Preparatory action on EU plant and animal genetic resources

Crop adaptation in on-farm management by natural and conscious selection: A case study with lentil

Overview

Compared to *ex situ* conservation, the on-farm conservation of old varieties is considered to lead to the continued evolution of crop biodiversity and adaptation, next to the use of genetic resources. In industrialised countries, only a small amount of studies have been performed on whether on-farm management results in local adaptation. This case study explores a long-term field experiment on lentils (*Lens culinaris* Medik.) in Germany.

1. Objectives

To assess the implications of these experiments for the on-farm management of plant genetic resources, an interview was held with the project leader, Dr Bernd Horneburg (Dep. of Crop sciences, Section of genetic resources and organic breeding, University of Göttingen).

2. Description of the case

Before the research started, discussions had already been held for some time in the organic sector about the extent of site-specific adaptation that may occur when varieties are grown from year to year from farm-saved seeds on different locations. Bernd Horneburg had already dedicated an MSc thesis to the subject five years earlier.

The study started with the multiplication of seeds from three landraces of the self-pollinating crop lentil species from the German genebank at IPK Gatersleben in Göttingen in 1996. In the field experiments, the three landraces were followed from 1997-2001, and then from 2006-2010, at three sites differing in pedoclimatic conditions: (1) the University field site near Göttingen (Reinshof, conventional cultivation); (2) Schönhagen, 20 km southeast of Göttingen (Demeter organic farm); and (3) Hof Tangsehl im Landkreis Lüneburg (Demeter organic farm). Treatments were natural selection and experimental selection for yield, following two schemes: mass selection and single plant progeny testing. The plants were characterised phenotypically (among others, for yield and seed weight). Changes in the traits

were observed over time, in one case leading to increased seed weight. Genetic drift may have been a factor in early years and, before the experiments, during *ex situ* conservation in the genebank; only one variety appeared to have significant variation. Nevertheless, outcrossing was observed up to 5%[1], which would increase genetic diversity. The effects of the conscious selection methods depended on variety and location, therefore no single method was generally better. Natural selection would likely be the most efficient method to follow in practice[2]. Presently, a PhD project is ongoing, in which also water use efficiency is studied and molecular markers are used to quantify genetic diversity.

Analysis

3. Funding and support

The work started with a small budget and some assistance with field work from the Plant Breeding group of Göttingen University. It was initially done as part of the PhD work of Bernd Horneburg. During this first phase of the project, the German Federal Ministry of Consumer Protection, Food and Agriculture supported a subproject “Enhanced species diversity in agriculture by means of lentil production and on-farm management”. From 2006 to 2010, support again came from the Plant Breeding group. The two Demeter farms contributed in kind, by performing the cultivation of the field trials at their respective sites. Presently, a PhD researcher is funded by the German Research Foundation DFG, plus part-time (50%) assistance.

Scientific support came from the head of the department, Prof. Heiko Becker. Dreschflegel e.V. (a cooperation of 14 organic seed producers jointly marketing seeds) and the organic seed group “Initiativkreis für Gemüsesaatgut aus biologisch-dynamischem Anbau” were involved in discussions about the work, as were the German Society for Plant Breeding and the genebank at IPK Gatersleben, from which the three landraces tested were obtained.

4. Positioning at local or regional level

A potential spin-off of the research could be the re-introduction of lentil cultivation in Central Europe. Lentil is originally a crop for poor marginal soils and more adapted to southern areas. It is difficult to grow and harvest at a larger scale, using combines. In central Europe, there is often a requirement for equipment for drying the harvest and also expensive equipment for separating the harvest from the support crop, mostly barley, and removing stones. Cultivation at a horticultural scale such as in the present research is simpler to perform. Some efforts have been put into providing growers with new seed materials, but these varieties are still not high-yielding, and it is not clear whether they are still cultivated by these growers. In the subproject during the first phase of the project, several varieties were multiplied by Dreschflegel. These varieties are still on offer for gardeners. Some interesting

[1] Horneburg 2006
[2] Horneburg & Becker 2008

lines stemming from outcrossing during the field trials have been taken up for further testing and breeding by the Kaiserling Institute in southern Germany, which has a more favourable climate for lentil cultivation.

5. Partnerships and networking, and communication

As a scientific research project, it has in the first place been communicated through papers in scientific journals and in the PhD thesis of Bernd Horneburg[3]. Furthermore, it has been presented in scientific forums, such as the Protein Crops Section of Eucarpia (the European Association for Research on Plant Breeding). In addition, presentations at the Rheinhof field site close to Göttingen and field trips are organised for students from the universities of Göttingen and Kassel/Witzenhausen (organic agriculture). For practitioners and growers, papers have been published for extension services (cf. the list of publications in Annex 2) and field days are regularly organised. In addition, there are mainly connections with researchers working on low-input or organic farming and genetic resources, such as Dreschflegel and the "Initiativkreis" mentioned above. There are also international contacts and meetings with IFOAM and seed platforms.

6. Outputs and added value

Legume crops such as lentil are valuable for improving crop rotations. Up till now, lentil remains restricted to gardens in the study area. Some farmers of the Alb-Leisa group (organic growers of lentils in Schwaben area), in particular the cleaning and marketing unit, have tested materials from the project. In addition, the Kaiserling Institute is testing interesting material, as mentioned above. A general book on lentil cultivation and its history was published[4], raising awareness of this interesting crop that is widely consumed but no very much grown in central Europe.

The scientific paper about the first phase of the project[5] received an award for best paper on genetic resources in the journal Crop Science in 2008. Yet, it had been difficult to get the paper published, as only one variety showed significant changes over time. It was hard to explain to a wider audience that even small changes from year to year regarding the cultivation from farm-saved seeds can imply important results.

As a rather unique research project worldwide, it received positive attention from genebanks, such as the one in Canada. This kind of project tends to receive more attention from countries where farm-saved seeds are more common than in western countries, apart from the biodynamic sector in the latter. As an intermediate between *ex situ* storage and active farmers, on-farm conservation might be an important driving force to further develop genetic diversity and the adaptation of varieties. The research led to insights useful for on-farm conservation in practice, namely the importance of being aware of population structure and of genetic diversity bottlenecks, and thus to keep back-up stocks, also for the case of failing

[3] Horneburg 2003a
[4] Horneburg 2003b
[5] Horneburg & Becker 2008

cultivations. The natural selection trials showed the impact of site-specific changes in varieties of a mostly autogamous crop. An implication for organic breeders would be to have nurseries on diverse soils when they wish the crop to develop while adapting to local conditions.

7. Sustainability

A challenge to this type of long-term project is that funding is usually limited to short-period projects. Partly due to this, researchers also may change positions. There were no particular administrative burdens regarding the application for research funds. The main difficulty lies in a lack of interest with the funding agencies in the subjects, farm-saved seeds, on-farm adaptation and small crops. It takes much effort to raise interest and get it in calls for proposals. Therefore, a point of attention would be to show policy makers the importance of this type of study for the (dynamic) conservation of genetic resources and food security in many parts of the world.

8. Upscaling and out-scaling

Next year, the results will first be analysed and compared to other people's results, and whether any particular research questions remain will also be assessed, e.g. in seed size development and drought tolerance. Only when open questions remain, further research funding will be applied for. Otherwise, the focus should be shifted to practical implications, including those for other mostly autogamous crops, leading to a value chain for on-farm conservation. Drivers of success lie in improving skills for on-farm conservation through education and workshops. In general, it is difficult to quantify precisely the effect of extending *ex situ* conservation by on-farm methods on genetic diversity, and even more difficult may be quantifying the effects of adaptation. This would be a good topic for a workshop with experts and opinion leaders. Bottlenecks lie in practical issues, i.e. proper equipment for seeding, harvesting and/or threshing to perform on-farm conservation research. Even small plot combines may be difficult to use and expensive. Modern machines are actually too expensive for small-scale research and difficult to repair due to the complex software. For instance, the old model combine harvester used in this project cost 10,000 DMark (i.e. 5,100 EUR) at the time; a modern model would be 240,000 EUR.

Conclusions

STRENGTHS	WEAKNESSES
Unique research project assessing the effects of on-farm management on regional adaptation and the genetic diversity of landraces of a mostly autogamous (self-pollinating) crop species; Insights were provided that will be useful for on-farm conservation in practice.	Difficulty to quantify precisely the effect on genetic diversity of extending *ex situ* conservation by on-farm methods; Despite providing regenerated seed material of lentil varieties, there has been no significantly increased interest yet in cultivation regionally, a.o. related to harvesting and yield problems.
OPPORTUNITIES	**THREATS**
Raising awareness on an interesting crop that is widely consumed but little grown in central Europe.	Little interest in on-farm conservation among research funding agencies and breeders/farmers except for the organic (biodynamic) community.

A strong point of the project is the actual long-term (more than 10 years) assessment of on-farm cultivation for its effects on landrace evolution. This will lead to practical insights for farmers using the farm-saved seeds of autogamous crops. Still, quantifying the effects of this type of conservation management on genetic diversity in a crop remains a complex issue. There was only limited spin-off in resuming regional lentil cultivation, but this had not been a specific objective from the start as this was primarily a research project. Continued research into more practical applications of the project may suffer from limited interest of funding agencies in on-farm conservation. Apart from that, the initiative could be duplicated, but it would need to be updated, based on insights from the lentil work, as explained above (cf. subsection 8). It should be directed to more practical on-farm work, involving horticulturalists and arable growers. A suitable crop with wider interest would be wheat, for example in France.

Challenges that the interviewee thought important to bring to the attention of public authorities are legal issues, such as seed Directives. There is no seed act on lentils in Germany, but for instance with maize, problems with seed acts are encountered, e.g. with sugar maize at organic growers. Likewise, there may be problems with product quality rules. The conservation varieties Directive would only provide a partial solution. For conservation organisations which have large numbers of varieties, the registration cost of 30 EUR per year per variety may lead to a prohibitively large sum of total costs. Another point of worry was ascertaining the GM-free status of organic crops; here maize also would need special attention due to the presence of GM varieties in Europe. Finally, the patenting of natural traits could affect the on-farm development of varieties and participatory breeding.

Annex 1 – List of interviewees

- Bern Horneburg Horneburg (Dep. of Crop sciences, Section of genetic resources and organic breeding, University of Göttingen). He is project leader of this project, and took care of the design, the data analysis, and the communication.

Annex 2 – List of references

Publications from the project cited in the text above

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