anja christinck seed4change

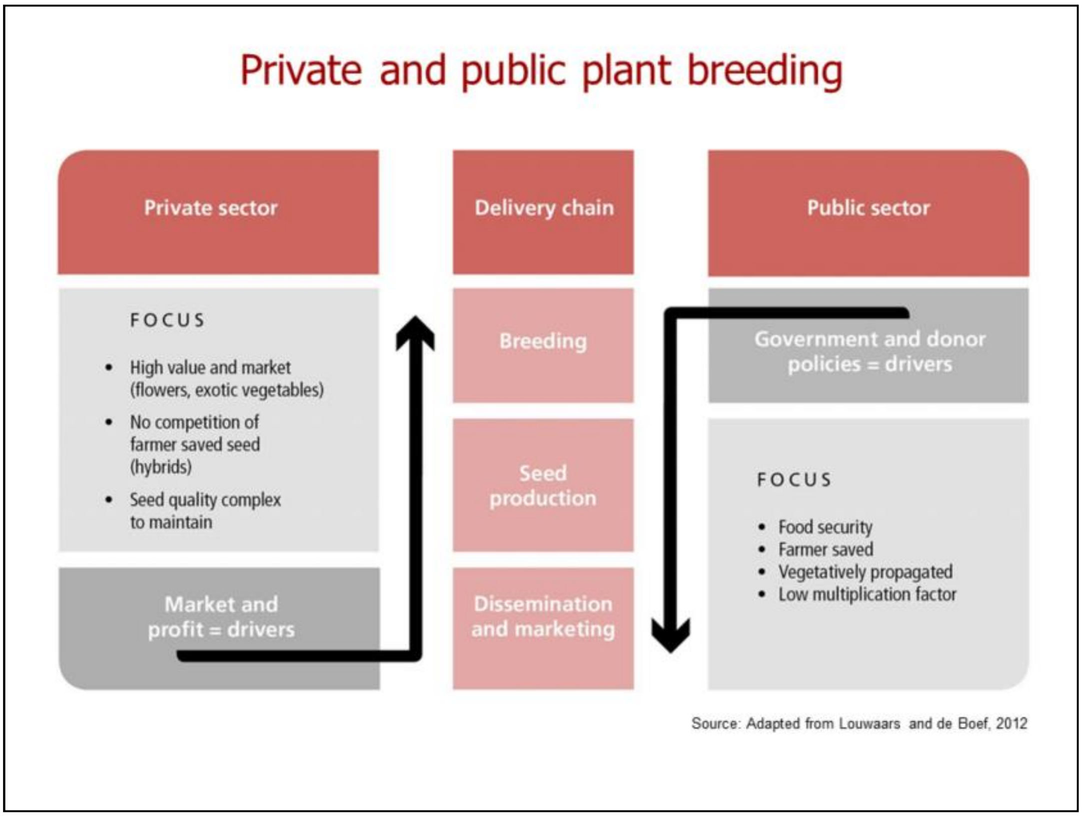
Institutionalizing farmer-breeder collaboration in formal plant breeding programs:

The potentials of participatory and decentralized approaches

This section of our conference is called ‘Resistance and Alternatives’ – and we have heard about several interesting examples how farmers themselves or their organizations create alternatives and follow innovative approaches in developing new plant varieties and strengthen traditional seed systems.

With this presentation, I would like to draw your attention to the fact that not only farmers, but also plant breeders working in scientific institutions have been actively seeking for alternatives to conventional plant breeding approaches.

This is a development that has been going on for approximately 25 years now, and it has resulted in new plant varieties for a variety of conditions and groups of farmers in many countries. But even more important may be that this work has led to initiating institutional change, since it builds on close collaboration between scientific plant breeders and farmers in formal plant breeding programs.

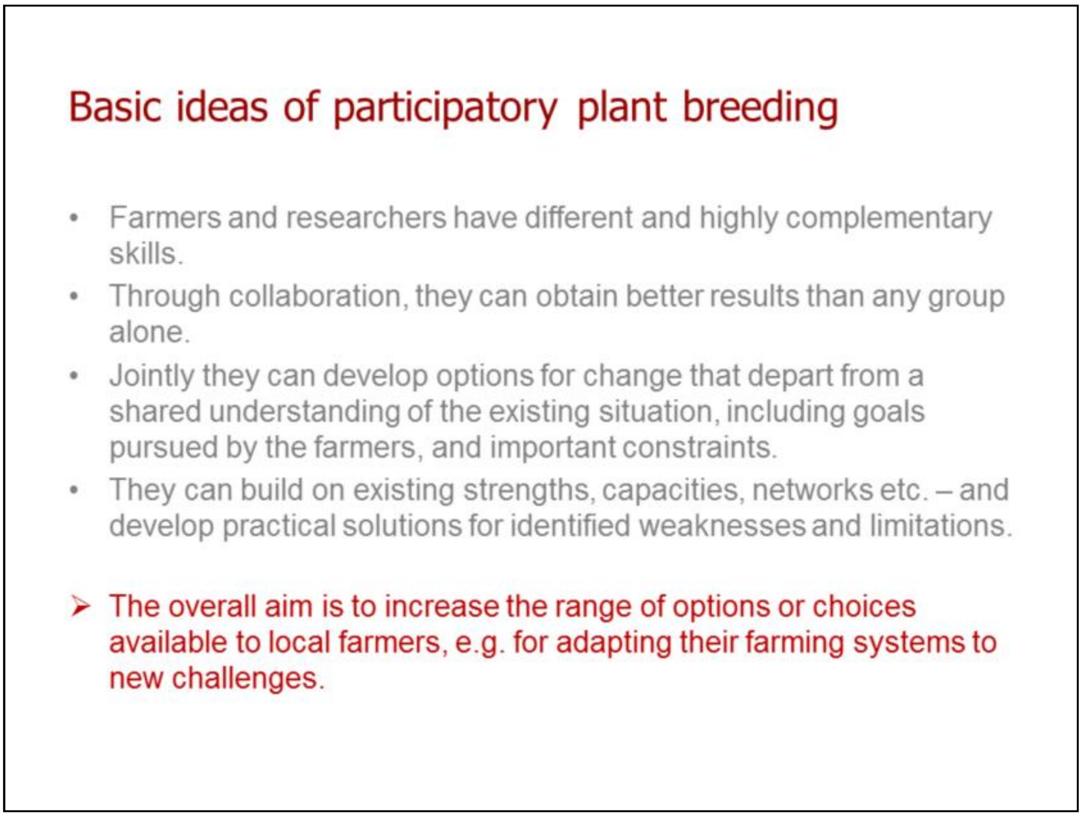


Before we go deeper into the topic, it may be necessary to clarify that within formal (scientific) plant breeding approaches, we can distinguish between a private sector and a publicly funded sector.

The private sector develops new varieties of plants based on private investment. This investment can be recovered by marketing seed of the newly developed varieties. Consequently, the private breeding sector focuses on high value and market crops, and often on crops where seed quality is more complex to maintain, so that there is less competition with farmer-saved seed.

The public sector, in contrast, is based on funding commitments of governments: In many developing countries, for example, national breeding programs exist for crops that are important for the farming sector of these countries. Furthermore, international agricultural research centers (e.g. ICRISAT, IRRI, CIP) can cooperate with national breeding programs of various countries. Publicly funded breeding programs can focus on crops that are important to food security, or on varieties that allow farmers to save their own seed. They do not rely on seed marketing, but are committed to the policy goals of governments and other donors.

A diversity of goals and approaches exists in both the private and the public sector. Hence, scientific plant breeding is more than the stories that have been told about Monsanto and other globally acting companies – there are also different stories to tell.



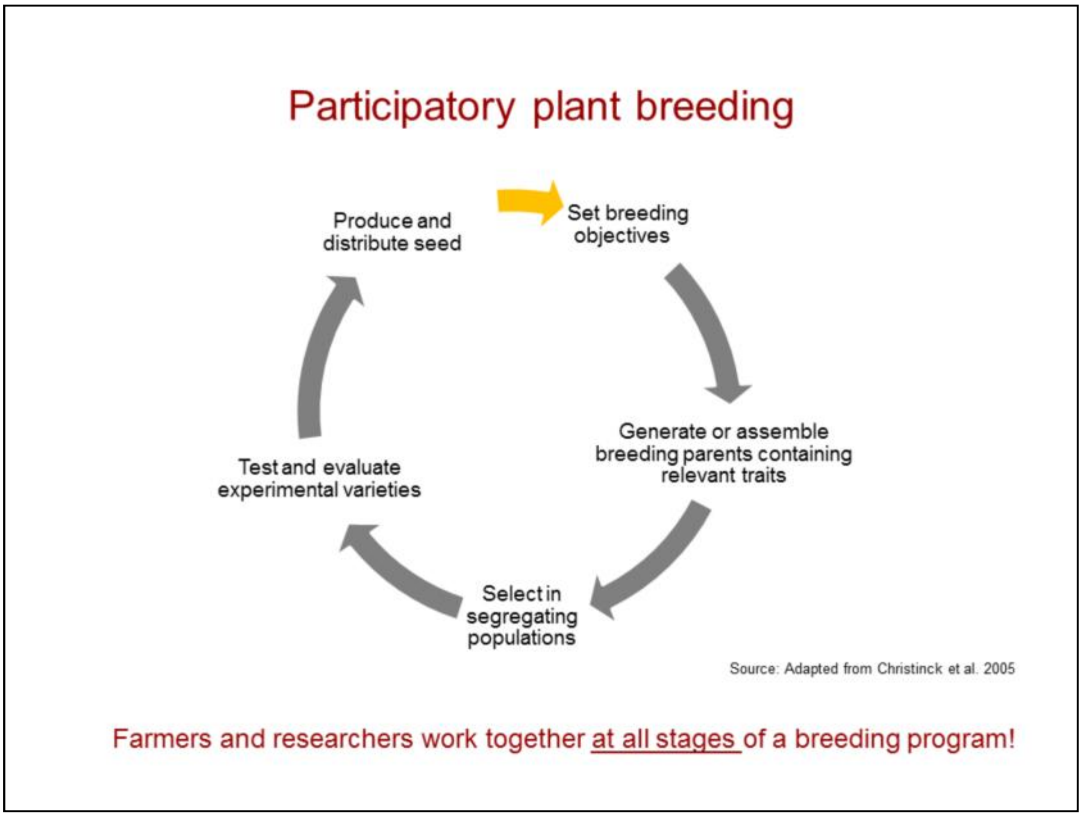
One of these different 'stories' is participatory plant breeding. It is a concept that evolved based on the understanding that farmers and researchers have different and highly complementary skills, and can obtain better results through collaboration than each group alone (Hoffmann et al. 2007).

Hence, it means more than just a general acknowledgement of farmers being 'knowledgeable people'; rather, the focus is on understanding how this knowledge of farmers is structured and how it is different and complementary to the scientific knowledge held by researchers.

Jointly, farmers and researchers can develop options for change that depart from a shared understanding of the situation, including goals pursued by the farmers to improve their situation, and important constraints.

Such options for change could then build on existing strengths, capacities and networks, and develop practical solutions for identified weaknesses and limitations (Restrepo et al., 2014).

The overall aim is to increase the range of options or choices that are available to farmers for adapting their farming system to new challenges, e.g. climate change, scarcity of land, or changing needs of rural families.

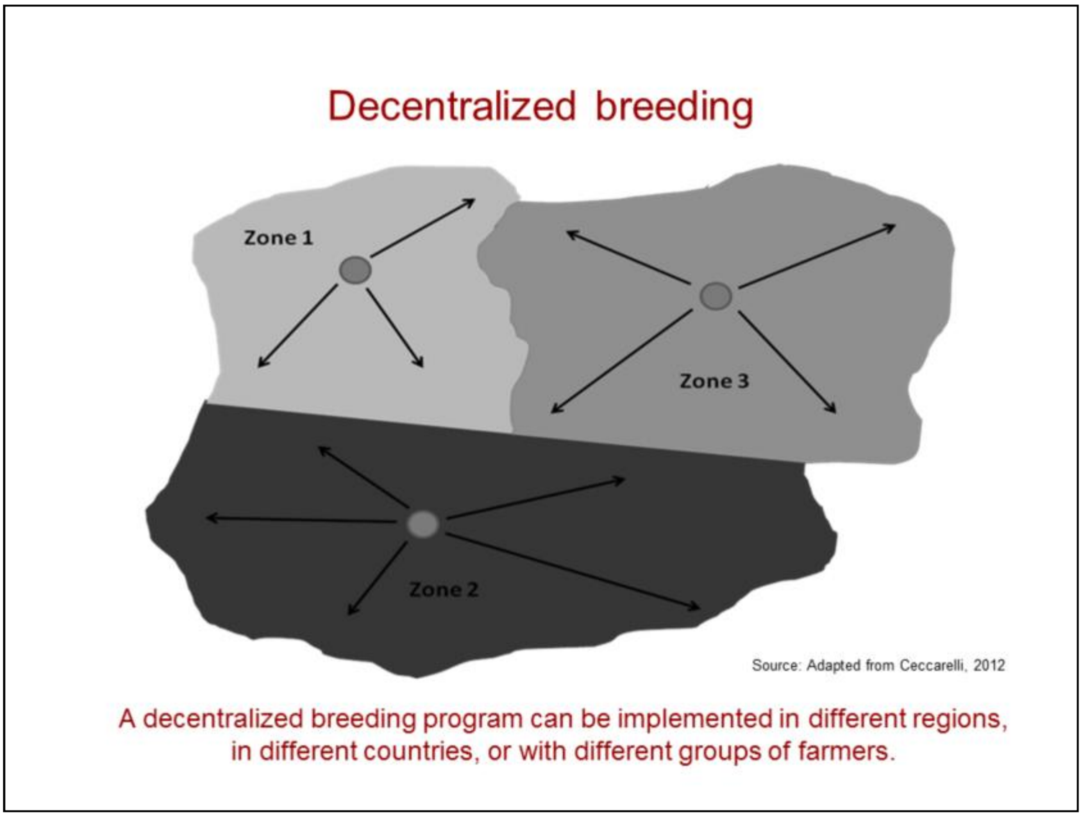


Even though the term ‘participatory plant breeding’ is not legally defined, it is clearly defined scientifically. The main difference to other forms of involving farmers, e.g. through on-farm trials or surveys, is that it involves close cooperation between farmers and researchers at all stages of a plant breeding program.

These stages are represented in the figure above. Hence, in participatory plant breeding programs, farmers and researchers work together in

1. Setting the breeding objectives
2. Generating and assembling breeding parents that show variation with regard to relevant traits
3. Selecting in segregating populations/lines
4. Testing and evaluating experimental cultivars
5. Producing and distributing seed

Participatory plant breeding initiatives can be led by farmer organizations, NGOs or formal breeding programs. Depending on the goals, they can have different foci, operate at different scales, and lead to different outcomes and impacts.



By taking a decentralized approach, a participatory breeding program can be implemented at larger geographical scales or with diverse groups of farmers. It can support the development of a range of varieties that are adapted to the diverse conditions, uses, or needs.

Farmers in the different zones (shown in the figure above) may select different varieties from an initial ‘pool’ of experimental cultivars for further breeding.

In this way, many more varieties can be developed in a decentralized, participatory breeding program compared to a ‘normal’ breeding program, hence increasing the number of choices available to farmers, the degree of adaptation to local conditions and needs, as well as the level of biodiversity in the farmers’ fields.

In Syria, for example, farmers have given names to and adopted more than 80 varieties from ICARDA’s participatory barley breeding program since 2000 (=in a period of 15 years), compared to 7 varieties that had been officially released through the conventional (non-participatory) breeding program in nearly 35 years (Ceccarelli, 2015).

Potentials of participatory and decentralized breeding from a breeder's point of view

- 'Conservation through use': locally adapted varieties are used as breeding parents
- Selection in the target environments
- Rapid feedback and adoption by farmers
- Improved scientific understanding of adaptation to needs, conditions and constraints faced by different groups of farmers (e.g. women and men)

From a breeder's perspective, this approach has a lot of potential. It opens up a possibility to reconcile the goals of breeding new varieties and conserving valuable local genetic resources by using them as breeding parents.

Selection in the target environments (=farmers' fields) can facilitate breeding progress for important adaptive traits.

Feedback from farmers can be obtained rapidly and promising new varieties reach the farmers' fields more quickly compared to conventional breeding programs.

Last but not least, the scientific understanding of diverse conditions and needs of farmers, including important constraints, can be improved, thus facilitating the breeding of well-adapted and relevant varieties in the future.

But also from a farmer’s perspective, there is a lot of potential:

Local varieties with preferred traits (but maybe some limitations) can be used as breeding parents – hence their valuable characteristics will not be lost.

For many farmers, the possibility to participate in the research and gain new knowledge that is related to the local context and conditions is a strong motivation.

They can participate in the decision making on goals, priorities and practical issues, thus taking influence on the direction of the breeding program.

They co-produce the new varieties and can be sure they are adapted to their local conditions and needs.

Very often, they can produce their own seed or in some cases even benefit from producing and marketing seed of the new varieties at larger scales.

Sorghum is an important staple crop cultivated in dryland areas of West Africa under rainfed conditions. Uncertainty of climatic conditions (low or excess rainfall), along with limited soil fertility are characteristic for the geographical area where the crop is grown (Haussmann et al., 2012; Rattunde et al., 2013; Leiser et al., 2012; 2015).

Before the participatory sorghum breeding program was initiated some 15 years ago, breeding progress for sorghum had been limited for this type of conditions, and farmers' adoption of new varieties had remained very low. New varieties had only moderate yield advantages and slightly earlier maturity, compared to local landraces.

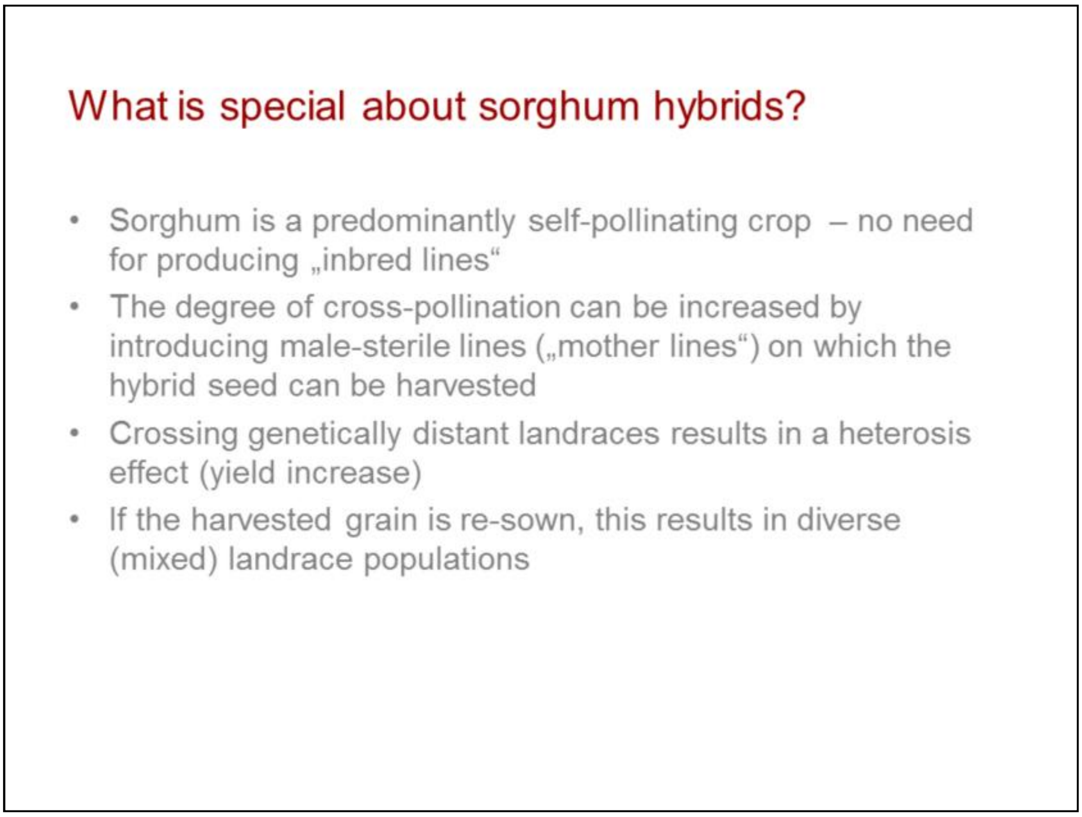
Collaboration was established between researchers from ICRISAT, national breeding programs, several farmer organizations and NGOs.Their joint activities include pre-breeding (e.g. evaluation of local and foreign germplasm), breeding and variety evaluation, as well as seed production activities.

The breeding activities follow a decentralized, participatory approach. Every year, farmers in participating villages can observe and evaluate a set of 32 varieties grown in two farmer-managed trials per village. Interested farmers can then grow a subset of 3-5 test varieties in their own fields for further evaluation.

Through this approach, farmers can gain experience with experimental varieties from the breeding program under their own, local conditions. The seed production is done by members of the farmer organizations, seed is marketed by these same organizations. There is not IPR on the seed that would hinder farmers to further multiply and use the seed.

Over the past 15 years, many open-pollinating varieties were developed, including diverse plant types for diverse conditions (e.g. short and tall plants, early and late maturity), with various grain qualities, nutrition-related traits, etc.

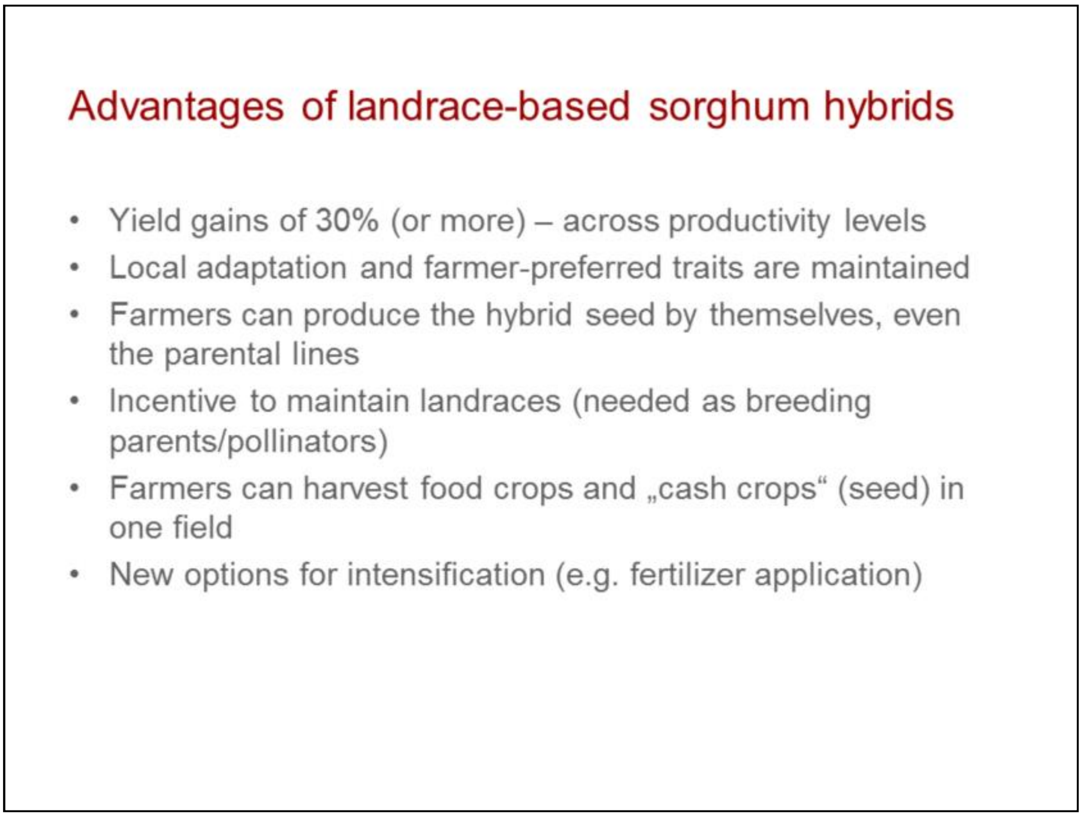
However, yield increase was only moderate (~10-15 %). This fact led to the latest development –landrace-based sorghum ‘hybrids’. I would like to present this as an example how scientific breeding methods can be applied in such a way that they serve farmers’ needs.



There are some differences between these landrace-based sorghum hybrids and hybrids of some other crops, e.g. maize. Sorghum is a predominantly self-pollinating crop, but the degree of cross-pollination varies depending on genetic and environmental conditions. Hence, it is not necessary to produce inbred lines (as is necessary in maize), because the predominant way of reproduction is through self-pollination. On the other hand, cross-pollination is not ‘unnatural’ for a sorghum plant; it occurs all the time, but only in a certain (low) percentage of plants. The degree of cross-pollination can be purposely increased by introducing male-sterile lines as ‘mother’ lines on which the hybrid seed can be harvested.

Crossing genetically distant sorghum varieties (e.g. landraces) results in an effect known as ‘heterosis’: The yield level of the first generation (F1) produces higher yields than either of the parental lines. If the harvested seed is re-sown (e.g. accidentally), this leads to highly diverse (F2) populations composed of plant types and characteristics that are similar to those of the parental lines (landraces). There is, however, no sharp yield decrease, because the parental lines are landraces that are adapted to the production environment.

The seed cost is moderate, because it is not the interest of publicly funded plant breeding programs to re-finance the breeding work through seed marketing. Members of the participating farmer organizations have been trained to produce seed, including hybrid seed.



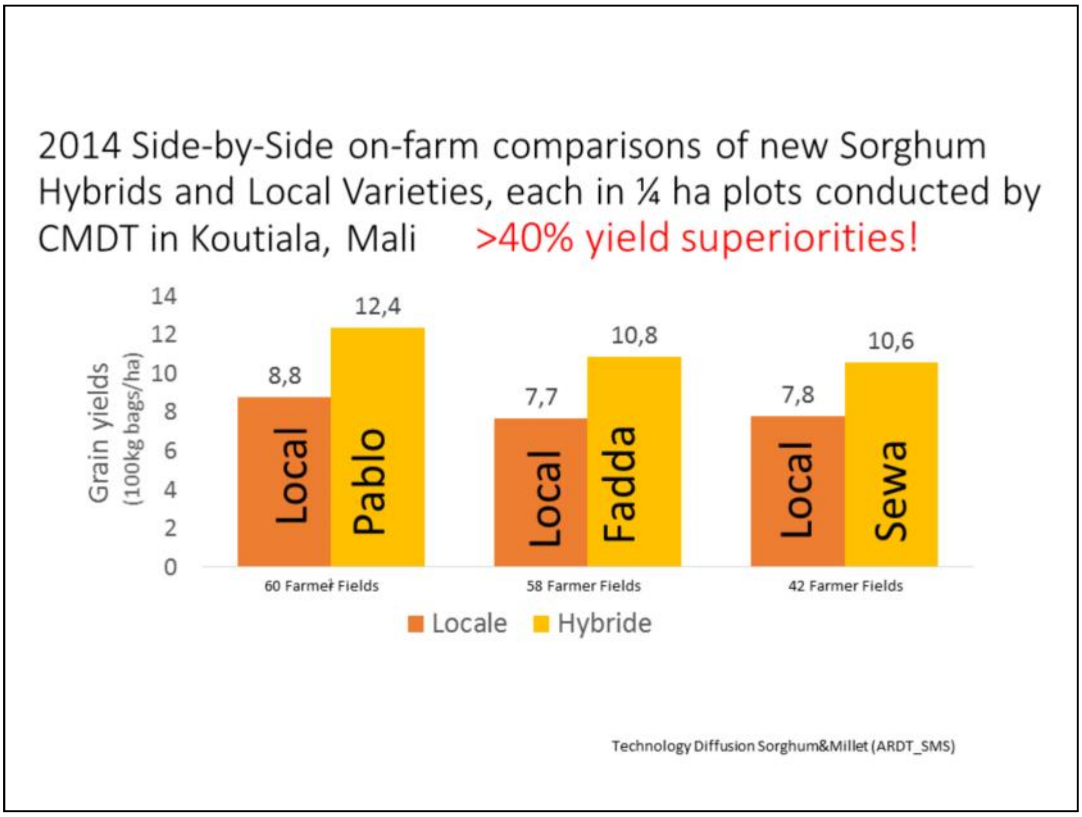
The most important advantage of landrace-based sorghum hybrids is that they produce higher yields. In scientific trials, the three top yielding hybrids showed yield advantages of 30% over a landrace check – across productivity levels. At some locations, the yield advantages were even as high as 40% (see next slide).

The absolute yield advantage was 380 kg/ha under lower and 660 kg/ha under higher productivity conditions (Rattunde et al. 2013). Hence, growing these hybrids is not only an option for farmers working under favorable conditions, but for many other farmers as well. The yield advantages could really make a difference with regard to food and nutrition security in the region.

Farmers have been trained to produce the seed by themselves, and increasingly also to produce seed of the ‘mother’ lines. Producing hybrid seed is at the same time an incentive to maintain the landraces, at least those that are needed as breeding parents/pollinators.

Farmers can harvest the hybrid seed and a food crop (landrace) from the same field. Selling the hybrid seed gives additional income.

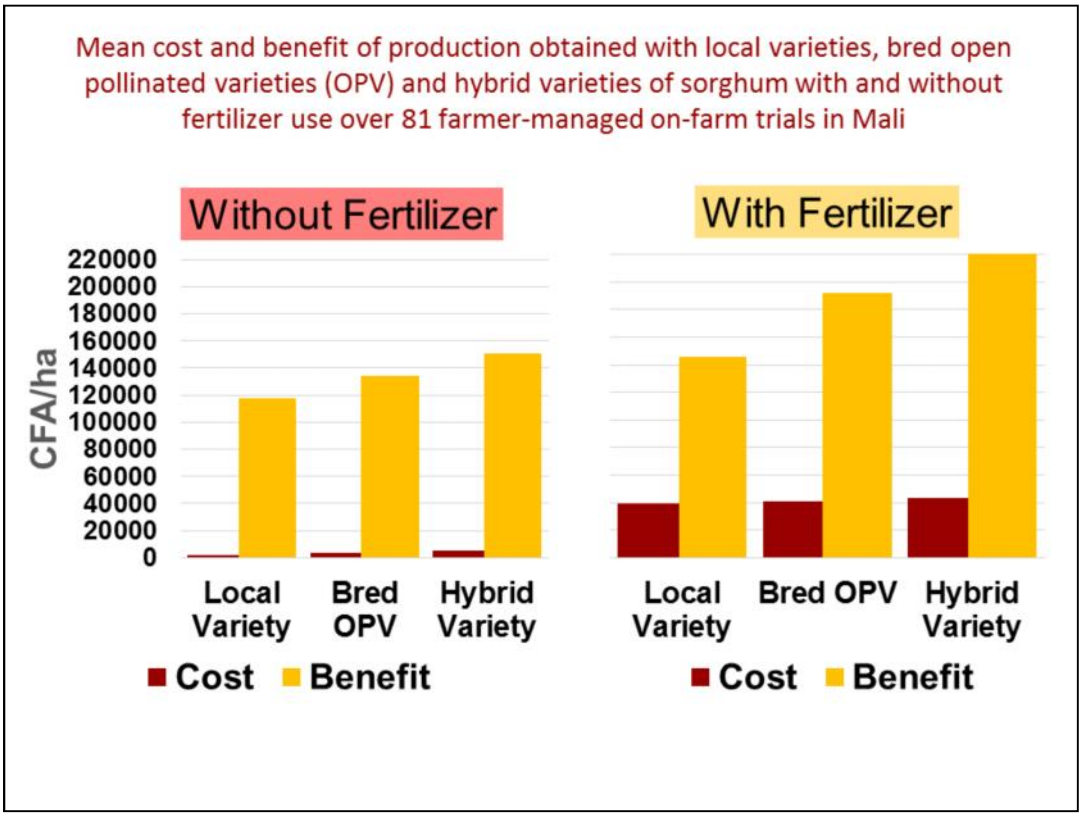
The new landrace-based sorghum hybrids have the additional advantage that they respond to fertilizer and render fertilizer use economic, even under rainfed farming conditions (see below) – which has not been the case for landraces or improved varieties so far.



The yield advantages (grain yield) of three hybrids (Pablo, Fadda, Sewa) over a local ‘check’ variety were found to be even higher in a trial conducted by a Koutiala, a region of southern Mali where cotton, sorghum and maize are extensively grown.

In this trial, conducted by farmers cooperating with the Malian state company CMDT, two varieties (one hybrid and one local ‘check’) were grown side by side on farmers’ fields and under farmers’ management. The number of participating farmers is indicated for each pair of varieties.

In this case, the hybrid varieties “Pablo” and “Fadda” show yield superiorities of 40% over the local ‘check’. For the hybrid variety “Sewa”, the yield superiority is 36%.

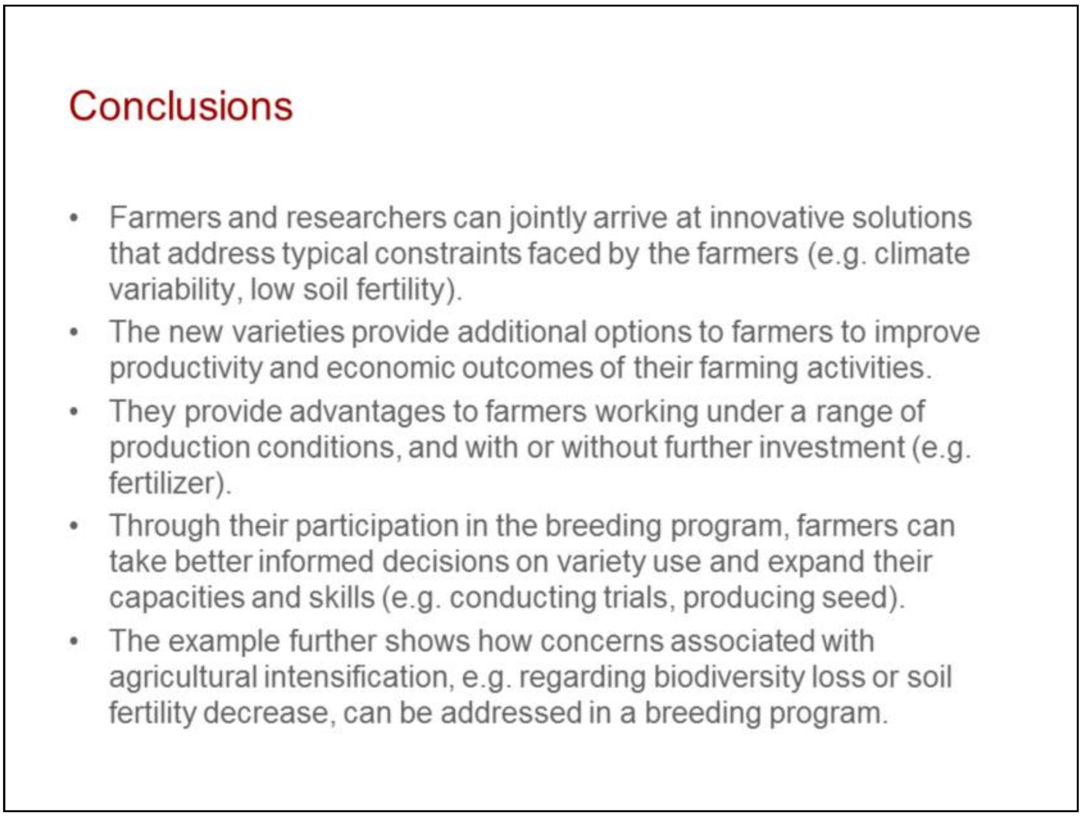


There are, however, not only advantages in physical grain yield, but also economic benefits. This slide shows the results of comparing monetary benefit and cost associated with growing a local variety, an improved open pollinating variety and a hybrid variety with (right) and without (left) fertilizer.

On the left hand side (without fertilizer) we can see that the (moderately) higher seed cost of the improved open-pollinating variety and the hybrid are fully recovered. The economic advantage of growing a bred open-pollinating or hybrid variety are 13% and 26%, respectively.

Fertilizer application in the local variety is uneconomic (in spite of increased yield), since the fertilizer cost exceeds the economic benefit. For the open-pollinating variety and the hybrid, fertilizer use can further increase the economic benefit. It increases to ~ 30% for the OPV and ~ 55% for the hybrid, compared to the previous situation (local variety without fertilizer). Furthermore, the fertilizer application (particularly P fertilizer) could have additional benefits for other crops grown in the crop rotation.

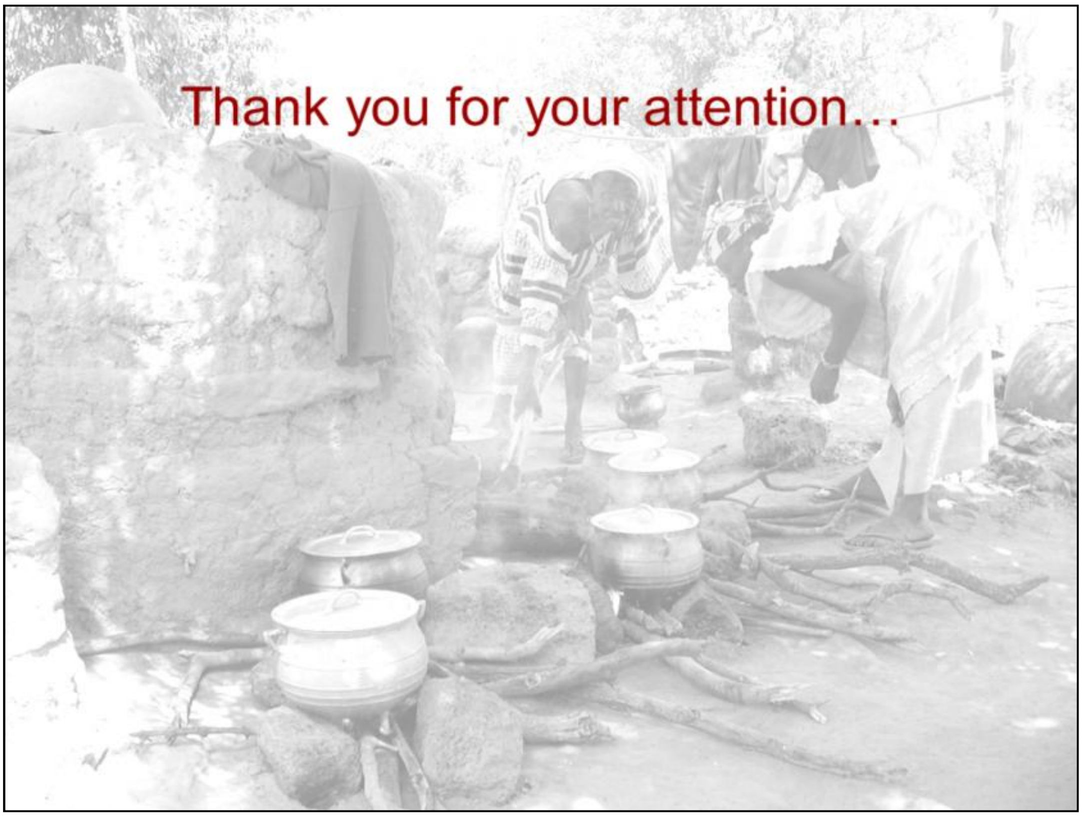
Thus, we can conclude that the bred open-pollinating variety and the hybrid can both provide economic benefits for farmers, with or without fertilizer application. However, the benefits are increased if fertilizer is used. The bred OPV and the hybrid provide an incentive for managing and improving soil fertility, as it is economically rewarded.



(Conclusions are in the slide)

Breeding hybrid varieties together with small-scale farmers is only one option among many others to address the challenges faced by them. It has emerged as an option in this particular case, where farmers had already been involved in seed production previously through their cooperatives.

The effects of these new varieties on sustainability of farming systems, including soil fertility and agricultural biodiversity, remain to be studied and followed up.



Thank you for your attention.

(The photo shows women involved in the evaluation of post-harvest and culinary traits of several experimental sorghum varieties).

Acknowledgements and works cited

Acknowledgements

All photos used in the presentation were kindly provided by Dr E Weltzien Rattunde, ICRISAT Bamako, Mali, and Dr Sonja Siart, Berlin, Germany. Data slides used in the presentation were kindly provided by Dr H.F.W. Rattunde and Dr E. Weltzien Rattunde, ICRISAT Bamako, Mali.

Works cited

Ceccarelli, S. (2012): Plant Breeding with Farmers – a Technical Manual, ICARDA, Aleppo, Syria.

Ceccarelli, S. (2015): Seeds of future. Paper published by the author on www.researchgate.net, 12 2015. DOI: 10.13140/RG.2.1.2346.0002.

Christinck, A., Weltzien, E., Hoffmann, V. (2005). Introduction. Pp. 11–14. In: Christinck, A., Weltzien, E., Hoffmann, V. (eda.). Setting breeding objectives and developing seed systems with farmers. Margraf Publkishers, Weikersheim, Germany.

Haussmann, B.I..G, Rattunde, H.F., Weltzien-Rattunde, E., Traoré, P.S.C., vom Brocke, K., Parzies, H. (2012): Breeding strategies for adaptation of pearl millet and sorghum to climate variability and change. Journal of Agronomy and Crop Science 198 (5): 327–339.

Hoffmann, V., Probst, K., Christinck, A. (2007): Farmers and researchers: How can collaborative advantages be created in participatory research and technology development? Agriculture and Human Values 24: 355–368.

Leiser, W.L., Rattunde, H.F.W., Piepho, H.P., Weltzien, E., Diallo, A., Melchinger, A.E., Parzies, H.K., Haussmann, B.I.G. (2012): Selection strategy for sorghum targeting phosphorus-limited environments in West Africa: analysis of multi-environment experiments. Crop Science 52 (6): 2517–2527.

Leiser, W.L., Rattunde, H.F.W., Piepho, H.P., Weltzien, E., Diallo, A., Toure, A., Haussmann B.I.G. (2015): Phosphorous Efficiency and Tolerance Traits for Selection of Sorghum for Performance in Phosphorous-Limited Environments. Crop Science 55:1152–1162.

Louwaars, N.P., De Boef, W.S. (2012): Integrated seed sector development in Africa: a conceptual framework for creating coherence between practices, programs, and policies. Journal of Crop Improvement, 26: 39–59.

Rattunde, H.F.W., Weltzien, E., Diallo, B., Diallo, A.G., Sidibé, M., Touré, A.O., Rathore, A., Das, R.R., Leiser, W.L., Touré, A. (2013): Yield of Photoperiod-sensitive Sorghum Hybrids Based on Guinea-race Germplasm under Farmers' Field Conditions in Mali. Crop Science 53: 2454–2461.

Restrepo Rodriguez, M.J., Lelea, M.A., Christinck, A., Hülsebusch, C., Kaufmann, B.A. (2014): Collaborative learning for fostering change in complex social-ecological systems: A transdisciplinary perspective on food and farming systems. Knowledge Management for Development Journal 10 (3): 38-59.