Organic Plant Breeding: What makes the difference?

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Preface

The first ten years of activities of the European Consortium of Organic Plant Breeding, ECO-PB 2001 - 2011

E.T. LAMMERTS VAN BUEREN[1, 2], K.-P. WILBOIS[3]

The idea of establishing the European Consortium for Organic Plant Breeding already originated in 1998 during an international workshop on organic research methodologies with FAO in Frick, Switzerland. The preparations took until 2001 when ECO-PB was officially founded during a meeting of the seven founding members at the Louis Bolk Institute, being: Organic Research Centre, Elm Farm (UK), Forschungsinstitut für Biologischen Landbau (FiBL-CH and FiBL-D), Institut Technique de l'Agriculture Biologique (ITAB-F), Louis Bolk Institute (LBI-NL), Arbeitsgemeinschaft Ökologischer Landbau (D), Danish Research Centre for Organic Farming (DARCOF-DK) and Vitalis Organic Seeds (NL). The aims were and still are a) to initiate, establish, support and maintain organic plant breeding programmes in compliance with the principles of organic agriculture; b) to develop and investigate the concepts and scientific basis of organic plant breeding; c) to develop and promote appropriate standards and practices as well as an appropriate legal framework for organic plant breeding; and d) to facilitate exchange of knowledge and ideas among its members, transfer of information to the public, and lobbying for best parliamentary and administrative policy making. An important aspect of ECO-PB is that it also gives room for new, experimental and unconventional breeding approaches and techniques that comply with organic values.

As a well established organic seed market is a prerequisite to create an interest in organic plant breeding for crop improvement, much emphasis has been put on policy workshops on the Organic Seed Regulation. Six ECO-PB meetings were organised from 2003-2011, with approx. 10-12 European countries attending with 25-70 participants representing ministries of agriculture and

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organic umbrella or certification organisations, organic database managers, and seed producers. From the feed back we received one can surmise that these meetings have been influential and inspiring for the participating Member States to learn from each other and to exchange procedures to move forward towards harmonisation of interpretation and implementation of the European regulation on Organic Seed.

This policy work also includes position papers, letters e.g. to the authorities in Brussels on conservation varieties regulation and the European seed regulation evaluation.

Another significant ECO-PB achievement was the collaboration with the world umbrella organisation IFOAM (International Federation of Organic Agriculture Movement). In 2001 ECO-PB produced a position paper on the evaluation of breeding techniques for suitability for organic agriculture based on the LBI report of 1999 and work of FiBL in 2001. This led to the inclusion of draft standards into the IFOAM Norms and Standards, agreed during the IFOAM General Assembly 2002. After a special workshop on organic breeding standards during the 1rst IFOAM World Conference on Organic Plant and Animal Breeding in Santa Fe 2009, IFOAM is now (2011) opting for (full) Organic Standards so that in the future organic breeders can certify their breeding programs and distinguish themselves in the market with their specific cultivars.

To stimulate knowledge exchange on the results of breeding research and breeding programs several ECO-PB symposia and workshop were organised, often in cooperation with other partners:

ECO-PB Symposium on organic seed production and plant breeding: strategies, problems and perspectives, Berlin-DE November 2002;

COST SUSVAR/ECO-PB workshop on Organic Breeding Strategies and the Use of Molecular Markers Driebergen-NL, January2005;

ECO-PB Workshop on Participatory Plant Breeding: Relevance for Organic Agriculture?, La Besse-F, June 2006;

ECO-PB workshop on Different Models to Finance Plant Breeding, Frankfurt-DE, February 2007;

COST SUSVAR/ECO-PB workshop on Value for Cultivation and Use Testing of Organic Cereal Varieties: What are the key issues? Brussels-B, February 2008.

ECO-PB/ITAB workshop on Strategies for a future without cell fusion techniques in varieties applied in Organic Farming, Paris/ France, April 2009.

Besides these symposia and workshops, ECO-PB supported the 1rst World Conference on Organic Seed in Rome 2004 and the 1rst World Conference on Organic Plant and Animal Breeding in Santa Fe, New Mexico 2009.

In addition to the organisation of symposia and workshops several proceedings and publications regarding the issue of organic plant breeding and seed production as well as the critical analysis of genetic engineering and some further biotechnological breeding methods were produced. The regular ECO-PB e-mail newsletter with 4 issues per year to approx 700 subscribers and the ECO-PB website www.eco-pb.org support the exchange of events and other results. Organic seed production and plant breeding has established itself over the past 10 years. However, still many challenges remain for the coming years both with respect to organic seed production and plant breeding, balancing organic values and market driven forces. The IFOAM EU Group's newly established Task Force Seed in Brussels has expressed the wish to closely cooperate with ECO PB. This proves how important it is that such a specific field as organic seed production and plant breeding is represented by a specialist organisation within the organic sector supported by full member institutes and individuals as associated members

Part A: Oral Presentations

Biodynamic apple breeding

N. BOLLIGER[1]

Organic plant breeding has its beginnings in the 1920s initiated by the biodynamic movement. For quite a long time all work was limited to very few crops, mainly to cereals and vegetables. What about fruit breeding?

A global survey on organic fruit breeding, which I did in 2005, showed that there were only a few projects on that subject.

For more than three decades the organic strawberry breeder Ernst Niederer (Berneck, Switzerland) has been busy in developing new varieties with great success.

In the Netherlands Mart Vandewall, a biodynamic fruit grower and private apple breeder, succeeded (2001) in releasing Collina, a very nice scab-resistant apple.

In 2004 Poma Culta was founded, an association for supporting the biodynamic apple breeding program, which I had begun on my own some years before.

Over the last five years interest in organic fruit breeding has increasingly grown. More and more fruit growers, consultants and last but not least people in the whole food trade are becoming convinced that in future it will be important to have organic varieties. In Germany, associations such as Föko and Netzwerk für ökologische Pflanzenzüchtung have promoted several activities on this subject. This encouraged a group of organic fruit growers around Matthias Ristl (breeder) and Hans-Joachim Bannier (pomological expert for old local varieties) to found an association for participative organic fruit breeding in 2011.

Let's look at Poma Culta apple breeding

As a result of disease problems in my biodynamic orchards, I had the vision of new resistant apple varieties suitable for organic cultivation back in the 1990s. So I became an on-farm breeder. I assume that the ambience of an organic farm is of great importance for my breeding work (maybe research on epigenetic phenomena will prove this one day). In the beginning, I selected seedlings from

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open pollinated fruit trees, but later crossbreeding became more and more important. In addition to observing cosmic rhythms, I have been experimenting with therapeutic eurythmy for the last five years. It appears that these methods can augment the fitness of the seedlings and in consequence the rate of positive cultivars.

Poma Culta apple breeding sows about 3,000 off-spring a year. About 10% of these seedlings pass the selection process and bear fruit after five or six years. Currently, there is one new cultivar being tested at ACW Agroscope Changins-Wädenswil (Wädenswil, Switzerland). Poma Culta has an annual budget of about 60,000 Euro. It is sponsored by several institutions (Sampo, Zukunftsstiftung Landwirtschaft and others) as well as by private donors.

Dehybridizing Hybrids - A Low-tech Breeding Approach for farmer-breeders of vegetables

F. EBNER[1], A. ZSCHUNKE[1]

Hybrid cultivars dominate the available commercial assortment in all vegetable species where the creation of hybrids has been found biologically and technically possible. Hybrid breeding has been the most important tool in transforming seeds from a formerly true cultural good, passed on from farmer generation to farmer generation over thousands of years, into a commercial commodity (Kloppenburg 2004).

Formal breeding companies all over the world have given up the genetic improvement of open pollinated, farmer reproducible varieties (OPVs) in favour of hybrid-programs, leaving behind simpler breeding techniques like population improvement as a "dying breed" (Knight 2003).

Sativa Rheinau AG is a young, purely organic vegetable breeding company in Switzerland, convinced that organic farming needs varieties specifically bred for and adapted to organic soils and demands. They should in addition be reproducible by farmers to permit adaptation to specific needs and to decrease dependency.

However, Sativa uses F1-hybrides as genetic starting material for their organic breeding programs in vegetables because most of the genetic progress of the past decades has been released in the final package of F1-hybrids. Not using hybrides would mean renouncing on all those positive agronomic achievements of intensive conventional breeding that are important in organic growing, too (e.g. yield, earliness, resistances, ease of harvesting or attractive physical appearance).

Breeding programmes using hybrids as basic genetic material were initiated in 2004 in extra sweet (sh2) sweetcorn, carrots, onions, Brussel sprouts, kohlrabi, eggplant and summer squash. Depending on breeding biology, the hybrids in a first step were either selfed (sweetcorn, eggplant, summer squash) or left to chance crossing among each other by insects (carrots, onions and cabbage). Both procedures need some basic knowledge of the crop but little technical input. Yield and uniformity of the F2-generation dropped in varying degrees:

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dramatically in sweetcorn, clearly in carrots to hardly visible in eggplant and onions. These findings correspond well with the established knowledge of strongly varying heterosis from crop to crop.

Yield and uniformity could be increased amazingly fast by simple mass or familiy selection during 3 cycles in the biannuals resp. 6 cycles in the annual crops. It was accompanied by selection on better taste where necessary and possible. In sweetcorn the marketable yield of the hybrid derived populations reach between 85 % in once-over harvest to 95 % when harvested in several in passages reflecting reduced uniformity. Yield in carrots is above 90 % with a strong improvement of taste. Onion yields are equal to hybrids with better storability. In kohlrabi, marketable yield is slightly lower, in eggplant and summer squash slightly retarded in comparison with hybrids.

Using hybrid genetic starting material for organic breeding should not be considered a makeshift or emergency solution. Technically, it is nothing else than selecting in F2-generations of crosses that others have made. Socially, it is just what farmer-breeders have done for thousands of years: adapting genetic diversity created by the last generation to the needs of the next. This constant flow and exchange of genetic diversity is severely threatened by patenting or induced pollen sterility without restorers.

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The Biodynamic Breeding Association Kultursaat e.V. and its Breeding Programs on Partnership Basis

R. Groenen[1, 2] , M. Fleck[1]

Kultursaat coordinates biodynamic vegetable breeding in German-speaking countries. Practical on-farm breeding work takes place in 20 biodynamic commercially run project locations. The breeders involved with Kultursaat are motivated by the need for independent maintenance and development of open-pollinated varieties a) as a base for quality-orientated organic growing conditions, b) as an opportunity to increase food quality and c) as an attempt to guarantee food sovereignty. For about 20 years, our activities have been integrated into the 'Initiativkreis für Gemüsesaatgut aus biologisch-dynamischem Anbau' (approx transl.: Initiative to promote biodynamic vegetable seed breeding') and we have been working in cooperation with our partner Bingenheimer Saatgut AG. Amongst other aspects, 44 new cultivars have evolved so far, all of which were registered by our non-profit association to safeguard them as part of our cultural heritage and to prevent them from falling prey to short-term profit-orientated interests.

Within the 'Initiativkreis', the Bingenheimer Saatgut Company and the non-profit association Kultursaat complement each other. While the main tasks of Kultursaat include maintenance of tested open-pollinated varieties as well as breeding of new cultivars (development and maintenance), the Bingenheimer Saatgut AG is responsible for the propagation, sales and marketing. 300 members - mostly individuals as well as 20 active seed breeders - form the core of Kultursaat; new members are always welcome. The Initiativkreis meets twice a year in order to exchange experience with respect to seed production. Workshops focussing on seed breeding and specific varieties, the so-called 'Züchtungs- und Sortentage', regularly take place on certified organic farms, where horticultural practitioners are able to discuss the particularities of growing open-pollinated varieties with their colleagues. In addition, the motives and approaches of biodynamic seed breeders are presented. The breeding programs are 'public'; one of the basic notions of biodynamic breeders is transparency (Müller 2009), thus the developmental process of each variety

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is published on www.kultursaat.org/ and on www.abdp.org/. In the association's journal, which is published twice a year, seed breeding projects and methods are outlined. A bottom-up approach is applied: in independently organised specialist groups (according to the species bred) breeders come to a decision on how to proceed with the various projects after discussing their individual concepts.

Finances are based on membership fees, donations from trusts, project related government grants, e.g. Program of the German Federal Government supporting organic and other sustainable forms of agriculture and voluntary contributions to promote the development of particular varieties (the equivalent of seed royalties). One special form of support was created in cooperation with the association Naturata International – Gemeinsam Handeln e.V.; since 2008 a number of health food retailers have committed themselves for a ten year period to pass a part of their own earnings from sales in the fruit and vegetable sector to biodynamic vegetable breeding activities without being granted any rights by doing so. Kultursaat is using the financial contributions gained through this FAIR-BREEDING® initiative primarily for breeding work on cauliflower varieties. This vegetable species is especially endangered because of the gradual disappearance of open-pollinated commercially viable varieties on the one hand and because of a massive increase of CMS hybrids on the other hand. At least once a year we conduct round-table-talks with representatives from all sections of the value chain - breeders, growers, wholesalers, retailers, consumers - in order to enter into dialogue about the present state of work as well as necessary future improvements and to plan accompanying measures. Beyond long-term financial support, the FAIR-BREEDING® program provides the opportunity to inform the customer about this complex topic.

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Experiments on the influence of tone intervals on plant growth

U. KIRCHGAESSER[1], M.A. HARING[2]

To investigate the effect of tone intervals on the growth habitat of a plant, imbibed seeds were exposed to different tone intervals for 15 minutes. Seeds were dried and then sown in soil. The first treatment was 2002. Since then, 18 different vegetables and wild plants have been treated and analyzed. There is a strong emphasis on the question whether the influence is established in the following generations. Beside the usual breeders rating lists there is documentation with photos, leave sequences, and analysis with the imaging methods (Bildschaffenden Methoden) and formative forces(Bildekräfteuntersuchung). In 2009, an experiment with *Arabidopsis thaliana* was started. The use of this model plant species should allow linkage of the phenotypic changes to molecular processes. Treated *Arabidopsis* seeds were grown on MS-medium containing agar plates. After 7-10 days incubation in a climate room, root architecture was analyzed using digitalized images of the seedlings. Growth of interval-treated seeds under standard conditions or on plates containing salt (75 mM NaCl) did not differ significantly from control seedlings. However, the differences in field test with the same treated seed batches were significant. These field trials will be repeated this year. On the one hand this will be done to repeat the experiments, and on the other hand to generate new ideas about what to examine on the molecular level. On the conference we will give a brief overview on the trials, with perhaps two or three more detailed results. We will also discuss our attempts to bring the empirical field experiments about „environmental“ breeding methods together with work on molecular level, in order to come to an understanding about what is happening with the plants. Our aim is to develop a breeding method where the intervals can be used to steer the developmental program of a crop species.

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Development of organic maintenance breeding methods of evolutionary populations in cereals

G. KOVÁCS[1]

The use of different, genetically heterogeneous population in organic cereal breeding and cultivation are more and more common in organic farming systems. The different composite cross population developed for example in case of wheat, barley and some other alternative cereals are already introduced in cultivation in several countries, and according to the results they are showing very good adaptability to organic farming conditions. Their yield and quality is highly stable over different environments and years, giving very good economic predictability for the farmers in real practical production. Unfortunately, the methods of variety maintenance in the case of such complex population are still not well developed. During the last decade, the organic maintenance breeding of the genetically homogenous “true” varieties had been successfully developed and in many countries, the organic seed supply is well organised, and the seeds of the successful organic varieties are continuously available for the farmers. On the contrary, the variety maintenance breeding methods for complex evolutionary populations are still missing. To solve this critical problem, an intensive study had been initiated at the Agricultural Research Institute, where the effect of the different variety maintenance breeding methods are studied and compared under organic and conventional production systems, including the study of the effect of different post harvest technologies on the performance of the next generations. The results obtained during the last years will be presented.

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Dignity of the lima bean and consequences for organic plant breeding: What makes the difference?

F. KOCHELIN[1]

Many discoveries in recent years suggest a new picture of plants. Plants communicate and actively interact with their surroundings. They can choose between two different possibilities and change their behaviour. On the cellular level, similarities between animals and plants are far greater than previously assumed. They have an immune system. Their roots can distinguish between themselves and others. Plants and animals have common roots, they developed both from one celled organisms.

"Dignity" in terms of plants is a difficult concept; it is religiously charged and comes from humans' history. The notion could however be understood as a sign, a metaphor, that plants are entitled to a value, a worth independent of human interests. "Dignity" could be a sign that plants are to be respected and that there are also certain obligations towards them.

If we look at plants simply as things, passive machines that follow the same set programs and are only seen as satisfying our interests, then an attribute like 'dignity' seems absurd; it doesn't make sense. But if we see plants as active, adaptable, perhaps even as living beings capable of perception, possessing in their lives a self independent of us, then there is good reason to accept that plants have a 'dignity' that is valid.

Plants experience the world in their own way. They have a life of their own. They are their own selves. This 'self' is hard for us to comprehend, but we can see that it exists. To view plants as entirely disposable objects is to do them an injustice.

Our interaction with plants should not be determined by scientific arguments only. Science is just one path to understanding among others, despite its significance in modern societies. The scientific path is not more important than other paths of understanding.

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[1] biologist, author of „PflanzenPalaver. Belauschte Geheimnisse der botanischen Welt" („Plant Chat. Overheard Secrets from the Botanical World") and „Zellgeflüster", initiator of the ‚Rheinauer Thesen I and II'

Our relationships to plants occur at various levels: at the scientific, humanistic and artistic levels, at the spiritual, intuitive and religious levels, at the emotional and aesthetic levels, as well as obviously as food, the basis for life. It is necessary to be open to these and further approaches.

The relationships we have with plants have meaning for our own way of life. The way we treat plants reflects our attitude towards other living beings and ourselves. The value we give to plants is related to our understanding of ourselves.

Rheinauer Theses II: Breeding as “dialogue”

As a group of farmers, breeders, biologists and philosophers we tried to come up with an ethical recommendation for Organic breeding; a kind of ‘constitution for organic plant breeding’.

Breeding should be a “dialogue” between breeder and plant and her surroundings. A “dialogue” over many years and not just a monologue of the breeder. A “dialogue” also in the social context where the breeding takes place.

Thus Organic Breeding has to respect the organic farming system as spatial limit, the integrity of the cell as technical limit (no manipulations below the level of the cell) and the ban of patents as legal limit.

Organic breeding respects these limits and commits itself to preserve the capacity to reproduce, the capacity to independence and the capacity to evolve.

Epigenetics and organic plant breeding

M.M. MESSMER[1]

One characteristic of process oriented organic plant breeding is that all breeding activities from the initial crosses up to final variety propagation are performed under organic growing conditions, allowing the plant to interact with its target environment across all generations. However, it is often argued that it is sufficient to select under conventional farming and test the released varieties under organic farming conditions. While for maize (Messmer et al. 2009) and wheat (Reid et al. 2010) it was possible to prove that direct selection for yield under organic farming was more efficient than under conventional farming, it is still a matter of debate if all breeding steps need to be under organic conditions. The recent elucidation of environmentally induced epigenetic mechanisms might deliver insight into the scientific basis for target specific breeding.

Plants have an outstanding ability to adapt to their environment. They have to withstand temperature extremes, drought, nutrient deficiency, radiation, as well as pathogens and herbivores. Plants can respond in a highly dynamic manner involving complex metabolic and/or morphological modifications. The molecular mechanisms for these adjustments of the plant to its environment are still not completely understood. While some adjustments are permanent and stable across generations, others are only of preliminary nature, like the acclimatization of a plant to cool growing conditions or the change into the reproductive phase after vernalisation. The DNA sequence as well as its expression pattern in response to stress are crucial for the adaptability of a genotype. Recently discovered epigenetic systems play a key role for genomic gene function at a higher level hierarchy, ranging from transducing environmental signals to altering gene expression, genomic architecture and defence of plants (Grant-Downtown and Dickinson 2006). Until now, three mechanisms have been identified for the epigenetic gene regulation: DNA methylation, histone modification and RNA-interference. These interacting epigenetic systems can regulate expression or silencing of genes, resulting in epigenetically controlled phenotypes (Tsaftaris et al. 2008; Fossey 2009) and are often in conflict with Mendelian genetic models. Epigenetic alleles can

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result from a genome response to stressful environments and may enable plants to tolerate stress (Tsaftaris et al. 2008). While most of these stress induced modifications are reset to the basal level once the stress is relieved, some modifications are stable and mitotically or meiotically transmitted as stress memory permitting heritability of acquired characteristics (Chinnusamy and Zhu 2009). Epigenetic variations can be generated at a much higher rate than genetic ones. Especially under rapidly changing environmental conditions, several new advantageous epimutations may be induced simultaneously in the same individual. Recent studies outlined the importance of epigenetic inheritance as an additional source of variation for selecting superior genotypes (King et al. 2009; Tsaftaris et al. 2008).

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Opportunities and obstacles in building up new breeding programs for organic agriculture in collaboration with the formal breeding industry in The Netherlands

E. NUIJTEN[1], M. TIEMENS-HULSCHER[1], E.T. LAMMERTS VAN BUEREN[1]

Because of the limited scale of organic agriculture in The Netherlands, not many plant breeding companies have programs to develop varieties well adapted to organic farming conditions. In the past five to ten years, the Louis Bolk Institute (LBI) has tried to stimulate, at different levels, the development of cooperative breeding programs for organic culture, with varied success. The aim of the cooperative breeding programs is to make the development of varieties more suited for organic agriculture and economically feasible. Currently a successful program is running for potato, whereas experiences in wheat are less promising, and prospects for programs for vegetable crops, such as cucumber, are limited. A few initiatives by farmers, at a more individual level, are about to deliver new varieties for several crops, such as carrots.

The success of the potato program depends on several factors. 1. There was an urgent, commonly shared problem (serious late blight disasters) which created commitment in the organic sector. 2. The long tradition in which Dutch potato breeding companies and conventional farmer breeders work together. We used this existing network to include organic farmer breeders. The general approach is for the breeding companies to make crosses of which seed tubers are given to the farmer breeders to select in for 3 to 5 generations. The selected bulbs are then returned to the breeding company for further testing at multiple sites. 3. A successful potato selection course set up by LBI to stimulate organic farmers to become involved in potato selection. 4 Farmer breeders do not need to invest in sophisticated equipment for planting harvesting and selection for quality related traits. Evaluation for disease resistance and yield is conducted by the company breeders in the following selection stages. 5. Potato is vegetatively propagated so farmer breeders do not need to worry about segregation in the next years of selection which makes selection relatively easy.

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The past five years LBI has been involved in setting up breeding programs for spring wheat to develop varieties with good baking quality. Spring wheat is a small crop in the Netherlands and Dutch breeding companies have not invested much in its improvement because of the limited profit margins. Seed production is relatively easily done by farmers. However, selection of breeding lines is more complicated due to segregation in the next generations (contrary to potato). Besides, a farmer would need to invest heavily in special equipment for harvesting small plots, processing and assessing traits related to baking quality. Hence, a collaborative approach was set-up in which several breeding companies, farmers, traders and bakeries were involved. A complicating factor is that the various stakeholders have diverse interests. Without a (neutral) facilitator to keep common commitment, the initial collaboration came to a stand-still.

A different approach is illustrated by a case in which a single Dutch farmer breeder, supported by the KulturSaat Foundation in Germany, has been making selections in existing populations of carrot under bio-dynamic conditions. His cooperation with Bingenheimer Saatgut AG ensures that his new selections, when evaluated positively, will be included in the catalogue. Without too much investment he is able to select for taste and cooking properties. For other crops that are currently developed as F1-hybrids, like cucumber, yet different strategies need to be looked for. Cucumber requires more sophisticated breeding tools. Findings so far suggest that it will be a challenge for breeding companies to find out how to adjust their programs to develop varieties more suitable for organic agriculture. Other stakeholders in the market chain are willing to support the breeding companies. We have analysed, through a comparative approach, the main factors that contribute to the success and failure of various initiatives. Crucial factors are the historical context and institutional organisation of breeding, the complexity of the market chain, and a shared sense of urgency for cooperation. Intertwined with these factors are crop traits and crop multiplication. Although each crop has specific plant traits and a specific farming context, general lessons can be drawn from these comparisons for future initiatives for other crops.

Winter Pea Breeding in Intercropping and Mixtures with Cereals

U. QUENDT[1], K.-J. MÜLLER[2]

Winter peas have been showing favourable traits for sandy soils and early spring droughts. But real winter hardiness can be found predominantly in old fashioned fodder peas like Austrian winter pea types. This means tall plants, leaves with three pairs of leaflets and a terminal tendril, coloured flowers and low TKW (Urbatzka et al. 2008). Coloured flowers are linked to dark pigmented seed coat with usually a high content of tannins which interfere the digestion process of monogastric animals. Otherwise, for polygastric animals there are several advantages of high contents of tannins in feed like stabilising proteins in rumen (Urbatzka 2010). Until now there aren't winter peas for use as grain protein livestock feed with sufficient winter hardiness available. At Cereal Breeding Research Darzau, first steps to do breeding of grain protein winter peas are done.

In the beginning, the first question was how to realise a breeding scheme without chemicals and cropping on a fence, as normal for peas. The solution now is to grow winter peas in intercropping with rye in the nursery. Rye grows tall enough to show the longest pea plant in its full dimension. In one plot there are now maximal 10 pea plants with 60 rye plants per square meter. A plot in the nursery has 6 rows. To increase the standing ability and discriminability, we plant peas in row 2 and 5 only. Rows 1, 3, 4 and 6 are planted with rye only. In this system, peas are stabilised through climbing on the rye plants and can be distinguished easily. Usually winter peas are sown from early September till October. Winter peas start growing and spend winter in small plants shortly above ground level. Winter peas in lone stands show sparse soil covering. That means there is a huge competitive pressure by weeds. Hereby, another advantage of the intercropping system with cereals was shown by protecting winter peas from overgrowing weeds.

In the ongoing breeding program at Cereal Breeding Research Darzau, white and coloured flowering winter pea with a high overwintering ability are selected. Beside the flowering colour there are several types available short and

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long stems from 70 to 180 cm with short and long internodes, normal and semi-leafless (afila) types and so forth. This diversity of winter peas comes from progenies of several hybridization of modern high quality white flowering spring peas and coloured fodder winter peas.

In addition to winter pea intercropping, in our nursery progeny lines were tested in field trails in mixture with triticale in growing season 2009 and 2010 and with triticale, wheat and rye in growing season 2011. We found out that in mixture cropping even winter peas that completely failed due to some reason, the cereal component could substitute the pea component, so that never a zero yield occurred. Furthermore, in growing season 2009 and 2010 a highly significant negative correlation was observed between pea and cereal yield. In summary, it can be stated that if there is a high yield on pea there will be a low yield on cereals and vice versa.

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Corporation and synergy between organic and conventional breeders at Vitalis Organic Seeds.

J. VELEMA[1]

In the Netherlands several seed companies are involved in breeding and seed production of certified organic vegetable seeds. The way they are organized is very different. Vitalis Organic Seed is an independent, 100% organic company but owned by an international conventional vegetable seed company, Enza Zaden. This context offers possibilities for synergy between both organic and conventional breeding. As in vegetable breeding there is more pressure on both demand and supply, the life cycle of varieties is shortening and investments in plant breeding are increasingly rapid. Although the budgets for breeding are extensive, in commercial seed companies they are always related to seed sales. So if the market share for organic seed is 5%, not more than 5% of the breeding budget can be spend for organic projects; this is not much when organic growers need an even wider diversity of varieties than in conventional agriculture.

Vitalis has developed a flexible corporation with the breeding department of Enza, so that with limited costs organic varieties (or suitable varieties for organic agriculture) can be obtained. We select new varieties in different ways: a) Successful conventional varieties are tested for organic conditions. These are varieties which are available in both conventional and organic seed; b) Experimental lines from conventional breeders are evaluated under organic conditions. This can lead to exclusive organic varieties; c) After communication, the conventional breeders look in earlier generation for specific lines for organic trials. They even can make specific crossings. After organic trialing this can lead to organic experimental lines or varieties; and d) The next step is selecting plants under organic conditions. In these examples, except for the last point, no organic plant- or line selection is made during one or more generations. Only evaluation of genotypes under organic conditions is included. The advantage of this is that we can test a wide range of genotypes under organic conditions at low costs (no seed production of lines, genetic information about resistances is already available).

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Evaluating breeding lines and experimental varieties under organic conditions turned out to be not only interesting for our organic-, but also for our conventional breeders, as the moderate organic fertilized fields provide a more discriminating selection environment for complex traits (e.g. field resistance, robustness) than rich fertilized conventional fields. This was, for example, very clear in lettuce and leek trials, where under organic conditions various diseases or physiological disorders developed rather slowly and many more differences between phenotypes with different levels of field resistance or tolerance could be distinguished. In conventional fields, fewer differences were found when the field was infected, or no expression was found in case of chemical disease control.

Also organic trial fields can contribute to high quality phenotype evaluation for breeders, both for our organic and conventional breeding programs. This synergic aspect within our corporation has become a new element in our organic breeding strategy. Although it is not calculated in money, it benefits conventional breeders.

The flexible way of integration and synergy of organic and conventional breeding projects makes it possible that the development of organic varieties can be achieved at much lower costs than what is possible in separate organic breeding projects, with a budget based on the share of organic seeds in total seed sales.

Family Inter-Crossing: a useful new breeding concept?

B. VOSSELMAN [1], L. MERTENS[1], B. GIEU-ARBARET[1]

All breeders are confronted with the requirements of uniformity (DUS criteria) to register new varieties. The traditional ways of breeding such as mass selection and different family selection methods are extremely time consuming, especially if the most important traits can only be observed after the flowering period. Therefore in the pumpkin (*Cucurbita maxima*) breeding program of the Bolster, Bart Vosselman started with a new breeding concept called Family Inter-Crossing (FIC). In 2007, after only four years of breeding, the first FIC-variety was released on the market. This pumpkin variety is called FICTOR and rapidly became one of the most popular organic pumpkin varieties in the Netherlands.

Such a FIC variety starts by producing a lot of inbred lines by selfing in order to select the desirable traits (for example the fruit size or storability) and reach uniformity. These inbred lines originate from the same genetic source (in this case, a landrace). After two generations of selfing, the best inbred lines were selected. The following year, crosses were made to test the combining ability. Two groups of inbred lines showing the best combining ability were chosen. Within each group, the inbred lines are directly related (they are `sister` lines). The next generation, the two groups of inbred lines form the two base families of the FIC-variety.

In practice, the rows of base family 1 are sown next to the rows of base family 2. Just before flowering, all male flowers from the maternal family are removed by hand. Pollination between the two families occurs by insects. No flowers are removed from the father family. So it is actually a production similar to the production of an OP variety. At the Bolster, the father family used is the new developed pumpkin OP variety called Solor. The breeding process is much shorter (at least 2 to 3 years) compared to other breeding methods. The parental lines originate from the same genetic source, so uniformity is more easily obtained. By crossing the two families, inbreeding depression is countered or in other words heterosis occurs. As it is not a F1-hybrid, uniformity will be less

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than 95 %. Family Intercrossing has been accepted in the Netherlands, by the NAKtuinbouw, as a new variety concept. The uniformity requirements used are the same as those of an OP variety.

It is an efficient way of developing a new variety and to reduce production costs and the price of seeds.

Organic breeding has to be innovative and productive, more research and new ideas are necessary. With this presented concept we hope to inspire other organic breeders.

New hulless spring barley 'Pirona' and how it was developed under organic farming

K.-J. MÜLLER [1]

Loose smut often stopped organic seed multiplication of our variety Lawina. Up till now there is no satisfactory organic seed treatment available and resistance is the only choice. But loose smut is not the only challenge for organic breeding. During the last decade, different methods had to be developed on a low cost budget base at Cereal Breeding Research Darzau to select also for resistance to barley leaf stripe, covered smut and fusarium head blight. Weed competitiveness had to be implemented in the selection procedure, even if there were no weeds. Last but not least, methods to distinguish quality characters had to be developed, adapted and compared. With respect to human nutrition, starch viscosity, soluble fibres, formative forces, taste and baking ability in relation to baking parameters were studied to find the right goal for breeding as food. At the end variety 'Pirona', which is under release in Germany, came out of this as a further step towards better varieties for organic farming and use for food and feed. 'Pirona' is more or less resistant to mildew, net blotch, barley leaf stripe, loose smut and fusarium head blight. It has middle-high starch viscosity, is complete hulless threshing with a shiny grain of mild taste. It can be added to breads with wheat or spelt in higher amounts than any other available barley. Last but not least the yield level of modern varieties was also reached. In the presentation, the different methods developed during selection procedure of 'Pirona' will be explained and how they were implemented in a certified organic breeding procedure.

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Part B: Poster Presentations

Organisation and Financing of Plant Breeding for Organic Farming

K. GILBERT[1], K.-P. WILBOIS[2]

Organic agriculture is particularly in need of using superior seeds and species that are especially suited for organic farming. Due to the small number of organic farms, investments in research and development of seed especially suited for organic farming is not financially attractive. Furthermore, the worldwide framework requirements in politics, seed law and economy seem to strengthen large plant breeding companies, while removing "small cultivars" from breeding businesses' portfolios. Our objectives of this explorative study were to (1) identify recent financial approaches as well as newly developed organizational approaches towards the support of organic plant breeding and (2) identify resulting challenges.

Multiple empirical methods (Multi-Mix-Method) were used to produce a current qualitative picture of state of the art (Lamnek 2005). Along with literature research, research included data collection from propagators and processors. Participatory observation conducted at working group meetings at one organic farming association and guided interviews with the decision makers of the same association and two group discussions for the BÖL project "network of eco-plant breeding" indicated current challenges. Following Mayring (2005), a problem-stakeholder oriented reductive content analysis was undertaken.

Breeding initiatives in the biodynamic area define seed as cultural and common good. Thus the variety holder is a non-profit organization. Financial resources (field trails, laboratory, machines) of breeding initiatives in the organic sector are scarce. Only a few public breeding research projects explicitly address the specific requirements of organic farming. Additionally, lack of resources hinders participation on research projects. License returns by selling seed are small because of the miniscule market. Exemplary patterns of financing exist between breeding initiatives and specific stakeholders of the organic food chain as well as organizations close to organic farming. They offer support by way of voluntary licenses, donations, foundations, membership fee and fundraising.

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Fundraising meets the limits of feasible budgets. It is aimed to enlarge fundraising, along with new breeding and maintenance initiatives which also demand funds. Presently, a complete breeding portfolio is not possible. Moreover, a fundamental improvement of financial situation is not foreseeable in the near future. The fact that products are produced with organically seeds is tried becoming a tool of marketing for organic farming associations. However, until now processors treating vegetables and cereals made of organic plant breeding do not have a competitive market advantage.

Within organizations of organic farming, matters of plant breeding and the access to organically plant breeding are becoming increasingly central themes. Often involved organizations are positioning with respect to acceptance of breeding methods and setting own definitions of "plant breeding under organic conditions". The organic sector in Germany continues to struggle with this theme as lone fighter with particular interests. Regarding potential fundraising and breeding partners, the balancing act between idealism and pragmatism is challenging and is sometimes affecting conclusionary to new partners. Unfortunately, a debate amongst decision-makers leading the organic farming movement in Germany could not yet be observed. Further, political empowerment is weak.

Recommendations include stronger organizational efforts and the support of an open network that embraces both organizations and institutions. Furthermore, stronger cooperation beyond the organic sector would be a useful gain to benefit from infrastructure. Thus, aspects in breeding, important for organic farming systems, could be enhanced in breeding efforts of conventional breeding companies and state-run research institutes. An implementation of further breeding and variety matters into organic farming associations or EU organic farming guidelines should be checked again. Finally, in order to maintain a level of trust, the organic sector must address the contradictory problems in the organic plant breeding sphere with open communication.

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Influence of seed treatment with eurythmic consonants on the growth habit of lettuce

C. HENATSCH[1]

A starting question for the trial has been whether it is possible to change the growth habit of plants through etheric forces – brought to the plants through the human being. "Etheric forces" mediated through p.e. cosmic constellations, tones, substances, eurythmic gestures. During the last eight years, several trials were made. Questions have been: Is it possible to change the growth habit of a plant this way? Is it possible to strengthen/intensify the vital forces of a plant? Is it possible to interpose cosmic influences through eurythmic gestures? In the trial described here, lettuce seed was treated with 12 eurythmic consonant gestures. The influence on head formation has been observed during three generations.

Methods

For the eurythmic treatment, seeds of a single plant (butterheadlettuce, Variety "Cindy") were soaked in water for half an hour. 13 portions were made – one was left untreated, the others were each treated for 5 minutes with the different eurythmic consonant gestures (W, R, F, T, D, B, C, S, G, L, M, N) cultivation steps were done on the same day (sowing, prikking, hoeing, harvesting). Seeds of three plants have been taken from every treatment and have been cultivated in three following years and generations without extra treatment. The investigations shown here have been done at the third generation after treatment. 30 heads have been planted in two repetitions; for B, L and the untreated line, the trial has been repeated on three extra planting dates in the same year.

Investigation and data recording has been done on outer appearance (characterisation of four people), weight, diameter, size of the inner head, height and compactness.

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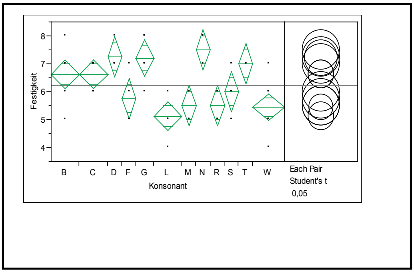
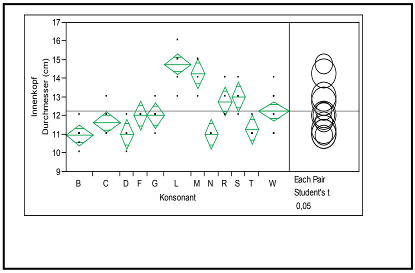
Results

The characterization shows that the plants of each treatment perform in a characteristic way: B, D, G and T form very compact and dense heads while ones treated with L, M, (R and W) give heads with more loose stratification. The differences in weight, size, diameter of inner head, hight and compactness) are clearly visible and statistically significant. Between the extrems (L and B, N) the differences are highly significant.

oneway analysis of compactness:



oneway analysis of diameter of the inner head:



Discussion

The trial shows a visible and measurable influence of the eurythmic treatment (one time, five minutes) of lettuce seeds on the attributes and quality of the headformation.

This influence is not only present in the year of the treatment – but the following generations (up to four now without extra treatment). How can we explain the durability through generations (in older trials up to seven) of an “etheric influence” brought to the plant from the outside? What, or who, is working/operating there?

Estimation of differences in plant nitrogen content under organic and conventional farming: development of selection method

A. KOKARE[1], I. BEINAROVICA[1], L. LEGZDINA[1], A. KRONBERGA[1], V. STRAZDINA[2], Z. VICUPE[2]

Organic farmers require varieties that are adapted to specific low input soil management system and are efficient in nutrient uptake under organic conditions. The readily available amount of nutrients is often lower in organic than in conventional farming systems. The use of organic (green and stable) manure makes the availability of nutrients less controllable. This might result in lower yield stability. The effective nitrogen (N) uptake ability of varieties is an important trait in selection and evaluation under organic conditions. The aim of trials was to determine differences in N uptake between cereal genotypes under organic conditions and to develop method applicable in selection for this trait. The field trials in organic and conventional management systems were carried out in 2010 at the State Stende Cereals Breeding Institute and State Priekuli Plant breeding institute. Twenty genotypes (cultivars and lines) of each: winter triticale, winter wheat, spring barley and oats were included in the experiment. The estimated index of N content in plants according to Cerling (1980) was evaluated at the development stages EC 32 (beginning of stem elongation) and EC 60 (beginning of flowering) under conventional and organic growing conditions. At beginning of flowering stage, the same samples of plants were taken and N content in plants was analyzed in by Kjeldahl method. The preliminary results of experiment (one year data) showed that there were no differences in plant N content at beginning of stem elongations stage between organic and conventional growing conditions. At the beginning of flowering stage, significantly lower N content was estimated for cereal genotypes grown under organic fields compared to conventional ones. Also the results of analytical testing showed lower N content in plants grown under organic conditions. Differences in N content between genotypes under organic conditions were found. The oats showed in average 39% and spring barley – 34% lower N content in plant under organic conditions compared to

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conventional. For winter cereal crops the decrease of N content in plant was less- wheat – 27% and triticale – 23 % respectively. Under organic conditions, N supply index at beginning of flowering correlated positively with N content in plants for all crops included in the experiment (oats $r = 0.291$, NS; barley $r = 0.453$, $p<0.05$; winter wheat $r = 0.476$, $p<0.05$ and triticale $r = 0.528$, $p<0.05$;). It supports the use possibility of the N content index in selection of genotypes for N uptake ability. No correlation between N content in plants, grain yield and protein content was found.

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Do selection results differ in organic and conventional conditions?

A. KRONBERGA[1], V. STRAZDINA[2], Z. VICUPE[2]

Several investigations were started in the last decades with aim to elaborate selection criteria that facilitate breeding of varieties for organic agriculture. However, because of expected genotype by environment interaction more research is needed to define the best selection environment for selecting organic varieties, but little research has been done on this issue (Lammerts van Bueren et al, 2007).

Because the breeding strategy for different species for organic farming is not clear yet, different experiments are being conducted. Some of them consider that breeding of varieties suitable for organic conditions should be carried out under organically managed land (Reid et al, 2009).

Experiment with triticale, wheat and oat breeding lines was started parallel under organic and conventional growing conditions. The same lines were grown under both conditions and selection of the best lines according to breeders' opinion with a respect to suitability for organic conditions was done. 100 F5 winter triticale lines, 110 F3 and F4 winter wheat lines and 100 F4 oat lines were selected from conventional breeding material in 2009 and sown in two different conventionally and organically managed fields. The conventional field was treated according to standard agricultural practices, including the use of herbicides and synthetic fertilizers. During the vegetation in 2010, different traits essential for organic conditions were evaluated for genotypes in both growing systems: winterhardiness, resistance to diseases, time of maturity, weed suppression ability as well as grain quality characteristics and plant productivity.

The preliminary results showed differences in breeders decisions about best genotypes selected in organically and conventionally managed fields.

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For triticale 10 breeding lines from organic growing conditions and 11 ones from conventional growing conditions were selected: 6 of them were selected in common from organic and conventional field.

For wheat 16 lines from each growing conditions were selected. Only 3 genotypes where selected in common from both fields.

From 100 evaluated oat genotypes, 10 lines were selected in each growing conditions. Only one line was selected in common from organic and conventional fields.

The evaluation of selected oat, triticale and wheat lines from each field is being continued under organic growing conditions for two growing seasons.

This study was performed with financial support of European Social Fund co-financed project 2009/0218/1DP/1.1.1.2.0/09/APIA/VIAA/099.

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Making potato breeding feasible for organic agriculture in the Netherlands

E. T. LAMMERTS VAN BUEREN[1], C. ENGELEN[2], M. TIEMENS-HULSCHER[1], R. HUTTEN[2]

After many years of severe late blight infestations, some 20% of the Dutch organic potato growers banned potato out of their cropping system. In 2007 the organic sector realised that it urgently needs better adapted and late blight resistant cultivars to deal with the constraints of the low-input organic farming system and the pressure of late blight without using copper treatments. Conventional breeding programmes do not generate (an appropriate number of) such varieties and commercial breeding companies cannot set up separate breeding programmes for the limited area of organic potato production in the Netherlands. To overcome this problem a joint organic potato breeding programme BIO-IMPULS started in 2008, bringing together all expertise and partners in the chain: six commercial potato breeding and trading companies, organic potato growers and breeding researchers of Louis Bolk Institute and Wageningen University.

We built on an unique collaborative structure that traditionally exists for potato breeding in the Netherlands. Here farmer-breeders conduct selection in the first three years in progenies (clones) of crossings made by commercial breeders, and return the selected and promising clones to the associated breeding company for further testing and selection towards cultivar registration and marketing. By this system, the Dutch potato breeding sector has gained great importance worldwide. Currently, the number of farmer-breeders still counts some 150 farmer-breeders. The importance of this collaboration can be expressed in the fact that almost 50% of the current cultivars grown in the Netherlands are from such collaborations between farmer-breeders and commercial breeders. The farmer-breeder collaborates on a no-cure, no-pay base, but as soon as he has managed to select a marketable variety he shares the royalties on a 50-50% base with the involved breeding company through a contract agreement.

The yearly selection effort of organic farmer-breeders reducing 90-95% of the initial clones during the first three years of selection starting each year with

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500-1500 or sometimes even 8000 clones/year, makes it economically attractive for commercial breeders to integrate more attention for cultivars suitable for organic farming in a commercial setting. In four years time 11 organic farmer-breeders have now joined the program. To support farmers training courses have been organised, and current available experience in farmer-breeding in potato is collected in a manual.

However, public funded pre-breeding program to introgress 10 new sources of *Phytophthora infestans* resistances that have been identified from wild relatives in earlier projects by Wageningen University into useful genitors, is a necessary precondition for success and is a crucial part of the Bioimpuls program, such as *Solanum bulbocastanum*, *S. edinese*, *S. brachycarpum*. Yearly we make some 300 new cross combinations for commercial crossing and genitor development, and distribute 20.000 seeds/year among the partners for selection and additionally 20.000 seeds/year are selected by the involved researcher-breeders.

BIO-IMPULS will not only focus on late blight resistance but includes other important traits for varieties adapted to organic growing conditions, such as N-efficiency, rhizoctonia, scab and early blight resistance, and early tuber setting and bulking.

Acknowledgement

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Participatory cotton breeding for organic and low input farming in India

M.M. MESSMER[1], T. RONER[2], M. FINCKH[2], D. FORSTER[1], R. VERMA[3], R. BARUAH[3], S.S. PATIL[4]

Organic cotton production currently takes place in 22 countries resulting in 241'697 metric tons of fibre and 1.1 % of the global cotton production (Truscott et al. 2010). Up to 80 % of world's organic cotton is produced in India. However, this market is threatened due to the displacement of traditional cotton species and cultivars by genetically modified (GM) hybrids selected for high input farming. Organic cotton farmers are facing increased difficulties in finding suitable cultivars in India (Nemes, 2010). Moreover, there is a big risk of physical and genetic contamination of organic cotton with GM cotton and the loss of locally adapted genetic resources. Therefore, fast action is needed to re-establish a GM-free seed chain and breeding programs for cultivars suited for organic and low input farming conditions.

Participatory plant breeding (PPB) offers a great opportunity for developing locally adapted cultivars as well as for maintaining and increasing genetic diversity (Kotschi, 2010). The close collaboration of farmers with breeders and extension agents in variety development allows the identification of cultivars that suit the actual circumstances of the resource-poor farmers where marginal production systems prevail (Gemuchu and Muhammad, 2010). The main goals of this study are (i) to introduce participatory breeding approaches, (ii) to test improved cotton cultivars in smallholders' organic cotton fields and (iii) to gain information about the suitability of different types of cotton cultivars for organic and low input farming conditions in Central India. The study is conducted in collaboration with bioRe India an organic cotton producer and the University of Agricultural Sciences (UAS) Dharwad. Different types of cotton cultivars are tested in replicated field trials at the research station of bioRe India (on-station) and at farmers' fields (on-farm) of an established network of farmers involved in participatory technology development (PTD). In experiment I, the dominating tetraploid *G. hirsutum* hybrids are compared with

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G. hirsutum varietal lines, native diploid *G. arboreum* varieties and interspecific hybrids under high and low input conditions on-station to test for genoytype x management interaction. In experiment II, five *G. hirsutum* hybrids are tested by 20 organic cotton farmers of the PTD network in their fields representing different soil fertility levels. Evaluation and selection process of the farmers are accompanied by detailed farmer's interviews and comparison with data obtained from the on-station trial. In experiment III, 20 *G. hirsutum* varietal lines, 5 intraspecific *G. hirsutum* hybrids, 6 interspecific hybrids, 5 *G. arboreum* lines, and 5 *G. hirsutum* compact hybrids are tested under organic farming with two replication at one location to identify the advantages and disadvantages of the different types of cultivars under organic farming conditions. In experiment IV, F2 progenies derived from five different *G. hirsutum* crosses will be tested for genetic segregation with respect of plant architecture and other characteristics on single plant basis under organic conditions. First results of the on-going experiments will be presented at the meeting.

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Improvement of organic wheat breeding materials with the use of *Triticum timopheevii* gene bank accessions

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The negative effects of global climate change are expected to be more pronounced in organic agricultural systems, where the resources needed by the crops are mostly limited, resulting in greater susceptibility. To prevent the yield losses caused by biotic and abiotic stresses, it is necessary to use sources of resistance genes. Wild species related to cultivated bread wheat (Triticum aestivum L.) are important sources for improving resistance to these stresses by increasing the genetic diversity of the wheat breeding base. Tetraploid wheats with the genome formula AAGG are representing the timopheevii group (Triticum timopheevii Zhuk.) of the genus Triticum, which is one of the most promising sources of wheat breeding. The Cereal Gene Bank of the Agricultural Research Institute of the Hungarian Academy of Sciences (Martonvásár, Hungary) preserves more than 50 timopheevii accessions, including 2 subspecies (ssp. timopheevii; ssp. armeniacum) and 8 varietas forms, which have been described in recent years, in order to select ones that are conducive to the improvement of organic wheat breeding.

The *timopheevii* accessions were examined for morphological traits (e.g. heading date) and for resistance to the main biotic and abiotic stresses. The morphological parameters of the accessions may determine their tolerance of abiotic or biotic stresses (e.g. thick pubescence), and their suitability for cultivation (e.g. plant height, ear type). There are several resistance genes on G genome chromosomes providing outstanding resistance to fungal diseases (e.g. powdery mildew, leaf rust and stem rust), which can be introgressed into modern bread wheat lines. The accessions were examined under organic conditions, where the incidence of stress factors is higher than under conventional agricultural conditions, in order to obtain a clearer picture of the differences between the accessions.

On the basis of our recent results we had selected one of the *timopheevii* accessions (*Triticum timopheevii* Zhuk. *var. rubiginosum* – Accession No.:

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MVGB845). As *timopheevii* genotypes are tetraploid forms, and direct hybrids with bread wheat are normally sterile, a further aim was to develop a bridge crossing system for transferring desirable genes into bread wheat. The main strategy is to create a synthetic amphiploid wheat by crossing the selected line with a semi-dwarf, pre-bred einkorn line (*Triticum monococcum* L. *ssp. monococcum* – 1T-1), which was selected for its high crossability with various *Triticum* species. Almost 2000 flowers were pollinated, resulting in 255 F1 hybrid seeds (seed set: 13%), which had a germination rate of 91%. As the hybrids are triploids, genome doubling was carried out, which was partly based on cold treatment during flowering and fertilization in phytotron chambers. For cytological research purposes colchicine based genome doubling was also applied. The first method is less effective than the colchicine treatment, but gives acceptable number of fertile hexaploid progenies. After these treatments and after self-pollination one part of the F2 progenies is now being grown in the fields, the other part is under controlled conditions in climate chambers, in order to multiply them.

The new synthetic amphiploid has a similar genome composition to that of the naturally occurring species *Triticum zhukovskyi* Men. et Ericz. (AAGGAA), giving the chance not only to improve the bread wheat breeding materials, but also to increase the very limited genetic variability of this natural species.

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Agro-morphological characterization of traditional tomato varieties grown under organic cultivation techniques in two regions of Spain

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In the last few years, traditional horticultural crop varieties are becoming popular due to raise awareness about the global biodiversity lost, including agricultural biodiversity, the traditional heritage knowledge associated to these varieties and their territorial significant values. In this context, but also considering the possible climatic changing conditions in the future, organic farmers and consumers are showing an increasing interest in the access and sustainable utilization of a wide range of plant genetic diversity for low-input agricultural local production and in-situ conservation. The present paper pretends to provide farmers, breeders and the public administrations with useful additional information from the results obtained of the agro-morphological characterization of 6 tomato varieties, grown outdoors in two regions of Spain according to IPGRI/FAO descriptors. It is observed in the characterization that some morphological parameters vary for the same variety and one location to another. The results are part of a broad study which evaluates agronomic and quality characters of 60 traditional and commercial horticultural crop varieties grown under cultivation management throughout participatory research in collaboration with farmers.

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Screening of certified German and Austrian oat varieties for resistance to loose smut from 2009 to 2011 as a precondition for breeding of new oat varieties for organic agriculture

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Loose smut of oat is a problem in the organic seed propagation and can also lead to significant yield losses under organic conditions (Menzies et al. 2009). According to the German seed law (Saatgutverordnung), the maximum number of smutted panicles on 150 m² are 3 for basic seed and 5 for certified seed (BGBl I 2006). Therefore it is a goal of the oat-breeding initiative on the 'Dottenfelderhof' to develop new oat varieties with a high resistance to loose smut. For this purpose it is necessary to identify the resistance level of the different certified varieties because these varieties are very often preferred for the development of new varieties.

Oat (*Avena sativa* L.) cultivars, presently available on the German and Austrian market, were tested for resistance to loose smut (*Ustilago avenae*) after artificial inoculation according to Nielsen (1976) in field trials in 2009, 2010 and 2011. Since screening for loose smut does not take place in the evaluation of new lines for registration for commercial production in Germany, the results are a useful addition to the official variety screenings. In 2009/10 the cultivars were inoculated under partial vacuum at -800 hPa with 1 g spores/litre water. In 2011 an increased concentration of 5 g spores/litre water was applied. At plant maturity the percentage of smutted panicles was determined. In all three years the seeds were planted relatively late (middle of April instead of February).

In the case of resistance tests a maximum infection of the check-cultivars is desirable. The check-cultivars (Aragon, Cavallo, Panther) had a mean infection rate of 20.9 % in 2009 and 6.5 % in 2010 which was relatively low. In these years only the cultivar Azur showed no infection. In 2011 the infection rate of the check cultivars after inoculation with increased spore concentration was 72.7 %. In this year all of the cultivars were infected while five cultivars had less than 10 % smutted panicles (Azur, Alonso, Auteuil, Curly, Zorro). All

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other cultivars had more than 20 % smutted panicles. The maximum rate was reached by Cavallo (78.8 %). Five other cultivars showed more than 70 % infection (Flämingsprofi, Auron, President, Flocke, Galaxy). The coefficient of determination (R^2) between the three different years is relatively low (2009/10: 0.36; 2010/11: 0.30; 2009/11: 0.42).

The results show the necessity to incorporate resistance against loose smut in oat-breeding programmes for the organic market because only few cultivars can be recommended for organic seed propagation. In case of low or no infection, the testing should be repeated over several years.

Furthermore the method of variety screening for resistance to loose smut is also being used for the testing of new breeding lines and thus helps to identify resistant lines suitable for organic seed propagation. For this purpose it would be desirable to build up cooperation with oat breeding initiatives on other locations where different races of loose smut are present.

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Marker assisted breeding and mass selection of wheat composite cross populations

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Utilising diverse populations instead of single line varieties is expected to lead to a number of advantages in cereal production. These include reduced epidemics of plant diseases, improved weed competition and better exploitation of soil nutrients, resulting in improved yield stability. However, a number of challenges must be met before diverse wheat populations can be introduced into commercial wheat production: one of these is the development of breeding technologies based on mass selection which enable breeders and farmers to improve specific traits in populations and maintain diversity at the same time.

BIOBREED is a project started in Denmark in 2011 to meet these challenges for wheat population breeding. The project is focusing on the development of tools and methods for mass selection of traits relevant for organic and low input production, as it is expected that the highest benefits by utilizing diverse populations can be achieved there. These tools and methods include the development of genetic markers for common bunt (*Tilletia caries*) resistance and for traits affecting baking quality, such as gluten content and seed hardiness, as well as for the content of nutritive components like anthocyanin and phytate. The development of a composite cross population both with and without common bunt stress will be observed by means of molecular markers and disease readings.

Resistance to common bunt

The project is screening a selection of 300 wheat varieties for resistance to common bunt in the framework of an association analysis based on field data and DArT marker data. A specific study in a doubled haploid population from the cross between PI 554099 (carrying the Bt-9 gene of resistance) and the susceptible variety Cortez (Wiersum, Netherlands) segregating for the common bunt resistance gene Bt-9 aims at the localisation of this gene.

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Composite crosses

A number of 218 crosses have been made between 30 varieties with a moderate to high degree of bunt resistance. These crosses are now in F2 (169 crosses) or F3 generation (49 crosses). The F3 generations are grown as a bulk population both with and without bunt infection. The diversity of the composite cross population will be assessed by molecular markers, and changes in population structure when growing the populations with and without common bunt infection will be followed using these markers. Head rows of the crosses will also be grown separately, and so far 20 heads of 44 of the F3 generation have been grown with bunt infection. The distribution of bunt resistance between the head rows will give some hints to the underlying genes determining common bunt resistance.

The seed of the populations will be sorted prior to sowing on a gravity separator and by single seed separation based on near infrared transmission (NIT) in order to remove lines with inferior quality traits like low seed hardiness and low gluten content. The genetic markers developed in the association analysis will be applied to the composite cross population.

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Development and organisation of organic PPB activities in Denmark

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A research project aiming at developing and organising participatory plant breeding activities in Denmark has recently been initiated. The research will be carried out as a Ph.D. study, over a period of three years and is financed by Aalborg University and Organic Denmark - an interest organisation for organic farmers, companies and consumers.

In Denmark there are only few people engaged in organic plant breeding and very few plant breeding activities are taking place that are customised to organic farming systems. However, currently there seems to be an increasing awareness and interest among some stakeholders in changing this state of affairs. The research project described here can be seen as one example springing from this interest. It was formulated and funded as a result of a development project carried out by Organic Denmark in 2010. The development project aimed at engaging farmers, companies, legal authorities and breeders in articulating strategic areas of importance for developing organic plant breeding activities for organic farming systems in Denmark. A number of strategic areas of importance were identified, one of them being the development of new ways of organising plant breeding activities for organic farming systems that engages stakeholders in new ways compared to today's formal breeding practices. The research plan described here focuses on the organisation and development of organic participatory plant breeding (PPB) activities in Denmark. The research project aims to explore a variety of cases of plant breeding that involves organic farmers, mostly in Denmark. The aim of the case studies is to gain a clearer understanding of how such breeding activities are organised, of the learning processes involved, as well as identifying likely needs and potentials for further development. It is expected that the organisational processes of the cases studied will vary in terms of, for example, motivation, goals, involvement and roles of different stakeholders. It is also expected that they will vary to different degrees in regard to seed legislation and certification processes, and that these are areas that pose

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difficulties and challenges for further development of organic PPB in Denmark. To facilitate emergence of possible solutions to such challenges, three organic Danish PPB cases will be selected, and research will be undertaken in collaboration with stakeholders, in an attempt to find acceptable models for issues concerning development, maintenance, ownership, certification and distribution of the seeds at stake.

Searching for potato crop characteristics associated with yield under low nitrogen level

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Organic and conventional breeders are searching for selection methods and criteria to breed nitrogen efficient crops under low nitrogen input condition to meet the organic cultivation conditions and the (future) nitrogen restrictions to avoid nitrate leaching. However, breeders lack knowledge about genetic variation in nitrogen response of potato under low input conditions, about relevant crop traits associated with variation in nitrogen response and about physiological mechanisms behind such variations. The objective of our research is to identify crop traits that are correlated with the ability to deal with low availability of nitrogen. These traits will be transformed into selection criteria, which can be used by potato breeders to develop nitrogen efficient potato varieties.

In 2008, 2009 and 2010 field trials were conducted at two sites (organic and conventional), with three nitrogen application levels (0, 60 and 210 kg N/ha (as organic respectively mineral fertilizer) and nine (2008), six (2009) or 18 (2010) varieties. The experiments were set up in a split-plot design with four replicates. The seed tubers were chitted and planted in ridges of 75 cm wide with a plant distance of 30 cm within the row. The tubers were planted around the 22nd of April. The final harvest was conducted about 100 days after planting.

We surmise that closely monitoring canopy development provides clues for crop characteristics that are correlated with nitrogen efficiency under low N-input conditions. Therefore, the canopy development was monitored by assessing ground cover twice a week using a grid with 100 rectangular cells. Each cell filled for more than 50 % with green foliage was counted as 1 % ground cover. With a curve fit program we fitted the ground cover progress curve of each plot and the variables Vx (percentage maximum ground cover), T1 (time to reach maximum ground cover), T2 (start of crop senescence), TE (time to complete crop senescence) were determined. With these variables the Area Under Ground Cover Progress Curve (AUGCPC), the period of maximum

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soil cover (T2-T1) and the period of crop senescence (TE-T2) were calculated. At the final harvest the yield (fresh and dry), nitrogen uptake, nitrogen use efficiency, the harvest index and radiation use efficiency were determined.

We found genotypic variation for all characteristics especially at the lowest two nitrogen levels. Most of the variation across the varieties was related to maturity type. The parameters T1, Vx, T2-T1 and AUGCPC were most sensitive to the level of nitrogen supply. The AUGCPC showed the best correlation with the dry matter production, but this correlation was different for each year and location.

In practice we met some difficulties to use the soil cover progress curve as a model. The parameters T2 and TE seemed difficult to determine in late varieties under organic conditions because of late blight infestation. Pests such as the Colorado potato beetle and other diseases such as early blight were disturbing factors too. The most unpredictable factor with a large effect on the curves was the weather. In 2008, the curves were broad with a relatively long period of maximum soil cover, whereas the curves in 2009 were narrow, with a very short period of maximum soil cover due to drought and high temperatures in early summer. The curves of the late varieties in 2010 showed a double S shape because of re-growth of the crop after rainfall following a long heat and drought period. To translate the ground cover curve fit parameters into reliable and stable selection criteria we must be aware of these disturbing factors. We will try to include them in the model.

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