# Breeding for resilience: a strategy for organic and low-input farming systems?

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**of the "Organic and Low-Input Agriculture" Section**

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**75000 Paris - FRANCE**

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# Breeding for resilience: a strategy for organic and low-input farming systems?

Isabelle Goldringer, Julie Dawson, Alice Vettoretti, Frédéric Rey

Global change is increasingly affecting agricultural production and threatening food security. Organic and low-input farming systems are less demanding in fossil energy and might thus contribute to moderating global carbon emissions. Moreover, under increased uncertainty and variability in environmental conditions, these systems offer solutions for buffering against climatic extremes, disease epidemics, changing nutrient availability, and other stresses that will add to already heterogeneous environmental conditions.

2010 has been designated the Biodiversity Target year by Parties to the Convention on Biological Diversity. Yet, it is clear that biological diversity in agroecosystems, measured as the number and abundance of species as well as genetic diversity within cultivated plants, is still decreasing, largely due to the negative impacts of intensive industrial agriculture. Overall, ecosystem services delivered by biodiversity such as plant disease control, soil fertility and pollination are jeopardized by its decline. These threats present an opportunity for the organic sector to develop original and innovative strategies for biodiversity preservation and increased resilience in the field.

The second EUCARPIA meeting of the Section Organic plant breeding and low-input agriculture organised in Paris, France, from the 1st to the 3rd of December 2010, by INRA – UMR Génétique Végétale Le Moulon and ITAB, wishes to take inspiration from the ecological sciences to highlight the use of biodiversity in agriculture while taking advantage of the new tools coming from genomics. Therefore, the symposium will deal with breeding strategies for organic and low-input farming systems with a special emphasis on approaches that allow for more resilience in response to global change. Some 130 participants representing 20 countries will attend the symposium, including students, researchers and other professionals from universities, institutes, breeding companies, governemental institutions, Non Governemental Organizations and farmers.

The programme features 30 oral and 37 poster presentations, covering the following areas:

- Improving resilience of agro-ecosystems
- Utilizing and conserving agrobiodiversity in agricultural landscape
- Global change and adaptability
- New insights into the mechanisms of adaptation to local conditions and organic farming
- Breeding for diverse environments and products
- Regional participatory plant breeding

The scientific committee has selected oral presentations based both on their scientific quality and with the aim to cover a diverse range of crops and species, different approaches, methods and viewpoints. Because the place and the conditions in which thoughts develop are also important, the organising committee chose Le Comptoir Général – a new space with strong environmental endowment dedicated to large audience events (80 Quai de Jemmapes, Paris 10ème, France) – as the location for the event, and an organic caterer (Grain de vie). We hope that all this will allow for fruitful discussions and the emergence of new ideas and collaborations for a future more resilient low-input and organic agriculture.

# Programme

## Wednesday, December 1st

**13:00 – Arrival – registration**

**13:30 – Welcome & introduction**

Welcome by Isabelle Goldringer, chair of the organising comittee.
Welcome by Zoltan Bedo,chair of the Eucarpia association.

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| 13:20 | Introduction by Edith Lammerts van Bueren, chair of EUCARPIA Section Organic & Low-input Agriculture | The challenges and the framework for future breeding for organic and low-input agriculture, and the goals of the conference |

**14:00 – 14:50 – Improving resilience of agro-ecosystems**

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| 14:00 | Keynote speaker:<br>Dr Jerry Glover, Science and Technology Policy Fellow, American Association for the Advancement of Science, Washington DC | Improving Agroecosystem Resilience and Sustainability |

**15:10 – 17:20 – Session 1 : Utilizing and conserving agrobiodiversity in agricultural landscapes**

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| 15:10 | Invited speakers:<br>Dr Devra Jarvis, Senior Scientist, Bioversity International, Rome, Italy<br>Dr Bhuwon Sthapit, Senior Scientist, Biodiversity International, New Delhi, India | Participatory plant breeding as a strategy for supporting the assessment, access, use and benefit of traditional crop genetic diversity in the farmer's production system: Overview and the case of the Mansara rice (*Oryza sativa* L.) landrace in Nepal |
| 16:00 | Géza Kovacs | Evolutionary breeding of cereals under organic conditions |
| 16:20 | Emmanuelle Porcher | Crop genetic diversity benefits farmland biodiversity in cultivated fields |
| 16:40 | Maria-José Suso | Potential power of the plant-pollinator relationship as a tool to enhance both environmental and production services of grain legumes in the context of low-input agriculture: what do we do? |
| 17:00 | Anders Borgen | Quality traits in conservation varieties |

**17:30 – 19:00 – Posters – 1st session**

Utilizing and conserving agrobiodiversity in agricultural landscapes / Global change and adaptability /
New insights into the mechanisms of adaptation to local conditions and organic farming

**20:00 – 23:00 – Dinner followed by a debate, with "Fondation Sciences Citoyennes"**

"Organic agriculture: so few research, so many questions - what are the lock-in, how to release?"
http://sciencescitoyennes.org (in French)

## Thursday, December 2nd

**8:30 – 11:00 – Session 2 : Global change and adaptability**

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| 8:30 | Invited speaker:<br>Dr Martin Wolfe, Principal Scientific Advisor, ORC, UK | Steps towards an ecological future |
| 9:15 | Invited speaker:<br>Dr R. Ford Denison, Adjunct Professor, University of Minnesota, USA | Economic, ecological, and evolutionary tradeoffs as past constraints and future opportunities |
| 10:00 | Thomas Döring | Breeding for resilience in wheat - Nature's choice |
| 10:20 | Maria Finckh | Population developments from the F5 to the F9 of three wheat composite crosses under organic and convetionnal conditions |
| 10:40 | Sébastien Barot | Breeding new cultivars to enhance positive feedbacks between soil and crops? |

**11:30 – 12:30 – Posters – 2nd session**

Breeding for diverse environments and products / Regional participatory plant breeding

**12:30 – 13:30 – Lunch**

**13:30 – 16:00 - Session 3: New insights into the mechanisms of adaptation to local conditions and organic farming**

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|---|---|---|
| 13:30 | Invited speaker:<br>Dr John M. Warren, Senior Lecturer in Agro-ecology, IBERS, UK | Building resilience in organic and low-input farming systems: an ecological geneticists view |
| 14:20 | Olga Scholten | Breeding onions for low-input and organic agriculture: Genetic analysis of the interaction between Allium species and arbuscular mycorrhizal fungi |
| 14:40 | Monika Messmer | Genetic variation for nutrient use efficiency in maize under different tillage and fertilization regimes with special emphasis to plant microbe interaction |
| 15:00 | Roeland. E. Voorrips | Validation of associations between plant traits and Thrips damage in cabbage |
| 15:20 | Bernard Rolland | Wheat varieties in competition with weeds for sustainable agriculture, in particular organic farming |
| 15:40 | Abdul Rehman Khan | DNA methylation patterns in VRN1 gene in vernalized and non-vernalized wheat |

**16:30 – 19:00 - Session 4: Breeding for diverse environments and products**

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|---|---|---|
| 16:30 | Invited speaker:<br>Dr Kevin Murphy, Assistant Research Professor, Washington State University, USA | Breeding for Diversity: Examples from quinoa, buckwheat, hops and spelt |
| 17:20 | Paolo Annicchiarico | Breeding forage and grain legumes for adaptation to specific agroclimatic regions and cropping systems: opportunities and limitations, |
| 17:40 | Pedro Revilla | Grain quality in traditional maize varieties for bakery under organic conditions |
| 18:00 | Mickael Fleck | Chinese cabbage variety 'Atsuko' as an example of biodynamic vegetable breeding with Kultursaat association, Germany |
| 18:20 | Ilze Skrabule | Evaluation of potato breeding clones in organic and conventional growing conditions |
| 18:40 | François Warlop | Urgent need for new fruit breeding methods better adapted to low-input agro ecosystems |

**20:00 – 23:00 – Dinner and concert performance : Balval** **http://www.myspace.com/balval**

## Friday, December 3rd

**8:30 – 11:00 - Session 5 : Regional participatory plant breeding**

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| 8:30 | Invited speaker:<br>Dr Lorenz Bachmann, MASIPAG, Germany | Farmer-led participatory plant breeding. Methods and impacts. The MASIPAG farmers Network in the Philippines |
| 9:20 | Julie Dawson | On-farm conservation and farmer selection as a strategy for varietal development in organic agricultural systems |
| 9:40 | Erica N.C. Renaud | Will regional selection provide better adapted and performing broccoli varieties combining agronomic, quality (phytochemical) traits and farmers' preferences in the USA? |
| 10:00 | P. Mendes-Moreira | On-farm conservation and particpatory maize breeding in Portugal; lessons learnt and future perspectives |
| 10:20 | Jingsong Li | Participatory breeding in China in maize and its institutional challenges |
| 10:40 | Bernd Horneburg | Participation, utilization and development of genetic resources in the Organic Outdoor Tomato Breeding Program |

**11:00 – 12:00 – Closing session**

**13:00 – 19:00 – Visit** (optional) to the Bergerie de Villarceaux (95) : an organic farm with an experimental platform for research in organic farming

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Follow the tomato! This picture indicates posters that are eligible for the poster content (posters made by PhD, post-doctoral positions, engineers, master students…)

# Chinese cabbage variety '*Atsuko*' as an example of biodynamic vegetable breeding with Kultursaat association, Germany

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*Keywords:* on-farm breeding, Ohio-method, robustness, taste

**Introduction**

Over the last decades the percentage of hybrids in the assortment of all important vegetable crops has strongly increased and today for many varieties only hybrids are available (Tay 2002, Maggioni 2004, Stadtlander 2005). As hybrids are not stable the possibility of conservation as well as developing and adapting varieties - not only under organic farming conditions - are increasingly limited. Even worth, many new hybrids especially in the *Brassica* family are so called CMS-hybrids that are not even fertile.

In very general terms popularity of hybrids is e.g. due to their vigour, uniformity, earliness and high yields. From the breeders' point of view hybrid breeding helps to control intellectual property rights through control and protection of the parental lines. However hybridisation requests either extreme inbreeding or sterility factors to allow homozygous parental lines and maximum degree of cross-pollination. Therefore hybrid breeding is considered inappropriate with biodynamic breeders. Since Chinese cabbage has been listed in the Common catalogue of vegetable species in the late 1980s, about 90 % of the registered varieties are hybrids (fig. 1). Within *Brassicaceae* many "successful" interspecific and intergeneric fusions are known (Navrátilová 2004), but information about commercially available Chinese cabbage CMS-hybrids made by cell fusion techniques[1] is rare.

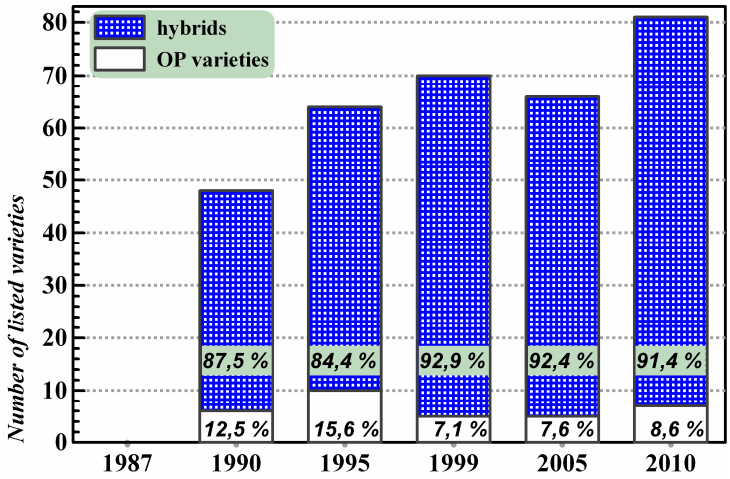



*Figure 1:*
*Development of open pollinating (OP) varieties (white bars) and hybrids (dark bars) of Chinese cabbage listed in the Common catalogue of vegetable species, source EU (several volumes 1987 to 2010)*

On this background the 'Atsuko' breeding programme was Kultursaat association's effort to develop an OP variety especially for quality oriented organic and biodynamic cropping.

[1] Such CMS-hybrids derived from cell fusion are banned by several organic farming associations and the IFOAM decided at its General Assembly 2008 in Vignola/Italy, that cell fusion techniques do not comply with the principles of Organic Farming (IFOAM 2008).

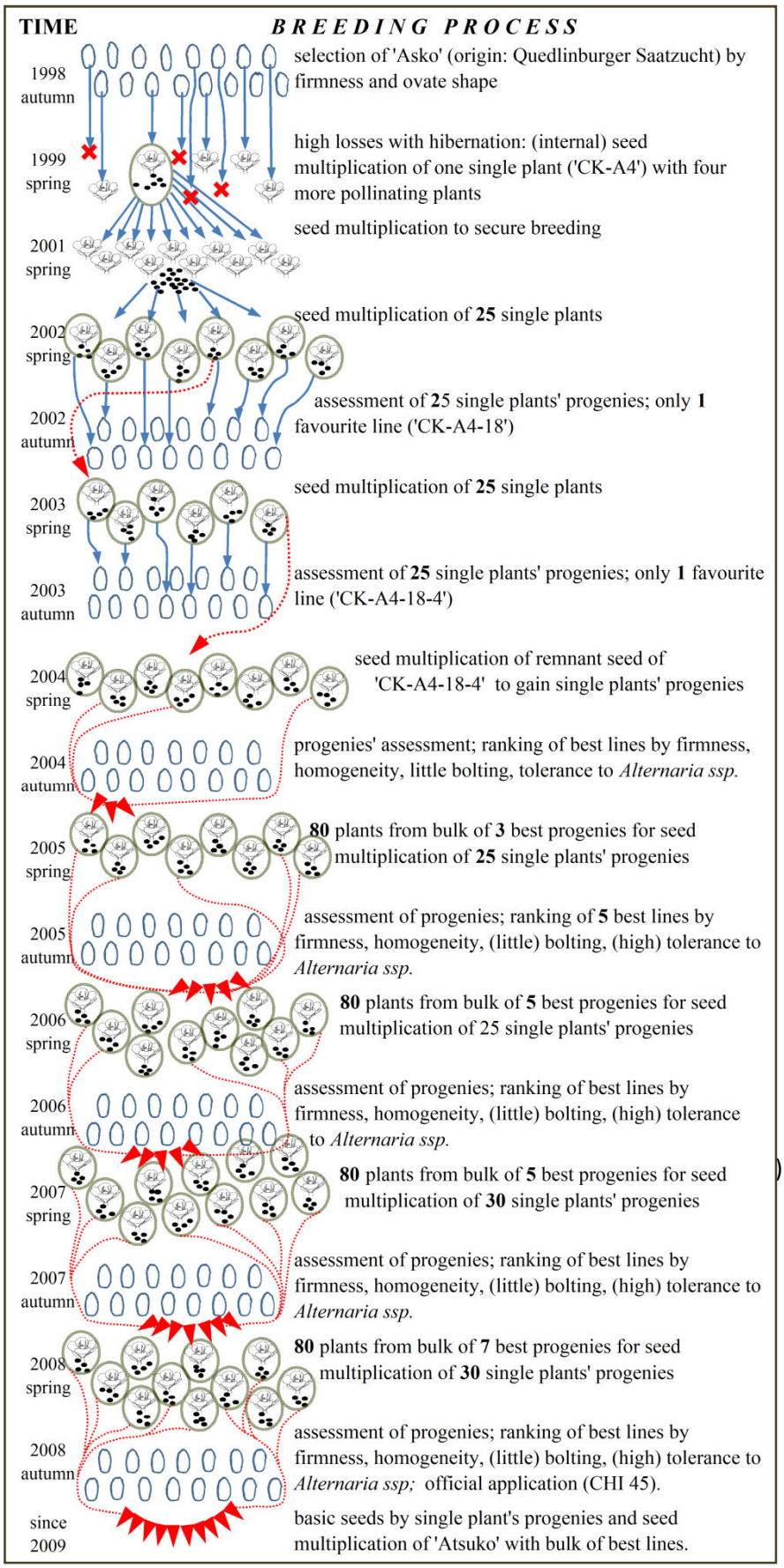



*Figure 2: Breeding scheme of 'Atsuko' from screening in 1998 up to registration in the National List (2009). Dashed lines mark selection steps by Ohio-method, encircled blossoms and seeds symbolize single plants' progenies.*

## Materials and Methods

'Atsuko''s origin is the open pollinating variety 'Asko' from the Quedlinburger Saatzucht which is no longer listed in the Common catalogue. Starting point of this *on-farm* breeding programme was a screening of ovate heads building accessions from the German gene bank (Gatersleben) under biodynamic conditions in autumn 1998. Despite significant inhomogeneities and a harvesting rate of just 20 % 'Asko' displayed the highest potential for commercial use. 20 elite plants were selected from a total of 250 plants using criteria such as

firmness, size, shape, weight (1.0 to 1.5 kg) and organoleptic quality.75 % of these elite plants died during the subsequent winter illustrating the risky hibernation of Chinese cabbage which is related to the high water content of the cabbage head. Of the five flowering elite plants only one produced seeds which formed the base for all further breeding work (fig. 2).

Seeds were sown for seed multiplication in spring 2001 to secure sufficient breeding material. In the following work the remnant seed procedure was used. Very early sowing of Chinese cabbage during the end of January/early February allows seed production in time for summer sowing. This technique allows for seed production from individual plants and offspring selection already in autumn of the same year. Seeds from plants displaying the best morphological characteristics were selected, mixed to a bulk and used for early sowing in the following year. This procedure was used continuously up until 2008 (fig. 2). With early sowing the plants do not form heads and selection has to be limited to the stage of rosette growth (up to BBCH 19) using following criteria: Homogeneity of leave colour, shape

and texture, as well as overall healthiness and vigour. In spring up to 100 plants were used from which in the rosette stage 25 to 30 were selected for progenies' assessment. Open pollination between all plants was allowed during flowering. In autumn head shapes were critically evaluated based on early timing, firmness and homogeneity, as well as plant affinity for inflorescence emergence and tolerance against *Alternaria*. Criteria for evaluation of *Alternaria* infestation were based on intensity of both, outer leaves and head inner part. For continuation only such progenies were used that performed better than average on all criteria. At the beginning the number of breeding lines used for seed production was only three to five, later up to 14 lines were used annually.

Sensory quality was determined using a tasting test with an ordinal scale based on a procedure originally developed for carrots (Fleck 2009). Criteria employed were aroma and sweetness on mature leaves that had achieved good to very good texture. Visual evaluation by picture forming methods (here Rising pictures ("Steigbild")) unveiled the good forming character and ripeness of 'Atsuko' when compared to 'Asko' and hybrid varieties (fig. 3).

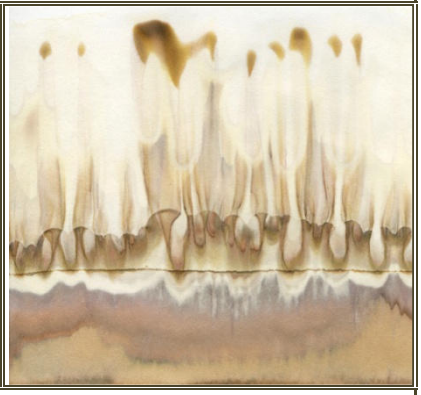
| Kazumi F1 (common hybrid) | CK-A4 ('Asko') one step of organic seed production (*F1*) | CK-A4-18-4 ('Atsuko') bulk of best progenies (*F8*) |
|---|---|---|
|  |  |  |
| • little pronounced drips' line („Tropfengirlande"),<br>• average form intensity,<br>• some indication of roughness and deterioration. | • average drips' line,<br>• uneven forms,<br>• slight deterioration. | • most expanded drips line (> indication of ripeness),<br>• superior form intensity,<br>• smooth, „moved", leaf-typical, "vegetatively vital" characteristic without any indication of deterioration. |

*Figure 3: Rising pictures ("Steigbild according to Wala") and importent patterns of 'Kazumi F1' (commonly used hybrid as reference), 'Asko' (one-time biodynamically farm saved seeds (F1) from the original OP variety) and 'Atsuko' (F8 generation's selection of 'Asko' (breeding progress by Ohio-method)); samples from growing season autumn 2007, qualitative assessment: 2010-11-13 to 11-15.*

Using tests with mid-scale organic growers during 2007 and 2008 a 70-90% harvesting rate was obtained, which is a high level and sufficient for commercial purposes. In autumn 2009 DUS test resulted in the variety recognition through Bundessortenamt (Federal Office of Plant Varieties) on the denomination 'Atsuko' (CHI 45).

**Results & Discussion**

Starting with an inhomogeneous cultivar with a high head shape variation and a poor harvesting rate a new commercially viable variety using individual selection was successfully developed. Compared to hybrids the new variety displays an ample homogeneity, excellent heads' firmness and a sufficient harvesting rate. Compared to the initial variety the field resistance is increased markedly although it is not resistant to fungal decay or bacterial rot. Following the UPOV variety description 'Atsuko' displays following characteristics: Low to medium plant height with egg shaped (ovate), intermediately wide, and short heads of yellow-greenish colour and whitish inner colour; medium number of blisters, small in size on upper side of outer leaf, excellent heads'

firmness and early harvesting time. Resistance and disposition to inflorescence emergence were not used in the variety accreditation.

During production and storage of Chinese cabbage infection with *Alternaria* ssp. forms a major problem: early infection during production leads to low returns and high storing losses occur if *Alternaria* invested harvest is stored. Compared to hybrids, 'Atsuko''s sensitivity against *Alternaria* is comparable (ranges in the middle). In addition, infested plants can easily be cleaned on the field so that only healthy plants are used for storage. So far, storage life was successfully tested up to December. Extended storage tests are still ongoing.

For 'Atsuko''s maintenance breeding the Ohio-method is continuously used. The number of individual plants should exceed 30 to circumvent genetic restriction that could cause inbreeding depression. Breeding experiments will continue to optimise *Alternaria* tolerance and disposition to inflorescence emergence. Identification of tolerant lines is enabled as the breeding area is characterised by a high risk of *Alternaria* infection.

Compared to usual hybrids 'Atsuko' has a smaller head, a fact this is often seen positively for marketing to the end consumer. The increased disposition to inflorescence emergence might present a problem. It occurs more frequently with early sowing, at more northern sites and with increased drought stress. So far, commercial tests evaluated the new variety mainly positively.

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