes. EPB follows a completely different approach, with farmers at the centre of producing new varieties and applying the principles of natural selection themselves.

In 2008, with support from Dr Salvatore Ceccarelli, CENESTA started with EPB by providing five farmers in provinces of Kermanshah and Semnan with mixtures of 1600 different types of barley that was supplied by the International Centre for Agricultural Research in the Dry Areas (ICARDA). This mixture included a wide range of germplasm: the wild progenitor

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Hordeum spontaneum, landraces from several countries, and modern breeding material. Within this 'evolutionary' mixture different plants crossed naturally to produce new types. Each year, the types produced more seed and gradually the population became better adapted to the specific and changing circumstances of farmers.

The success of EPB spread far beyond these first five farmers of the first years. They were so satisfied with the population's performance that they shared their mixtures of barley with other farmers in several provinces, via both CENESTA's PPB programme and also informally with neighbours, friends and relatives. As of early 2016, the seeds cover several hundred hectares and are planted in 19 provinces by about 300 farmers.

EPB is increasingly used in other crops. Based on the success of the barley population, the Dryland Agricultural Research Institute (DARSI) established a similar programme for bread wheat. In 2013, we started to turn our attention towards rice. By combining Iranian landraces currently in use in Iran, with 202 repatriated Iranian landraces provided by the International Rice Research Institute, we created a new mixture to start EPB in rice. Evolutionary populations for a variety of crops are now also grown in several other countries.

Living gene banks

Gene banks perform an important role in the conservation of species, but they 'freeze' not only seeds but also their evolution at the time of collection. Local varieties and wild relatives must also be conserved *in situ*. By combining participation and evolution in breeding programmes, farmers can guide the evolution of their crop mixtures in the most desirable way for them. In the words of Abdol-Reza Biglari, a farmer in Garmsar:

Different varieties of wheat. Photo: Maede Salimi

With EPB, farmers become the owners of their future. Photo: Maede Salimi

"Thirty years ago we used to have many different varieties. Most of the new varieties introduced to us were not suitable for more than one or two years. This shows that we have to return to biodiversity."

The evolutionary populations can be considered as a living gene bank. Farmers (by themselves or in collaboration with scientists) select the most desirable plants and use them in participatory breeding programmes. For farmers who prefer to sow mixtures rather than single varieties, the evolutionary populations serve as a source of genetic resources for creating new mixtures. The importance of having secure access to such a collection of seeds became apparent in Jordan, for instance, where farmers and scientists are turning to evolutionary populations now that the civil war in Syria disrupted their regular source of breeding materials. With EPB, farmers become the owners of their future; with the best varieties evolving in their fields, there is little or no need to buy seeds.

Access to better seeds

Nemat Salemian, a farmer in Anjirak, recalls his first encounter with EPB.

"We received this wheat from another farmer who told us that it's a mixture of hundreds of different varieties and that we should plant it in our worst soil. My father said that in the 80 years that he has been a farmer, he has never seen better plants, despite the very bad soil and the climatic conditions this year."

The EPB mixtures have been shown to produce higher yields and perform better in adverse conditions than their local or improved counterparts. Despite late sowing, in the first year of CENESTA's programme, the evolutionary populations of barley outyielded the local barley and performed almost as well as the improved barley cultivar. In the following year, the evolutionary populations of wheat yielded more than twice as much as the local varieties.

The EPB populations are also more resistant to weeds, diseases and pests. In 2011-2012, a farmer in the district of Garmsar witnessed that his evolutionary population of wheat had higher yields than the local improved variety and the evolutionary population did not need to be treated with pesticides and herbicides. This suggests that evolutionary populations could be very useful in agroecology and organic agriculture and are cheaper to grow.

Farmers have faced some challenges with EPB, but they have also found creative solutions which provide important lessons. For example, very small plots of land may not be enough to grow their own evolutionary population. To resolve this, a community of smallholder farmers can rotate the evolutionary population among them. Another challenge would be severe climatic events in which only a small fraction of the population may survive - leaving too little diversity in the mixture to continue to adapt. In this event it may be necessary to supplement the mixture with new types. Nevertheless, in such circumstances the farmers growing the evolutionary population will still have more chance of harvesting some of their crops, while fields with only one variety may be entirely destroyed.

Unexpected results

After receiving a small amount of seed in the first year of the EPB trials, we expected farmers to continue to sow just enough to allow the population to evolve and to act as a source of locally adapted varieties. One of the most unexpected outcomes of the evolutionary population trials was that some farmers decided to sow all the seed they had harvested, multiplying and cultivating the seed as their main crop.

> *"About 20 farmers have asked me for this seed after they saw it in my field last year,"* farmer Faraj Safari recalls. *"This year I am only going to grow this mixture. I'm going to plant about 40 hectares with this mixture. I can give seed to about 10 or 15 other farmers this year, and more next year."*

Similarly, the cultivation of evolutionary population of barley started in 2010 in the nomadic tribal territory of Bakhtiari and had positive results. In the first year, 55 kg of seed was produced on each hectare, reaching 6 tons per hectare in 2015. Five other tribes in different areas joined in, also using EPB. Among the reasons for the success in Bakhtiari they mentioned the adaptability of the evolutionary populations of barley to drought and the fact that they can feed their livestock highly nutritious EPB barley, which reduces cost for feed, contributes to better animal health, and provides better milk.

The consumer and the market

Many people wonder whether the final product from EPB mixtures is of a high enough quality for use and

By combining participation and evolution in breeding programmes, farmers can guide the evolution of their crop mixtures. Photo: Maede Salimi

Evolutionary populations serve as living gene banks where farmers can source individual varieties.
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sale. But there is no need to worry. A protein analysis of the Iranian barley varieties, which are mostly used as an animal feed in Iran, showed that the evolutionary population had more protein in them than the local improved variety. For wheat, farmers and bakers in the provinces of Seman and Kermanshah have made bread from the evolutionary populations and were very pleased with the results. Some are even marketing this bread in local artisanal bakeries. Farmers growing evolutionary populations in France and Italy confirmed that creating mixtures not only brings greater yield stability, but also produces greater aroma and quality when making bread.

Evolutionary plant breeding is reviving a traditional system of access and benefit sharing

In the case of rice, farmers first thought the mixture of rice varieties would not be good for cooking and eating, and as such were afraid they wouldn't be able to sell it. But after harvest, they tested the rice and found that the taste to be excellent. Farmers are currently negotiating agreements with several restaurants who are interested in buying their EPB products.

The suitability of evolutionary populations as a farmer's main crop depends on the use of the crop and the cultural preferences of farmers and consumers. Even when the crop does not lend itself to being consumed as a mixture (which is the case with many vegetable varieties), evolutionary populations can still serve as living gene banks for farmers to source individual varieties. The use of EPB with vegetables is currently underway in Italy with tomato, beans and courgettes.

Access and benefit sharing in evolutionary plant breeding

Iran has no formal ABS policy, but this does not mean that there is no access and benefit sharing. Since the varieties that constituted the first evolutionary populations were taken from ICARDA (barley), DARSI (wheat), and IRRI (rice), there was some sort of access to genetic resources for small scale farmers and local communities. However, in relation to benefit sharing, evolutionary plant breeding does not fit within the official ABS framework.

The main issue is the condition that seeds must be commercialised, and in doing sp needs to be registered and certified. The formal seed release system in Iran requires that new seed varieties pass a series of tests: the value for cultivation and use (VCU) test and the distinctiveness, uniformity and stability (DUS) test. But EPB populations are unlikely to comply with these variety release criteria, which are tailored to the characteristics of modern varieties, since farmer improved varieties cannot show 'clear improvement' under different growing conditions and can hardly meet the DUS criteria. In addition, Iran's seed regulations do not recognise collective intellectual property rights and there is no national ABS regulation.

Yet evolutionary plant breeding is reviving an informal and traditional system of access and benefit sharing. Many EPB farmers share their seeds with other local small scale farmers free of charge, while others sell their seed to other farmers. And CENESTA identifies seed producing farmer cooperatives around the country and works with them to distribute EPB populations in new areas.

Where next? The evolutionary populations of wheat and barley continue to be spread throughout Iran, both through farmer-to-farmer exchanges and through exchanges organised through DARSI, the Department of Agriculture of Fars Province, and CENESTA. Since 2013, there have been annual national workshops on EPB where farmers from several provinces shared their experiences. Regular local, regional and national workshops and field visits continue to be needed to strengthen farmers' knowledge about how to use these populations. The main challenge is to keep up with the fast spread of these seeds, to track the spread and the outcomes, and to support farmers' management practices.

Plant genetic resources for food and agriculture have been developed over millennia to satisfy the most fundamental of human needs. The free flow and exchange of these resources was once governed by individuals and communities. However, this has changed as intellectual property regimes have been applied to agriculture. In international and national law intellectual property laws often overshadow or even extinguish the natural rights of farmers and farming communities to the landraces and varieties they have developed. Commercial plant breeders have benefited from this, as they have been able to develop new seeds, often based on farmers' plant genetic resources, and then protect their investment through commercial patents or plant variety protection laws which prevent farmers from legally exchanging and saving seed for future use.

Therefore, at the same time, we must try to develop awareness of the potential impacts of different seed laws and policies on farmers' rights to save, exchange, develop and sustainably use their seeds.

In workshops, farmers from several provinces share their experiences with evolutionary plant breeding. Photo: Maede Salimi

Maryam Rahmanian (maryam@cenesta.org) and **Maede Salimi** (maede@cenesta.org) are Research Associates at CENESTA, www.cenesta.org. **Khadija Razavi** (khadija@cenesta.org) is CENESTA's Executive Director. **Dr Reza Haghparast** is an expert at the Rainfed Cereals Department at DARSI in Kermanshah, Iran (r.haghparast@areo.ir). **Dr Salvatore Ceccarelli** is a consultant at ICARDA (s.ceccarelli@cgiar.org). **Ali Razmkhah** (ali.razmkhah88@gmail.com) is Legal Advisor at Cenesta.

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Evolutionary Plant Breeding is now also used in rice production. Photo: Maede Salimi