PLANT BEEDING FOR ORGANIC FARMING: CURRENT STATUS AND PROBLEMS IN EUROPE

COMPENDIUM

SEMINAR

ENVIRONMENTAL FRIENDLY FOOD PRODUCTION SYSTEM:REQUIREMENTS FOR PLANT BREEDING AND SEED PRODUCTION

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I. INTERNATIONAL ORGANISATIONS AND NETWORKS RELATED TO PLANT BREEDING FOR ORGANIC FARMING

ECO-PB: European Consortium for Organic plant breeding

Founded 20th April 2001 in Driebergen, the Netherlands

Goals:

- providing a platform for discussion and exchange of knowledge and experiences.
- the initiation, support of organic plant breeding Programmes,
- the development of scientific concepts of an organic Plant Breeding
- the provision of independent, competent expertise to develop standard setting with respect to organic plant breeding

The Foundation Members:

- Louis Bolk Instituut (NL) | www.louisbolk.nl
- Danish Research Centre for Organic Farming (DK) | www.foejo.dk
- Elm Farm Research Center (UK) | www.efrc.com
- Forschungsinstitut für Biologischen Landbau (CH, D) | www.fibl.org
- Institut Technique de l'Agricluture Biologique (F)
- ArbeitsGemeinschaft Ökologischer Landbau (D)
- Vitalis Biologische Zaden B.V. (NL) | www.vitaliszaden.nl

(www.eco-pb.org)

ABDP: Association af Biodynamic Plant Breeders

17 members, most of them are working with vegetable species:

- Dieter Bauer (DE) "Kultursaat" {carrot, cabbages}
- Ulrike Behrendt (DE) "Kultursaat" {tomato, bean, carrot, cabbages}
- Reinhild Frech-Emmelmann (AT) "Reinsaat" {vegetables}
- Werner Friedl (DE) "Kultursaat" {tomato, pepper, salad, radicchio}
- Thomas Heinze (DE) "Kultursaat" {carrot, Gurke, Chinakohl, bean, Porree}
- Christina Henatsch (DE) "Kultursaat" {Brokkoli, Rote Bete, salad}
- Dr.Bertold Heyden (DE) “J. und C. Graf Keyserlingk-Institut“ {wheat, Dasypyrum}
- Eckart Irion (DE) “Verein für Pflanzenzucht Hof Grub“ {rye, emmer}
- Julian Jacobs (DE) "Kultursaat" {Blumenkohl, Bohne, Tomate, Kürbis, Mangold, Zuckerhut}
- Ute Kirchgaesser (DE) "Kultursaat" {Rote Bete, Kopfsalat, Feldsalat, Fenchel, Chicoree}
- Peter Kunz (CH) “Getreidezuechtung Peter Kunz“ {wheat, spelt, triticale, maize}
- Hans Larssorn (SE) {old wheats}
- Dr.Peter Lassnig (AT) {vegetables}
- Dr.Karl-Josef Mueller (DE) “Getreidezuechtungsforschung Darzau“ {wheat, rye, barley, einkorn} (president of the association)
- Arne von Schulz (DE) "Kultursaat" {Rettich, Kürbis, Wirsing}
- Richard Specht (DE) "Kultursaat" {pepper, tomato, Lauch, carrot, salad}
- Dr.Hartmut Spiess (DE) “IBDF-Dottenfelderhof" {wheat, rye, cabbage, radies, tomato, cucumber)

It is a group of plant breeders working from a spiritual scientific and biodynamic background who have come together in order to breed cultivated plant varieties for the organic sector

Goals:

To breed varieties appropriate to human nutritional needs.
To develop plant breeding directly linked to local conditions thereby enhancing regional diversity.
Using the insights of the biodynamic approach they wish to breed varieties suited to organic growing conditions.
Under the concept of „intervention through plant breeding," they understand such selection and creation of variation as is brought about through natural crossing and transformation of the environment.
They intend to bring about mutual development between human beings, the earth wand plant life.

(www.abdp.org)

COST 860: SUSVAR

Sustainable low-input cereal production : required varietal characteristics and crop diversity

network supporting sustainable cereal production

COST is an intergovernmental framework for European co-operation in the field of scientific and technical research, allowing the co-ordination of nationally funded research on a European level. COST Actions cover basic and pre-competitive research as well as activities of public utility.
In March 2004, the EU COST 860 network 'Sustainable low-input cereal production: required varietal characteristics and crop diversity' (SUSVAR) was initiated. By January 2005, 24 European countries had signed the Memorandum of Understanding, the official document defining the network, and researchers from about 100 institutions had started co-operating.
The main aims of the network are to ensure stable and acceptable yields of good quality for low-input, especially organic, cereal production in Europe. This will be achieved by developing ways to **increase and make use of crop diversity** (e.g. variety mixtures, crop populations or intercropping) and by **establishing methods for selecting varieties**, **lines and populations with special emphasis on the influence of genotype-environment interactions**. Finally, the network will also establish common appropriate methodology for variety testing.
For the last 50 years, cereals have been specifically developed to produce high yields under potentially unlimited use of pesticides and synthetic fertilisers. These inputs are therefore necessary to achieve optimal yields independent of the actual conditions in the farmer's field. As a result, the presently available crops and varieties may not be the best to ensure stable and acceptable yields under low-input conditions.
The network is organised into six Working Groups, five focusing on specific research areas and one focusing on the practical application of the research results for variety testing: **1) plant genetics and plant breeding,** 2) biostatistics, 3) plant nutrition and soil microbiology, 4) weed biology and plant competition, 5) plant pathology and plant disease resistance biology and 6) variety testing and certification.
The network is chaired by Senior Research Specialist Hanne Østergård, Risø National Laboratory, Denmark (vice-chair: Maria Finckh, Kassel University, Germany).

Aims for Working Group 1 (plant genetics and plant breeding):
Screening of genetic diversity in low-input/organic conditions

1. Evaluation of different kinds of material : varieties, breeding lines, genebanks resources, populations, mixtures

2. Identify traits specific for adaptation to low-input/organic conditions

Breeding methods for low-input/organic farming

1. Line breeding in low-input/organic conditions
2. Breeding for mixture ability
3. Participatory/decentralized breeding
4. Selection in genetically diverse populations

Identification of gene/QTL involved in low-input/organic adaptation

1. QTL detection, gene association mapping, mapping genes in evolving populations
2. Testing gene/QTL effect using transformed plants
3. Marker assisted selection

Organic breeding strategies and use of molecular markers: Workshop organised in cooperation of ECO-PB and SUSVAR, 17-19 January, Driebergen, the Netherlands

(www.cost860.dk)

ISOFAR: International Society of Organic Agriculture Research

Section 6: Plant Breeding and Seed Production (head: E.Lammerts van Bueren)

(www.isofar.org)

EUCARPIA: European Association for Plant Breeding Research

Working Group on Organic Plant Breeding, established in 2004.

Stichting Zaadgoed (the Netherlands)

Chair: Edith Lammerts van Bueren (Louis Bolk Institute)

'Foundation Seedgood' is a Dutch NGO committed to stimulating and co-ordinating plant breeding projects for GMO-free, organic agriculture.

The foundation does:

- develop policy proposals, strategies and a long term vision for breeding in the organic production chain and to assess breeding methods for their suitability for organic breeding.
- stimulate, initiate, co-ordinate and commission plant breeding activities by professional organic breeders, and participative breeding, by groups of farmers who commit to the breeding of a specific crop, in cooperation with breeding professionals.
- develop, initiate and maintain national and international contacts.
- promote organic breeding through publications, lectures and extension days for breeders, farmers, consumers, retailers, wholesalers and scientists.

(www.zaadgoed.nl)

II. REQUIREMENTS FOR ORGANIC PLANT BREEDING

1.BREEDING PRINCIPLES AND METHODS

In general, the **characteristics of organic varieties** - and by extension of organic plant breeding - differ from that of conventional breeding systems and conventional varieties. Realising an organic plant breeding system and subsequently steering it to meet changing demands is no less than a mammoth task. The many actions to be undertaken can be divided into short-term commercial and scientific activities, and longer or long-term commercial and scientific activities. Within the breeding sector, variety groups should be established to streamline communication in the chain. Variety groups should have a large contingent of farmers, as well as representatives from the trade branch and breeders. Members should communicate intensively with each other, share experiences, and participate in trials and variety assessments. Questions, wishes and bottlenecks could be recorded by variety groups and passed on to other parties in the chain.

(Lammerts van Bueren, E.T.; Hulscher, M.; Jongerden, J.; Ruivenkamp, G.T.P.; Haring, M.; van Mansvelt, J.D. and den Nijs, A.M.P. (1999) Sustainable organic plant breeding: Final report - a vision, choices, consequences and steps. Louis Bolk Instituut Publications no. G24, Plant Breeding, Louis Bolk Instituut and Wageningen UR. http://www.louisbolk.nl/downloads/g24.pdf

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Organically bred varieties shall be:
- fertile, and able to be propagated under organic (soil) conditions;
- adapted to organic farm conditions, which means: efficient uptake and use of nutrients, good rooting system, broad durable tolerance to diseases and pests, weed suppressive ability; yield will have lower priority in organic breeding, relative to quality. For organic breeding programmes there is interest in maintaining variation within varieties to allow for buffered response to variation in the local environment;
- Organic plant breeding should be a holistic approach; breeders should respect (functional) genetic diversity and species authenticity (natural crossing barriers).

Definition of the Concept behind Organic Plant Breeding: The aim of organic plant breeding is to develop plants, which enhance the potential of organic farming and bio-diversity. Organic plant breeding is a holistic approach, which respects natural crossing barriers and is based on fertile plants that can establish a viable relationship with the living soil.

Definition of Organic Variety: An organic variety is a variety obtained by breeding methods that are in compliance with the above concept and is the result of a certified organic plant breeding programme.

Definition of Organic Seeds and planting material: Organic seed and planting material are multiplied or propagated for at least one generation under organic management. They origin from varieties that are a result of (conventional) breeding programmes with the possible help of all kinds of permitted breeding techniques for organic agriculture, including the field and some in vitro techniques.

Not permitted techniques:

- GMO's
- CMS Hybridisation without restorer genes
  hybrids may have a role in organic farming, provided that the F1 is fertile and that the parent lines may be maintained in natural circumstances (cms is not applied without a restorer line)
- Protoplast fusion (Organic breeding will not allow techniques that operate below cell level)
- Patenting: patents prohibit free exchange of varieties as input/geniteurs for future breeding programmes among breeders of other companies, and therefore threaten genetic diversity as a general principle of organic farming and breeding
- Radiation

Some details on permitted techniques

Hybrids: From the definition of the concept behind organic breeding hybridisation as such can be permitted, provided that the F1-offspring is fertile and the parent lines can be propagated under organic conditions.

DNA marker assisted selection can be permitted in an organic breeding programme, if DNA screening is performed without enzymes originating form GMOs and without radiation.
Meristem culture can be used in certified organic breeding programmes because it is considered as being close to classical breeding techniques.
The suitability of different breeding techniques for organic plant breeding based on three ethical interpretations of the smallest living entity – the plant, the cell and the DNA – is assessed in the journal "Plant Breeding Techniques: An Evaluation for Organic Plant Breeding".

(E.Lammerts van Bueren, K.P.Wilbois, L.Luttikholt, E.Wyss, L.Woodward. Short Report of the Results of the International Workshop on Organic Plant Breeding Techniques, Driebergen-NL, 17th and 18th October 2001, Newsletter on Organic Seeds and Plant Breeding, 2002)
Eric Wyss, Edith Lammerts van Bueren, Marjolein Hulscher, Michael Haring. Plant Breeding Techniques: An Evaluation for Organic Plant Breeding, FiBL, Dossier N° 2, 2001, 24 p.)
Wolfe M.S. 2002. Organic plant breeding. Powell et all. (eds), UK Organic research: Proceedings of the COR Conference, 26-28th March 2002, Aberystwyth, pp. 303-305.)

The public discussion about the use of gene-technology has also triggered a discussion in the organic movement about **suitable methods used in plant breeding for organic farming.** The question has arisen if there is a definition of organic breeding and, if one exists, can private standards be developed for it? Previous workers have tried to transpose basic organic principles on organic breeding and have suggested that breeder fields should be farmed to organic standards, in vitro technologies should be avoided where possible and the use of phytohormones and chemicals restricted. The "minimal living unit" should be respected at each breeding step. This unit has been defined as a growing or rooted plant, or a single unharmed cell. Reproducibility should always be retained, therefore cytoplasmic male sterility should be excluded. In discussions within the organic movement, a controversy arises about the "minimal living unit". If defined as a whole plant organic farming would have no access to modern technologies like embryo culture, haploid techniques, in vitro and marker assisted selection, and protoplast fusion. With the definition of a single cell as minimum living unit only protoplast fusion would be banned. The discussion is ongoing.

(Arnchen, C.; Thommen, A. 2003. Organic plant breeding - a discussion of breeding strategies in organic farming. [German] Bericht uber die Arbeitstagung 2002 der Vereinigung der Pflanzenzuchter und Saatgutkaufleute Osterreichs gehalten vom 26. bis 28 November 2002 in Gumpenstein. Bundesanstalt fur alpenlandische Landwirtschaft Gumpenstein, Irdning, Austria: 93-94. 5 ref.)

Common misconceptions about the choice of varieties in organic farming
Because many of the inputs used in conventional farming are not permitted, the priorities for variety selection may be different (e.g. competitiveness against weeds is unimportant in conventional farming when effective selective herbicides are available), but is a main selection criterion in organic systems where herbicides are not permitted and mechanical, flame and/or hand weeding represent the main variable cost factor.
When considering the seed/variety requirements of the organic farming industry one has to first discuss a range of commonly made statements:

- **"The conventional varieties are unsuitable for organic agriculture"**
  At present varieties suitable for organic production systems are available/certified for nearly all crop species. However, some breeding activities are going for specific characteristics, which may no longer be suitable for organic production systems (e.g. short straw in some cereals).
- **"The organic agriculture wants to cultivate old varieties"**

This is very much a misconception and very much the opposite is true. Organic agriculture wants to share in the progress in crop breeding, because organic farmers equally depend on productivity and profitability. Although old varieties may be conserved more easily by organic agriculture e.g. varieties with a lack of resistance to lodging, a sufficient profitability of the cultivation of old varieties must be made possible by additional governmental grants (like already intended in some state programmes).

- **"The number of the varieties for the organic agriculture decreases."**
  Indeed varieties, which are highly suitable for organic production systems have been removed from national variety-lists again and again and were not always replaced with equivalents (e.g. this happened with baking quality-wheat or high organoleptic quality ware potato varieties). Nevertheless the choice of varieties available to organic farmers is higher now than it was 10 years ago, which is mainly due better access to interesting varieties from other EU-countries. However, in the future, the choice of varieties available to organic farmers may become more restricted, if genetically modified crop varieties will be grown on a commercial scale in the EU.
- **"Organic agriculture needs regionally adapted varieties."**
  Adaptation of crops to regional soil, climate and production systems is an important variety characteristic. However, agronomic benefits of selecting/breeding local adaptation varies and the definition of a "region" varies between crop species. Breeding companies will always have to consider the additional benefit but also costs associated with developing a wide range of varieties which are adapted to very specific conditions and the seed production economies associated with varieties which can be used for a wide range of locations. Because of the need for profitability for the relatively smaller (organic) segment of seed market, breeding programmes for organic agriculture should initially focus on the development of varieties suitable for many locations.
- **"The best varieties for conventional farmers are the best varieties for the organic farmers, too"**
  This statement is also not generally true. <u>There are traits associated with conventional varieties, which are unsuitable for organic production systems and certain traits required in organic farming systems are not present in recently developed "conventional" varieties</u>. This includes: a) Ability to compete with weeds. The ability to suppress weeds is an important trait in both cereals and non-cereals; b) Longer straw. Cereal varieties with longer straw often have got more mass of roots, so they have got a higher ability to take up nutrients; c) The best resistance traits are often of no particular benefit as disease pressure in organic agriculture is generally lower (exceptions are e.g. *Helminthosporium, Rynchosporium* and some rusts). Many traits in varieties bred for conventional agriculture are also required in organic farming, but the priority given to individual traits is often different. A high level of disease resistance is necessary especially with respect to *Fusarium, Helminthosporium, Septoria, Claviceps* and viruses. An intermediate level of resistance is sufficient for many biothrophic fungal diseases e.g. mildew, which decrease in importance in organic management systems since disease pressure is generally lower. It is important to identify the exact balance of characteristics required and not to miss out specific traits altogether.

Tasks

<u>If governments want to increase the number of organic farms</u>, there has to be an increase in research underpinning organic agriculture and plant breeding. We propose the following objectives/tasks for the next five years:

- Evaluation of existing varieties/breeding lines (both older and newer ones) for characteristic traits required in organic farming systems

- Organic variety trials for varieties of crops, which were not yet widely tested for their performance under organic management practices.
- Research and development of seed production, processing and conservation breeding for the organic agriculture.
- Selection of breeding material under organic conditions. Evaluation and development of variety mixtures
- Evaluation of breeding methods for organic breeding. Developing alternatives for non-suitable breeding methods.

(Werner Vogt-Kaute, AGÖL standards - draft paper, 2001, originally from Edith Lammerts van Bueren (changed), www.naturaland.de)

In **organic farming** the characters **competitiveness against weeds, nutrient efficiency** and **tolerance to diseases** are in the choice of a variety of much higher importance than in traditional farming.
The tolerance to diseases is both in organic as in traditional farming of growing importance. Nevertheless the importance given to each disease is different due to differences in crop rotation and plant density.
Varieties for organic farming need a higher stress tolerance to abiotic causes. Nevertheless simple methods for the examination of stress tolerance are lacking. The product quality is valued higher in organic farming as the quality argument is of higher importance in marketing and price. The requirements suitability for storing, processing and feeding quality are higher in organic farming since no additives may be used. There is a demand for a certification system for breeders involved in organic breeding.
The promotion of research has to be long-term scheduled. It has to be ensured that the classical breeding methods used and accepted in organic as in traditional farming are further developed.

(Steinberger, Josef (2002) Workshop: Züchtung für den Ökolandbau [Workshop: Breeding for organic farming]. Report, Bundessortenamt Hannover.
http://www.bundesprogramm-oekolandbau.de/pdf/02oe452_tagungsband.pdf)

Breeding organic varieties is essential for the development of the organic sector and for the quality of organic products. But at the same time it is an ambitious striving because it is not yet realised on a large scale, and still very much in development. Organic agriculture needs a breeding system, which, as a primary objective, takes into account the complexity and, biodiversity of agro-ecological systems and which works at high levels of plant organisation. In some cases, techniques will have to be (further) developed to meet these criteria.
Organic plant breeding distinguishes itself from the mainstream breeding by focussing on three quality aspects: ecological, ethical and edible.
Ecological: organic farmers require varieties with characteristics that are better adapted to this kind of farming system. The desired variety traits include for instance adaptation to organic soil fertility management, implying lower and organic inputs, better root system, ability to suppress weeds, high yield level and yield stability.
The plant's natural reproductive ability should be retained, thus ensuring the sustainable use of the cultivar. Varieties must be able to adapt easily and independently to organic farming conditions.
-phenotype and genotype are considered equally;
-greater genetic diversity within and between varieties enhances the plant's ability to adapt to local farming conditions;

-broad resistance to disease and pests enhances the self-regulating ability of the organic farming system;
-new varieties should preferably be selected for (regional) organic farming conditions.
Ethical: Organic breeding techniques and strategies should be compatible with the principles of organic agriculture, respecting the intrinsic value and integrity of living organisms, including plants. It is the reason why organic agriculture excludes the use of GMO's. Organic plant breeding strategies also imply sustainability of the breeding system. In that respect varieties should not be sterile or patented, so that free exchange of the genetic inputs can safeguard plants for the future, being the cultural heritage of mankind.
Edible: Good organic potato and onion products require higher demands for varieties with good long-term storage potential without the use of chemical sprouting inhibitors. Positive quality aspects include aspects related to the inner quality of products, such as taste, good structure and vitality. Qualities such as taste, colour, form, nutritional value and keeping quality must be retained and improved;
Socio-economic principles of organic plant breeding:
-farmers and breeders should work together closely to ensure a mutual exchange of know-how and experience; farmers' privilege should be upheld;
-regulations should be amended to enable the marketing of organic varieties;
-there should be a free exchange of genetic seed stock between organic breeders;
-legal regulations and requirements should consider organic farmers' interests;
-a new financing structure should be developed for an organic breeding system.

(E. T. Lammerts van Bueren, 2004, Breeding organic varieties – importance for the quality of organic products. Louis Bolk Institute, Hoofdstraat 24, NL-3972 LA Driebergen, The Netherlands.
www.agravivendi.org/download/ Biofach%20-%20E.Lammerts.doc
E.T. Lammerts van Bueren, M. Hulscher, J. Jongerden, M. Haring, J. Hoogendoorn, J.D. van Mansvelt, G.T.P. Ruivenkamp. Sustainable organic plant breeding. Subproject 1 - Discussion paper: defining a vision and assessing breeding methods. http://www.ifgene.org/breed2.htm)

The IFOAM (International Federation of Organic Agriculture Movements) started a discussion process in 2000 to outline basic standards for organic breeding. Suitable **breeding techniques** for organic breeding are combination breeding, variety crosses, bridge and back crosses, temperature treatment, grafting and cutting style, untreated mentor pollen, mass and pedigree selection, indirect selection, ear bed method, test crossing, DNA markers without GMO, hybrids with fertile F1, meristem and tissue culture, generative and vegetative propagation.

(Leibinger, T.; Reiners, E. 2002. Demands of sector bodies for organic plant breeding. [German] Beitrage zur Zuchtungsforschung - Bundesanstalt fur Zuchtungsforschung an Kulturpflanzen. Bundesanstalt fur Zuchtungsforschung an Kulturpflanzen, Quedlinburg, Germany: 8: 1, 19-23.)

One of the topics in Breeders-meeting in Gumpstein, Austria, November 2002 was special **breeding aims for organic farming**. The tenor of the attendant breeders was: "most of the purposes of organic breeding are already an issue of conventional breeding programs". Let's hope that there will be another occasion to convince Austrian breeders of the urgent need for independent organic plant breeding programs! (By Andreas Thommen)

(Newsletter on organic seeds and plant breeding. Jan.03.
http://www.ecoplantbreeding.com)

Need for certification of breeding programmes

‘Organic breeding’ programmes will need to be certified, in order to guarantee that only allowed techniques have been used. In some interpretation the exchange of plant material between ‘organic breeding’ programmes and other breeding programmes would not be allowed.

The IFOAM started a discussion process in 2000 to outline **basic standards for organic breeding**. Three criteria were used. First, breeding methods should be based on general principles of organic agriculture (breeds should be fertile and adapted to organic production systems, respect for genetic diversity). Second, they should be possible to inspect and trace them with samples. Genetically modified organisms (GMOs), cytoplasmic male sterility (CMS) hybrids, and F1-hybrids are traceable, protoplast fusion and artificial mutations are not. Third, they should be practical and definitions should last as long as breeding cycles.

The banning of several modern breeding techniques is also discussed. GMO’s and radioactive radiation should be excluded because they are also excluded in organic agriculture. Anther culture, microspore culture, and CMS hybrids without restorer genes, protoplast fusion, induced mutations should be excluded, because they do not treat the whole organism as the smallest living unit. Patents on plants, which prevent them from being a free breeding material, should not exist in organic plant breeding. Hybrids are accepted, but bio-dynamic breeders want to ban them as well. DNA marker techniques are accepted if the enzymes used are GMO-free and no radioactivity is used. Embryo culture, ovary culture and in-vitro pollination could be also excluded in the future.

(Muller, K. J. 2002. Aims and methods of organic plant breeding - current situation of the international discussion. [German], Beitrage zur Zuchtungsforschung - Bundesanstalt fur Zuchtungsforschung an Kulturpflanzen. Bundesanstalt fur Zuchtungsforschung an Kulturpflanzen, Quedlinburg, Germany. 8: 1, 24-26.
Edith T. Lammerts van Bueren, Challenging new concepts and strategies for organic plant breeding and propagation. *Louis Bolk Institute, The Netherlands.)*
(International Seed Federation, Plant Breeding for Organic Farming**,** Chicago, May 2002, http://www.worldseed.org/Position_papers/Pos_org_farming.htm)

A distinction is made between (certified) organic breeding and breeding for the organic market. In the first case, the entire breeding process is under guard to meet organic standards, in the second, the final product and its properties are especially suited to organic culture.
Breeder's rights are respected and accepted.

(http://www.vitaliszaden.nl/)

Participatory plant breeding method

Participatory plant breeding (PPB) is a form of interaction between breeders and farmers (consultative, collaborative or collegial). PPB methods help to improve local adaptation, to promote genetic diversity, to decentralize plant breeding. Organic breeding is aimed more on adaptation to local growing conditions, whereas conventional breeding concentrates on varieties suitable for wide growing areas.

PPB is in accordance with the principles of organic farming.

The private French breeding companies are not interested in organic plant breeding.

PPB program at INRA – Montpellier (France) involves the whole durum wheat interprofessional organization, from farmers to consumers.

The parental material, pure lines, mixtures and populations are grown and evaluated directly on organic farms. Farmers do not only evaluation of material but also the selection of plants from populations. The main traits for selection are plant height and competitive ability. Currently 15 host farmers are involved in the programme, but about 200 more would be interested to participate as well.

(Dominique Desclaux, INRA Montpellier- France, www.cost860.dk)

Participative approaches to agricultural research and development are now extensively used throughout the world to help define and address the practical research needs of farmers. They have proved useful in solving practical problems in complex and diverse farming systems, characteristics typical of organic farming systems. A project with the aim to develop a robust system for identifying, testing, multiplying and marketing cereal varieties, lines, mixtures and populations best suited to organic production in different parts of the country is carried out by Elm Farm Research Centre (UK).
Farmers will be involved in developing the methodology of the trials, establishing the measurement criteria, running the trials and evaluating both the trails and the methodology. The research process will be closely monitored throughout and the methodologies developed will be disseminated at the end to farmers, research scientists and agricultural students. This project will build on the existing relationships with farmer groups built up by Elm Farm Research Centre over many years.
Some of the project objectives are: development of a participatory research and development methodology for UK organic farmers using variety trialling and the management of seed-borne disease as examples; collect information on the range of cereal varieties currently grown by organic farmers to help identify the major priorities and constraints among the varieties available; establish a pilot programme of cereal variety trials with organic farmers on organic farms.

(Cereal varieties for organic production: developing a participatory approach to seed production and varietal selection, www.organicfqhresearch.org)

2. REQUIREMENTS FOR CROPS

CEREALS

Breeding goals for "organic" cereal varieties:

- resistance or tolerance against bunt (*Tilletia tritici*) and other seed borne diseases. If we want to establish organic seed production and conservation breeding systems, problems with seed borne diseases are likely to increase. For the near future we may be able to develop organically acceptable seed treatment methods, but in the longer run there is pressure to replace treatments with resistance breeding;
- ability to suppress weeds, longer straw;
- stability of yield and quality under different conditions (nutrient uptake efficiency, resistance to abiotic stress factors);
- high quality and stability of quality characteristics under extensive conditions.

(W. Vogt-Kaute, AGÖL standards - draft paper, 2001, originally from Edith Lammerts van Bueren (changed), www.naturaland.de)

A provisional study lists and evaluates **breeding targets for organic cereal breeding.** Criteria and conditions for the assessment of seed quality for use in organic farming are discussed. A holistic approach is suggested as the most suitable for organic conditions. Included in organic breeding objectives, where organic seed quality can offer the best selection contribution, are resistance to loose smut (*Ustilago nuda*), dwarf bunt (*Tilletia controversa*) and barley leaf stripe disease (*Drechslera graminea*). To a lesser extent, earliness, plant vigour and resistance to snow mould [*Monographella nivalis*] are also important.

(Girsch, L.; Weinhappel, M. 2003. Traits for assessing seed quality in organic farming - aspects for new breeding targets? [German], Bericht uber die Arbeitstagung 2002 der Vereinigung der Pflanzenzuchter und Saatgutkaufleute Osterreichs gehalten vom 26. bis 28 November 2002 in Gumpenstein. Bundesanstalt fur alpenlandische Landwirtschaft Gumpenstein, Irdning, Austria: 79-90.)

Characteristics of spring barley varieties for organic farming:

The important spring barley traits to be considered in organic farming are related to the inherited viability and adaptation of plants to survive biotic and abiotic stresses and includes competitive ability (morphology, weed tolerance, growth rate, allelopathy), disease resistance (morphology, specific and non-specific resistance properties, disease tolerance) and nutrient acquisition ability (root morphology, nutrient uptake and use efficiencies, low-nutrient tolerance, symbioses). An important question is whether modern spring barley varieties possess the right combinations of these characteristics to ensure a stable and acceptable yield of good quality when grown under different organic growing conditions. It remains unclear to date whether the differences between the conventional and the organic growing systems are large enough to justify breeding and testing of varieties in both environments.

Breeding related to organic farming may take advantage of modern biotechnology by using DNA-markers to enhance the breeding process. More such markers for traits of importance to organic farming are needed.

Main objectives:

- Identify combinations of plant characteristics required for a barley crop to be successful in organic growing systems and develop methodologies for measuring these characteristics.
- Evaluate, by investigating genotype-environment interactions, the need for specific variety trials for organic farming, and if necessary implement such trials.
- Improve yield and yield stability in different organic farming systems by strategic use of the appropriate varieties and variety mixtures.
- Investigate the potential of different variety mixtures for reducing diseases and weeds and increasing nutrient uptake efficiency.
- Obtain new knowledge on plant competition, disease complexes, epidemiological models, nutrient acquisition and associations between molecular markers and agronomical traits.

(Research project carried out by DARCOF (Danish Research Centre for Organic Farming), www.darcof.dk)

Ideotype of Organic Spring Wheat

The development of organic spring wheat ideotype is as a first step to stimulate the focus of conventional breeders on the organic sector. It was done in a participatory approach, involving farmers, traders and breeders. The ideotype with desired traits to support the realisation of the principles of organic farming systems include adaptation to organic soil fertility management based on lower and organic inputs, better root system and ability to interact with beneficial soil micro-organisms, weed supressiveness, contributing to soil, crop and seed health, high product quality, high yield level and high yield stability. The ideotype was developed for a wheat crop grown on clay soil without undersown clover. It differs from the conventional farmers' ideotype in priorities set for the different characteristics.

Traits included in the ideotype are:

- good backing quality
- good grain yield (minimum 6.5 t/ha) and yield stability

- efficient use of (organic) manure
- reducing risk of diseases (long stem, ear high above flag leaf, ear not too compact, last leaves green for the longest time possible)
- resistance against diseases (yellow rust, brown rust, *Fusarium* spp., Septoria leaf spot, mildew)
- supporting weed management (good recovery after mechanical harrowing, good tillering, rapid closing of canopy, dense crop canopy)
- reducing risks at harvest (stiff stem, early ripening, resistance against sprouting)

(E.T.Lammerts van Bueren, 2002, Organic plant breeding and propagation: concepts and strategies. PhD Thesis, Wageningen University, The Netherlands, 196 p.)

Influence of Environment on Breeding Criteria for Wheat

Selection for special adaptation to very extensive low-input conditions (yield level less than 4 t/ha) proved to be superior for grain and protein yield, but this could not be confirmed for gluten characteristics. Special breeding program is able to improve protein content and backing quality. Breeding for specific growing conditions is more effective for yield than for quality traits.

(J.P.Baresel, H.J.Reents, G.Zimmermann, 2005, Influence of Environment on Breeding Criteria for Wheat in Germany. In Heß, J and Rahmann, G, Eds. *Ende der Nische, Beiträge zur 8. Wissenschaftstagung Ökologischer Landbau*, pp. 33-36.)

Breeding aims for different cereal species in organic farming:

- Winter wheat: competitiveness (roots, leafs, plant height), quality in connection to better N uptake, high N uptake in early stages of plant development, good protein forming efficiency, resistance (e.g. covered smut)
- Winter rye: resistance to early sowing, good cohabitance with undersown crops, vigorous plants with big ears, special backing quality, displacement of assimilates, resistance (brawn rust, ergot: good pollination ability)
- Triticale: more “wheat type” for feed quality and “rye type” for growing particularities due to better competitive ability (roots, leaf formation), good cohabitance with under sown crops
- Spelt: lodging resistance, backing quality (based on different proteins than quality wheat), lower content of hulls, big kernels, rust resistance
- Spring wheat: competitive ability, good protein forming efficiency, gluten characteristics
- Spring barley, hulless barley: lodging resistance, big kernels, competitive ability (plant height, leaf area, root formation), good threshability for hulless barley, loose smut resistance
- Oats, hulless oats: big white kernels, good threshability for hulless oats, winter oats for feed, resistance (loose smut, crown rust)

(H.J.Reents, Sorteneigenschaften und Zuchtziele fur Getreidearten im Okologischen Landbau, Workshop: Zuchtung fur den Okolandbau, Hannover, 2002, http://orgprints.org)

Plant height is one of the important characteristics of spring barley for organic farming being much related to **competitiveness against weeds**. Grain yield was found to correlate differently to plant height under organic and conventional growing conditions.

(Ostergaard H., Jensen J.W. (2004) Characteristics of spring barley varieties for organic farming. In: Vollmann J., Grausgruber H., Ruckenbauer P. (eds.) Genetic variation for plant breeding. Proceedings of the 17th EUCARPIA General Congress, BOKU, Vienna, Austria, p. 483.)

Selection for competitiveness against weeds:

Weed suppression cannot be attributed to a single characteristic; important is the interaction between the series of desirable characteristics, with varieties compensating for weakness in certain characteristics with strength in others. The complex of traits responsible for competitive ability consists of: ground cover (%), leaf angle, speed of early plant development, tillering ability etc.

The number of shoots in developmental stage EC 31 correlates with weed cover. Good crop establishment is important.

Early ground cover: even if the number of plants is less than 160 per m^2, varieties with good tillering ability can give good results.

Growth habit: planophile growth habit (angle > 45^o) has a clear advantage for weed suppression over erectophile type; the early plantophile – late erectophyle type can compensate more for lower crop establishment than the early erectophyles; the early erectophile – late season plantophile habit is a good model when crop establishment is high and sown in narrow rows, but risky when crop establishment is poor or early weed growth high; continuous erectophile type is risky, if weed development is moderate or high.

Leaf angle: in connection with plant growth habit (plantophile type - bigger leaf angle).

Plant height: most important for erectophile plant type.

In practical selection recommended traits:

- early plantophile (prostrate) growth habit;
- good crop establishment;
- ground cover in EC 13/21 (tillering stage) (correlates with a season long weed suppression; can be assessed visually in %);
- tillering ability (more important in cool moderate climate);
- rapid early growth (until shouting);
- leaf angle, length and bending;
- plant height.

The best yielding genotypes have a tendency to be with the best competitive ability against the weeds.

(S.Hood, Field evaluation and selection for competitiveness against weeds, Workshop on Organic Breeding Strategies and the Use of Molecular Markers, 2005, Driebergen, The Netherlands)

The **disease pressure in organic wheat** production is in most cases lower than in conventional systems. In most cases the incidence of mildew is particularly lower in organic than in conventional systems. In most seasons most of the fungi appear later in the season under organic conditions. Organic farmers not only look for genetic resistances, they also want to reduce the risk by selecting for additional morphological traits and look for a more robust plant architecture not conductive to disease development. E.g. longer stems allowing ear to ripen above the moist canopy, more vertical distance between the leaves, less compact ears. An important field criterion is a long stay green index of the upper leaves.

One approach of organic breeders is not so much look for single specific resistance genes, but to search for **durable or partial resistance**. The selection criterion is not a specific level of resistance, but the ability of plant to build up sufficient yield level and backing quality despite a certain level of presence of fungi. Resistance mechanisms such as field tolerance would fit the organic farming system because of the available lower disease pressure at lower N levels.

(E.T.Lammerts van Bueren, 2002, Organic plant breeding and propagation: concepts and strategies. PhD Thesis, Wageningen University, The Netherlands, 196 p.)

The significance of particular cereal diseases in organic agriculture and breeding

In organic breeding important is regionality, because the varieties are bred for narrow area. Because of that in particular regions resistances to some diseases are not needed. It makes the breeding cheaper and improves the biodiversity. The individual diseases are assessed following:

- Loose smut, covered smut: very significant in breeding and seed production; not clear if resistance or partial resistance should be used
- Ergot: hybrid varieties should not be grown
- Septoria and Fusarium on the grain (seed and bread grain): very significant
- Fusarium head blight: significant in particular regions, after maize and partially after clovergrass, breeding for "healthy plant morphology and architecture" gives better results than resistance breeding
- Ear-septoria: in particular regions, breeding for "healthy plant morphology and architecture" gives good results
- Leaf-septoria: in particular regions, spreading slower than in conventional farming, higher varieties have less problems
- Braunrust: in particular regions resistance is required, spreading slower than in conventional farming, longer varieties are more tolerant than short ones, for rye populations are better than hybrid varieties
- Yellow rust: in particular regions resistance is required, spreading slower than in conventional farming
- Fusarium root rot: growing problem for organic farming
- Mildew: less important, no influence on yield

(P.Kunz, Phytopathologie/Resistenzzuchtung, Workshop: Zuchtung fur den Okolandbau, Hannover, 2002, http://orgprints.org)

Basic research on breeding for resistance to ergot (*Claviceps purpurea*) for organic farming in rye and triticale

The objective of the study is to (1) analyse the genetic variation for ergot resistance independenly from pollen shedding in self-incompatible (population varieties, genetic ressources, full-sib families) and self-fertile (inbred lines, testcrosses) rye breeding materials and (2) to estimate population parameters relevant for resistance selection. All materials are tested at two locations in each of two years on organic farms in Germany in microplots. Genotypes are inoculated by spraying a spore suspension during flowering. To compensate for different flowering dates, all materials are sprayed thrice. Resistance trait is percentage of ergot sclerotia in grain by weight. Analytical aspects are: 1) Optimal design of experiments to exclude the influence of pollen on ergot severity, 2) estimation of genotypic, genotype-environment interaction, and error variances, and heritability under organic farming; 3) genetic variation between and within populations, 4) covariation among lines and their testcrosses; 5) identification of resistance sources for further breeding, 6) establishing the relationship between ergot severity and alcaloid content.

(Project leader: Dr.T.Miedaner, University of Hohenheim, State Plant Breeding Institute, Germany, www.uni-hohenheim.de)

Exploiting and enhancing disease resistance in wheat and triticale to stabilize yield under low-input and organic farming conditions

Aims: to provide information about resistance patterns in actual and old varieties, landraces and other genotypes for the main wheat and triticale leaf, ear and seed transmitted diseases. Identify durably resistant varieties and breeding lines, contribute to the obtention of new resistant varieties.

Experiments: greenhouse and field trials to test resistance of genotypes, including powdery mildew, leaf and stripe rust, Septoria diseases, Fusarium ear blight; field trials to determine interaction between disease resistance and yield potential; field and greenhouse screening of stinking smut (*Tilletia caries*); greenhouse trials to test interaction of *Azospirillum* inoculants with wheat genotypes to enhance resistance against Fusarium ear blight and foliar diseases.

(*Research project carried out by:* F.Mascher, D.Fossati, A.Schori, Agroscope RAC Changins, Switzerland, Y.Moënne-Loccoz, Université Lyon1, France, www.cost860.dk)

Triticale with improved nitrogen efficiency for organic farming

Triticale combines high protein content with high protein quality. Due to its tolerance to marginal conditions and high competition against weeds triticale is very suitable for organic farming. A central problem with organic farming is the low nitrogen supply, because nitrogen is one of the most important yield limiting factors and an essential component for proteins. Breeding triticale varieties with improved nitrogen efficiency can help to increase productivity of organic farming and improve the protein supply. From a breeding point of view it is important to investigate N-use efficiency under different nitrogen conditions. Therefore all materials are tested at two locations with two N-regimes (fertilized vs. non-fertilized) on organic farms. The objective of the study is to (1) estimate genetic parameters for N-use efficiency, (2) analyse the contribution of N-uptake and N-utilization for improved N-use efficiency, and (3) investigate breeding strategies for improved N-use efficiency that meet the special demands of organic farming systems.

(Project leader: Dr. E. Thiemt, University of Hohenheim, State Plant Breeding Institute, Germany, www.uni-hohenheim.de)

Selection Criteria for N-efficient Barley Cultivars Suitable for Organic Agriculture

***Aim*: to collect critically needed data on nutrient use efficiency (NUUE) of different barley varieties on conventionally and organically managed soils.**

Experiments: 1) 40 varieties will be compared in 2 organic and 2 conventional field sites over two years, to determine N uptake and utilization efficiency of old and modern barley varieties under conventional and organic growing conditions and measure plant characteristics that explain the observed differences in NUUE i.e. growth-habit, root distribution, susceptibility to root diseases and ammonium/nitrate uptake; 2) AFLP-mapped populations will be used to identify QTLs associated with traits linked to NUUE, such as root architecture, preference for ammonium uptake, and attraction of beneficial microorganisms; 3) experiments with root observation boxes with organically and conventionally managed soils, to determine detailed characteristics of a subset of varieties that cover the range of observed variation in NUUE and plant characteristics in the field, such as, root-architecture, root hair growth, stimulation of beneficial soil microorganisms including mycorrhiza and suppression of root diseases.

(*Project participants:* A.J. Termorshuizen, A.H.C. van Bruggen, J.C. Goud, Biological Farming Systems, Wageningen University; R. Niks, Plant Breeding; E. Lammerts van Bueren, Louis Bolk Institute, The Netherlands, www.cost860.dk)

Introduction of N-use efficiency, weed competition and allelopathy in breeding of barley and wheat for organic farming.

Aim: Screening of breeding lines for N-use efficiency and allelopathy. Testing of selected lines on organic yield trials.

Experiments: 1) breeding lines of barley and spring wheat are screened in hydroponics and further tested in organic yield trials; 2) cultivars from a world collection is screened for high allelopathic activity using a bioassay method with ryegrass as receiver plant; 2) high allelopathic cultivars are crossed with Swedish material and screened again in F2 and F3.

Analytical aspects: 1) Evaluation of the use of hydroponic selection methods for NUE and early vigour; 2) evaluation of bioassay screening of allelopathic activity and its heritability; 3) evaluation of the role of allelopathy in the weed interference.

(Nils-Ove Bertholdsson, Svaloef Weibull AB, www.cost860.dk)

The objectives of this study were to identify traits in **spring barley** (*Hordeum vulgare*) and **spring wheat** (*Triticum aestivum*) related to the **competitive ability** of the crop and to determine their importance. Weed biomass 1–2 weeks prior to ear emergence was used as a measure of genotypic differences in competitiveness against weeds. Crop trait measurements comprised early crop biomass, early shoot height, straw length, heading and maturity. Early crop biomass 1–2 weeks prior to ear emergence was used as an overall trait for the various characters related to early vigour. In addition to these morphological traits, the potential **allelopathic activity** of the tested cultivars was determined using an agar-based bioassay with *Lolium perenne* (ryegrass). In both barley and wheat, multiple regression analysis revealed that early crop biomass and potential allelopathic activity were the only parameters that significantly contributed to competitiveness. In barley, early crop biomass explained 24–57% of the observed genotypic variance across 4 years, allelopathic activity explained 7–58% and combined they explained 44–69% of the observed genotypic variance. In wheat, the corresponding figures were lower: 14–21% for early biomass, 0–21% for allelopathic activity and 27–37% when combined. Model predictions suggested that new cultivars with increased early vigour and allelopathic activity offer a potential to further reduce weed interference.

(*N-O BERTHOLDSSON, 2005.* Early vigour and allelopathy - two useful traits for enhanced barley and wheat competitiveness against weeds, Weed Research, 45 (2), P. 94)

In contrast to the conventional farming systems, the variation between different organic growing systems is very large. In some organic crop rotations with weed problems, a highly competitive variety is the most suitable while this variety might not be very useful if used with undersown crops. In situations with high soil fertility, e.g. after grass-clover leys, a high yielding variety with certain disease resistance genes would be the most optimal while in situations with low fertility a variety with high nutrient uptake or use efficiencies would be preferred and susceptibility to diseases may not be a great problem. Further, at some locations and years one type of disease may be prevailing requiring specific resistance genes or morphology of the plant, in other cases other disease complexes demand another type of plant phenotype. Therefore, it is not possible to obtain a single best variety for organic farming in general and in many cases the best choice might be to grow a **mixture of varieties**, which combines many desirable characteristics. Using mixtures of appropriate varieties in organic farming might, therefore, be a way of obtaining stable and acceptable yields.

(Characteristics of spring barley varieties for organic farming, www.darcof.dk)

Plants bred for monoculture require inputs for high fertility, and to control weeds, pests and diseases. Plants that are bred for such monospecific communities are likely to be incompatible with the deployment of biodiversity to improve resource use and underpin ecosystem services. Two different approaches to breeding for agricultural diversity are described: (1) the **use of composite cross populations** and (2) **breeding for improved performance in crop mixtures**. The basic idea of the composite populations is that the introduction of genetic diversity may a) allow the isolation of superior individual lines in a cost effective manner and b) that diverse populations may offer better performance than pure lines. These lines and populations are the result of adaptation to those selection pressures imposed during the breeding process, both natural and artificial, providing improved fitness to given environmental conditions. Hill (1996) calls for an approach to breeding for mixtures that selects for good general and specific combining abilities with other varieties/species.

(PHILLIPS, S. L. AND WOLFE, M. S. Plant Breeding For Agricultural Diversity. Elm Farm Research Centre, Hamstead Marshall, Nr Newbury, Berkshire, RG20 0HR
This article appears also in: Science and Practice for Profitable Livestock and Cropping Occasional Symposium No.37, British Grassland Society, 2004. ISBN 0 905944 844. p: 184-187. Edited by A. Hopkins
http://www.eco-pb.org/09/cp.htm)

Much of the EFRC research programme is designed to move further towards higher levels of biodiversity in the cropping system, which has important positive consequences for biodiversity in general, unlike other current systems of agriculture. In wheat and kale, we are trying to develop breeding programmes based on the notion of producing **crop populations** rather than pure breeding lines. The hypothesis is that a crop population selected under local conditions should have the ability to act as a polyculture at the subspecies level, with the advantages described in paper.

(Dr Martin Wolfe, July 2001.Functional Biodiversity, Elm Farm Research Bulletin No. 56)

Organic farmers depend greatly on conventionally bred and produced varieties, but require varieties better adapted to organic farming systems for further optimisation of organic agriculture.This includes a greater need for ‘reliable ’ varieties contributing to higher yield stability. Organic agriculture can only gain further progress when the genetic basis is renewed and broadened, and when the selection process is conducted under organic farming conditions. For self-fertilisers the concept of (isophenic) **line mixture varieties** seems most promising, being composed of lines, which are phenotypically uniform but genetically heterogeneous.

(Lammerts van Bueren, E. (2002) *Organic plant breeding and propagation: concepts and strategies*. PhD Thesis, Department of Plant breeding, Wageningen University, The Netherlands / Louis Bolk Instituut, Netherlands. Published in Louis Bolk Instituut Publications no. G36. http://www.louisbolk.nl/e/projects/plantver/index.htm)

Studying evolution and adaptation of bread wheat populations and early-stage breeding for mixing ability

Aim: 1) Study and compare the evolution of diversity for molecular markers, candidate genes and adaptive traits in experimental wheat populations conducted under dynamic management for 10 to 20 generations and in old varieties populations cultivated by farmers. 2) Test whether selection in the early stage can allow to identify genotypes with a good mixing ability among a large number of varieties representing a wide genetic variability in bread wheat.

Experiments: 1) Evaluation of different wheat populations (from experimental dynamic management and cultivated by farmers) in different growing conditions: low input and organic, in different locations (research stations, farms). Measurements of agronomic, adaptive and quality traits, and genetic diversity. 2) 20 lines derived from of a wheat dynamic management programme, 20 lines from a multilocal and multitrait recurrent selection programme and 10 official varieties are evaluated.

(Isabelle Goldringer, INRA, France, www.cost860.dk)

Drought tolerant barley for organic farming

Aim: Better understanding of abiotic interactions (drought) in the organic growing system, investigate the importance of genotype-environment interactions, identify molecular markers linked to drought tolerance, select (hulled and naked) genotypes suitable for organic farming conditions, implement organic variety testing in Southern Europe conditions if needed.

Experiments: 1) about 250 barley genotypes, including landraces and old cultivars assessed over two years in Mediterranean sites for drought tolerance, and association mapping of drought tolerance; 2) about 130 barley doubled haploids assessed over two years for drought tolerance, and QTL mapping of important loci; 3) about 20 selected genotypes by means of marker-assisted selection assessed over two years under organic and non-organic conditions for agronomical characters including disease resistance to natural occurring diseases and weed competitiveness in both fertile and drought prone environments.

(*Project participants:* N. Pecchioni, D. Barabaschi from Università di Modena e Reggio Emilia - Facoltà di Agraria, E. Francia, A. Tondelli from Università di Milano, Italy, www.cost860.dk)

Evaluation of Einkorn and Emmer in consideration of different locations and farming systems as well as developing of varieties for agricultural production

In consideration of preservation the plant diversity in agronomical production, people remember ancient crops as Einkorn (*Triticum monococcum*) and Emmer (*Triticum dicoccum*). Mainly in the organic farming there is increasing interest in these two kinds. Both have good resistance properties against leaf diseases and good quality characteristics, which can also be used in the durum breeding program. In this project such properties should be evaluated with the aim to develop varieties for agricultural production and to find suitable genotypes for durum wheat crosses.

(Project leader: Dr. C.I.Kling, University of Hohenheim, State Plant Breeding Institute, Germany, www.uni-hohenheim.de)

POTATOES

There are similar **ideotypes of potato cultivars** suitable for using in the managements systems: low income countries, low input production system and organic farming. The following traits are of major interest:

- resistance to late blight,
- resistance to viruses,
- resistance to other diseases and pests (nematodes, CPB),
- physiological properties (good general adaptability, storage adaptability, drought or other stress tolerance).

(E.Zimnoch-Guzovska. 2003. Demand for low input varieties. Breeding and adaptation of potatoes, EAPR and EUCARPIA meeting 26-30 July 2003, abstracts of papers and posters.)

Organic potato growing differs from the conventional system in several respects. The question is whether these differences are important enough to make separate breeding activities for organic potato growing necessary. Many organic growers are unable to produce a marketable crop if late blight strikes in their crop early – in tuberizing phase. Implications for breeding strategies of commercial programms will be discussed.

(L.T.Colon, D.J. Budding, M.H.P.W. Visker. 2003. Potato breeding strategies for organic farming. Breeding and adaptation of potatoes, EAPR and EUCARPIA meeting 26-30 July 2003, abstracts of papers and posters.)

The practice of organic potato production offers a frame of **desired characteristics for organic potato breeding**:

- adapted to organic fertilization (animal manure, composts)
  - take roots very rapidly, also under cold circumstances,
  - have an adequate root system architecture,
  - are efficient in mineral uptake and use,
  - have a rapid juvenal development,
  - have a good growth vigour.
- crop protection by prevention and self regulation to diseases
  - Phythophtora
  - Rhizoctonia
  - resistance to silver scurf, scab and several viruses are also desirable.
- short growing pwriod
  - have a rapid juvenal development
  - bulk early
  - ripen early
  - give a stable and net yield of 30 tons/ha
  - reach a good quality in a short growing period (high dry matter, good cooking and baking quality, good storability)
- demands for market
  - exterior appearance
  - the same traits as for conventional varieties.

(M.Tiemens-Hulscher, M.Hospers, G.J. van der Burgt, C.ter Berg, E.Bremer, E.T.Lammerts van Bueren. 2003. Towards an organic potato ideotype. Breeding and adaptation of potatoes, EAPR and EUCARPIA meeting 26-30 July 2003, abstracts of papers and posters.)

Breeding goals for potatoes:

- *Phytoptora infestans* (late blight). *Phytophtora* causes variable yields. Considering the pending prohibition on the use of copper fungicides and the increased aggressiveness of the Phytophtora pathovar spectrum present in the EU this is the most important problem for the increasing organic potato market. Although there are some new varieties with higher resistance levels, many have low organoleptic (taste) quality, poor visual appearance and/or limited storage ability.
- *Rhizoctonia*

(Werner Vogt-Kaute, AGÖL standards - draft paper, 2001, originally from Edith Lammerts van Bueren (changed), www.naturaland.de)

OTHER CROPS

Important **breeding objectives and methods** for organic cereals and **grain legumes** are discussed and recommendations for priorities are given in reports.
In beans and peas breeding the aim is yield potential, quality, weed suppression, and bean varieties with zero-vicin/convicin and zero-tannin.

(Kristensen, Lars; Østergård, Hanne and Jørnsgård, Bjarne (2001) Forædlingsmål og forædlingsopgaver i økologisk korn og bælgsæd [Breeding objectives and breeding activities in organic cereals and grainlegumes], in Nielsen, Bent and Kristensen, Lars, Eds. *Forædling af korn og bælgsæd samt produktion af såsæd i økologisk Jordbrug.*. FØJO-rapport no. 15/2001, chapter 8, page pp. 109-137. DIAS.
(Leibinger, T.; Reiners, E. 2002. Demands of sector bodies for organic plant breeding. [German] Beitrage zur Zuchtungsforschung - Bundesanstalt fur Zuchtungsforschung an Kulturpflanzen. Bundesanstalt fur Zuchtungsforschung an Kulturpflanzen, Quedlinburg, Germany: 8: 1, 19-23.)
http://www.foejo.dk/publikation/f_rap.html#anchor15)

A workshop on plant breeding and plant breeding research related to organic farming was organized by the 'Bundesanstalt fur Zuchtungsforschung an Kulturpflanzen' (BAZ) and 'Naturschutzbund Deutschland' (NABU). Papers addressed a wide scope ranging from available plant genetic resources to breeding strategies suitable for organic agriculture. **Aims and demands for organic breeding** were presented from sector bodies (bio-organic and bio-dynamic) as well as from nature protection and food quality points of view. Papers on resistance breeding in bio-dynamic **vegetables, grapes**, barley, wheat, rye, potatoes and fodder plants are presented. Resistance against various pests and diseases, drought tolerance and modified carbohydrate composition are also discussed.

(Plant breeding reserach, plant breeding and organic farming, 22-23 November 2001, Quedlinburg, Germany. [German], Beitrage zur Zuchtungsforschung - Bundesanstalt fur Zuchtungsforschung an Kulturpflanzen. Bundesanstalt fur Zuchtungsforschung an Kulturpflanzen, Quedlinburg, Germany: 2002. 8: 1, 128.)

- **Sugar beet**: Because of the relatively low loss in yield (about 20%) sugar beet would be a commercially interesting crop for farmers in areas where casual labour is available. Rapid growth during the early growth stages is thought to be important in areas with high abundance of animal pests. However, there are no processors available for organic sugar beet in several EU-countries. This is disappointing since sugar beet is an excellent break crop (providing both agronomic and economic benefits) for organic arable rotations especially in regions with fertile soils.
- **Maize**: There are already interesting breeding programmes focusing on the development of varieties for low-input conditions. Again the ability to establish/grow rapidly during the early growth stages is thought to be a desired characteristic for "organic varieties".
- **Sunflower**: There is currently no difference between the characteristics desired for organic and conventional production systems. High straw strength and early maturing being important selection criteria as well as high yield.
- **Oil seed rape**: It would be very desirable to have an alternative oil/animal feed protein crop to sunflower available in Germany. In Germany organic rape is attacked by several animal pests with resulting in yields of under 1000 kg per ha. Another problem with winter rape are weeds and the high fertility demand. It is therefore necessary to carry out fundamental research in the development of organic rape varieties and agronomic strategies use to produce oil seed rape crops in Germany.

(Werner Vogt-Kaute, AGÖL standards - draft paper, 2001, originally from Edith Lammerts van Bueren (changed), www.naturaland.de)

III. ACHIEVEMENTS: CURRENTLY WORKING ORGANIC BREEDING PROGRAMMES AND REGISTERED ORGANIC VARIETIES

Getreidezuchtung Peter Kunz (Switzerland)

The grain seed producer Grain Breeding Peter Kunz has been doing pioneering work in the development of new, regionally adapted cultivars of **wheat and spelt** (*Triticum spelta*), in cooperation with organic farming operations in Switzerland and in Germany for nearly 20 years. Inspired by the ideals and commitment to quality striven for in biodynamic agriculture, a number of new varieties with excellent cultivation, processing and nutritional characteristics have already been developed. Through an intensive work on fundamentals, it has been possible to revive traditional methods of plant breeding, to develop them further, and to adapt them to the special needs of organic agriculture. Thus, the way has been cleared for an independent breeding and seed production suited to the specific needs of organic agriculture. The breeding process, from the beginning up through to the completed, registered new variety, typically takes an average of 12 to 15 years.
2002: Entry of the first newly developed spelt variety **Alkor** in the Swiss National Seed Varieties Catalog and in the OECD seed variety catalog.
2004: Entry of 3 wheat varieties **Pollux, Ataro and Wenga** and spelt varieties **Sirino and Tauro** in the Swiss resp. German Seed Varieties Catalog.
2005: Entry of wheat varieties **Aszita and Wiwa** and spelt variety **Titan** in the German resp. Swiss Seed Varieties Catalog.
Breeding aims:
Wheat: yield 3.5-6 t/ha; suitability to fertilization with stable manure; vitality, competitive ability with weeds; lodging resistance; disease resistance (FHB, mildew, septoria, rust); best backing quality and very good food quality. 150 crosses per year are made.
Spelt: lodging resistance, processing quality; 50 crosses per year.
In organic farming spelt is popular due to its good yields and special quality traits. In Switzerland many organic farmers grow spelt even more successful than wheat.

(www.peter-kunz.ch)

Specific selection criteria of Peter Kunz are baking quality, contribution to weed restriction and resistance to smut. To develop his selection criteria he also carried out comparative studies on baking quality. On account of the great variation in altitude, soil and climate in Switzerland, Kunz carries out his work on farms in different regions (Standort-orientierte Zuchtung).
Kunz' principles for breeding for organic conditions are as follows:

1. In the selection of parent stock for cross breeding purposes the specific conditions on the farm must be taken into account. Various biodynamic farms and one conventional farm in Switzerland made trial plots available.
2. Selection and the development of hybrids must take place directly in the area where the new hybrid is to grow so that site-specific natural selection can take place. The prevailing specific selection criteria can be taken into account and they can be worked out more specifically.
3. The hybrid population should be narrowed down genetically only to the extent that is necessary for the given site. Heterogeneity should be maintained to some extent, not only to allow continued organic development of the variety (progeny) under the supervision of a breeder but also to allow for crop diversity, which seems to make more sense than conserving a range of gene banks.

Crossings were made on a central trial plot. The F1, which is available for further breeding, is also grown there. From F2 and F3 (depending on the amount of available seed stock and breeding method) the various populations go to the different organic trial sites on farms either as pedigrees or as mixtures, where assessments and selections will be made every 3 or 4 weeks, or as required.

After the harvest the final selection (grain quality etc.) and processing is done at one central site. The progeny is selected and processed at the same site over a period of years. The great difference between the breeding scheme of P. Kunz and conventional breeding scheme is that the lines are not tested on different sites until F6 is reached. The priority in conventional breeding is not adaptability to location but pheno-typical stability.

(Cereal breeding, www.ifgene.org)

Cereal Breeding Research Darzau, Dr.Karl-Josef Mueller (Germany):
Developing Criteria For Breeding And Breeding Itself Of Cereals For Organic Farming In Northern Germany

Under the umbrella of the 'Association For Goetheanistic Research' in the 'Cereal Breeding Research Station Darzau' criteria for breeding cereals are developed under bio-dynamic farming. In particular the focus is on the special situation of organic farming (soil fertility, natural manure, weed competitiveness, seedtransmitted diseases) and a nutrition of human being as an organism with spiritual skills. Becoming aware of the importance of older or new characters of cereals, we try to put them into action by breeding new varieties for modern circumstances of organic farming.
Aim: Getting knowledge about differences of susceptibility between common varieties related to loose and covered smut and leaf stripe disease, finding resistant varieties as a source for further breeding, distinguishing different sources of loose smut on a set of test-varieties. Developing principals to implement natural infection conditions into the area with plots for breeding. Weighing and selecting parameters for distinguishing varieties related to light competitiveness under practical conditions of selection.

Breeding projects:

- Quality winter wheat breeding for organic farming on sandy soils
- Developing a light colored grain rye population
- Hulless food barley breeding
- Nacked oat breeding
- Einkorn (*Triticum monococcum* L.)

Winter wheat: sandy soils are quite common in Lower Saxonia, Mecklenburg-Vorpommern and Brandenburg (around Darzau). Together with occurring spring drought, it is very difficult for ecological farmers to reach the quality standards, which are demanded by mills and bakers, who produce ecological food. The loss of nitrogen during the winter months can be minimized by early sowing in autumn. For this purpose it is necessary to have wheat varieties, which will not develop to far before winter (this would cause losses during winter), but, on the other hand, develop strong enough in order to suppress competing weeds like *Apera spica-venti*. In the breeding process attention are paid to: fast development in spring, high gluten and a more favorable relation between gluten-content and yield, high sedimentation value, protein quality of wheat regarding human nutrition, morphological characters, which allow better understanding of the process of ripening, resistance or tolerance regarding the seed-born common bunt disease *Tilletia caries.*
Yellowish light colored grains occur more or less in heterogenous rye populations. Varieties with this character have formerly been more frequent in Central Europe. Due to existing literature light-grained-rye is expected to be more easily digestible and to support a mild taste of the bread. For judging the quality of rye for baking it is necessary to measure the activity of the enzymes (amylases), which decompose the starch within the grain. Important is vitality and growth in spring, a plant height, lodging resistance according to the plant height and

straw of golden-yellow color and a satisfying yield. The population has the following origin: 1/3 Schmidt-Rye, 1/3 Hack-Rye (its changeable history goes back to the variety 'Petkuser Nomaro'), 1/3 'Danko', 'Halo', 'Kustro', 'Carokurz' and 'EHO-Kurz'.

Ceral Breeding Research Darzau has developed **Lawina** spring food barley under bio-dynamic cultivation designed in particular for the conditions of organic cultivation on poor grounds. This variety stands out for its growth height to permit a good weed control by shading. It has an absolutely hull-free threshing and an almost entirely light beige grain. Compared to the hulled malting barley, it achieves a yield level of approx. 65 percent, keeping in mind, however, that the hulled malting barley is weighed with the hulls. Thus, the price for this variety has to be at least 50 percent over that of malting barley so that the farmer can cover his expenses.

The next aim is to improve the resistance of barley to seed-transmitted diseases so that an organic seed multiplication can increase and a farm saved seed cultivation can be carried out without any problems. At present, initial research is being carried out on the resistance to loose smut, covered smut and stripe disease.

Breeding aims for nacked oats: free threshing, with as possible few hairs on the grain, with high viscosity.

Einkorn (*Triticum monococcum* L.) is a specific grain type with extraordinary characters formerly grown mainly in European regions. It got a special interest already at the beginning of bio-dynamic farming when some gardeners searched for cereal forms between wild grasses and modern cereals. Very little attention had been paid to breeding those forms. It was hope the older forms would show original characteristics which have been lost in the modern breeding process. A very special characteristic of einkorn is its yellowish color of flour. The harvest can be hulled or hulless after threshing. Presently available winterhardy varieties of einkorn, bred at Cereal Breeding Reserach Station Darzau: wintereinkorn **Albini** (hulled, white-hulls, early ripening, high light competitiveness, grain weight middle high, gluten middle and very weak, awns breaking easily); wintereinkorn **Tifi** (hulled, brown-hulls, middle late ripening, high light competitiveness, grain weight high, gluten high, for dry and sandy soils);wintereinkorn **Terzino** (hulled, brown-hulls, late ripening, grain weight middle, good yielding, gluten middle high, carotene content high, also for better soils).

(www.darzau.de)

Saatzucht Schweiger (Germany): wheat breeding for organic farming

The limited nitrogen availability in organic systems is a specific problem for yield and baking quality parameters like gluten content. The variety **Ökostar (Naturastar)** was developed as a compromise between these breeding targets. It is a polycross of the varieties Severin, Monopol, Huntsman, Mission, Ares and Urban. In 1998, an application was submitted for varietal registration and addition to the German national variety list. Selected results from the 3-year variety registration tests are presented and compared with standard varieties. Results for 1999 show a short growth period, above average plant height, relative yields of 98%, and relatively high protein and gluten contents. Sedimentation value and baking volume were also high. A comparison between the standard field test and tests under organic conditions revealed that Ökostar had similar quality parameters above the minimum standard for E-wheat (Elite-wheat) in both tests. Only the parameter baking volume was clearly different: under conventional conditions it was below standard while under organic conditions it was well above. It is concluded that Ökostar, successfully registered in 2002, can produce superior qualities under organic conditions. For future organic breeding programmes, improving baking quality and gluten content are seen as key objectives.

(Kempf K., Weizenzuchtung fur den okologischen Landbau - Zuchtung und Zulassung der Sorte Okostar in Deutschland. Bericht uber die Arbeitstagung 2002 der Vereinigung der Pflanzenzuchter und Saatgutkaufleute Osterreichs gehalten vom 26. bis 28 November 2002 in Gumpenstein. Bundesanstalt fur alpenlandische Landwirtschaft Gumpenstein, Irdning, Austria: 2003. 65-70.)

Institute for Biodynamic Research (IBDF, Germany)

Dr. habil. Hartmut Spieß

Since 1995 IBDF carries out breeding of cereals and vegetables and maintenance of genetic resources.
Organic plant breeding; crop diversity; seed health; organic plant protection: site-appropriate cereal and vegetable varieties are bred, which are adapted to the specific conditions of production in organic agriculture. This work is part of the Association of biodynamic Plant Breeders. Another focus of this department is the development of biological techniques for plant protection and mainly against seed-borne diseases.

(http://www.ibdf.de)

Saatzucht Donau (Austria)

Because of increasing share of organic farming in Austria and many other European Countries, Saatzucht Donau is breeding and developing varieties, which are especially suited for organic conditions. Even now varieties from the breeding stations Probstdorf and Reichersberg are very well adapted to organic farming. Examples are winter wheat CAPO (leading variety in organic farming in Austria and some other European Countries) and SATURNUS and spring barleys EUNOVA and MODENA.
In a project that is funded by the agricultural ministry and coordinated by ARGE Biolandbau extensive trials are conducted with winter wheat and spring barley on organic farms in different climatic regions of Austria. The best lines of these trials are tested in an official registration process by the federal office for Food Safety.
In December 2004 the high quality winter wheat varieties **Pireneo** and **Aurolus** were registered in the Austrian list of varieties. **These two varieties are the first in Austria as well as in European Union that are registered based upon organic testing only**. In the coming years additional varieties of winter wheat and spring barley are expected to be registered for organic farming.
The same breeding scheme is used for breeding of organic and conventional varieties. The first generations are grown in conventional conditions. In F5 generation special attention is paid to tillering ability, early vigour, competitive ability with weeds, disease resistance. Testing of material in organic growing conditions is started in F6 generation (without reps), in F7 testing is done in 2-3 organic locations.

(www.saatzucht-donau.at)

Elm Farm Research Center (UK): wheat breeding

Elm Farm Research Center is the UK's leading research, development and advisory institution for organic agriculture, having played a pivotal role in the development of organic research, policy and standards since 1980

The research department at Elm Farm Research Centre (EFRC), in collaboration with the John Innes Centre, have recently begun work on an exciting and highly innovative new project 'Generating and Evaluating a Novel Genetic Resource in Wheat in Diverse Environments'. The aim of this project is to develop and test the concept of population breeding for wheat. This six-year project started in November 2001.
The approach we are using is to produce composite cross populations in wheat. The key to this is to ensure that we include the greatest possible genetic diversity in the parent lines, as this will provide the populations with the capability to adapt to different growing conditions. Some 20 outstanding wheat varieties from the last half-century in Europe are being crossed in all possible combinations. Unlike physical cereal mixtures, this inter-crossing will result in a re-assortment of genes, providing completely new genotypes. Population samples from the F2 generation will be grown at a range of organic and non-organic sites to determine the degree and rate at which the populations adapt to the local environment over several generations. If successful, the material produced could be used either directly by farmers or as a rich genetic resource for further selection and breeding. The genetic variation should allow the mechanisms of niche spread, complementarities and compensation to make the populations highly, and rapidly, adaptable in terms of disease, pest and weed restriction together with buffering against variation in the physical environment.
This type of approach was used very successfully in a barley breeding programme undertaken in California during the early part of last century (1920s). In fact, many of the barley varieties we see today can trace their ancestry back to these populations. We hope that our programme will be equally successful and look forward to presenting results as the project develops over the next few years.

(J. P. Welsh, 2002. NEWSLETTER ON ORGANIC SEEDS AND PLANT BREEDING)

ITAB, the French Technical Institute for Organic Farming

ITAB, the French Technical Institute for Organic Farming, is involved as coordinator or partner in different programs of organic plant breeding. ITAB is working with Lemaire Deffontaines company on **wheat** selection. Selection criteria were established by ITAB cereal committee (weed control, straw height, low inputs, yield, baker quality). One to three line could be proposed for variety registration. A new selection program began in 2002 with Michel 'Obtention (**legume fodder**) and Cameau (**grass fodder**) companies on fodder selection. The selection criteria are seed yield, fodder yield, livestock trampling, fodder quality and weed control.

(www.itab.asso.fr
Newsletter on organic seeds and plant breeding. Jan.03.
http://www.ecoplantbreeding.com)

Sejet Plant Breeding (Denmark)

Breeding for barley and wheat for Danish low-input conditions with emphasis on disease resistance, weed competitiveness and nutrient uptake. Prebreeding.

(www.cost860.dk)

Organic **potato** production demands cultivars with efficient nutrient uptake and resistance to pests and diseases while maintaining biodiversity. Existing cultivars were tested for the characteristics required and released for organic production. Peronospora is a major problem, particularly in early potatoes, and is rendered more acute by the gradual reduction planned for the amount of copper products that may be used in organic production. Zagara, MN 450, MN 475 and MN 319 are early genotypes currently available with a marked resistance to the fungus.

(Lovatti, L.; Rosta, R. 2003. Selection of new potato cultivars for organic production. [Italian], Informatore Agrario. Edizioni l'Informatore Agrario Srl, Verona, Italy: 59: 2, 45-47.)

In ecological **potato** growing, Phytophthora infestans, Streptomyces sp., Rhizoctonia solani and virus diseases are most devasting. Breeding for host resistance toward Rhizoctonia solani does not appear promising at present. Breeding for resistance to common scab is difficult but has some potential. In respect to virus resistances, partly good knowledge on resistance mechanisms as well as a wide range of host resistances and long experiences in breeding practice are available. Consequent use of these factors in variety breeding could make increased future contribution to sustainable potato growing. Generally, late blight resistance is of uppermost importance for integrated and ecological potato growing. At the Federal Centre for Breeding Research on Cultivated Plants (BAZ), combining of foliage and tuber blight resistance with second early maturity and specific quality traits has arrived to first success and is intensively continued. A long-term prebreeding programme closely oriented at the requirements of variety breeding is a precondition for the successful transfer of quantitative late blight resistance to novel, marketable varieties. The best cross parents of he institute are steadily offered to be used in variety breeding.

(Darsow, Ulrich (2002) Resistenzzüchtung bei der Kartoffel: Beitrag des genetischen Pflanzenschutzes für einen ökologisch verträglichen Kartoffelanbau [Resistance breeding in potato: Contribution of genetic plant protection to ecologically compatible potato growing]. Paper presented at Workshop "Züchtungsforschung, Pflanzenzüchtung und Ökologischer Landbau", Quedlinburg, 22-23 Nov. 2001, page pp. 110-114. Beiträge zur Züchtungsforschung 8/ 2002 (Heft 1).
http://www.bafz.de/baz99_d/baz_orte/gl/glstart/glstart.htm)

Breeding selection of **lupines** and a complex quality analysis are necessary. In addition to agronomical characteristics quality parameters are estimated, such as protein content, amino acid composition, fat, fatty acid composition, starch and sugar as well as antinutritive substances (non-starch polysaccharides and alkaloides). On the basis of determined data, NIR/NIT-calibrations are developed as breeding relevant methods. The project serves to both opening up and use of genetic resources and breeding of lupines suitable for ecological cultivation.

(Jansen, Gisela; Jürgens, Dr. Hans-Ulrich; Kuhlmann, Josy and Flamme, Professor Dr. Wilhelm (2005) Züchterische Bearbeitung von Süßlupinen für den ökologischen Landbau – Erste Ergebnisse zu Ertrags- und Qualitätsuntersuchungen [Breeding of lupines for the ecological farming – First results regarding yield and quality investigations]. Poster presented at 8. Wissenschaftstagung Ökologischer Landbau - Ende der Nische, Kassel, 01.03.2005 - 04.03.2005; Published in Heß, J and Rahmann, G, Eds. *Ende der Nische, Beiträge zur 8. Wissenschaftstagung Ökologischer Landbau*.)

High and significant correlation coefficients were found between quality parameters of summer and autumn **carrots** from a biodynamical breeding project determined by physico-chemical analysis and PFMs. This indicates close relationships between the two quality approaches which should be investigated further in future work.

(Hagel, I.; Bauer, D.; Haneklaus, S. and Schnug, E. (2000) Quality Assessment of Summer and Autumn Carrots from a Biodynamic Breeding Project and Correlations of Physico-Chemical Parameters and Features Determined by Picture Forming Methods. Paper presented at 13th IFOAM Scientific Conference, Basel, 28.08.2000 -

31.08.2000; Published in Alföldi, Thomas; Lockeretz, William and Niggli, Urs, Eds. *Proceedings 13th International IFOAM Scientific Conference*, page pp. 284-287. IFOAM.
http://orgprints.org/00002122/, http://www.ibdf.de/, http://www.pb.fal.de/en/index.htm, http://www.ifoam.org/)

To make gene bank accessions more accessible for the utilization in organic breeding programmes, a participatory research project with farmers was carried out in 2002 to 2003. From the Dutch gene bank collection, 37 **onion** accessions, divided into five different groups (according to their market use), were selected and planted at a commercial organic farm. Farmer participation in characterization and evaluation of the material resulted in including additional plant traits for gene bank characterization as well as new selection criteria for breeding. Variation for important properties was found within and between the five groups. To establish base populations, the farmers, in collaboration with the researchers, selected the best genotypes within the five groups of onion accessions. The new base populations may be exploited to achieve better-adapted material for organic farming systems.

(Bueren, E. T. L. van; Soest, L. J. M. van; Groot, L. C. de; Boukema, I. W.; Osman, A. M., 2004. Broadening the genetic base for better-adapted varieties for organic farming systems: participatory characterisation, evaluation and selection of onion accessions for new base populations. Genetic variation for plant breeding. Proceedings of the 17th EUCARPIA General Congress, Tulln, Austria, 8-11 September 2004. BOUK - University of Natural Resources and Applied Life Sciences, Vienna, Austria. 447-450. 6 ref.)

Zaadgoed (SeedGood) is a foundation established for the promotion of organic plant breeding. We want to promote and develop

- biodiversity,
- sustainable use of cultivars, and
- organic breeding methods.

Donations made to Stichting Zaadgoed are being used for at least 70% in concrete projects. In the season 2000/2001, these are the following projects.
Beetroot breeding led by farmer René Groenen, with 4 biodynamic farmers on clay soils. Varieties in testing and crossing: Rote Kugel, Action F, Boltardy, Libero and others.
More projects and research are being carried out by our Dutch partner, the Louis Bolk Institute. This research institute for organic agriculture has laid the foundation for policy on organic plant breeding with the report "Sustainable organic plant breeding". This is the Final Report of the international discussion on organic breeding by scientists and organic farmers of the Netherlands, Germany, Switzerland and the United Kingdom in 1998 and 1999. The organic sector has discussed various breeding techniques currently in use in conventional plant breeding, and has chosen which should and which should not be used in organic agriculture. For ordering information, and more organic plant breeding projects, see the Louis Bolk website www.louisbolk.nl A summary is printable from www.biogene.org

(http://www.fibl.org/forschung/gentechnik/)

The biggest obstacle for an increased proportion of **grain legumes** (pea (*Pisum sativum*), faba beans (*Vicia faba*) and lupines (*Lupinus* sp.)) in the organic rotation is presently diseases, which are accumulated in the system over time, especially soil and seed borne pathogens. Various breeding methods are used when introducing resistance genes into highly adapted material. Methods involve backcrossing, where defined genes are transferred, recurrent selection involving repeated cycles of intermating and selection often used in pyramiding genes in outbreeding species and composite crosses used in selfpollinating cereals. In this project the “composite cross” method will be evaluated as a tool for selecting breeding lines with improved resistance.

("Grain legumes for organic farming. Improvement of disease resistance" Acronym: Grainleg, Research in organic farming 2000-2005 (DARCOF II))

IV. PROBLEMS

Problems with GMO

"The great progress of agro-genetic engineering is that it unites conventional and organic farmers", Georg Janssen, National Manager of the ABL (Arbeitsgemeinschaft Bäuerliche Landwirtschaft) rejoices. He refers to thousands of farmers who have decided from below that genetic seeds will never get onto their fields. This is the right way, Victor Gonzálves of SEAO (Spanish Society for Organic Farming) emphasized. He reported of Spanish organic farmers whose organic maize- and soya crops have lost its organic status by gmo contamination and so couldn´t be sold on the organic market anymore. "Spain is a good example that co-existence doesn´t work."

„Most of the consumers don't want gmos on their plates. Here, organic farming of the Europe must offer a consistent alternative. Independence must also be extended by means of organic seeds and organic breeding," emphasized Friedrich-Wilhelm Graefe zu Baringdorf, Vice-Chairman of the Agricultural Committee of the EU-Parliament.

Protection against Genetic Engineering is only the Beginning – It Is Time for Active Steps towards Organic Breeding Now, Press Release 19 February 2004, www.ifoam.org/press/GE_Protection.htm - 10k

Nowadays in all ecological associations concerned with breeding as well as in the Swiss government's organic regulations, the introduction of genetically modified organisms is forbidden. Nevertheless not all the questions affecting the **relationship of genetic engineering and organic agriculture have been discussed** exhaustively. The issue also touches other so called conventional methods of plant breeding, which until now were, at most, discussed only in marginal groups.

(Christine Karutz, April 1998, Ecological cereal breeding and genetic engineering. A Discussion Paper. *Research Institute for Organic Agriculture (FiBL), Ackerstrasse, Postfach, CH-5070 Frick, Switzerland)*

In recent discussions on purity in organic breeding, the **use of colchicine is criticised** because of its toxicity and there are calls for a ban on varieties bred where use of this substance was involved. To assess the effects of such a ban, diploid varieties of red clover (Trifolium pratense), Italian and English ryegrass (Lolium multiflorum and L. perenne, respectively) from the breeding programme of the FAL Reckenholz in Germany were compared with their tetraploid equivalents and the latest diploid varieties. Results showed clear advantages of tetraploid varieties in most agronomic traits. Resistance to leaf diseases and digestibility were improved the most. Only with Italian ryegrass, the latest diploid varieties were on average better than the tetraploid varieties. Because more then 50% of the listed red clover and ryegrass varieties in Europe are tetraploid, it is concluded that a ban in organic agriculture would have a severe effect on the sector. Especially since disease resistance and fodder quality will be affected, both important characteristics in organic systems. Snow mould [Monographella nivalis] resistance of tetraploid English ryegrass, important for organic farms in marginal areas, will also be unavailable.

(Boller, B.; Schubiger, F. X.; Tanner, P. 2003. Can organic agriculture abandon tetraploid varieties of red clover and ryegrass? [German] Bericht uber die Arbeitstagung 2002 der Vereinigung der Pflanzenzuchter und

Saatgutkaufleute Osterreichs gehalten vom 26. bis 28 November 2002 in Gumpenstein. Bundesanstalt fur alpenlandische Landwirtschaft Gumpenstein, Irdning, Austria: 71-74. 5 ref.)

Genomics is the mapping, sequencing and analysis of DNA to characterise, determine functions and understand how gene products interact. Genetic engineering is just one application of genomics.
What other potential applications are there for the knowledge about plant **genomics** and how can these **meet the needs of sustainable and organic agriculture**?
From here a short brainstorm produced a list of key needs for organic/sustainable agriculture that plant genomics may help with, such as:

- greater efficiency in carbon and nitrogen metabolism/utilization;
- land reclamination uses;
- non-food crops;
- high performing spring sown cereals;
- increase organic seed bank/quality;
- crop types that encourage mixed cropping
- weed tolerance;
- pest and diseases resistance;
- finding non-GM solutions, e.g. signal/smart plants.

Some issues and fundamental questions raised by participants had potential for further work:

- what is the minimum scale a genomics system can operate at profitably and is there a different business model a plant breeder can adopt?
- how will adequate resources be made available to incorporate genomics into breeding of sustainable varieties?
- what are the needs of organic farming?
- what are the needs of sustainable agriculture?
- how do we develop information from the public and private sector into plant breeding?
- is the seed registration process facilitating or hindering plant breeding towards a more sustainable direction?
- what is the countryside for, inclciding what are the needs of sustainable agriculture and land management?
- what are parameters for construction of plants using genomics
- what is acceptable/unacceptable?
- the need for further discussion on microbial genomics.

(Exploring thePotential forPlantGenomics to SupportOrganic and Sustainable Agriculture. Summary Paper of a Workshop held on 23rd and 24th July 2001
www the-environmentt-council.org.uk)

A plant breeding system for organic production should be based on the organic concept of plant health and on the organic position on chain relationships. As the total land area under organic production is still relatively small, it is unlikely that commercial breeders will make large investments to develop organic breeding programmes without financial support from other parties, i.e. the government. In this early stage**, it is vital that the government provides generous funding and plays an active enabling role.**

(Lammerts van Bueren, E.T.; Hulscher, M.; Jongerden, J.; Ruivenkamp, G.T.P.; Haring, M.; van Mansvelt, J.D. and den Nijs, A.M.P. (1999) Sustainable organic plant breeding: Final report - a vision, choices, consequences and steps. Louis Bolk Instituut Publications no. G24, Plant Breeding, Louis Bolk Instituut and Wageningen UR. http://www.louisbolk.nl/downloads/g24.pdf)

In the short and middle long run, organic crop ideotypes per crop and per market segment can help in the selection of the best available varieties amongst the existing which can also be propagated organically. In the long term, breeders can influence further improvement of organic seed production not only by organically propagating the best suitable, existing varieties, but also by integrating organic traits in future breeding programmes. **Because of the small market, adaptation to organic agriculture has not received enough priority in conventional breeding programmes until now**. In some cases a new and broadened gene pool should be established by composite or population crossings among a large number of selected parents/varieties to come to better adapted genotypes. Chablé (2003) recently presented the INRA-organic breeding programme for *Brassica*, which departs from a newly established population. Due to the expectedly larger plant x environment x management interaction under lower (organic) input conditions in organic farming, the most efficient way is to select as early in the selection process as possible.

Along with the search for **new breeding strategies for organic farming systems,** there is an ongoing discussion about which breeding techniques are compatible with both the ecological and the ethical principles in organic agriculture. This discussion started at the time when genetic engineering became important in breeding and organic farmers realised that they are not only concerned about variety traits but also about how varieties are bred and propagated.

(Edith T. Lammerts van Bueren, Challenging new concepts and strategies for organic plant breeding and propagation.
Louis Bolk Institute, Hoofdstraat 24, NL-3972 LA Driebergen, The Netherlands.
Contact: e.lammerts@louisbolk.nl,)

For further optimization of organic product quality and yield stability new varieties are required that are adapted to organic farming systems. The desired variety traits include adaptation to organic soil fertility management, implying low(er) and organic inputs, a better root system and ability to interact with beneficial soil micro-rganisms, ability to suppress weeds, contributing to soil, crop and seed health, good product quality, high yield level and high yield stability. In the short run, organic crop ideotypes per crop and per market segment can help to select the best varieties available among existing (conventional) ones. However, until now many of the desired traits have not received enough priority in conventional breeding programmes. Traits like adaptation to organic soil fertility management require selection under organic soil conditions for optimal results. **The limited area of organic agriculture will be the bottleneck for economic interest in establishing specific breeding programmes for organic farming systems.** The proposed organic crop ideotypes may benefit not only organic farming systems, but in the future also conventional systems that move away from high inputs of nutrients and chemical pesticides.

(E.T. LAMMERTS VAN BUEREN,, P.C. STRUIK AND E. JACOBSEN *(2002)* Ecological concepts in organic farming and their consequences for an organic crop ideotype. *Netherlands Journal of Agricultural Science 501-26.)*

Diseases of plants cause significant losses in crop yield and quality. Plants contain a battery of genes whose role is to prevent pathogens invading. Their effective use in crop plants is very important in crop production and especially in chemical free cropping systems. Such genes are introduced into crop varieties by plant breeding. The new science of genomics may enable scientists to recognise all the resistance genes present in a plant. This will eventually allow plant breeders to more precisely and rapidly select useful resistant plants in their breeding programmes. Furthermore, genomics could enable effective deployment of these genes in cropping systems, so providing more durable resistance.

(Jim Beynon *Horticulture Research International, Wellesbourne, Warwick, CV35 9EF, UK. 26-28th March 2002,* Plant genomics – a way forward? Powell et al. (eds), *UK Organic Research 2002: Proceedings of the COR Conference, Aberystwyth*, pp. 307-310.)

Long-term perspectives and outlook

Long-term perspectives will depend on developments in a range of areas and is currently very difficult to predict:

- If genetic modified varieties will be grown on a large scale within the EU - will there be breeding of non-genetic modified varieties? Can organic agriculture only react and conserve old varieties?
- Will the increase in organic agriculture make it commercially interesting to breed specifically for organic agriculture?
- How can we create a balance between a conventional breeding for the organic agriculture and an organic breeding, so that the organic farmers will harvest the greatest benefit? Organic agriculture cannot (and doesn't have to) work on all the crops (especially not on the less relevant ones), but nevertheless the share of organically bred varieties should increase.

(Werner Vogt-Kaute, AGÖL standards - draft paper, 2001, originally from Edith Lammerts van Bueren (changed), www.naturaland.de)
