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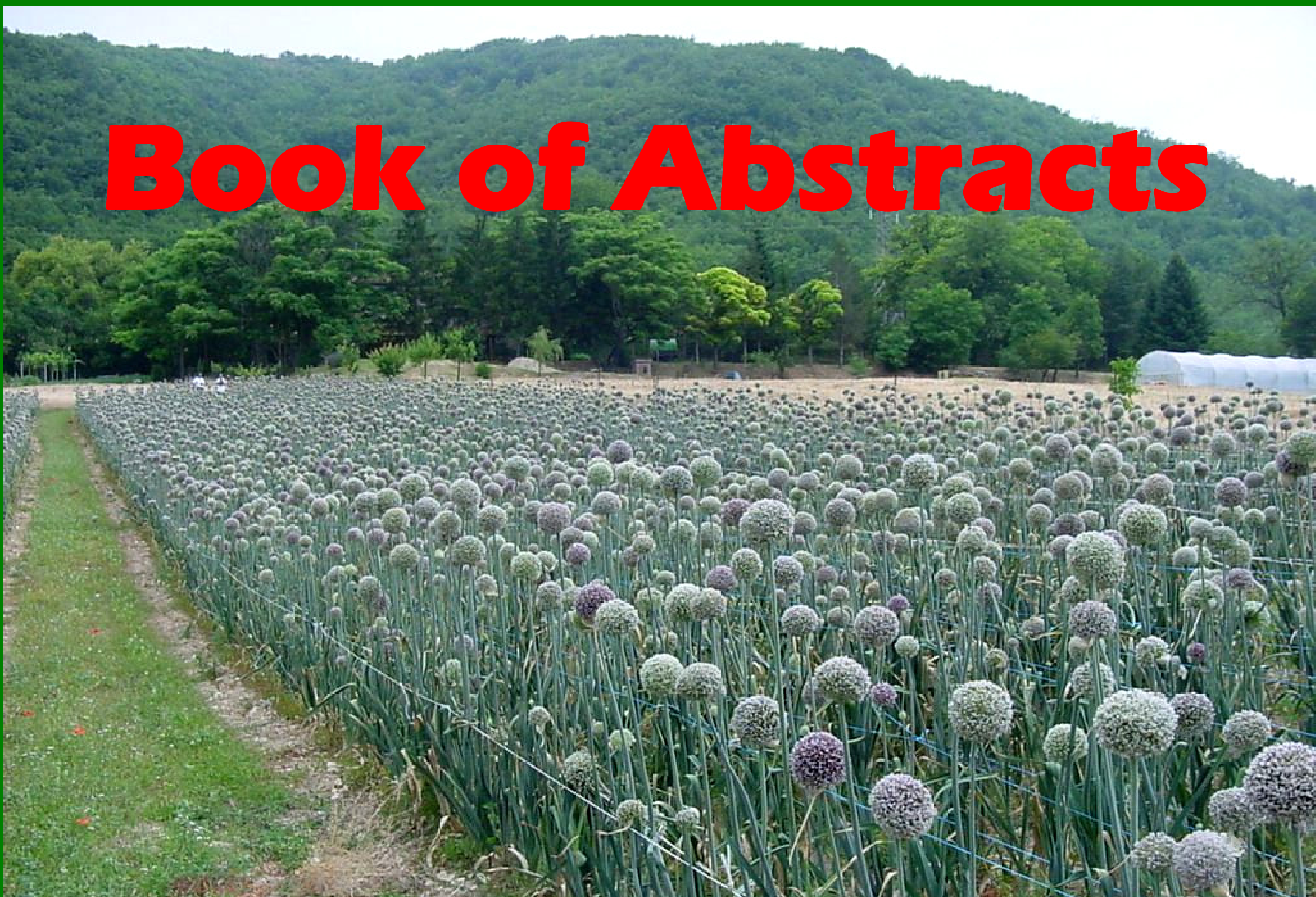
7 – 9 November 2007
Wageningen, The Netherlands

Plant breeding for organic and sustainable, low-input agriculture: dealing with genotype-environment interactions



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EUCARPIA

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Plant breeding for organic and sustainable, low-input agriculture: dealing with genotype-environment interactions

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P.O.Box 386, NL-6700 AJ Wageningen, The Netherlands
Tel: + 31 (0)317 482836
E-mail: edith.lammertsvanbueren@wur.nl

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Preface

Progress in yield and quality of crops is rightfully claimed as mainly dominated by plant breeding. But we have second thoughts whether the available products of plant breeding are suitable for the demands of Organic and low-input Agriculture (O-LI-A). Without a doubt, numerous breeding goals are the same in the different cropping systems. Thus, cultivars for practical use in O-LI-A need to fulfil general traits such as high yield potential, high product quality and high disease resistance, too. But the question is whether a yield progress that we have seen mainly based on a higher harvest index will lead to the intended results under O-LI-A conditions. For example, litter straw of cereals is needed for bedding and for feeding animals in mixed farms. Due to lower crop stand density and lower leaf area index (LAI) longer culms and more planophile upper leaves are necessary to enhance competitiveness against weeds.

Until the 1980s it was regarded as certain among breeders that the most successful cultivars in mainstream agriculture were successful under low-input conditions as well, although even then genotype by environment interactions could be assumed known as essential. There is no doubt that the crop environment in O-LI-A surely is a different one than in mainstream cultivation with intensive supply of nutrients and numerous synthetic inputs.

The general growth conditions in O-LI-A can be characterized as follows: limited soil nutrient availability (especially nitrogen) and no split-application of nitrogen. Nitrogen availability in O-LI-A is a function of precrop effects, rotation design and a delayed mineralization and nitrification under the conditions of temperate climate in early spring, normally all resulting in delayed early development. Thus, LAI, leaf area duration, crop ground cover, water use efficiency, light interception and crop yield are limited.

For O-LI-A, breeding has to make nutrients in the system internally available by increasing rooting density and efficiency of nutrient absorption. Selection of an efficient root system, adapted to limited soil nutrient availability has to consider limited competition for shoot assimilates and an extended active root surface. Cultivars that realise small root diameters might result presumably more successfully under these conditions. High root-length density and a high percentage of active young and fine roots can result from high branching and include *per se* a higher number of root hairs that further increase the root surface considerably.

As has been demonstrated by the so-called nitrogen efficient wheat cultivars, selection under less favourable soil conditions can result in a better adaptation for nutrient acquisition and nitrogen utilisation efficiency which allows the general conclusion that breeding programs performed under the specific growing condition should *per se* result in well-adapted cultivars. But no doubt: to realize a high baking quality under conditions of limited nitrogen availability can still be considered as a big challenge.

Selection for a high nitrogen efficiency has resulted in cultivars of winter wheat corresponding with the morphology of ideotypes that realize high crop competitiveness against weeds. The evaluation of new cultivars in relation to weed suppression has to focus on growth habit and speed of early development. Generally, a high season-long crop ground cover and leaf area duration are important. Ground cover is based on different parameters and weed suppression cannot be attributed to a single characteristic only. Selection for weed competitiveness that includes tall types and morphological features such as higher insertation height of flag leaf or longer flag leaf to ear-distance must not result in lower-yielding cultivars when selection is performed under conditions of O-LI-A.

Thus, breeders looking for ideotypes suitable for O-LI-A are facing a broad spectrum of topics that have to be solved. A lot of knowledge has been gained in previous workshops of SUSVAR (COST 860) network and working groups of COST 851. I very much appreciate that the expertise of breeders of different origin and a highly reputed organisation like EUCARPIA have found together now. I would like to thank the organisers, especially Prof. Dr. Edith Lammerts van Bueren, for all their efforts in realizing this symposium. May this event become a valuable cornerstone for the evolution of plant breeding for Organic and Low-Input Agriculture.

Ulrich Köpke
President ISOFAR

Introduction

Developments in breeding cereals for organic farming systems in Europe

Edith T. Lammerts van Bueren[1], JorgPeter Baresel[2], Dominique Desclaux[3], Isabelle Goldringer[4], Steven Hoad[5] , Geza Kovacs[6], Franziska Löschenberger[7], Thomas Miedaner[8], Hanne Østergård[9], Martin Wolfe[10]

[1]Wageningen University, Plant Sciences Group, Wageningen, The Netherlands; [2] Technical University, München-Weihenstephan, Freising, Germany; [3]INRA - UMR Diversité et Génome des Plantes Cultivées, Mauguio, France; [4] INRA - UMR de Génétique Végétale - INRA UPS INA-PG CNRS, Gif sur Yvette, France; [5] SAC, Edinburgh, Scotland, UK; [6] Agricultural Research Institute of the Hungarian Academy of Sciences, Brunszvik, Hungary; [7] Saatzucht Donau GesmbH & CoKG, Probstdorf, Austria; [8] University of Hohenheim, Landessaatzuchtanstalt, State Plant Breeding Institute, Stuttgart, Germany; [9] Risø National Laboratory, Biosystems Department, Roskilde, Denmark; [10] Elm Farm Research Centre, Wakelyns Agroforestry, Fressingfield, Eye Suffolk, UK.

To deal with the rapidly increasing range of environmental diversity, caused by declining oil-based support for agricultural systems together with global climate change, we will need a tremendous increase in crop and livestock diversity. Therefore the current framework of cereal pedigree line breeding focussed on large scale production of rapidly diminishing genetic diversity will be increasingly inappropriate in the future. Organic farming systems are holistic systems according to the concept of naturalness, including the non-chemical approach, agro-ecological approach and the integrity of life approach. Such systems are necessarily adapted to (a wide diversity of) their localities. This requires therefore a fine-grained adaptation of the crop plants used on individual farms. We argue that there is a need for more breeding activities to improve the organic farming systems and organic product quality. Within the organic sector we distinguish roughly three farming systems: a) global commodity farming, b) regional market farming and c) local market farming systems, each demanding different kind of variety requirements. We also distinguish two type of breeding programmes: conventional breeding for organic agriculture (BFOA) including testing of advanced lines under organic conditions in later stages of breeding program, and organic breeding programs (OBP) where all steps in the breeding process are taken under organic conditions, and including breeding techniques that apply with the organic principles. Developing a holistic approach to breeding individual cereal crops demands a different set of breeding objectives with respect to soil, weed, pest, disease and quality management, and a different set of methods dealing with questions such as wide versus specific adaptation, the structure of varieties (pure line, mixtures, composite cross populations), the choice of selection environment, and participatory approaches. We will discuss the state of the art of current approaches and research, and will end up with recommendations for further breeding research and programs. A summary table is produced indicating the general characteristics of breeding trends for a continuous range of organic farming systems.

Acknowledgement: This work was supported by COST Action 860 „SUSVAR" within Working Group 1 Breeding and Genetics

Genotype
X
Environment
Interaction

Quantitative-genetic basis of breeding maize for adaptation to organic and low-input farming

Hartwig H. Geiger[1], *Walter Schmidt*[2], *Henriette Burger*[1]
[1]University of Hohenheim, Stuttgart, Germany
[2]KWS SAAT AG, Einbeck, Germany

Ecologically sustainable production of healthy food has become a major goal in present-day farming. Nutrient-efficient crop varieties with specific adaptation to organic farming may significantly contribute to achieve this goal. This paper presents quantitative-genetic data on the perspectives of breeding such varieties in maize.

Large representative samples of testcrosses from the current KWS breeding program were evaluated under N-deficiency (LN = low N) and conventional (HN = high N) conditions in multi-environment field trials. In subsequent experiments additional testcross series, synthetic populations, and landrace-derived haploid (DH) lines were compared under organic (OF) and conventional (CF) farming conditions.

Soil nitrogen deficiency caused an average grain yield reduction of about 35-50 %. Phenotypic correlations between LN and HN were moderate to high for random samples of test-cross materials and low to moderate for single crosses selected for specific adaptation to LN or HN conditions. Significant genetic variation existed for the reaction to N-deficiency stress. Heritability coefficients were similar under LN and HN. Molecular marker studies revealed eight quantitative trait loci (QTL) for yield under LN jointly explaining 70 % of the genotypic variance. Growth chamber studies indicated that lateral root development of seedlings correlates with tolerance to N-deficiency.

Grain yields under OF compared to CF were reduced by 5 - 25 % depending on the test environments and, to a lesser extent, the genetic material. Only small to moderate phenotypic correlations existed between OF and CF for grain yield but strong ones for plant height and dry matter content. Re-evaluation of the top genotypes confirmed their specific adaptedness to OF or CF or both. Testcrosses of landrace-derived DH-lines were about 20-25 % lower performing that those of modern inbred lines, but the difference was smaller under OF than under CF. Open pollinated populations synthesized from superior inbred lines performed much lower (20 - 30 %) than predicted by quantitative genetic theory. Again, the difference was smaller under OF.

Data demonstrate that significant genetic variation exists in modern Central European maize germplasm for tolerance to N-deficiency and adaptedness to organic farming. Extending the scope of hybrid maize breeding to these attributes should soon furnish varieties satisfying the needs of low-input and organic farming.

Breeding forage grasses for organic conditions

Beat Boller, Peter Tanner and Franz Xaver Schubiger
Agroscope Reckenholz-Tänikon, Research Station ART, Zürich, Switzerland.

Grass-clover leys are vital components of organic production systems. The growing demand of the organic agriculture movements for organically bred varieties led ART in 2004 to initiate a targeted breeding programme of forage grasses and clovers best suited for organic conditions. Selection of variety constituents, constitution of synthetic varieties, and yield trials are performed under these conditions. This is a basic prerequisite for organic plant breeding (Wyss et al. 2001).
In order to elucidate a particular suitability of candidate varieties for organic conditions in view of their application to official variety testing, we run herbage yield trials under organic conditions, in parallel with two trials at other sites under conventional conditions. Plot trials are sown on organic farmers' fields next to the research station at Reckenholz, Zürich. A contract assures that on these fields, agricultural practices, like fertilization with manure, are performed by the partner farmers, while sowing, trial management, and forage harvests are carried out by personnel of the research station. Five cuts are taken in each main harvest year. Here, we report on second and third year results of the sowings 2004 and 2005, and on second year results of the sowings 2006. The latter included, for the first time, candidate varieties the constituents of which had been selected under organic conditions.
Irregular colonisation of pure grass plots with adventitious plants, in particular white clover, proved to be a major constraint to the quality of the results obtained under organic conditions. The coefficients of variation in dry matter yield almost doubled when compared to conventional trials. In order to improve variety discrimination, we visually estimated the yield proportion of non-sown species for each plot before each cut. Herbage yield was then corrected for adventitious plant infestation by multiplying total herbage yield with the estimated pure sown species fraction. While coefficients of variation were only slightly reduced by this procedure, the number of instances with statistically significant differences among varieties nearly doubled and was even slightly superior to that obtained under conventional conditions.
Even though an overall significant positive correlation between organic and conventional conditions was evident, analysis of variance of the trials sown in 2004 showed a significant culture type by variety interaction for one of the six grass species investigated, early heading perennial ryegrass. Three tetraploid varieties showed a significant "organic-friendly" yield response while three diploid varieties responded more "organic-hostile". This result highlights the importance of finding ways to utilize polyploidization of forage plants in agreement with the principles of organic plant breeding.
The results obtained so far show a high discriminatory power of herbage yield trials under organic conditions. Such trials will eventually identify organically bred varieties particularly suited for organic farming.

Do varieties rank differently in organic and conventional systems?

M. Przystalski[1], E. Thiemt[2], B. Rolland[3], L. Ericson[4], A. Osman[5], H. Østergård[6], L. Levy[7], M. Wolfe[8], A. Büchse[9], H.-P. Piepho[9], P. Krajewski[1]

[1]Institute of Plant Genetics PAS, Poznań, Poland; [2]State Plant Breeding Institute, University of Hohenheim, Germany; [3]INRA, Rennes, France; [4]SLU, Umeå, Sweden; [5]Louis Bolk Instituut, Driebergen, The Netherlands; [6]Risø National Laboratory, Denmark; [7]Agroscope Changins-Waedenswil, Switzerland; [8]The Organic Research Centre Elm Farm, UK; [9]University of Hohenheim, Department of Bioinformatics, Stuttgart, Germany

Recently, interest has increased in plant varieties specifically adapted to organic farming conditions. The aim of this study was to answer the question if varieties rank differently in organic and conventional systems and if separate organic trials are needed. The problem was approached by a comprehensive analysis of several data sets using a common statistical model involving parameters related to decisions concerning planning of the trials.

The data come from experiments performed in two systems in several environments (years or sites) in Danmark, the Netherlands, France, Germany, Sweden, Switzerland and U.K., with wheat, barley and Triticale varieties. Measurements of yield, height, thousand grain weight, hectoliter weight, protein content, soil coverage, lodging, breaking of straw, and infection by septoria and brown rust were taken into account. The analysis was done using a mixed models methodology allowing to estimate genetic variance and genetic covariance. Estimates of the genetic correlation between organic and conventional trials were interpreted in terms of ranking agreement. An approach based on index selection was used to study the effect of the number of organic trials on the response to selection.

Trait means in the organic system were lower than in conventional trials. Environments had a large influence on the level of the traits. System x environment interaction was significant in most cases. The genetic correlation between systems for yield and height was between 0.79 and 1. For lodging and septoria it was from 0.80 to 0.90. For other traits the genetic correlation usually was close to 1. It was found that for the genetic correlation of 0.90 the probability of ranking agreement in the top 10% of varieties is about 0.65. The gain from adding organic trials was found to depend on the relation between the values of the genetic and non-genetic variance components; the functional form of this dependence was given.
The genetic correlation between the organic and conventional system was found to be high in most cases. Results presented in this paper provide a way to interpret this correlation in terms of the agreement of ranking of varieties and in terms of the gain of information rovided by organic trials. Such interpretation can be helpful to the experimenters in making decisions about the future series of trials.

Acknowledgement: The work was partially supported by COST Action 860 SUSVAR within WG 2 Biostatistics and WG6 Variety Testing and Certification; the work of M. Przystalski was additionally supported by the grant SPB/COST/KN/DWM 74/2005-2008 from the Polish Ministry of Science and Higher Education.

Yield loss of spring barley in low-input cropping systems explained by varietal and environmental characteristics

Hanne Østergård[1], Kristian Kristensen[2], Mogens S. Hovmøller[3]
[1]Risø National Laboratory, Technical University of Denmark-DTU, Roskild; [2]University of Aarhus, Tjele; [3]University of Aarhus, Slagelse, Denmark,

For low-input crop production, well-characterised varieties increase the possibilities for controlling diseases and weeds and for compensating for deficits in nutrients. Here we consider grain yield in variety trials and how it may be predicted from external varietal information about genetic yield potential, disease resistance and height characteristics when weighting with actual disease severity and weed infestation levels in low-input cropping systems.
Variation in grain yield was studied in 52 spring barley varieties and 17 environments (combinations of location, growing system and year) being part of a large Danish field trial study (Østergård et al, 2005,2006). Only varieties grown in at least two trial years were included. The genetic yield potential of individual varieties and the interaction between varieties and environments were analysed using regression with environmental variables and externally obtained information on variety traits as covariates. The external information included grain yield potential, disease susceptibility for four diseases and straw length and was provided from the official Danish VCU testing.

Disease resistance characteristics of the varieties weighted with the environmental disease level of powdery mildew, leaf rust and net blotch, respectively, but not scald, had a highly significant influence on grain yield. The effect of external determined straw length weighted with weed infestation level was weaker although significant in most cases. The results demonstrate a good explanatory value of environmental variables combined with external variety characteristics when these were used as covariates in crop loss analyses. The model was used for predicting yield loss for a specific variety in a specific environment as influenced by varietal disease resistance group and the disease level on susceptible varieties in the specific environment.

Additive main effects and multiplicative interaction analysis in hulless barley (*Hordeum vulgare L.*) genotypes in temperate regions of Iran

Shahram Bahrami[1], *Mohammad Reza Bihamta*[2], *Mahboobeh Hosseani*[1]
[1]Zabol University, Zabol, Iran; [2]Tehran University, Tehran, Iran,

Different genotypes show various responses in different conditions (including low and high-input agriculture). Therefore, there is interaction between genotype and environment. There are several methods for determining the genotype environment interaction. Richard et al. (1988) stated that the Additive Main effect and Multiplicative (AMMI) model for the yield of g^{th} genotype in the e^{th} environment and with r^{th} replication is as:

$$X_{ger}= \mu+ \alpha_g+ \beta_e+\Sigma\lambda_n\gamma_{gn}\delta_{en}+\rho_{ge}+\varepsilon_{ger}$$

Vijaykumar et al.(2001) while making use of the AMMI model, in order to determine the adaptable genotypes in different locations, used the Biplot method. The aim of this research is to introduce the most stable and adaptable genotype(s) for each location using AMMI with Biplot method.

In order to analyze the genotype and environment interaction, 20 genotypes were studied in six locations (Karaj, Esfahan, Neyshaboor, Yazd, Birjand and Zarghan which Yazd, Birjand and Zarghan were low-input factors) for two years (2002-2004) in Iran. The data obtained from yield were examined via Additive Main effect and Multiplicative (AMMI) method. Sum of the value of the IPC scores (SIPC) and Eigenvector value (EV) were used for determining the stability of parameters in AMMI method. Also the Biplot method is used for recognizing those genotypes that are adapted to special locations.

The results showed that ICNB93-369, Aleli/4/ mola 3 and SB91925 (7) by having the least interaction in both parameters, were the most stable genotypes which suitable for low-input locations. ICNBF8-653, Condor-BAR/4 and EHYTM80-1 with the most interaction in SIPC4 parameter were the least stable genotype and ICNB93-328, Condor-BAR/4 and Gloria with the most interaction in EV4 parameter, were the least stable genotypes. Based on Biplot method, ICNBF8-582, Gloria and SB91925 (13) genotypes, were distinguished for Karaj location and Aleli/4/mola3 and SB91488 genotypes were determined for Esfahan location.

Wheat breeding lines for low-input agriculture

Ciro De Pace[1], *Patrizia Vaccino*[2], *Mara Corbellini*[2], *Gaetano Boggini*[2], *Marina Pasquini*[3], *PierGiorgio Cionini*[4], *Eugenia Caceres*[4], *Doriano Vittori*[1], *Angelo Ciofo*[1]
[1]Dept. Agrobiology and Agrochemistry, University of Tuscia, Viterbo, Italy; [2]CRA-Experimental Institute for Cereal Crops, Sant'Angelo Lodigiano, Lodi, Italy; [3]CRA-Experimental Institute for Cereal Crops, Roma, Italy; [4]Dept. of Cellular and Environmental Biology, University of Perugia, Perugia, Italy

Sustainable and organic agriculture involve production management systems based on some fundamental principles such as minimal use of off-farm inputs. Crop production in low-input agricultures requires cultivated varieties showing resilience to adverse or varying environmental effects in farmers' fields. The assessment of the genotype x environment interaction pattern for parental breeding lines have an important bearing on their choice for crossing to cultivated varieties to derive new resilient varieties. Inbred breeding lines (IBLs) derived from interspecific hybridization of *Triticum aestivum* cv "Chinese Spring" (CS) x *D. villosum* (*Dv*) were used to explore which genotype x environment interaction pattern is expressed when tested in multienvironment low-input cropping system.
Eleven IBLs lines have been selected from a population of 150 aneuploid lines developed through [(CS x *Dv*, F_1) x CS] backcross, followed by three generation of selfing (BC_1F_1 S_1 through S_3), five generations of single-spike descent (from S_4 through S_8), and four generations of seed increase (S_{12} IBLs). S_{12} breeding lines traced to the same S_4 plant were considered "sister lines". Genetic uniformity within lines and differentiation among lines have been tested using AFLP and GISH analyses. In average sister lines differed for 7% of AFLP fragments and non-sister lines differed for > 20% of AFLP fragments. In a uniform (greenhouse) environment, three pairs of sister lines (CSxV_58<u>a</u> and <u>b</u>, CSxV_59<u>a</u> and <u>b</u>, and CSxV_60<u>a</u> and <u>b</u>) initiate anthesis about 10 days earlier than CS and show 2n=42 chromosome number; two pairs of sister lines (CSxV_32<u>a</u> and <u>b</u> and CSxV_63<u>a</u> and <u>b</u>) are immune to powdery mildew and have the additional comosome 6V from *Dv*; one line (CSxV1BL/1VS) show high gluten strength. The 11 IBL and CS have been tested in 7 different environments: 5 years in one locality as representative of unpredictable environmental variation features, and one additional year in two localities to include features of predictable environmental variation. In each cropping environment, off-farm inputs were minimized.
The main genotype x environment interaction pattern displayed by the breeding lines revealed a higher proportion of genotypic variance compared to the genotype x environment interaction variance component. Multiplicative model and biplot invariably grouped similar genotypes (sister lines) in the same cluster and intercluster distance paralleled the AFLP distance among non-sister IBLs. CSxV_60 was dected as the "ideal breeding line" in terms of genotypic main effects and stability for yield in the tested environments. This line has been crossed to five elite bread wheat cultivars and several F_2 progenies express better performance than the elite parent in low-input greenhouse experiment. The tested IBLs are also ideal starting points for studying individual QTLs with a pre-tested environmental stability.

Participatory varietal selection: a strategy to better manage GxE interactions?

D. Desclaux, J.M. Nolot, Y. Chiffoleau, Bui Van Minh
INRA - UMR Diversité et Adaptation des Plantes Cultivées
Domaine de Melgueil, Mauguio, France

Participatory varietal selection (PVS) projects have appeared relatively recently in Northern countries especially in organic contexts. The hypothesis underlying PVS projects can be resumed in (i) varietal specifications vary according to the considered area (ii) the interaction (G x E) is higher than the main effects (G or E) and therefore justify a direct evaluation i.e on target environment, (iii) this interaction is mainly caused by local conditions (soil, practices) that can not or costly be simulate in research stations, (iv) the term E must include not only agro-ecological but also socio-economic conditions.

Based on an experimental decentralized PVS program aiming to create durum wheat varieties adapted to organic conditions in the south of France, these hypotheses are discussed. All of them are not confirmed by the results of the program but structuring environments according to agronomical, sociological and economical diagnosis helps to improve the choice of the right genotypes and lead to a better mastering of breeding targets. This project also emphasizes the benefits to be obtained from open interactions between different professional partners and researchers from relevant disciplines. Multi-level interactions and cross-linked learning processes about breeding methods are needed for effective communication between different stakeholders and scientific disciplines. Varietal selection or co-evaluating is no longer only an end in itself but also a means of facilitating the production of knowledge and rules relevant for the development of sustainable development of specific agro-food system.

Exploiting genotype x environment interactions for breeding barley for organic and low-input agriculture

Dionysia A. Fasoula
Agricultural Research Institute, Nicosia, Cyprus

Over thirty barley varieties and advanced breeding lines have been tested in Cyprus during the 2006-2007 growing period in three distinct experimental conditions and planting densities in order to study GxE interactions and reveal desired characteristics of those genotypes that are most suitable for organic and/or low input breeding.

In one location (organic field, in a rotation with vetch, cereals and fallow), the experiments have been established in two planting densities, i.e., 1 plant/ m^2 and 16 plants/ m^2, with 50 replications per breeding line in each, exploring the properties of the honeycomb field designs to control the masking effect of soil heterogeneity and select reliably both among and within entries (Fasoulas and Fasoula, 1995; Fasoula and Fasoula, 2000). The latter is justifiably considered one of the big challenges in a breeding program. The same set of experiments has been repeated in another location in a conventional field of non-organic conditions. Thirdly, all entries included in the former experiments, have been tested in a randomized-complete-block experiment at the standard crop density with 6 replications, to confirm or not the rankings obtained in the other experiments based on the criteria of yield, stability, and responsiveness to inputs (Fasoula, 1990; Fasoula and Fasoula, 2002).

The data provide interesting answers as to the genotypic characteristics and selection criteria that represent distinct breeding advantages under the different densities, competition, and soil environments. In addition, the data provide insights to the intriguing question of whether any breeding targets and selection criteria exist that can serve well both organic and conventional farming variety requirements.

On-farm dynamic management of wheat populations/varieties in organic agriculture: a way to valorize GxE interactions

Isabelle Goldringer [1], Galic Nathalie[1], Rousselle Yves[1], Demeulenaere Elise[2], Bonneuil Christophe[3], Payement Joël[4], Berthellot Jean-François[4], Chesneau Vincent[4], Mercier Florent[4], Ferté Henri[4], Pommart Alain[4], Zaharia Hélène[4]

[1]UMR de Génétique Végétale, INRA Univ. Paris Sud CNRS AgroParisTech, France; [2]ENS, CERES, Paris, France; [3]CNRS - EHESS – MNHN, Paris, France; [4]Réseau Semences Paysannes, Brens, France

Numerous studies of traditional agricultural systems in the South have shown that the farmers practices for seeds management were the key for local adaptation whilst maintening the genetic diversity, due to the co-exixtence in the populations of all evolutionary mecanisms: selection, genetic drift, migration, mutation (Smith *et al.*, 2001 ; Almekinder *et al.*, 2000 ; Louette *et al.*, 1997 ; Bertaud *et al.*, 2001 ; Elias *et al.*, 2001). Hence, this can be described as a dynamic management approach. In industrialized countries, such approaches are usually developped through the cooperation of farmers and breeders and/or researchers, and they might be of a great interest for organic or low input farming systems where the effects of environment and practices combine to produce a large range of contrasted conditions. Yet, these approaches are scarce and they still do not have found a clear position in the seed regulation framework in France.

To help on farm management or participatory approaches to find an official recognition, we are conducting a sociological, historical, ethno-botanical study of the actors, and a parallel genetic study of the varieties/populations in order to assess the ability of farmers networks to conserve and develop genetic diversity through local adaptation and seeds exchanges. Here, we present a case study of an old wheat variety (Rouge de Bordeaux, RB) grown for several generations in different farms under different conditions and farming practices. This old variety (~1880) has recently spread over organic farms in France due to its high "artisanale" bread making quality and good adaptation to organic conditions. Seeds samples were collected for about 25 different farmers RB varieties as well as for 4 RB accessions from the Inra collection. In 2006-2007, they were assessed phenotypically in 6 farms and in a research station (Le Moulon). Leaf samples of 20-35 individuals / RB-sample were collected, DNA was extracted and they will be genotyped with a set of "neutral" SSR markers and markers of the *VRN1* loci (vernalization response).

Based on the sociological survey, a partial network of seeds exchange was drawn indicating complex and active exchanges, especially for the variety RB. The first phenotypic data show that the different samples are significantly differentiated with regards to their early development and to their vernalization response. Within-sample phenotypic and genetic diversity will be studied together with the differentiation between samples at both levels.

Adaptability of grass-clover mixtures to different environmental conditions

Jerko Gunjaca, Snjezana Bolaric, Vinko Kozumplik
Faculty of Agriculture, University of Zagreb, Croatia

Growing the grass crops in monoculture necessarily requests for the input of high levels of nitrogen fertilizer. This kind of practice is becoming increasingly undesirable both due to economic and environmental protection reasons. Consequently, representing a valuable alternative, the grass-clover mixtures are becoming the object of increased interest in sustainable agricultural production (Mela, 2003), as well as for scientific research.
The aim of our work was to investigate the suitability of introduced grass-clover mixtures to Croatian growing conditions.
First phase of the research involved 14 introduced mixtures from Austria, Germany, and Slovenia, compared with one domestic mixture in field trials set on three sites in Croatia. Trial set included either commercial mixtures designed for appropriate environmental conditions, or instant mixtures especially designed by the breeders. Initial clover content varied from 10 to 80 % and only in one mixture clover was completely substituted with alfalfa, combined with various grass species. During the three-year growing cycle mixtures were scored for green and dry matter yield, as well as for crude protein, crude fiber, and fat content. Four mixtures with best adaptive capability were then selected for further testing in large-plot trials together with domestic mixture, on a different set of six sites, during 2003-04, scoring for green and dry matter yield. Trials were carried out within a participatory scheme, most of them being set on commercial farms. Analysis of obtained data sets involved AMMI (Ebdon & Gauch, 2002) and factorial regression (van Eeuwijk & Elgersma, 1993) models for genotype by environment interaction analysis in order to asses the adaptive capabilities of introduced grass-clover mixtures for growing in different environmental conditions.
Statistical analysis revealed that performance of the mixtures for the analyzed traits could be associated with initial clover content on genotypic side, as well as with total temperature sum on the environmental side. Mixtures with specific adaptation were recommended for the regions represented by the trial sites.

Relation between growth characteristics and yield of barley in different environments

Kristian Kristensen[1], *Lars Ericson*[2]
[1] University of Aarhus, Tjele, Denmark
[2] Swedish University of Agricultural Sciences, Umeå, Sweden

The increasing interest in organic farming has increased the interest in examining the importance of the different growing characteristics, such as attack of diseases, grain weight, lodging and heading date. One of the important questions raised was whether the relationship between the growing characteristics and yield would be the same for conventionally and organically grown crop or would some growing characteristics be more important for organically than for conventionally grown crops. This work will focus on that question.
The analyses are performed using two datasets with comparable trials in both conventional and organic grown systems for barley (*Hordeum vulgare)*. The two datasets were from Sweden and Denmark. From Sweden 22 conventional and 22 organic grown trials were available. The trials were laid out at 4 locations in Northern Sweden during the years from 1994-2003. The number of varieties per trial varied between 7 and 15 and 50 varieties were represented. Most of the trials were laid out as split-plot designs with 2 nitrogen levels in the conventional grown trial and 2 seed rates in the organic grown trials. From Denmark 4 conventional and 4 organic grown trials were available. The trials were laid out as α-designs at 2 locations in 2 years (2003 and 2004). The number of varieties per trial varied between 108 and 113 and 146 varieties were represented. The data from each country were analysed in a linear mixed model. The effects of location, year, variety, their interaction and interaction with system were included as random effect. The effect of growing system and growing characteristics were included as fixed effects to see how much of the variation caused by varieties and interaction with varieties that could be explained by the growing characteristic and to se if the effect of the growing characteristics depended on the growing system.
The analyses showed that the growing characteristics could explain a considerable part of the variance components for variety or interaction with variety. The effect of some growing characteristics depended significantly on the growing system, but the results varied to some extent between the two countries. In Sweden the effect of volume weight were more important in the conventional grown trials than in the organic grown trials whereas in Denmark grain weight was more important in the organic grown trials than in the conventional grown trials. In Denmark powdery mildew decreased the yield significantly more in conventional grown trials than in organic grown trials. In most cases the other diseases decreased the yield more in the organic grown trials than in the conventional grown trials. In some models the yield in organic grown trials increased as the level of scald attach increased. The results indicated that the effect of a given disease level decreased the yield more in the conventional grown trials than in the organic grown trials – or in some cases increased the yield in the organic grown trial while the yield in conventionally grown trials were increased less or decreased.

Genotype and environment interaction of various spring barley genotypes in organic and conventional growing conditions

Linda Legzdina[1], Aina Kokare[1], Edith Lammerts van Bueren[2]
[1]State Priekuli Plant Breeding Institute, Latvia;
[2]Wageningen University, Plant Sciences Group, the Netherlands

Majority of requirements for varieties in organic production system are distinctive from those in conventional farming. The main requirements are related to improved nutrient uptake and use efficiency due to limited nutrient availability in soil, competitive ability with weeds and resistance to diseases, especially seed born diseases. The aim of experiment was to evaluate yield and trait expression of various spring barley genotypes in organic and conventional growing conditions, to identify essential traits for organic breeding and to find parental genotypes for breeding for organic farming. Selection from F_3 generation of 2 cross populations was started simultaneously in two organic and two conventional environments. Selected lines from all environments in F_6 generation will be compared to prove the influence of growing conditions in which selection is carried out.

Ten spring barley genotypes with various origins, types of intensity, plant morphology and time of release were grown in two organic and two conventional growing conditions in 2006. The main difference between the locations was the fertilization system, crop rotation and minor differences in soil. In organic location 1 only green manure was used, but in organic location 2 stable manure was applied in crop rotation. In conventional location 1 medium amount of mineral fertilizers was applied (N 81, P 40.5, K 67.5 kg ha^{-1}), but in conventional location 2 high amount of fertilizers was used (N 99, P 49.5, K 82.5 kg ha^{-1} before sowing and N 20 kg ha^{-1} in tillering stage). Herbicide and insecticide was used in conventional locations, and harrowing was used in organic location 1. Soil type was sod-podzolic sandy loam in all locations, except organic location 2, were it was loamy sand. The amount of available N in spring was 48 kg ha^{-1} in organic location 1 and 33 kg ha^{-1} in organic location 2. Meteorological conditions were uncharacteristic: very dry and temperature above the long term average. The germination was retarded due to dry soil. The amount of rainfall in June was 44% and in July 7% only of long term data. Correlations between grain yield and traits important for organic farming will be analyzed in the presentation.

Results showed, that higher yields in organic conditions were obtained for extensive type varieties with good stress tolerance (‘Anni’ – 125 and 113%, ‘Abava’ – 127% to standard variety ‘Idumeja’, organic location 1), but in conventional conditions intensive short straw variety ‘Annabell’ was the highest yielding one (123 and 132% to standard variety ‘Idumeja’). Old barley genotypes (landrace ‘Latvijas vietejie’ and Swedish variety ‘Primus’ released in 1901) were the poorest yielding in all locations (92-25% to standard). The influence of growing conditions on yield was significant (influence proportion 84%, $p<0.001$). The mean yield in organic locations were 2.55 and 0.31 t ha^{-1} and in conventional locations 2.85 and 3.44 t ha^{-1} ($LSD_{0.05}$= 0.18). The influence of genotype on yield was significant too ($p<0.001$), but the influence proportion was only 6.3%.

SUSVAR - Winter wheat ringtest over 15 environments in Europe – Results

Franziska Löschenberger[1]*, Gheorghe Ittu*[2]*, Hubert Kempf*[3]*, Bernard Rolland*[4]
David Schneider[5]
[1]Saatzucht Donau, Probstdorf, Austria; [2]RICIC Fundulea, Romania; [3]Saatzucht Schweiger, Moosburg, Germany; [4]INRA Rennes, France; [5]Agroscope Changins-Wädenswil ACW, Switzerland.

The SUSVAR (www.cost860.dk) bread wheat ringtest aims at comparing the performance of a particular set of varieties over contrasting environments across Europe with an emphasis on low-input and organic conditions. GxE interaction, specific and broad adaptation to environments, stability of yield and quality as well as research for particularly useful germplasm, traits and ideotypes for low-input and organic farming – for both direct use and breeding – are the main interest of the testing network to the participants.
The ring test was performed on 15 different pedoclimatic environments from France (F) to Romania (RO), all without fungicides, ranging from organic (Org) to conventional without fertilisation (N0) or "low input" (LI) to a few "high input"(HI).
In the organic trials of Romania, Germany and Austria the best yielding genotype was always coming from the respective country, reflecting the station or region of selection (Table: grey). This shows the importance of specific adaptation to regional agro-environmental conditions and the success of local breeding efforts in the past, but it also stresses the need for better characterization of the environments. The yield results from six conventional N0 or LI trials are highly correlated with Org trials (r=0,77*). The HI trial results are not related to neither Org nor N0+LI. Protein content of the genotypes is similarly correlated between all three "input groups": ORG to N0+LI: r=0,74**; NO+LI to HI: r=0,64*, ORG to HI: r=0,70**.
Calculation of the dynamic stability parameter "ecovalence" according to Becker & Leon (1998) revealed Titlis, Aurolus, Cornelius, Zinal and Bitop as first ranking for yield stability.
Winter hardiness, tillering capacity, early ground cover, plant height at booting, hanging growth habit, vigorous growth dynamics and high leaf area index as well as final plant height all significantly and positively influenced protein yield evaluated in organic trials. Disease resistance did not show any significant correlation to mean yield or other agronomic traits.
Both LI and Org trials are useful for low-input and organic selection. Local adaptation was advantageous under some of the organic conditions. Under organic conditions protein yield was significantly influenced by several well defined criteria, which may facilitate selection for improved varieties.

Country/location	**RO**	**D**	**F-2**	**R**	**CH**	**F-3**	**F-2**	**RO**	**A**	**F-1**	**A**	**F-1**	**F-3**	**CH**	**CH**
System	Org	Org	Org	NO	NO	Org	LI	HI	Org	Org	HI	LI	LI	LI	HI
Fertilizer kg N/ha	0	0	50	0	0	0	90	100	0	0	130	40	100	100	180
Mean yield t/ha	**1,64**	**3,59**	**3,74**	**4,32**	**5,02**	**5,15**	**5,21**	**5,22**	**5,26**	**5,71**	**6,36**	**6,63**	**7,56**	**7,69**	**8,26**
Best three varieties	JP	NA	DI	AR	DI	ZI	FO	AR	CO	CF	JN	DI	DI	DI	CO
Grey: origin = testing	BI	ZI	RE	RE	NA	NA	DI	RE	AU	RE	CO	CF	CO	CO	DI
country	CO	CO	FO	JN	CO	CF	CF	JP	NA	DI	AR	RE	CF	CF	JP
Mean Protein %DM	**10,0**	**--**	**10,6**	**11,8**	**9,7**	**--**	**12,3**	**13,8**	**15,3**	**13,3**	**16,4**	**12,0**	**11,7**	**11,7**	**13,7**
Best three varieties	SI		AU	TI	BI		RE	AU	SI	AU	AU	TI	TI	AU	TI
Grey: origin = testing	DI		BI	AU	AU		JP	BI	TI	TI	TI	AU	AU	TI	SI
country	AR		TI	BI	JN		AR	CF	AU	SI	SI	BI	BI	SI	AU

Varieties/ country: RO: Ardeal 1=AR; Junona=JN; Jupiter=JP; F: CF99102=CF; DI9714=DI; Renan=RE; D: Format=FO; Naturastar=NA;CH: Siala=SI; Zinal=ZI, Titlis=TI; A: Bitop=BI; Aurolus=AU; Cornelius=CO.

Barley (*Hordeum vulgare* L.) adaptation and improvement in the Mediterranean basin

Pswarayi, A.[1], Comadran, J.[2], Molina-Cano, J.L.[1], Russell, J.R.[2], van Eeuwijk, F.[3], Ceccarelli, S.[4], Grando, S.[4], Stanca, A.M.[5], Francia, E.[5,6], Pecchioni, N.[6]. Akar, T.[7]. Al-Yassin, A.[8], Benbelkacem, A.[9], Choumane, W.[10], Karrou, M.[11], Ouabbou, H.[11], Bort, J.[12], Araus, J.L.[12], Hackett, C.A.[13], Thomas, W.T.B.[1], Romagosa, I.[1]

[1] Centre UdL-IRTA, Lleida; [2] SCRI, Invergowrie, Dundee, UK; [3] WUR, Department of Statistics, Wageningen, The Netherlands; [4] ICARDA, Aleppo, Syria; [5] Istituto Sperimentale per la Cerealicoltura, Fiorenzuola d'Arda, Italy; [6] Dipartimento di Scienze Agrarie, Università di Modena e Reggio Emilia, Reggio Emilia, Italy; [7] Central Research for Field Crops, Ankara, Turkey; [8] NCARTT, Amman, Jordan; [9] ITGC, Constantine, Algeria; [10] Tishreen University, Latakia, Syria; [11] INRA, Rabat, Morocco; [12] Department de Biologia Vegetal, UB, Barcelona, Spain; [13] BioSS, SCRI, Invergowrie, Dundee, UK

Barley adaptation and improvement in the Mediterranean basin was studied on a wide Diverse Barley Germplasm collection made of 192 selected key landraces (83), old (released before 1980) (43) and modern varieties (66) from regions around the Mediterranean rim and elsewhere. Each accession was genotyped with Diversity Array Technology (DArT®) yielding close to 1200 polymorphic markers. The genotypes were structured, based on their DNA, into five subpopulations, namely East Mediterranean (E), South-West Mediterranean (SW), North Mediterranean 2 rows mainly spring (N2r), North Mediterranean winter 6 rows (N6r) and Turkish (T). The collection was assayed in two contrasting sites (dry and wet) at each of seven Mediterranean countries (Algeria, Italy, Jordan, Morocco, Spain, Syria and Turkey) for harvest seasons 2004 and 2005 and grain yield data collected. We used a 25% replicated augmented experimental design at each site from which spatially generated BLUPS were used for individual site analysis of variance and genotype by environment interaction analysis (GEI) using AMMI biplots of yield ranked data. Mean yield ranged from near crop failure to 6 t/ha. Barley breeding has mainly benefited productive sites yielding above 3.5 t/ha, where genetic gain (modern genotypes out yielding old cultivars and landraces) was positive (mean 15 % and range 0.1 to 29 % depending on site and year). There is hardly any breeding progress below 3.5 t/ha (local landraces out yielded modern genotypes) since genetic gain was negative (mean -1 % and range-17 to 15 %). Breeding has resulted in reduced cold tolerance for N2r and SW genotypes, reduced stability for all genotype structures (N2r, N6r, SW, T and E), reduced stress tolerance for N2r, N6r and T genotypes and increased stress tolerance for SW genotypes. No wide adaptation was detected, rather specific adaptation to environments of breeding and/or commercial release. Landraces adapted better to stress environments while old and modern genotypes to non stress environments. Due to the tendency for specific adaptation, the real impact of breeding on stress environments yielding below 2 t/ha was undetected since there were no modern genotypes originating from these environments. Comparisons were therefore made between modern genotypes from other regions with landraces from the regions yielding below 2 t/ha to get an idea.

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Cultivar x growing cycle interaction in lettuce grown under certified organic conditions: implications for selection, breeding and use of diversity

María Dolores Raigón[1], Jaime Prohens[2], Fernando Nuez[2]
[1]Departamento de Química, Universidad Politécnica de Valencia, Spain
[2]Instituto de Conservación y Mejora de la Agrodiversidad Valenciana, Universidad Politécnica de Valencia, Spain

The increased demand of organically produced lettuce (*Lactuca sativa*) has led to the necessity to offer an extended period of supply of the produce. While this can be achieved by growing the crop in different regions or by the use of protected cultivation, the use of several growing cycles in a certain region, combined with appropriate varieties can contribute to extending the period of production, which is important if the combination of “organic + local” production is pursued. Given that the conditions in early and late cycles may be different from those of the common cycle, interactions cultivar x growing cycle may exist.
Fifteen varieties of lettuce from six varietal groups (“Batavia”, “butterhead”, “lollo green”, “lollo red”, “oakleaf green”, and “oakleaf red”) were grown in three growing cycles (early, intermediate, and late) under organic cultivation conditions in a farm of the Committee of Organic Agriculture of the Valentian Community situated in Sagunto (Valencia, Spain). The transplants of the early, intermediate and late cycles were made in December, January and February, respectively, using a completely randomized design, with 3 replications and 32 plants per replication. Traits evaluated have been total and commercial yield, gross and net weight, size of the head, and resistance to bolting.
Under the organic cultivation conditions tested, there are important effects of cultivation cycle, varietal group, cultivar within varietal group, as well as interactions between cultivation cycle and varietal group, and between cultivation cycle and cultivar within varietal group. In general, the best average results are obtained in the intermediate cycle, followed by the late cycle, and finally by the early cycle. Important differences were also found among the means for cultivar groups, with the highest yields obtained in the “oakleaf green” and “lollo green” cultivar groups, and the lowest in the “lollo red” group. However, there were important interactions between cultivation cycle and varietal group. At this respect the highest yielding varietal type in the early and intermediate cycle has been the “oakleaf green”, while for the late cycle has been the “butterhead”. Differences in the performance and crossed interactions with the cultivation cycle have also been found within varietal type. Some differences were also observed in the resistance to early bolting. While no cultivar was prone to bolting in the early cycle, three of them (all of the “oakleaf” groups) showed symptoms of early bolting in the intermediate cycle, and three other (all of the “lollo” groups) in the late cycle. The results show that the important cultivar x growing cycle interaction that takes place in the cultivation of lettuce under organic conditions can be exploited by selecting the best cultivars for each growing cycle. The fact that the materials of lettuce with better performance in each growing cycle are different, even within the same cultivar group, supports the general view that the use of diversity can be used to a great advantage in the production of organically grown vegetables.

Evaluation of advanced potato clones in organic and conventional conditions

Ilze Skrabule
State Priekuli Plant Breeding Institute, Cesis, Latvia

The development of organic farming raises requirement to suitable varieties for organic growing conditions. The evaluation of potato varieties in organic fields brought out most important traits for organic potato production, which should contain organic potato variety. As the most important trait resistance to different pathogens, (late blight, black scurf, virus diseases, rhizoctonia etc.) has been notified (Zimnoch-Guzovska, 2003; Tiemens-Hulscher et all., 2003; Vogt-Kaute, 2001). The desired traits for organic potato breeding are adaptability to organic fertilizations (adequate root system, rapid juvenal root and plant development, good growth vigour, efficient mineral uptake and use), ability to give yield in short growing period (early bulking and ripening, yield stability, reaching acceptable quality, good storability) (Tiemens-Hulscher et all., 2003) and compliance to marketing. A part of named traits are included in conventional potato breeding programmes, but some of characters are particularly significant for organic growing conditions. As conventional and organic growing conditions are different, requirements to varieties are different too; should these differences be a reason for creating separate breeding activities (Colon et all., 2003). One of ways is to start breeding for organic farming in conventional programme and at defined generation evaluates probably acceptable clones in organic conditions. The aim of study is to compare evaluation of selected clones from conventional breeding programme in conventional and organic growing conditions.

In 2006 and 2007 nine potato clones (4th field generation) have been evaluated in conventional and organic fields. The clones were selected according assessment of leaf coverage, maturity, resistance to late blight of foliage, starch content in under conventional growing conditions. The earliness, resistance to pests in field, the length of growing period, yield, starch content and others were evaluated and compared in both growing conditions. The suitability of clones to organic growing conditions will be assessed.

The plant emergence was little faster in organic field due to presprouting, but later the development was similar to each clone in both fields. If compared to standard variety ‘Brasla’, one clone tuber yield was significantly higher in organic field, but in conventional field four varieties exceeded ‘Brasla’. The starch content for almost all clones was higher in organic field than in conventional field.

The breeding of new varieties for organic farming could be done in conventional conditions as part of existing breeding programme in the early generations (hybridisation, first year selection). Results of this trial proof, that selection for organic conditions have to be done in organic field, as selected preferably suitable genotypes in conventional field did not fit to organic conditions as expected.

Selection Criteria

Basic principles for breeding, multiplication and variety testing for organic agriculture - outlines and first results of an interdisciplinary Austrian research project

W. Hartl[1], J. Birschitzky[4], H. Bürstmayr[6], I. Diethart[1], C. Flamm[2], A. Fleck[4], J. Friedel[6], F. Fuchs[3], H. Grausgruber[6], M. Gollner[6], M. Hofer[1], K. Huber[6], A. Kinastberger[7], J. Lafferty[4], F. Löschenberger[4], H. Luftensteiner[2], K. Mechtler[2], M. Oberforster[2], R. Petrasek[1], K. Schulmeister[7], P. Schweiger[1], J. Vollmann[6], M. Weinhappel[2], J. Winkler[5], E. Zechner[7]

[1]Bio Forschung Austria; [2]Agentur für Gesundheit und Ernährungssicherheit (Austian Agency for Health and Food Safety); [3]Niederösterreichische Saatbaugenossenschaft; [4]Saatzucht Donau; [5]Saatzucht Gleisdorf; [6]Universität für Bodenkultur Wien; [7]VFMG / Saatzucht Edelhof.

Choice of suitable crop variety and use of healthy seed are of paramount importance in organic farming. So far, organic farmers have relied on varieties developed for conventional farming, but organic systems differ fundamentally in weed, disease, pest and soil fertility management. Therefore, new crop varieties are required for increasing yield stability and product quality. In this project, novel methods for the assessment of seed suitability for organic farming are evaluated. Moreover, basic principles for breeding of varieties suitable for organic farming are developed. These objectives are achieved by the interdisciplinary co-operation of researchers, breeders and variety testers.

In this project, the following crops were selected for investigation: cereals and legumes widely grown in organic crop rotations, crops with added value like oil seed pumpkin, potato and soybean as well as crops already included in organic breeding programs by Austrian breeders. The main emphasis of our research is to combine both technical (vigour, contaminations with e.g. weeds, pathogens and GMOś) and genetic seed quality parameters (classical variety characters). To achieve optimal seed quality, our research is focussing on seed quality as a whole including tests on seed suitability for organic farming. Crop varieties suitable for organic farming systems should be characterised by an adaptation to organic soil fertility management, good weed suppression or tolerance, positive effect on soil fertility, robust crop health, high yield, maximum yield stability and high product quality. Selected criteria from within all of these general variety characters will be examined in this project. Emphasis is put on root systems with high nutrient and water uptake efficiency as well as on symbiotic associations with plant-beneficial mycorrhizal fungi. Furthermore, shoot architecture for good weed suppression, tolerance against mechanical weed control, both disease resistance and tolerance, high germination percentage and high seedling vigour will be determined. Concerning crop yield maximum yield stability under low-input conditions, high baking and malting quality of cereals, good taste of oil seed pumpkin, quality and appearance of soybean seed, early tuber formation and high storage potential of potatoes and nutritive value of ancient and underutilised wheat species will be examined.

Due to the interdisciplinary analysis and the duration (2004 – 2008) of this project conclusive results will be published as a final report in 2008. Some selected results are provided in the presentation. Based on the results of this research project a comprehensive concept for the breeding and multiplication of varieties suitable for organic farming systems will be developed. The concept will include an assessment of the use of conventional breeding techniques in breeding for organic farming systems. The necessity for a revision of selection criteria and the adoption of modified upper and lower selection margins will be examined.

The pattern of N uptake in time, N translocation and root growth as possible factors determining genotype x environment interactions in wheat (*Triticum aestivum* L.)

Jörg Peter Baresel, Hans-Jürgen Reents
Technical University of Munich, Chair of organic Farming, Freising, Germany

Baking quality of wheat grown under organic management in Germany often does not match the requirements of the milling and baking industry. Like in other species and for more general criteria, it has therefore often been proposed, to breed special varieties adapted to the conditions of organic farming. There are two ways to improve baking quality: one is to improve protein quality, another possibility is an improvement of nitrogen (N) efficiency and thus, grain protein content. Subject of this contribution is *N efficiency*, which is here intended as the ratio of grain N uptake to N availability. Objectives of our trials were, to explain a part of the genotype x environment interactions on N efficiency, analyzing N uptake, N partitioning and N translocation processes of selected varieties in conditions of organic farming. Our focus is specifically on the temporal patterns of N dynamics.

Six varieties (*Altos, Batis, Bussard, Capo, Dream* and *Naturastar*) were grown in replicated plots over three years in four locations, differing in yield potential. All trials were conducted on organic farms. Above-ground N uptake was determined at the development stages EC 32 (begin of stem elongation), 62 (begin of flowering) and 95 (ripeness). At EC 95, grain and straw N content were determined separately. Soil samples for determination of mineral soluble N were taken in early spring and at the EC stages 32, 62 and 95 from surface to a depth of 90 cm. Total mineralization and mineralization in single sub-periods, N uptake before and after anthesis and N translocation from vegetative tissues to the grain were estimated basing on these data. Root growth of the same six varieties was observed nondestructively in a separate trial in cylindrical vessels of transparent polyethylene. The height of the vessels was 1.4 m, their diameter 25 cm.

The estimated global amount of mineralized N ranged from 160 to 220 kg/ha in the whole cycle; approx. 70-120 kg (60%) were absorbed by the plant canopy. Mineralization during grain filling varied from 0 to 15 \% of totally mineralized N. The variability of mineralization among environments was highest after anthesis. There were significant differences in total N uptake of the varieties. Differences between varieties were low in the earlier development stages, while N uptake during the grain filling stage, despite contributing little to total uptake, were most variable, but only in environments with relatively high N availability. Thus, genetic differences of N efficiency depended mainly on uptake ability in the later stages. The pattern of root development in time varied among the varieties and was in part correlated with the temporal pattern of N uptake: consequently, the differences in N efficiency and in N uptake in time may be partly due to differences in root growth. Significant differences could also be found in the proportion of direct N uptake after anthesis and N translocation from vegetative plant tissues into the grain.

Three main conclusions may be drawn from the results: (1) Organic farming may include very different environments, with different requirements on varieties, also with respect to the physiology of N uptake and utilization. (2) The pattern of N uptake in time, and N translocation processes are of importance: uptake efficiency in late development stages may be useful in environments with relatively high N availability, genotypes with a uptake efficiency in earlier development stages and a high translocation efficiency may be better adapted to environments with low N availability. (3) Root growth and the temporal pattern of root development may play a role in N uptake efficiency.

Breeding for improved responsiveness to arbuscular mycorrhizal fungi in onion

Guillermo A. Galvan[1,2], *Karin Burger-Meijer*[1], *Thom W. Kuyper*[3], *Chris Kik*[4], *Olga E. Scholten*[1]
[1]Plant Research International, Wageningen, The Netherlands; [2]University of the Republic, Montevideo, Uruguay; [3]Soil Quality Group, WUR, Wageningen, The Netherlands; [4]Centre for Genetic Resources (CGN), WUR, Wageningen, the Netherlands.

Onion (*Allium cepa* L.) is one of the leading vegetable crops worldwide. Due to its superficial root system that is rarely branched and lacks root hairs, onion is very inefficient in the uptake of water and nutrients. As a result, large amounts of fertilizer are used in onion cultivation. In low-input systems crops need to be nutrient scavengers. To improve nutrient uptake in onions it is possible to breed for larger root systems using *A. fistulosum*. A complementary approach is to use arbuscular mycorrhizal fungi (AMF), which associate with onion and improve plant growth and the uptake of nutrients and water from soils. Previous research showed high responsiveness of *A. fistulosum* to AMF. The aim of the present research was to study possibilities to improve onions for mycorrhizal responsiveness by breeding.

A tri-hybrid population of *A. cepa* x (*A. roylei* x *A. fistulosum*) called CCxRF was obtained (Khrustaleva and Kik, 2000). Seventy-seven genotypes, vegetatively multiplied, were tested for responsiveness in a greenhouse (day/night 22/17 °C). AMF species *G. intraradices* was kindly provided by Dr. Kapulnik, Volcani Centre, Israel. Responsiveness was calculated as the increase in plant height/weight compared to the non-mycorrhiza treatment: $(W_{AMF} – W_{NM})/W_{NM} * 100\%$. Responsiveness was considered significant when the AMF and control treatment were statistically different ($p<0.05$).

AMF had a significant effect on plant height and fresh weight of genotypes of the population. The frequency distribution for height responsiveness demonstrated genetic variation between genotypes that varied from hardly or no response to genotypes with up to 100% increase in plant height and up to 500% for weight. Analysis of the genetic basis of AMF responsiveness will be done by QTL mapping in this population. We expect not only to find traits to improve the rooting system but also to improve the mycorrhizal responsiveness. The results support our hypothesis that using *A. fistulosum* is an interesting option to improve onions by breeding to obtain cultivars better adapted to low input farming because of their improved rooting system and mycorrhizal responsiveness.

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Quantifying genotype and environment interactions to benefit selection and evaluation of cereals for competitiveness against weeds

S.P. Hoad and C.F.E Topp
Scottish Agricultural College, Edinburgh, Scotland, UK.

Traits for weed suppression are important in the selection of cereals for organic farming and sustainable low-input agriculture. The environment, including both seasonal and management factors, has a significant impact on the ability of a genotype to suppress weeds.

Selection and evaluation of new genotypes would benefit from a better understanding of the relative contributions of genetic variation and genotype *x* environment interactions on key plant traits and crop characteristics for weed suppression.

This includes important measures such as: (1) an early prostrate habit at the start of tillering combined with a high leaf area index; (2) high shoot population density that is a function of plant number and the ability of a plant to produce and maintain tillers; (3) rapid early growth allowing the crop to maintain a light interception lead over the rapidly growing weeds, and with an appropriate growth habit, shade newly emerging weeds and (4) increased plant height that adds to competitiveness at moderate to high plant population densities, as well as increasing tolerance to weeds.

Generally, a high season-long crop ground cover is important. Crop ground cover integrates several plant and crop characteristics. In fact, ground cover is strongly influenced by genotype *x* environment *x* crop management interactions. High ground cover by the crop at the end of tillering is strongly correlated with weed suppression up to full canopy cover and even to harvest.

The balance between different characteristics for weed suppression will determine the value of a genotype, for early, late and season-long weed control. It is clear that selection for genotypes should be considered in relation to climatic factors that affect both crop and weed growth.

For plant breeders, selection and evaluation of genotypes should be based on an understanding the role of different characteristics in weed competition under organic farming or low-input conditions.

Genotypes for organic agriculture need to be more robust in both their percentage establishment, under contrasting conditions, and in their ability shade weeds, through increased ground cover, that is complemented by beneficial effects of increasing tiller production and plant height.

Factors affecting thrips resistance in cabbage

R.E. Voorrips[1], G. Steenhuis-Broers[1],
M. Tiemens-Hulscher[2], E. T. Lammerts van Bueren[2]
[1]Plant Research International, Wageningen, The Netherlands
[2]Louis Bolk Instituut, Driebergen, The Netherlands

Cabbage is one of the main field crops grown by organic farmers in the Netherlands. When cabbage is cultivated for storage, it is usually harvested around mid-October. This type of cabbage crop may be severely damaged by thrips (*Thrips tabaci*). The damage caused by thrips is due to the symptoms that develop after feeding, which are small callus growths that will turn brownish after some time. These symptoms necessitate the removal of the outer leaf layers before marketing. Among modern cabbage varieties, large differences exist in the susceptibility to thrips damage, but it is not clear whether these differences are due to resistance (affecting the thrips population in the plant) or to tolerance (affecting the development of symptoms upon thrips feeding).

Through farmer interviews we learned that from their experience certain morphological variety traits, such as wax layer and compactness of the head, might be related to thrips damage. We carried out field experiments to further elucidate which plant traits are involved in resistance or tolerance. A diverse collection of old and modern storage cabbage varieties was grown in 2005 and 2006. Seedlings transplanted to the field by the end of May, and in 2005 four accessions were also planted mid-June. The experiments were replicated in two organically managed fields at different locations in the Netherlands. At four dates from early August to early October three plants per plot were evaluated for morphology, anatomy and Brix., as well as for thrips damage and thrips numbers.

In the 2005 experiment, four accessions were sown and planted at two dates. For developmental stage, size en compactness large differences between the two dates were observed during the earlier harvests, which decreased towards the last harvest date. No clear effects on leaf wax or leaf thickness were observed, while Brix and dry matter content were slightly lower in heads from the late planting. The number of thrips was considerably smaller, and the damage slightly smaller in the late planting, with exception of the highly resistant cultivar Galaxy which showed no consistent differences between the plant dates.

The ten varieties showed a large variation for all traits studied, as was expected from the selection criteria. Thrips population and damage were highly correlated (R=0.81 to 0.96 in the third and fourth harvests of both years). There were no varieties with a remarkably low damage in relation to the number of thrips, which suggests that some form of resistance rather than tolerance causes the difference in damage between varieties.

Thrips damage positively correlated with Brix, and also with compactness and developmental stage in the first two harvests. This indicates that a cabbage head with tightly packed leaves early in the season leads to higher thrips damage; presumably because the insects are sheltered against predators. Further, a high amount of leaf surface wax is negatively correlated with thrips damage, indicating that wax gives some protection against thrips.

Yield performance of yellow rust resistant winter durum wheat landraces under dryland conditions of Turkey

T. Akar , F. Dusunceli, M. Avci, S.Yazar, T. Sanal
Central Research Institute for Field Crops, Ulus, Ankara, Turkey.

Turkish highlands are characterized with severe cold damage before and after long winter season and drought period especially just after pollination stage of cereals which limits yield level around 2 tons per hectare. Farmers especially living under remote areas of these regions generally use low fertilizers and chemicals due to their limited socio-economic situations and unfavorable ecological conditions. In addition to these, erratic rainfalls some years could cause yellow rust epidemics which resulted in low yield and grain quality for wheat production. So far many effort were spent for improving yellow rust resistant bread wheat cultivars but **t**here are few durum wheat cultivars resistant to yellow rust which have been cultivated under dry-lands of Turkish highland.

So for that reason twenty durum wheat (*Triticum durum L*) landraces collected from various provinces of Turkish highlands including old and new durum wheat cultivars such as Kunduru, Kiziltan, C-1252, Cakmak and Altintas developed for Central Anatolia and Transitional Zones (CAT) of the country were tested under mist-irrigated conditions in order to determine their adult plant yellow rust (*Puccinia striiformis f. sp. tritici*) reactions. These germ-plasm screened for yellow rust population consisting of Yr2, Yr6, Yr7 and Yr9 virulence genes during 2003 and 2004 seasons were winter planted.

Average of yellow rust infection coefficient of populations and cultivars was 32,44 in 2003 while 26,24 in 2004. It is clearly indicated that more severe epidemic occurred at Adult Plant Stage (APS) in 2003, therefore variation between resistant and moderately resistant line numbers greatly changed. Selected lines and cultivars number were 31 in 2003 while 70 in 2004, respectively. 20 of the 30 resistant and moderately resistant lines selected from 18 populations according to the first year epidemic results were also included one year yield trial including five checks under low input areas of Turkish highlands in the next year. Yield, quality and yellow rust resistance data were bi-plotted. Promising yield and grain quality data of some yellow rust resistant lines compared to the commonly cultivated checks demonstrated that lines 19-5, 13-5, 20-5, 15-1, 17-4 and 13-4 can be directly used as candidate lines or genetic sources for durum wheat breeding studies under dry-land conditions of Turkey. Due to the fact that these types of disease resistant germ-plasm do not need chemical control and that they can tolerate low input application they are suitable for small scale farmers in the region.

Breeding the plants for a sustainable future will need to exploit their genotype-specific differential interactions with plant-probiotic micro-organisms

Marco Bosco, Christine Picard
DiSTA, Università di Bologna, Italy

In natural populations of plants, the ability to interact with plant-probiotic micro-organisms (PPM) is a very well conserved genetic trait. In fact, during their evolution, terrestrial plants have not achieved the ability to grow independently of their own PPM, and all investigated natural plant genotypes show the biological need to find specific micro-organisms in their habitat to successfully complete their growth cycle (Picard & Bosco, 2007). Thus, probiotic micro-organisms are indeed part of plant inherent nature (Lammerts van Bueren et al., 2003), and should not be considered only as one of several environmental factors.

Conventional breeding often resulted in varieties much less interactive with PPM than it is needed for low-input and organic agriculture. Evidences for the loss of host genes driving plant-PPM interactions (Smith & Goodman, 1999) explained why modern conventional varieties don’t maximize the benefits of root interactions with natural (or inoculated) PPM.

Our aim is to help in avoiding such loss of genes in organic breeding. By using knowledge on microbial ecology, we are generating and testing simple tools for organic breeders work.

Zea mays L. and *Solanum lycopersicon* L. genotype-specific differential interactions with arbuscular mycorrhizal fungi (AMF), nitrogen-fixing bacteria (NFB) and antimicrobial-producing fluorescent *Pseudomonas* (PFP) were investigated in field trials during 2 to 4 years by MPN-PCR (Picard et al., 2007), a cheap tool for assessing PPM population dynamics.

As it was already known for *Rhizobium* and AMF, we confirmed the genetic basis of PPM interactions with maize (Picard & Bosco, 2006) and tomato. The laboratory tools validated under our research are simple enough to be used broadly and can be further improved. Thus, future efforts of crop breeding in low-input and organic environments would indeed be able to take into account the role of PPM in crop integrity and sustainable production. A European-wide organic breeding programme for genotypes able to exploit PPM is now needed.

Genotypic variation of attack degree (AD%) with downy mildew (*Plasmopara viticola* Berk & Curt) in six grape varieties, under chemical and organic control treatments

Claudiu Bunea, Marin Ardelean,
University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca, Romania

Six grape varieties (three domestic and three foreign) destined for wine production (Aromat de Iaşi, Pink Traminer, Italian Riesling, Fetească Regală, Muscat Ottonel, Blasius) were tested in 2006, in Gherla, Cluj county, Romania, concerning their level of attack degree (AD%) with downy mildew (*Plasmopara viticola* Berk & Curt) under two types of control treatments: chemical and organic. Two treatments were applied both in the chemical and organic variants of control. The chemical treatments consisted in SHAVIT 72 WP, 0.2%, before flowering stage, and Curzate Manox 0.25% between flowering and green grape berry stages while the organic treatments consisted in Bordeaux mixture 0.5% + purine of greater nettle 1/20 dilution, before flowering and Bordeaux mixture 0.75% + soluble sulfur 0,4% between flowering and green grape berry stages. There resulted a trifactorial experiment (types of treatments, genotype and number of treatment) with a total number of 24 variants.
Both variety, type of treatment, number of treatments and two simple interactions (type of treatment × variety and type of treatment × number of treatments) showed significant effects on AD% level while the triple interaction (type of treatment × variety × number of treatments) proved nonsignificant. The lowest AD% level was registered in Aromat de Iaşi and Pink Traminer varieties (AD% = 1.08) while the highest AD% was found in Italian Riesling (3.07%), the intervarietal coefficient of variability for this character being rather high (32.6). These results are in total agreement with previous data published by other authors (Husfeld, 1962; Zăvoi, 1979; Deacon & Berry, 1993; Cheregi, 2003) who found an impressing intervarietal variability of AD% level among different grape varieties, both under natural or/and artificial inoculation with downy mildew. The general effects of chemical treatments were slightly better than those of the organic ones as far as the AD% was concerned (1.47% vs. 2.11%), but it must be emphasized the fact that in the least sensitive varieties (Aromat de Iaşi and Pink Traminer) the AD% level was, practically, identical both under chemical and organic treatments. These results are of great interest since such varieties seem to be better adapted to organic control practices of downy mildew and, conseqeuently, are recommended for organic grapeyards and, on the other hand, they could prove as valuable genitors in creating new grape varieties adapted to organic control of downy mildew.

Evaluation of winter wheat germplasm for resistance to common bunt and dwarf bunt

Karin Huber, Hermann Buerstmayr, Heinrich Grausgruber
BOKU – University of Natural Resources and Applied Life Sciences Vienna, Austria.

Common bunt of wheat, caused by *Tilletia caries* (DC.) Tul. (syn. *T. tritici* (Bjerk.) Wint) and dwarf bunt of wheat, caused by *T. controversa* Kühn, are major seed- and soil-borne diseases in many wheat growing areas with severe impact especially in organic wheat cultivation. Sustainable control of the damage due to bunt diseases can be best achieved by cultivating resistant varieties of wheat.
An international winter wheat assortment was evaluated for resistance to *T. caries* and *T. controversa* under organic farming conditions in Austria in 2005/06. Ninety-eight genotypes were screened for resistance to *T. caries* and 29 genotypes for resistance to *T. controversa* using artificial inoculation according to Goates (1996). A set of differential cultivars (*Bt1* to *Bt15*) was included for testing virulence / avirulence against particular resistant genes (Goates 1996).
For *T. caries* no disease symptoms were observed for 9 genotypes, 25 genotypes showed low infection (0.1% - 1% infection) and 14 genotypes were highly susceptible (40.5% - 70.6% diseased spikes). Screening for resistance to *T. controversa* resulted in only 1 fully resistant genotype (0.0% infection), one genotype showed low infection (0.5% infection) and 11 genotypes were highly susceptible (39.0 % - 85.3% infection).
All lines resistant to *T. controversa* were also resistant to *T. caries* but not vice versa. Resistance genes *Bt12* and *Bt13* conferred resistance to both species: *T. caries* and *T. controversa*. More details have been published by Huber & Buerstmayr (2006).

Methodology of testing of the suitability of varieties for the condition of organic farming

Petr Konvalina, Zdeněk Štěrba, Jan Moudrý
University of South Bohemia, České Budějovice, Czech Republic

The Czech organic production of cereals is characterised by low and fluctuating yield which is caused by an absence of varieties bred and tested specifically for the conditions of organic farming. The farmers nevertheless need the varieties adapted to this type of management (Lammerts van Bueren, 2002). However, the testing of the varieties for certain station conditions would be very expensive (Wolfe, 2002). Because the proportion of arable land is low and the area of organic cereals is small there, the official tests are not supposed to be established in the Czech Republic. Therefore, it is a need to create a simple methodology of testing for suitability of varieties at an organic farm and at breeder's level.
In 2006, a work version of the „Methodology" has been conceived. The part of methodology for evaluating biological characteristics such as resistance to diseases is based on the methodology of Central Institute for Supervising and Testing in Agriculture for tests of VCU. The Descriptor of genus *Triticum* L. for the international evaluation of genetic ressources is applied for evaluating the morphological and economic characters. Some characters are also evaluated according to the handbook called Cereal variety testing for organic and low input agriculture (especially competitivness, etc.). Methodology is being tested in small-plot trials at two stations under two different types of the land-climatic conditions (production, non-production areas). The testing has been carried out with a divers set of varieties (modern, obsolete cultivars, landraces of spring wheat and emmer wheat).
The methodology is divided into four parts: morphological, biological, economic and quality characters. When evaluating each character, a user finds a code, name, description, scale of the evaluation and point evaluation of each character, combined with its importance for organic farming system. The characters may be evaluated as individual results in each category of the morphological, biological, economic and quality characters or as a sum of all of them and a variety number may be indicated. The Methodology may be used by several users. A farmer can find a list of characteristics which can be evaluated in the agroecosystem, in particular land-climatic conditions of a particular farm there. He is able to test the suitability of the varieties available. A breeder can find a proposal of the characteristics serving as a simple indicator of the suitability for the screening of the considerable collections of the genetic resources. The main difference between the testing of the varieties in organic system and conventional one is based on an emphasis on indirect measurable indicators as the morphological characteristics are, e. q.: a distance between flag leaf and spike which is very important for the spreading of *Septoria nodorum* infection or the optimal position, length and width of flag leaf as a condition for a higher degree of the assimilation of sunlight.

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Influence of nitrogen fertilisation on bread wheat*

Lilia Levy, Ruedi Schwaerzel, Geert Kleijer
Agroscope Changins-Waedenswil ACW, Nyon, Switzerland

The Swiss government encourages an extensive agriculture. In this context, the present studies intended to evidence the impact of nitrogen fertilisation on baking quality, on the evolution of the reported negative relationship between quality and yield as well as possible GxE interactions.
During three years, nitrogen fertilisation treatments (0, 65, 105, 145 and 185 kg N/ha) were applied to a total of eight cultivars of different baking qualities, a minimum of five being tested simultaneously in the same experiment. Trials were carried out at two sites, as randomized blocks with four replications, which were pooled for laboratory and rheological analyses and considered as a statistical unit. Quality criteria were evaluated and summarised to an weighted index, according to the "scheme 90" (Saurer et al., 1991) .
An increasing N-fertilisation had a positive impact on the majority of the quality traits. Yield, protein content and quality increased, as well as grain hardness. The nitrogen content in the grain, but also in the straw, was more important with the higher nitrogen applications. Dough stability to kneading increased and loss of consistency decreased with higher nitrogen treatments. Cultivars x N interactions were found in only 2 out of 13 parameters. Runal, the best bread making cultivar of the set, responded with an over proportional improvement of dough stability with increasing fertilisation. Water absorption was optimal at approximately 145 units of nitrogen, all cultivars pooled.
The N-fertilisation tended to increase maximal gelatinisation as well as tenacity and the relationship between tenacity and extensibility of the dough. Tenacity of Arina, the eldest cultivar, did not improve significantly with higher N-fertiliser. Quality is mainly determined by the cultivar, but the N-fertilisation influences positively its various components. The marginal gain of quality (reflected by the weighted index) and grain yield decreased with increasing fertilisation. However, at high N-input we did found a negative relationship between quality and yield.
Cultivar and nitrogen fertilisation had a highly significant impact on most of the studied parameters. Cultivars of diverse bread making qualities showed the same pattern for the majority of the monitored traits. However, GxE interactions could be observed for the stability of the dough (farinogramme) and tenacity of the dough (extensogramme). N-fertilisation increased absolute quality and yield, but decreased their marginal gain, and emphasised the negative relationship between quality and yield at high N-input.

*This abstract is based on the publication to appear (September): Levy L., Schwaerzel R. & Kleijer G., 2007. Influence de la fumure azotée sur la qualité des céréales panifiables, Revue suisse d'agriculture, 41.

Breeding for organic greenhouse production in zucchini squash

S. Manzano [1], H. Bos[1], M.A Suarez[1], J. Ferre[1], C. Payán[2], P. Gómez[2] and M. Jamilena[1]
[1]Department of Applied Biology. University of Almería, Spain.
[2]Department of Plant Breeding and Biotechnology, IFAPA Almería, Spain.

The production of zucchini squash under organic greenhouse conditions in the southeast of Spain requires the development of new varieties which not only satisfy the needs of growers but also the fruit quality that European consumers demand. In collaboration with organic growers, the University of Almería has started a zucchini breeding program, the main goal of which is the development of parthenocarpic varieties adapted to low-input production in greenhouses. Parthenocarpy is an essential trait for zucchini organic greenhouse production, since the use of synthetic hormones for fruit set is a conventional practice that is prohibited in organic agriculture and the use of pollinating insects is insufficient for winter productions.
Landraces of zucchini squash derived from the Spanish COMAV germplasm bank, as well as a number of hybrids from different seeds companies were evaluated in two variety trials that were carried out under organic greenhouse conditions in the research centre of IFAPA-Almería for Spring-Summer 2005, and in the greenhouse of an organic grower for Spring-Summer 2006. Both essays were done in absence of pollinating insects, but following the recommendations proposed by organic growers. In each trial, the field plan was a randomized complete block design with three blocks, and 6-10 replicates per block, for each cultivar.
In addition to the general performance of a number of commercial varieties and landraces under organic greenhouse conditions, it was evaluated the parthenocarpic potential of each material and the quality of parthenocarpic fruits, including their postharvest storage potential. In the first trial, the evaluation was carried out on a number of Spanish landraces. The most parthenocarpic materials were then selected and compared with commercial hybrids in a second variety trial grown in collaboration with an organic grower association in Almería. Longitudinal and transversal fruit growth rates before and after flower anthesis allowed us to determine the level of parthenocarpy in each variety. In most of the commercial varieties non-pollinated parthenocarpic fruits reached a commercial size, although the quality of some of the fruits diminished considerably. In many of the analysed landraces the fruits of non-pollinated flowers aborted a few days after anthesis. Nevertheless some of the evaluated landraces showed a level of parthenocarpy and fruit quality comparable to that of the commercial hybrids used as the positive control. The most parthenocarpic landraces and hybrids under organic conditions, but also those that developed fruit with superior quality and better postharvest conservation, are being selected as the starting plant material for an organic breeding program in zucchini squash.

Competitive ability of various winter wheat genotypes to suppress the weeds *Galium spp*. and *Stellaria media* in an organically managed field

R. Petrasek
Bio Forschung Austria Institute, Vienna, Austria

Due to the abandonment of herbicides weed control in organic farming is achieved by a combination of mechanical and cultural practices. The latter include choice of suitable crop cultivars with the ability to effectively suppress weeds. In this regard a study was conducted with winter wheat to determine the impact of growth dynamics and shoot morphology on competitive ability against weeds, with a precise examination of the genus *Galium* (*G.aparine* and *G.spurium*) and the species *Stellaria media*. The study was part of a wider Austrian project entitled „Basic principles for breeding, multiplication and variety testing for organic agriculture". A further intention was to identify parameters that contribute to the competitive ability of wheat genotypes against weeds that may be considered in future breeding efforts.

A field experiment with sixteen winter wheat genotypes was conducted in Austria in the vegetation period 2005/06. Aboveground wheat and weed biomass was destructively harvested four times. Wheat leaf area was measured and biomass data were used to calculate growth rates. Total weed biomass was sorted according to *G. spp*. and *S. media*. Weed biomass was used as an indicator for the efficiency of the wheat genotypes to suppress weeds. Wheat height development, leaf orientation and wheat as well as weed coverage were assessed throughout the growth period.

An analysis of the complete dataset revealed that early height development from tillering to shooting in combination with a high plant density in spring were important characters for competitive ability of wheat against *G. spp*. Even an early high plant coverage of *S. media* resulted in less biomass of *G. spp*. So there is the potential for competition between different weed species, with some species affecting the rate of increase of others (McCloskey et al., 1998). At a later date in the vegetation period an ability to produce a high biomass even beyond shooting proved advantageous for the wheat genotypes to compete against *G. spp*. An early wheat height growth until shooting and a rather horizontal leaf structure at ear emergence suppressed *S. media* effectively. High biomass of *G. spp*. and *S. media* at wheat ear emergence had a significant negative influence on the protein content of wheat.

Our work identified genotypic variation in characters that may be used for the breeding of winter wheat varieties competitive against weeds. Nevertheless the ecology of relevant weed species should be known and considered for an effective and site-specific weed control (Weiner, 2003).

Selection of tomato cultivars for organic production

Ewa Rembiałkowska, Ewelina Hallmann
Warsaw University of Life Sciences – SGGW, Warsaw, Poland

The organic food products are recognized by the consumers as better and safer than conventional ones. Organically produced plants have often lower yields but higher nutritive values that are very important quality indicators for the consumers. Therefore the aim of the presented work was to identify and to select the best cultivars of tomatoes in terms of their nutritive values. Food quality can be understood as food safety, measured by the minimal content of harmful substances (as nitrates, pesticide residues etc.) and nutritive quality, measured by the maximal content of desirable substances (as vitamins, bioactive compounds etc). In the case of tomatoes the most important is nutritive quality, because these fruits contain only low levels of the harmful substances; the strategy of the plant protects the fruits (and seeds inside) against toxins' accumulation. That is a high advantage for the consumers, especially in the organic sector. Therefore in the presented study it has been decided to focus only on the nutritive values of the tomato fruits. It's well known that tomatoes are very good source of the antioxidant compounds such as carotenoids (lycopene and beta-carotene), flavonoids as quercetin, and vitamin C.

In the presented experiment nine tomato cultivars have been analysed, in that seven standard cultivars: Atol, Awizo, Etna, Gigant, Juhas, Rumba, Kmicic, and two cherry cultivars: Piko and Koralik. The experiment has been carried out for three years in organic and conventional farms (two pairs of farms) located in Mazovia region. A lot of quality parameters were investigated to select the best cultivars for organic production: the content of dry matter by scale method, total and reducing sugars, total acidity, vitamin C, carotenoids (lycopene and beta-carotene) and quercetin.

The results obtained indicated that five of nine studied tomato cultivars had much better quality parameters when plants were cultivated in organic way: standard cultivars Rumba, Gigant, Juhas, Kmicic, and cherry cultivar Koralik. The last cultivar contained the highest level of the most investigated bioactive compounds. For example Gigant cultivar from organic production contained 8.58 mg flavonols and only 5.35 mg per 100 g.f.m. in conventional cultivation, while the lowest level of flavonols was found in Awizo cultivar: in organic cultivation it was only 1.54 mg per 100 g.f.m, and in conventional 1.18 mg per 100 g.f.m. Similarly, the organic cultivar Gigant contained 4.87 mg betacarotene per 100 g.f.m, and conventionally cultivated cultivar Gigant only 0.73 mg per 100 g.f.m. Awizo cultivar contained 1.26 mg betacarotene per 100 g.f.m. when cultivated in organic way, and in conventional cultivation it contained 1.12 mg betacarotene per 100 g.f.m.

The above data indicate that some cultivars are able to collect significantly more desirable compounds when cultivated in organic way in comparison to other cultivars. These cultivars can be really recommended for organic cultivation.

Organic maize for bread: yield, quality and corn borer resistance

Pedro Revilla[1], Arsenio Landa[2], Germán Sandoya[1], Ana Butrón[1], María Cinta Romay[1], Amando Ordás[1], Rosa Ana Malvar[1]
[1] Misión Biológica de Galicia (CSIC), Pontevedra, Spain
[2] Promotora Orxeira S.A., Ermille, Lobeira, Ourense, Spain

Maize bread is a specialty from the northwest of the Iberian Peninsula made from whole grain of maize. The maize varieties traditionally used by local farmers have been replaced by modern hybrids with higher yield and lower flour quality. Nowadays, consumers are becoming more interested on traditional foods, paying more attention to quality, health, and safety. Consequently, organic agriculture is becoming a promising alternative to the high yielding intensive agriculture, which is suffering a crisis in the northwest of the Iberian Peninsula. Indeed, organic production of traditional maize for human consumption could respond to consumer demands and raise the returns of small local farmers in the northwest of Spain and the north of Portugal. We evaluated agronomic performance and hedonic quality of autochthonous maize varieties from the germplasm bank of the Misión Biológica de Galicia (CSIC) and the Portuguese Bank of Germplasm under organic farming. Furthermore, we studied the stem and ear resistance of these maize varieties to corn borer attack, and the possible relationships among yield, quality and corn borer damage traits under the usual agriculture of the area. We identified four autochthonous varieties with the best agronomic performance under organic conditions and low insect pressure, which had adequate quality for making bread and other traditional maize foods. Those varieties are Tuy (yellow kernel and medium growing cycle), Sarreaus (yellow kernel and early cycle), Meiro (black kernel and medium cycle), and Rebordanes (white kernel and medium cycle). Populations with the highest yield and kernel density under high insect pressure showed high values for yield and kernel density under low insect pressure. Under high insect pressure, populations with less stem and shank damage by *Sesamia nonagrioides*, are recommended for reducing losses and the risk of kernel contamination with fumonisins. Among the late populations, Bianco Perla showed both high yield and reduced stem damage by *Sesamia nonagrioides* and reduced risk of fumonisin contamination. Among the populations with short growing cycle, EPS21(FR)C1 and Rebordanes produced high quality flours under high insect pressure conditions. These varieties are available upon request, and selection programs for increasing yield or flour yield are being performed for them.

Agronomic properties of triticale (x *Triticosecale* wittmack) selected for tolerance to nutrition deficiency under laboratory conditions.

Danuta Rzepka-Plevneš[1], *Marta Stępień-Słodkowska*[2]
[1]Agricultural University of Szczecin, Poland; [2]University of Szczecin, Poland

Mineral nutrient that are taken up by plant roots are essential for plant growth and crop production. The macronutrients nitrogen, phosphorus and potassium are frequently added to soil where crops are grown, because they contain either deficit or suboptimal levels of these nutrients (Marschner 1995, Shin et al. 2005).

The studies were conducted over the years 2001-2002 and covered 26 varieties of triticale examined for tolerance to nitrogen and potassium deficiency under *in vitro* cultures of mature embryos. The selection of tolerant and partially tolerant seedlings was performed 10 days after the growth initiation of triticale embryos on a MS medium containing 0.333 mM $\cdot$ dm^{-3} nitrogen, 0.225 mM $\cdot$ dm^{-3} phosphorus and 0.332 mM $\cdot$ dm^{-3} potassium. The MS medium with a full NPK composition (N - 6.003 mM $\cdot$ dm^{-3}, P - 0.125 mM $\cdot$ dm^{-3}, K - 2.005 mM $\cdot$ dm^{-3}) comprised the control medium. Seedlings longer than 5 cm with two well formed leaves and well branched seminal roots were classified as tolerant, with reduced height to 2.5 cm and developed roots - as partially tolerant to nitrogen and potassium deficiency. Seedlings tolerant and partially tolerant were planted into pit pots and after hardening in a glass-house, moved on 0.5 m^2 plots in the field experiment. The experiment was based on random blocks in three repeats in soil containing in a 100 g of 0.11% total nitrogen, 12 mg P_2O_5 and 12 mg K_2O. During the whole vegetation period no additional mineral fertilisation was applied. The control seeds of all tested triticale varieties were obtained from the breeders. The triticale properties were determined at the stage of full maturity – crop components from an area unit. The obtained results were evaluated statistically.

The results obtained show that tolerant and partially tolerant seedlings, identified by way of selection at the stage of a mature plant, did not differ from the control plants as regards many of the properties examined. Some of them proved even superior as regards height, ear length, number of spikelets in ear, tillering, number of grains per plant and per ear. For most of the studied features, a significant correlation was observed, both in the tolerant forms and in the control forms. Special attention should be paid to two triticale varieties that in the *in vitro* test were described as partially tolerant (Bogo and Chrono) as well as eight varieties identified as susceptible (Lasko, Malno, Marko, Moreno, Mundo, Nemo, Prego, Pronto). The results obtained indicate that from Polish triticale varieties it is possible to select source material for breeding of varieties for extensive conditions of cultivation.

Nitrogenase activity as the criterion for selection in the red clover breeding

Tomas Simon[1], *Hana Jakesova*[2]
[1]Crop Research Institute, Prague, Czech Republic
[2] CSc., Red Clover, Grass Breeding, Hladke Zivotice, Czech Republic

Low-input agriculture which becomes a common farming practice needs the perennial forage legumes such as clover that markedly contribute to the soil nitrogen balance through effective N_2 fixation. Improving N_2 fixation by means of selection and breeding reduce reliance on soil and N fertilizers, whilst enhancing residual benefits to subsequent crops.

Hydroponic perlite culture as the cultivation environment enabling to eliminate soil N was used for screening of 4000 individual plants obtained from previous cycles of recurrent breeding for enhanced nitrogenase activity. Plants were inoculated with effective *Rhizobium leguminosarum* bv. *trifolii* strain. Total nitrogenase activity (TNA) (µmol/plant/hour) was measured at the onset of flowering and root volume (ml/plant) and forage matter (fresh and dry) (g/plant) were determined. Water soluble carbohydrates content (WSC) was determined in dry forage matter using both liquid chromatography and NIR spectrometry. 360 of them were selected according to TNA and planted to the nursery in 2003. Forty plants within the nursery were selected for open pollination according to the health status, vigour, size of plant, seed harvest etc. in the summer 2004. Consequently fourteen individual plants with extremely high nitrogenase activity and very good agronomical value were selected after seed harvest. Their seed progenies (1008 plants in total) were screened in the second experiment (2005) and plant characteristics were determined as described above. Intraclass correlation coefficients (h^2) were calculated for parents and progenies as an estimate of heritability and relationships among determined characteristics were assessed for both the populations.

Heritability estimate for TNA was more than six times higher in progenies screened in the second experiment (h^2=0.4645) that those for parents from the first experiment (h^2=0.0739). Increased h^2 was observed also for root volume (3.24 times) for progenies compared to the parents. On the other hand, selection for high nitrogenase activity did not affect the heritability estimates for forage yield. Selection for enhanced nitrogenase activity resulted in increased number of above-average plants in progenies screened in the second experiment (by 8.8% for TNA; 3.5% for root volume and 5.0% for dry forage matter) compared to the parents from the first experiment. Total nitrogenase activity was significantly positively correlated with root volume, fresh forage and dry forage ($p<0.05$), while correlation coefficients varied depending on individual populations. WSC content was positively but weakly related to TNA. Selection for high nitrogenase activity slightly increased the correlation between TNA and dry forage matter in progenies (r=0.521) compared to the parents (r=0.418).

Promising plant material with enhanced nitrogenase activity (N_2 fixation), and good forage yield a forage quality (WSC) should contribute to the functioning of the ecosystems as is organic and sustainable, low-input agriculture.

Morphological parameters used in the characterization of rye recombinant inbred lines for nutrient deficiency in medium

Miłosz Smolik, Rzepka-Plevneš Danuta, Kurek Jadwiga
Department of Horticultural Plant Breeding, Agricultural University of Szczecin, Poland

Selection using *in vitro* cultures is useful in identifying genotypes tolerant to biotic and abiotic stresses at seedling and cellular stages (Dahleen et al. 1991). According to Rzepka-Plevneš (1996) selection of cereals for tolerance to nutrient deficiency at the seedlings stage is possible, when length of primary roots and number of secondary roots is used as a selection criterion. The aim of the present studies was to determine the reaction of RILs to the nutritional (N and K) stress in the medium and select the lines (RILs) of tolerance of extreme difference to the caused stress. The 139 RILs (F_5) were derived from generation F_2 of the hybrid (153/79-1 x Ot 1-3) obtained from the crossing of two rye inbred lines: high tolerant - 153/79-1 - was derived from the hybrid (544-7-1-5 x 542-9-1-11) and low tolerant to nutrient deficiency in the medium - Ot 1-3 which was derived from old swedish variety Otello. The tolerance of parental rye inbred lines and RILs was assessed by means of the *in vitro* test (Rzepka-Plevneš et al. 1997). The biometric measurements of seedlings were made in which the height of coleoptile, the length and number of roots were estimated. These studies, like the *in vitro* test itself, were carried out using both the seedlings exposed to the stress and the control seedlings. The RILs seedlings which did not differ significantly as regards the estimated morphometrical parameters were the lines tolerating the nutritional stress. The lines in which this reaction was significantly different were regarded as non-tolerant to nutrient deficiency.

The results of the studies showed that within the range of the examined inbred lines there is large variability both with regard to the height of seedlings, the number and length of roots. Rye seedlings tested on the medium with deficit in N and K formed on average longer coleoptiles but shorter germ roots compared to the control seedlings. In regard to the number of roots no significant differences in relation to the controls were observed. By means of the described method Rzepka-Plevneš et al. (1999) selected forms of both rye and triticale characterised by high tolerance to nutrient deficiency in the medium. Their agronomic features described in the experiments did not differ significantly in respect of most traits compared to the control ones. Hence, in this study this test was used to examine the reactions of the RIL lines to nutrient deficiency stress. The described RIL lines can be used in organic breeding as components for crossing. Moreover, they are a valuable source of genes of tolerance to abiotic stress. They serve for maintenance of biodiversity and can constitute material for physiological, biochemical and molecular studies.

Wheat genotypes suitable for organic farming

Zdeněk Štěrba, Petr Konvalina, Jan Moudrý
University of South Bohemia, Faculty of Agriculture, České Budějovice, Czech Republic

An ideal variety of wheat for organic farming system is characterised by high resistance to fungal diseases, especially to the ear diseases (fusarium and septoria) (Moudrý, 1994). It has a long upper internode which assures the assimilation in the grain period even if the leaves are affected by fungal diseases (*Puccinia* ssp.). The other internodes are shorter – this feature assures a higher resistance to the lodging (Urban & Šarapatka, 2003). The varieties with the average or long stalk, forming few tillers, providing the yield by the spike productivity (more and large grains) are suitable for organic farming system. The advantage of such varieties is that they do not need nitrogen to support the tillering as the mineralization process runs slowly in spring. Later in the season, when they need more nitrogen to form spikelets and grains, there is enough nitrogen available, because then the temperature is higher (Moudrý, 1994). When comparing the chemical composition and protein content in grain we find that organic wheat contains less proteins, but contains more albumines and globulines (Krejčířová et al., 2007). The purpose of this project was to compare the morphological, biological and economic characteristics and chemical composition of the wheat varieties.

From 2006 to 2007, a small-field experiment has been set up at the Faculty of Agriculture, University of South Bohemia in České Budějovice. Altitude - 380 m, soil type – sandy loam, the average annual air temperature – 7.8°C, the average annual amount of precipitation – 620 mm. The trail included wheat varieties bred for organic (Austrian genotypes from the breeding station in Edelhof) and conventional (Austrian genotypes) farming system, landraces of wheat and emmer.

The following results were found from the first evaluation. Landraces of wheat, organic varieties and emmer are supposed to be better from the point of view of their morphological characteristics. Conventional varieties are supposed not to be good mainly by reason tuft form and position resp. length of flag leaf. Concerning the biological characteristics (resistance to diseases) the results are not evident yet, by reason of low infectious pressure in year 2006 and 2007. When comparing the economic characteristics (spice productivity, yield of grain), the organic and conventional varieties perform best. Some varieties of emmer and landraces showed good results in the evaluating the quality parameters (crude protein content). According to two-year results cannot be convey the definite conclusion, but wheat varieties bred for organic farming system appear to be best.

What is a stable characteristic of cover crops in weed control ability?

Hiroshi Uchino, Kazuto Iwama, Yutaka Jitsuyama, Toshiko Yudate, Keiko Ichiyama
Crop Science Laboratory, Department of Botany and Agronomy, Sapporo, Japan

Weeds are often recognized as the most serious threat to crop production in organic farming. Apprehension about the consequences of managing weeds without the use of herbicides is a major factor limiting the conversion from conventional to organic farming Cover crops are paid attention as an effective non-chemical method for weed control. In mixed cropping system, however, cover crops sometimes suppressed not only the growth of weeds but also main crops, or could not suppress weeds efficiently. This study clarified stable characteristics of cover crops to suppress weeds by screening optimal cover crops species to control weed growth and by evaluating weed suppressive ability under mixed cropping with main crops in organic farming.

Screening test of cover crops; Ten species of cover crops, which had high variations in plant type (plant height, dry matter production etc.), were grown in fields without the main crop to compare the weed control ability. Dry weight of weeds and cover crops, vegetation cover ratio (VCR) and plant height of cover crops were measured at 4 and 10 weeks after sowing.

Mixed cropping test; Winter rye (*Secale cereale*) and hairy vetch (*Vicia villosa*) were grown in the inter-row space as cover crops with main crops, maize (*Zea mays*) and soybean (*Glycine max*). Cover crops were sown 3 or 4 weeks after main crops for reducing the competition between main crops and cover crops. VCR of the canopy was measured every week and dry weight of main crops, cover crops and weeds were recorded at harvest time.

Screening test of cover crops; Weed dry weight was correlated strongly and negatively with the VCR of cover crop, but weekly with dry weight of cover crop or not significantly with cover crop height. The results indicated that cover crops with high VCR could suppress weed growth sufficiently, even if its plant height was low.

Mixed cropping test; Weed dry weight was significantly reduced by the sowing of cover crops in the inter-row space, and was negatively correlated with the VCR of main crops plus cover crops, which increased significantly by cover crops. These results indicate that VCR is the most stable characteristic for weed control and reliable index for the selection.

Evaluation of 36 lentil (*Lens culinaris* Medik.) genotypes under conventional and organic environment

Dimitrios Vlachostergios[1], Dimitrios Baxevanos[2], Demetrios Roupakias[3].
[1] Fodder Crops and Pasture Institute, Larissa Greece.
[2] Lab. of Biometry, Sch. of Agricultural Sciences, University of Thessaly, Volos Greece
[3] Lab. of Genetics and Plant Breeding, Aristotle University of Thessaloniki, Greece

Lentil (*Lens culinaris* Medik.) is an important crop throughout the Meditterrenean region, W. Asia, and N. America (Erskine W., 1996). It is also broadely used in organic agriculture as it improves soil fertility. The main objectives in the current study were: (1) to investigate the productivity of lentil genotypes under organic and conventional management and (2) to detect the promising genetic material for an organic plant breeding program.

Thirty six lentil varieties were evaluated under organic and conventional environments under field experiments that were established for two consecutive years at the Fodder Crops and Pastures Institute in Larissa, Greece. The genetic material studied originated from Greece, ICARDA, Morocco, India, Turkey, Jordan, Chile, Canada, USA, Algeria and Bulgaria. In the conventional trial plots standard cultural practices (P mineral fertilization & pest control) were applied throughout the growing season, while in the organic ones no fertilizers or pest agrochemicals were applied. The experimental field arrangement was the triple lattice with three replications. ANOVA and GGE Biplot analysis were applied for identifying significant differences and repeatable GEI patterns in relation to genotype adaptability and stability.

ANOVA indicated statistically significant differences between genotypes and environments. GxE interaction (GEI) was also significant. It was observed that under conventional management most genotypes had a higher yield compared to the organic one. This is likely due to the effect of fertilizers and pest control applied under conventional management. On the other hand, certain genotypes adapted better under organic environment. The ranking of the mean yield per genotype and environment revealed two types of GEI. Firstly, genotypes occupying the same ranking position at both the organic and the conventional environment (non-crossover GEI), and secondly, those that exhibited a significant alter in the ranking (crossover GEI) under the two environments. Thus, among the 10% highest yielding genotypes under the conventional environment there was also included half of the 10% highest yielding genotypes under the organic environment. Moreover, these genotypes exhibited broad adaptability and stability. This observation is in agreement with the statement: a lot of genetic material developed under conventional management is also exploitable in organic agriculture (Vogt - Kaute W., 2001). Finally, most of the low yielding genetic material was at the bottom of the rank under both the conventional and organic environment.

Selection for weed tolerance in soybean

Johann Vollmann and Helmut Wagentrist
Department of Applied Plant Sciences and Plant Biotechnology, BOKU - University of Natural Resources and Applied Life Sciences, Vienna, Austria

Soybean (Glycine max [L.] Merr.) has recently proved to be an interesting grain legume crop for organic farming in Central European countries (Bavec & Bavec, 2006). As a consequence, early maturity, acceptable agronomic performance and quality features such as high seed protein content, large seed weight or yellow hilum are important features for food grade soybeans. As soybean is slowly developing during early stages of crop establishment, competition of the soybean crop with seed-propagated weeds is important, and weed control is a major challenge for farmers. Genetic variation in weed suppression or weed tolerance of soybean is largely unknown. As soybean does not show significant allelopathic effects in general, genetic differences in competitiveness against weeds might be due to mechanisms such as rapid development during juvenile stages (Jannink et al., 2000), branching habit or weed shading through increased leaf area or leaflet shape. Therefore, an experiment was initiated in order to identify differences in competitiveness of soybean cultivars against weeds, by which selection criteria for weed tolerance might subsequently be established.
During the 2005 and 2006 growing seasons, twelve soybean genotypes were either grown in weed-free plots or in plots with heavy weed infestation in a split-plot experimental design at a location near Vienna/Austria. Weed infestation was simulated by broad-sowing of winter oilseed rape seeds after the emergence of soybean. Grain yield as well as other agronomic and seed quality characters were recorded for pure stands and simulated weed stands, and grain yield reduction by weed infestation was determined for individual genotypes.
Weed infestation had statistically significant effects on various characters of soybean. Across all genotypes, weed infestation caused a delay in time to maturity by about 2 days, a reduction in plant height by 12 cm and a decrease in grain yield by 450 kg/ha (i.e. 20 % in average). Thousand-seed weight was increased from 157 to 165 g, and seed protein content was also significantly increased from 342 to 350 g/kg by weed infestation. Yield reduction of individual cultivars was between 0 and 48 % and between 0 and 20 % for the 2005 and 2006 growing seasons, respectively. Moreover, yield reduction of individual genotypes was clearly reproducible over the two years indicating a genetic difference in this character. The degree of yield reduction by weed infestation for individual cultivars was not related with leaf area, but significantly correlated with time to maturity. Therefore, the lesser yield reduction in early maturing cultivars as compared to late cultivars should be considered as weed tolerance rather than weed suppression under the experimental conditions applied.

Should resistance to harrowing be included as selection criteria for organic barley and oat varieties?

Elisabeth Zechner[1], *Alexandra Kinastberger* [2]
[1]Saatzucht Edelhof, Zwettl, Austria
[2]Verein zur Förderung der Mohn- und Getreidezüchtung, Zwettl, Austria

Within the Austrian project „Basic principles for breeding, multiplication and variety testing for organic agriculture” (financing body: Ministry of Agriculture and State Governments, 2004-2008) breeders do research for the development of new methods for the evaluation of suitable seeds and varieties for organic agriculture, so also research is done in “Tolerance to harrowing of spring barley and oats”. To combine the demands on powerful and healthy varieties for organic farming with high quality it makes sense to select lines out of the wide range in a conventional breeding garden.

At the Austrian location Edelhof near Zwettl 16 varieties of each spring barley and oats used in Austrian organic farming were grown to monitor their tolerance to harrowing in the years 2005 to 2007. The drilling was done with 400 seeds/m². The monitoring consisted of two trials with each three replications, one trial had been harrowed and one trial without harrowing. Different criteria were noted e.g. growth rate, plant habit, plant length, reaction to the mechanical weed control, soil covering rate, ear emergence, diseases. After harvesting and weighting also several quality analysis had been carried out.

Results

- No - respectively only insignificant - differences between the same variety in harrowed and not-harrowed model in ear emergence, maturity, soil covering, diseases
- the not-harrowed model yielded better in three years for spring barley and spring oats
- In most varieties the quality characters are going down
- Only few varieties reacted positively to harrowing
- But not in all years varieties react in the same way

Although in the harrowed model less weed emerged, the competition of these weeds had no strong negative effects to the varieties in the not-harrowed model. The mobilisation of nutrients through the use of the harrow could not be realised for most of them. The harrowing could not generate higher monetary surpluses through higher yields or better qualities, respectively the harrowing seems to be an unnecessary work and expense at first glance. But as harrowing is necessary to keep under control the weed seed bank the breeder has to look for varieties resistant to harrowing and reacting also positively with higher yields and better quality. So far there are no shared characters found from the few positively reacting varieties useable as a selection criteria.

Breeding Strategies

Breeding for organic agriculture – Strategy and example in practice

Franziska Löschenberger
Saatzucht Donau GmbH&CoKG (SZD), Probstdorf, Austria

Breeding for organic agriculture (BFOA) takes advantage of the fact that the expression of many traits is highly correlated between conventional agriculture (CA) and organic agriculture (OA) (Baresel, 2006; Oberforster 2000 & 2006). Low input CA with limited nitrogen supply and without the application of fungicides leads to yield levels comparable to OA. Selection in CA can be a useful step for a preliminary selection for OA (and can thus be regarded as indirect selection for OA). Tillering capacity, early vigorous growth, earliness (heading date), disease resistance, culm length, spike- and other morphological and grain characteristics, like thousand kernel weight (TKW), and protein quality are examples for highly heritable traits – for which indirect selection is most promising.

BFOA in winter wheat: Variability is created by including material especially adapted to OA into the crossing program. Selection starts in F3 on single plants on a conventional field. Single ears are cut from selected plants and continued as F3-derived lines. At this stage, in F4, the most important selection occurs by means of scores and measurements for highly heritable morphological, agronomic, resistance and quality traits. In F5:3, the lines are grown on three locations for observation. Yield potential is estimated by harvesting only one location, several parameters of quality are being analysed. Analysing visual scores, yield and quality data, the genotypes are then divided into lines fitting solely for CA and material better adapted to OA. The first yield trial is grown parallel under organic and conventional conditions for most genotypes. According to the results, genotypes can be switched from the conventional to the organic route and vice versa. The advantage of this shuttle-strategy in BFOA lies in exploiting the larger genetic variance of both the organic and the conventional genepool that can be exploited in selection for OA.
An alternative route is followed by growing F2 to F5 as a bulk on organic fields, each year performing mass selection of spikes and rebulking them. Lines are derived as ear- rows, further selected as above mentioned “indirectly” for 2 years on the conventional fields and then again yield tested on organic fields.

Usually in Austria, the varieties released for OA are tested for 5-6 years at minimum under organic conditions: 2-3 years before application, and 3 years in official organic VCU testing. Up to now, six winter wheat varieties have passed the organic VCU test in Austria: Aurolus, Bitop, Eriwan, Indigo, Pireneo and Stefanus. The range of varieties for organic farming is variable from speciality varieties with specific adaptation and/or special quality characteristics to broadly adapted varieties. Summarizing the experiences, varieties for organic agriculture should have a broad range of adaptability for different environment conditions – these environments vary even more in organic as compared to conventional production. To be even more successful in the future, BFOA needs a strong commitment.

Organic cereal breeding – towards a holistic approach

Karl-Josef Mueller
Cereal Breeding Research Darzau, Neu Darchau, Germany

Variation is usually taken from genetic resources, varieties and different origins of a species. But only the field performance in either the targeted environment or more intensified circumstances can show the necessary differences between the varieties. After 10.000 years of coevolution cereals offer a lot of features and characters for the different demands of farmers, processors and consumers. Organic farmers want an extraordinary yield and high light competitiveness related to weeds, but also seeds to be multiplied and maintained under organic farming. Processors prefer a high output without losses and for different or specified uses, and consumers like shiny and spotless grain with mild taste, easily to digest and well nourishing.
Is there an 'organic' way to arrange all this in a new variety? What kind of characters can for instance barley offer to meet the different above mentioned demands? There are different strategies in principal to suppress weeds with light competitiveness, but they all have a negative correlation to yield when there are no weeds. Which strategy should then be preferred? Our experience is that including analysis of the metamorphosis of leaves and the development of different types of shoots offers an evaluation of plant quality by comparing between plants. And how can we learn to distinguish characters related to formative forces in the plant that express its nutritional quality?

Cereals are not only food for human but also for animal feed. It is possible to have higher or lower amounts of soluble fibre, but then a breeder has to distinguish between the diet for hens and that of humans. What could be the concept of cereal breeding for feeding with human being in the centre of the targeted characters? Following this way of thinking from a spiritual point of view leads to the question what breeding should add to cultivated species. Next to this multiplication of seeds under organic farming needs resistance to seed borne diseases to minimise declassification of certified seed production. Different resistances to seed transmitted diseases are available, but the question is, which methods for selection under natural infestation are suitable for organic breeding under organic certification. For some characters it is good to know the number of components which might segregate and whether they are dominant-recessive or intermediate when following a classic breeding procedure. For instance smut resistance can be developed fairly rapidly, with a monogenic inheritance, but it can also rapidly break down. It is also necessary to develop quantitative resistance as a genetic background. This is practically done with a 'pre-mendelian' knowledge of heritability, because there is no time for analysing every parent, whether they have the same or different components of quantitative resistance.
Studies of metamorphosis of leaves and plant habit in the field plots will lead to a knowledge about a new breeding line, that is more related to an artistically understanding The inner comparing of colour, shape and consistence of different lines will lead to a 'post-gmo-method' with an environmental arrangement for a further co-evolution of cereal and man. With 'post-gmo-method' I mean a kind of creative development of plant characters beyond a free and arbitrary combination of features or genes. When characters of a plant are related to each other in their chronological succession the qualitative integrity will become an experience of organic development of living plants. This could be a part of an 'organic' cereal breeding.

Potentials of molecular markers to exploit G x E interactions for organic farming

Gunter Backes[1], Hanne Østergård[2]
[1]University of Copenhagen, Faculty of Life Sciences, Frederiksberg, Denmark;
[2]Risø National Laboratory, Technical University of Denmark-DTU, Denmark

One of the substantial differences between conventional and organic farming is the degree to which the farmer has the possibility to implement short-term changes of environmental factors. This implies that organic farming carries along a higher environmental dependency and thereby a much greater focus on genotype × environment interactions (GEI). GEI is often neglected in practical breeding and breeding research due to 1) high complexity, 2) lack of procedures in a breeding pipeline, and 3) variety approval system building mainly on traits *per se*, not on GEI. While the latter is based on political decisions, there is help ahead for the first two issues using molecular markers and marker-assisted selected (MAS). However, within the organic sector there is much debate about the application of molecular markers with respect to the methods used in marker establishments as well as the integrity of plants (Lammerts van Bueren et al., 2005)

Recent developments of knowledge on genetic networks and physiological systems, together with new approaches for the analysis of the relation of genetic marker data with phenotypic traits, make it possible to analyze not only the effect of a gene on a trait (the phenotype), but the effect of a system of genes as a response to environmental influences (van Eeuwijk et al., 2005). Encouraging results from this approach have been obtained in pilot studies, especially in cases where GEI is important, e.g., yield under stressed conditions (Vargas et al., 2006). In relation to breeding for organic farming, this approach and MAS could gain importance on several levels: (a) the way breeders deal with the traits and their environmental influence; (b) the identification of conventional bred varieties with desirable GEI reaction pattern; (c) direct application of MAS for GEI reaction patterns in breeding for organics. The latter depends on costs of molecular analyses and the market potential of varieties for organic farming as well as on ethical considerations within the organic sector. Still, future experience has to show if this application of markers is superior to a traditional selection that directly selects on the trait and indirectly on the gene.

Heritability and genotype x environment interactions of mineral nutrient concentration in wheat grown in organic systems

Kevin M. Murphy[1], Julie C. Dawson[1], Philip G. Reeves[2], Stephen S. Jones[1]
[1]Department of Crop and Soil Sciences, Washington State University; [2]USDA-ARS, Grand Forks Human Nutrition Research Center, Grand Forks ND, USA.

Increasingly, consumers cite personal health as the most important reason for buying organic food. Selection for increased mineral concentration in wheat demands a working knowledge of the inheritance of the traits in question and an understanding of genotype x environment interactions that influence the mean trait value. This paper will focus on the nutritional value of organic wheat using calcium (Ca), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), phosphorus (P), selenium (Se), and zinc (Zn) as response variables. We will report results of the genotype x environment analysis of variance, estimations of the genetic correlation among minerals and between locations, and the heritability of mineral concentration in organic systems. We tested sixty-three spring wheat cultivars that ranged in release date from 1842 to 2001 for grain yield and mineral nutrient concentration of Ca, Cu, Fe, Mg, Mn, P, Se and Zn in low-input agronomic conditions. In addition, we estimated the heritability of Ca, Cu, Fe, Mg, Mn, P, Se and Zn in ten winter wheat populations (high x high, high x low, low x low) in two locations in certified organic conditions for the F_2 through the F_5 generations.
While grain yield has increased in the modern cultivars, mineral nutrient concentration has decreased significantly in modern cultivars for all minerals except Ca. The decrease in mineral concentration over time is found primarily in the soft white wheat market class, while the hard red market class has remained largely constant. This suggests that plant breeders, through intentional selection of low ash concentration in soft white wheat cultivars, have contributed to the decreased mineral nutrient in modern wheat cultivars. These results contradict the theory that there exists a genetically based, biological trade-off between yield and mineral concentration. Moderate to high narrow-sense heritability estimates using parent-offspring regression for each mineral suggested the dominance of additive gene action. Analysis of variance showed significant interactions for genotype x environment for all minerals tested. However, significant rank correlations among parental genotypes and populations suggest that the genotype x environment interactions are due primarily to scalar interactions rather than genotypic rank changes. Therefore, using the abundant variation present in wheat cultivars, plant breeders should be able to increase mineral concentration in modern cultivars without negatively affecting yield.

Maintenance breeding of conservation cereal varieties for organic farming in Denmark

Anders Borgen, Per Grupe, Hans Larsson
Agrologica, Mariager, Denmark

The current area of organic farming is small compared with the cost for a conventional breeding program, and the organic plant production suffers from a lack of diversity in the varieties offered on the organic seed market. Moreover, organic farming is more diverse than conventional agriculture in terms of growing conditions. Therefore, organic farming has a high need for a wider range of varieties suited for different niches.
Conservation or heritage varieties, and especially landraces often has a high level of genetic diversity within the varieties and may therefore satisfy the lack of diversity in varieties offered on the organic seed market. Heritage varieties also often have a high genetic variability within the varieties, which allows for a relatively cheap maintenance breeding based on positive selection.
Organic products are often sold at a surplus price on a market for quality products. In such a market, it is becoming increasingly important not only to provide a product and information about the physical content, but also to offer information about the background of the product, e.g. how and where it was produced, and by who. For the organic market, heritage varieties offers a unique storytelling about the product, were the history of the varieties, and the effort to conserve plant genetic resources adds value to produce in line with modern marketing principles. Therefore, the heritage varieties need a thorough evaluation for growth habit in organic farming and for quality traits including backing and malting quality.
Varieties of Danish origin and other varieties grown in Denmark before 1950 are requested from genebanks and other sources. The history of the varieties are being described based on historic literature, and the varieties are grown in the field for assessment of agronomic performance and quality traits. In the first year, only few seeds are available, and these are grown for multiplication under organic conditions at The Swedish Agricultural University (SLU) in Alnarp. Homogeneous lines are in the second year grown in 15 m^2 plots under organic conditions in loamy soil at Mørdrupgård in Denmark. In the third year, the lines are grown in 15 m^2 plots in 4 replications at Mørdrupgård in Denmark and under organic conditions in sandy soil at The Danish Agricultural Museum. Positive selection in the material is made at SLU, Alnarp, and the selected material is grown in head rows for development of lines suitable for organic conditions. In addition to the Danish heritage varieties, Swedish heritage varieties which have already been selected and multiplied at SLU in previous projects, are grown at Mørdrupgård and at The Danish Agricultural Museum.
The requested material include 82 barley varieties, 194 wheat varieties including *Triticum aestivum, T.spelta, T. monococcum, T.sinskajae, T.dicoccon, T.turgidum, T.durum*, 84 oat varieties and 23 varieties of common rye (*Secale cereale*) and midsummer rye (*S. cereale* var. *multicaule*).

The experiments shows that within the heritage genetic resources, varieties are identified with unique quality traits, including taste, colour and backing quality, which are not found in high yielding modern varieties available for organic farming. The poster presents the second year result of field evaluation of 212 Scandinavian heritage varieties grown in two sites in Denmark in 2007.

Potato cultivar Lady Balfour, an example of breeding for organic production

John Bradshaw[1], *Paul Coleman*[2], *Finlay Dale*[1]
[1]Scottish Crop Research Institute, Dundee, UK;
[2]GreenvaleAP, Doddington, UK

Late blight (*Phytophthora infestans*) resistance is highly desirable in potato cultivars for organic production. Without it, when blight appears, organic growers have to use copper-based fungicides or defoliation with a resultant loss of yield. Blight resistance has always been an important objective in the potato breeding programmes of the Scottish Crop Research Institute. When simply inherited major-genes failed to provide durable resistance, the breeders switched to selecting for high levels of field resistance. By 1991 some promising cultivars were available, in particular, cultivars Torridon, Brodick and Stirling. The effectiveness of their resistance and their yield advantage were demonstrated on organic farms (Wastie et al., 1992). However, commercial success was not achieved until 2001 when cultivar Lady Balfour [88P43(5)] was added to the UK National List. It has since become established as the leading organic potato in Great Britain.

It was selected from a cross made in 1988 between clone 8204a(4) and clone 15119ac(5). Clone 8204a(4) had good field resistance to late blight. Its pedigree traces back through eight generations to the few seed secured from a cross made in 1937 between diploid *S. rybinii* (= *S. phureja*) and hexaploid *S. demissum*, presumably the source of its blight resistance. Clone 15119ac(5) had good quantitative resistance to both the golden and white potato cyst nematodes (*Globodera rostochiensis* and *G. pallida*). Its pedigree traces back through five generations to tetraploid *S. vernei* produced in 1958 by colchicine treatment of seed from a cross between two diploid accessions in the Commonwealth Potato Collection which had been screened and found resistant. Lady Balfour was selected to have resistance to both late blight and cyst nematodes. Organic ware trials in England conducted by GreenvaleAP (three sites, 2001-2003) and NIAB (two sites, 2000-2006)(NIAB, 2007) demonstrated the high marketable yield and suitability of Lady Balfour for organic production. Furthermore, NIAB disease tests confirmed Lady Balfour's high level of resistance to late blight and useful level of partial resistance to cyst nematodes.

Conventional breeding for resistance to late blight and cyst nematodes produced a variety suitable for organic production. The chances of future success may be increased by selection in organic or low input environments, with increased emphasis on rapid establishment, good ground cover, early bulking yield potential and tolerance to drought stress through a better root system.

Evidence on genetic variability among and within three runner beans local landraces (*P. coccineus*) grown under organic farming conditions

Vasilios-Chatzitheodorou[1], Athanassios-Mavromatis[1], Athanassios-Korkovelos[1], Ebrahim-Khah[1], Christos-Goulas[2]
[1] Laboratory of Plant Breeding and Genetics, University of Thessaly, Volos, Greece;
[2] Laboratory of Vegetable Production, Aristotle University of Thessaloniki, Thessaloniki, Greece

Runner bean (*Phaseolus coccineus*) is mainly a cross pollinated species but seems to have high percentage of selfing and is one of the most popular grain legumes in Mediterranean countries. Although commercial cultivars are currently available, the majority of growers are cropping local landraces either for self consumption or for production in both conventional and organic farming use.
In this study farmer's seed from three distinct areas different in their altitude were used. Landraces were: Distrato, Zagora and Prespes grown in high, medium high and medium altitude respectively. The three landraces entered field evaluation during 2004-05 growing seasons in the University of Thessaly Experimental Farm in Velestino-Volos under organic farming conditions in a nearly sea level growing environment. Sixty individual fully competitive plants were evaluated from each landrace in a grid mass selection arrangement. Planting was in hills at a final density of one plant *per* m^2. Dry bean yield on a per plant basis along with number of pods and 100 seed weight was recorded.
Selection for high dry bean yield was practiced. Selection intensity was 0.10 (one plant from each grid) and the six half sib families (HS) selected were pooled to form $C_{1\ HY}$ composites for each landrace. Bidirectional selection (high *vs* low) for dry bean yield was practiced within each of the three $C_{1\ HY}$ composites following evaluation during 2005 season in the same manner as in 2004. Seed from the six high yielding plants and the respective low yielding ones were pooled to form the respective high and low composites ($C_{2\ HY}$ *vs* $C_{2\ LY}$) from each landrace. The resulted six composites were further evaluated during 2005 season following the procedure previously described. Furthermore five plants from Co were selfed to create S_1 families (2004) and next year 2005 formed the S_2. According to agronomy performance, high significant differences were found in yield, number and weight of pods *per* plant. Data indicated that Distrato and Prespes landrace were of the same yielding potential and superior as compared to Zagora. Bidirectional selection was effective in the organic environment giving a mean response 15% *per* year. Furthermore, the heterogeneity of landraces was expressed better (in organic environment) as was proved from the initial population of Grevena (C_0) originated from highlands and expressed the highest genetic variability among all landraces. This growing season a simultaneous evaluation for C_0, C_1, C_2 and S_1, S_2 families for each landrace was applied to estimate the inbreeding effect, the real genetic gain and the efficiency of the selection method.

Dynamics of doubled haploidy breeding and molecular cytogenetic approaches *vis-a-vis* genetic upgradation of bread wheat for organic and low input farming systems in north-west Himalayas

Harinder K. Chaudhary, Rakesh K. Chahota, Naval Kishore, Vijay Kumar, Shailesh P. Sood
Molecular Cytogenetics & Tissue Culture Lab, CSK HP Agricultural University, Palampur, India

Bread wheat (*Triticum aestivum* L.), one of the major cereals of north-west Himalayas is cultivated under varied agroclimatic situations and farming systems in the hills and mountainous tracts of this zone. Some of the progressive & tribal farming communities of these Himalayan mountains have adopted a practice of organic farming system since last decade. The diverse genotypes of winter and spring wheat ecotypes cultivated in different regions are very low yielding and highly susceptible to the rusts and powdery mildew hence, there is a dire need to genetically upgrade these genotypes for developing the elite stocks to be cultivated under organic and low input farming systems.

The north-west Himalayan germplasm resources in respect of winter and spring wheat ecotypes and rye have been used for the introgression of the target genes. The breeding programmes have been accelerated with enhanced precision and efficiency following chromosome elimination technique (Chaudhary et al., 2005) and novel tools of molecular cytogenetic approach (Mukai et al., 1989).

The ongoing wheat improvement endeavour for the genetic upgradation of local genotypes in this Lab has been expedited through the application of novel tools of the doubled haploidy (DH) breeding and molecular cytogenetic approaches by a team of North-West Himalayan Crop Improvement & Genome Research Group. The chromosome elimination-mediated approach of DH breeding has curtailed the time period to develop the new-recombinants derived from the triticale x wheat (introgressed rye genes into wheat) and winter x spring wheat (introgression of the gene pools of winter and spring ecotypes) hybridization. The genomic *in situ* hybridization (GISH) and fluorescene *in situ* hybridization (FISH) has further enhanced the efficiency of selection of elite recombinants carrying targeted introgressions needed for the organic farming and low input management systems of the north west Himalayan regions. About 150 DH lines developed in Molecular Cytogenetics & Tissue Culture Lab of this Department by involving the local land races of winter and spring wheat ecotypes following chromosome- elimination mediated system and the molecular cytogenetic approaches are being screened under highly diverse agroclimatic situations for further recommendations to the organic and low input farming systems.

Conservation and generation of genetic resources through development of modern landraces of wheat: co-evolution in the field

Maria R. Finckh
Faculty of Organic Agricultural Sciences, Department of Ecological Plant Protection, University of Kassel, Witzenhausen, Germany

Over the past 100 years, the biodiversity within varieties and species of field crops in agriculture has been reduced drastically through plant breeding approaches favouring genetic uniformity for all traits. This has practically eliminated all co-evolutionary processes between hosts and their pests and pathogens. It also does not allow for dynamic adaptation of plant populations to changing environment e.g. climatic change. Breeders and pathologists have all along pointed out the danger of this approach. In contrast to the modern varieties, for most crops landraces are characterised by a larger inherent genetic diversity and thus also a higher adpatability. However, the existing landraces usually are not competitive with modern varieties under current agricultural conditions due to a lack of systematic population improvement for the past 100 or so years.

Alternative approaches to pure line breeding have been developed by using composite crosses, top crosses and population breeding. The “modern landrace” or “evolutionary breeding” approach aims at combining the advantages of the breeding success of the last century and the use of genetic variation producing high yielding and high quality but genetically diverse crop populations that can be adapted to local conditions by the farmers.

Three different winter wheat composite crosses were produced by Elm Farm Research Centre and the John Innes Institute in 2001 (Wolfe et al, 2006) and are currently maintained at different sites in Europe under conventional and organic conditions. The overall aim is to provide materials for interested farmers for the development of locally adapted materials. Research is being conducted on the evolution of the populations with respect to diversity and adaptation processes to various selective pressures.

In Germany, the populations are maintained since the F4 under organic and conventional conditions. Morphological diversity is still high in the currently growing F6 while in contrast to popular local varieties disease pressure is low. Data on the relevant diseases in 2007 and the population development with respect to yield and quality parameters will be presented.

Appropriate breeding approach and type of cultivar in breeding faba bean for organic farming

Lamiae Ghaouti, Wolfgang Link
Department of Crop Sciences, Georg-August University, Göttingen, Germany

As organic farming refrains from the use of agrochemical inputs, the organic environments are characterized by a large environmental heterogeneity. Therefore, genotype × location interaction is expected to be larger across organic cropping areas than across conventional ones. So far, formal plant breeding generally has concentrated on increasing yield and quality in environments that were modified by application of agro-chemicals. The importance of adaptation to variable and even risky low-input conditions often found in organic farming received little or no attention. A strong asset of local breeding is the possibility to select in the target environment and to exploit genotype × location interactions, being repeatable over time. Therefore, the objective was to compare for faba bean the effectiveness of local breeding and formal breeding for grain yield in organic farming and to compare the performance of inbred lines and corresponding synthetics using the two breeding approaches.
The material involved included a set of 18 inbred lines, their polycross progenies and 13 checks. The entries were tested in four organic locations and one conventional station in Germany in 2004, 2005 and 2006. Three organic farmers were involved in a participatory breeding approach and gave a score of a personal appreciation to the material tested in their farm.
Results showed that the correlations between the personal appreciation scores attributed to the studied locations were very low and sometimes even negative. Personal appreciation score was strongly influenced by biotic and abiotic constraints faced by the crop in each location. For grain yield, genotype × location interactions were the highest component of the genotype × environment interactions and contributed more than three quarter as much as the genotypes to the yield variation. The genetic correlations between the locations for grain yield were generally low indicating that the performances in the studied locations were controlled by substantially different sets of genes. To increase gain from selection in an organic location, local breeding proved to be markedly more efficient than formal breeding. Based on the genotypic performance and variance of inbred lines and synthetics at the first generation Syn-1, and on intensity of selection, the best Syn-1(4) and the best inbred lines were predicted. Despite the large variance of inbred lines available in local breeding, due to the partial realization of heterosis in the synthetics, these were the best performing in both breeding approaches. Unlike pure lines, they are providing the option of further local evolution and adaptation over time.

Hulled wheats and naked barley – Prime examples for participatory research

Heinrich Grausgruber, Firdissa Eticha, Christine Sailer, Negash Geleta, Ingrid Weinzetl, Julia Schmidt, Susanne Siebenhandl
Department of Applied Plant Sciences and Plant Biotechnology, BOKU–University of Natural Resources and Applied Life Sciences, Vienna, Austria.

Years ago, einkorn (*Triticum monococcum*), emmer (*T. dicoccum*), and naked (hull-less) barley (*Hordeum vulgare*) were rediscovered by organic farmers due to their adaptability to harsh climatic conditions and soils of low-productivity, and their status as niche and specialty grains. Newly, einkorn, emmer and naked barley became increasingly popular due to the discovery of health promoting phytochemicals (Abdel-Aal & Wood, 2005) and the growing interest of consumers towards ‘slow food’. Due to their neglected and under-utilized status and the non-existence of intensive breeding programmes einkorn, emmer and naked barley represent prime examples for participatory research. At present seeds of some genebank accessions are multiplied by farmers only at random. Efficient screening of the diversity of genotypes for valuable traits required by producers and processors is essential.
Accessions of genebanks and seed savours networks were tested in Eastern Austria. Agronomic traits were evaluated together with farmers. Quality traits, e.g. yellow pigment content of einkorn, beta-glucan content of barley were studied by food scientists. Processing quality, e.g. suitability for dehulling, pearling and milling, cooking quality of pearled grain or baking quality, was investigated by food technologists, processors and farmers.
Yield, yield stability and tolerance to lodging are major agronomic traits required by farmers. Although genetic variability is available no emmer or einkorn was found without lodging. Net kernel yield is dependent on gross yield, dehulling suitability and kernel size. Plump kernels are required for pearling and cooking, whereas for whole-grain flour kernel size is of less importance. Variability in health promoting compounds is considerable: contents of yellow pigments in einkorn and beta-glucan in naked barley are up to 22 ppm and 7.4%, respectively. For marketing reasons unique quality characteristics are demanded more increasingly by processors. Products already marketed cover einkorn bread and pastry, einkorn and emmer pearled grain, and polished and/or pearled naked barley grain. Research on naked barleys with high contents of beta-glucan and polyphenolics and their use in food products is ongoing.

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Organic outdoor tomatoes - regional screening and breeding in Germany

Bernd Horneburg, Heiko C. Becker
Department of Crop Sciences, University of Göttingen, Göttingen, Germany

Tomatoes are the most important vegetable in Germany, but more than 90% of the consumption are imported. One of the major obstacles for increased production is the breakdown of outdoor tomato production. Increasing infections with late blight (*Phytophthora infestans*) have almost eliminated commercial cropping and seriously impaired private production. The aim of the project during the years 2003-2006 was 1) to screen for and recommend suitable open pollinated varieties for organic outdoor production and 2) develop a regional breeding program within organic agriculture.
The screening was based on 3500 accessions. In close contact with genebanks, NGOs, seed trade, and private seed savers 92 varieties were selected for comparative trials at 3 locations in central and northwestern Germany. The number of varieties was reduced from 2003 to 2006. Some additional varieties with superior performance in a screening at one location were included. Per location 2 replications with 2 plants (2006: 3 x 2) were grown. Layout and maintenance of the plots favoured *Phytophthora*-infections.
Each year a group of 10-12 varieties was tested at 25 to 35 locations. Included were backyard and market gardens, botanical and other public gardens, and research institutions.
Suitable varieties identified in the screening were used to make crosses to combine the important traits earlyness, field resistance against late blight, high yield, and good fruit quality. The most advanced crosses were included in the screening 2005-2006.
After 2 years of screening the share of commercial varieties was 9.1% and 31.8% were obtained from genebanks. 59.1% of the most interesting varieties originated from NGOs and individual seed savers. 4 years of screening and regional tests resulted in the top ten varieties with a high field resistence against *Phytophthora* and favourable agronomic, morphological, and phenological attributes. Included are wild-, cocktail-, salad-, processing-, and beefsteak-tomatoes. Seeds are available.
The high heritability of *Phytophthora*-infections on leaves and fruits, and for yield (>79%) confirmed the suitability of the experimental design. For all traits the varieties were the most important variance component. Site specific adaptation, i.e. variety x location interaction, was of minor importance or absent. For fruit infections variety x year interactions were stronger than variety x location interactions.
As an example for the regional breeding program a wide cross between the wild tomato Golden Currant and the salad tomato Matina is shown. Field resistance against late blight and long harvest period of the wild tomato were successfully incorporated in the F_5- and F_6-generations and resulted in the highest yield in the screening 2006.
The methodology for a regional breeding program is developed and needs to be put into practice! We would appreciate co-operation with neighbouring countries with similar problems.

Target oriented organic breeding of maize (*Zea mays* L.)

Géza Kovács
Agricultural Research Institute of the Hungarian Academy of Sciences, Brunszvik, Hungary

Consumers expect organic food to have a higher nutritional value, to be healthier, or simply to be safer or less risky. The effects of organic and 'low input' production methods on food quality and safety and finally on livestock and human health are essential, and according to our recent knowledge, the used crop varieties are playing a crucial role in the production of „functional organic food". For example, an extensive milk quality survey of different dairy production systems demonstrated that milk from organic dairy systems has significantly higher levels of the nutritionally desirable unsaturated fatty acids and fat soluble antioxidants compared to milk from conventional production methods (Bauman et al. 2004). Unfortunately, under Hungarian continental conditions the grazing-based period is quite limited and grain-feeding supplementation is highly necessary for the animals, which results in a decreased quality of the end product. To solve such problem nutritionally enhanced high oil maize varieties shall be bred under certified organic conditions.
The development of nutritionally enhanced high oil inbred lines was initiated from an open pollinated composite cross population (CCP) developed in our institute 12 years ago, and were improved using xenia assisted reciproc recurrent selection under low input conditions. The inbred line production was made under certified organic conditions, and the lines with excellent combining ability were selected based on their high oil and protein content. Using the best nutritionally enhanced (NE) inbreds several Sc and Tc hybrids were created and tested in large scale experiments for 3 years on 4 organic farms at different locations in the country in comparison of the conventional hybrids. At the same time new open pollinated varieties (OPV) were produced and tested in the same places, to be able to evaluate the effectiveness of on farm participatory breeding methods compared to the centralized hybrid breeding. The yielding capacity and quality of the tested materials were analysed in all cases using standard chemical and nutritional analytical methods.

According to the results obtained in the hybrid experiments the new NE Tc hybrids showed the best adaptation under organic farming conditions, and their yield were highly competitive with the conventional Tc maize hybrids in all locations, with a significantly better quality (8 % oil and 14 % protein). The data suggests, that, especially under low fertility conditions the Sc hybrids are less adaptive in general, and they are highly sensitive to the farming technology (especially weed management). The organically bred Sc hybrids showed significantly better results than the conventional ones. The results of the VE OPVs are quite variable, as in some farms their yield and quality were competitive with the VE Tc hybrids, and the farmers selection resulted in a significant improvement of the population. On the contrary, under better conditions the same OPVs had significantly lower yield and quality than the VE TC hybrids. According to the feeding value tests the organically produced new VE hybrids and OPVs gave significantly better results than the conventional hybrids.

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Identification of the components of several cultivar mixtures in Spanish wheat by means of SSR markers

Fernando Martínez, Mar Cátedra, Pilar Rallo
Dpto. Ciencias Agroforestales, EUITA, University of Seville, Spain

Cultivar mixture is one of the proposed solutions to increase genetic diversity within a crop, which is one of the major issues in the organic farming. Several positive effects have been reported on cultivar mixtures, being the reduction of foliar diseases the main cited effect in the literature. It reduces also the risk of resistance gene break-down again these diseases. Abiotic stresses are also better buffered than in pure stands, yield stability increases and even quality of the product can be enhanced (Finck et al., 2001).
This work aims at differentiating the pure stands within a mixture in order to overcome legal problems in dealing with genetic diversity in the seed market.
In this work, four cultivar mixtures of bread wheat and four of durum wheat have been designed for improving disease resistance, production and quality. All the cultivar mixtures were four-way, i.e. composed by four cultivars. Mixtures were picked from the field (before flowering), where 25 sample leaves were collected in order to be sure (99% probability) of getting at least one leaf of each cultivar. Besides, mixtures were also collected from the greenhouse, where one leaf of each cultivar was collected to create the mixture with certainty.
Five SSR markers or microsatellites were used (BARC109, BARC176, Xgwm448, DuPw67 and DuPw254). The microsatellite DuPw167 and BARC176 were the most suitable for the discrimination of cultivar mixtures in bread and durum wheat (Röder et al., 2002). They showed a fair level of polymorphism. It is remarkable that, sometimes, differences in the amplification within a mixture have been detected. That means that some alleles are better amplified than others. This may suggest a competence of the alleles within the mixture to be amplified, which is not desirable at all but it has been reported (Rallo et al., 2001).
In general, the level of polymorphism detected in durum wheat was higher than in bread wheat.

Prebreeding methods used on Portuguese maize germplasm and its applications for on-farm conservation.

Pedro Mendes Moreira[1], *Carlota Vaz Patto*[2], *João Santos*[1], *Liliana Morgado*[1], *João Santos*[1] , *Silas E. Pêgo*[3]
[1]Escola Superior Agrária de Coimbra, Coimbra, Portugal;
[2]Instituto de Tecnologia Química e Biológica, Universidade Nova de Lisboa, Oeiras, Portugal;
[3]Instituto Nacional de Recursos Biológicos/Estação Agronómica Nacional, Oeiras, Portugal.

After its introduction from America, by Columbus, maize was spread over Portugal and evolved in an enormous range of natural cultivation conditions (e.g. topography, microclimate, precocity, pest and disease resistance). This process gave place to the development of different landraces, i.e., genetic adaptation under human selection. These maize landraces, mass reservoirs of genetic adaptability, have therefore a valuable conservation function, justifying the existence of a participatory conservation program. Subjacent to the conservation of maize germplasm, a Participatory Maize Breeding (PMB) project was initiated in 1984 by Silas Pêgo in the Sousa Valley (VASO), Portugal. This project was planned to answer the problems of small farmers, *i.e.* increasing yield without losing the parameters defined and important to the farmers, as suitability for polycrop systems, quality and adaptability to low input sustainable agriculture.
In order to screen new potential germplasm, either for classical breeding, either for on-farm conservation and breeding projects, where adaptation to organic farming and polycrop systems could be easily fitted, some pre-breeding methodologies, according to Pêgo, are being used (e.g. Hunters, Overlapping Index).
Landraces obtained from collecting missions are being submitted to Hunters, Overlapping Index and ear characterization methods. Yield trials are also being done.
The results obtained from the pre-breeding evaluations are being used for future implementation of new on farm breeding and conservation programmes. A holistic approach should be done taking into consideration:

1) Genetic resources conservation and conservation of specific agroecological, cultural and biological processes (e.g. co-evolution process).
2) Farmer "erosion" and impact of local authorities support on marginal areas agriculture. Community recognition for the complex work done by farmer (e.g. food production, genetic resources conservation, environmental sustainability, forest protection).
3) Development of the lacking appropriate legislation allowing the certification of OPV with a certain level of heterogeneity, in order to ease distribution and commercialization.
4) Landraces use to create new high market value products that could be associated with organic farming.

Do we need a separate breeding program for organic soybeans?

Michelle L. Menken, James Orf
Department of Agronomy and Plant Genetics, University of Minnesota, USA

Farmers often express the need for breeding programs to develop crops specifically adapted to organic farming conditions.
We have designed an experiment to test whether this is true for food-grade soybeans. We will be growing 554 new breeding lines, divided into 12 tests based on maturity group, in five certified organic and five conventional environments in south central and southwestern Minnesota. The lines include small, medium and large-seeded types with high protein levels, uniform seed size and shape, with higher yields suitable to the food grade market which were developed from crosses made between good food-grade lines, high-yielding lines and Minnesota adapted lines. The lines will be evaluated based on yield, seed size, protein and oil content, as well as on agronomic traits such as stand, lodging, canopy closure, and maturity date.
Results from 2006 indicate that seed size and protein and oil levels are stable traits with levels in the conventional trial averaging >36% protein (at 13% moisture) and in the organic trial averaging >37% protein across all tests. Average yields for the 12 test in the conventional trial ranged from 2150 to 3360 kg/ha and from 1680 to 2352 kg/ha in the organic trial. Maximum yields ranged from 3629 to 5442 kg/ha in the conventional and from 3091 to 4099 kg/ha in the organic trial. A very preliminary analysis indicates that some lines perform well in both systems and some lines perform uniquely well in either the organic or the conventional system.
The trials will continue in 2007 and 2008. If in the end we make different best selections in the two systems, it would indicate why we should have a separate breeding program to produce varieties for organic farmers. We also expect to find several high-yielding, high protein lines adapted to Minnesota growing conditions that could move on to further trials and possible future release.

Utilisation of spelt and emmer wheat genetic resources as cultivars in organic farming

Zdeněk Stehno[1], Petr Konvalina[2], Ladislav Dotlačil[1], Jan Moudrý[2],
[1]Division of Genetics, Plant Breeding and Product Quality, Crop Research Institute, Ruzyně, Czech Republic; [2]Department of Agroecology, Faculty of Agriculture, University of South Bohemia, České Budějovice, Czech Republic

With the aim to extend the spectra of grown crops mainly for organic farming, a collection of spelt and emmer genetic resources in the Czech Gene Bank was screened and some promising genotypes were selected. We focused on spelt wheat (*Triticum spelta* L.) because it is a traditional crop grown mainly in the North - West European countries. Interest in this crop in the Czech Republic is still increasing remarkably since 1990. Emmer wheat (*T. dicoccon* Schrank) has very long tradition in its growing and use in human nutrition. In the place of present Czech Republic it was important crop till ingress of Slavs in 6th century A.D. when it was replaced by bread wheat. In spite of its considerable importance it was not much bred and at present there are only landraces and wild forms of this species available.

Spelt wheat has been collected as part of wheat collection of genetic resources. At present the collection contains 77 accessions of *Triticum spelta* L. and most of them (38) come under var. *duhamelianum.* Within the collection, the genotype 01C01-00670 ('Fuggers Babenhauser Zuchtweizen') showed very high protein content. Repeated individual selection was used to improve lodging resistance and stabilised high protein content. In 2001 material was registered as 'Rubiota' cultivar. Among genetic resources of emmer wheat (114 accessions), the genotype 01C02-00948 appeared to be very perspective. Material later in ripeness, with good level of resistance to fungal diseases and with high yield potential among genotypes of this species was selected by bulk selection from this genetic resource. After three-year testing (DUS), it gained certificate of legal protection as cultivar 'Rudico'.

Winter spelt wheat 'Rubiota' has big grain with TKW reaching 60 g or more, which are not released from spikelets as easily as in second registered spelt cultivar in CR, 'Franckenkorn'. Proportion of glumes in harvest varies between 23 and 25 %. Crude protein content (19.19 % in 2002) is usually 1.5 - 2 % higher then in 'Franckenkorn'. The cultivar is relatively susceptible to powdery mildew. Yield of naked grain in official test (UKZUZ, 2006) was 4.32 t/ha. Emmer wheat 'Rudico' has proportion of glumes in harvested spikelets ranging closely around 20 %. It is resistant to most of fungal diseases as powdery mildew, *Pyranophora, Septoria tritici, Septoria nodorum.* In resistance to these diseases, it exceeds registered spring bread wheat cultivars. Its resistance to *Fusarium* is medium. Among quality parameters, high crude protein content (19 – 20 %) and gluten content approx. 45 % are important ones. Values of SDS sedimentation test ranges between 35 and 40 ml. Grain yield is in comparison with other emmer genotypes very high and reaches under favorable conditions 3 t/ha; in plot experiment in 1998 even 4.38 t naked grain per hectare. Maintance breeding of both cultivars which is in progress in the Crop Research Institute and ensured seed groving under organic system create favourable conditions for their successful utilization. That extends possibility to use spelt and emmer wheat for production of bio-food.

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The effect of the selection environment on several traits of onion (*Allium cepa*).

M. Tiemens-Hulscher[1], E.T. Lammerts van Bueren[1], A. Osman[1], R. de Heer[2]
[1]Louis Bolk Instituut, Driebergen, The Netherlands;
[2] Limagrain Advanta, Rilland, The Netherlands

The organic sector is searching for the best strategies to obtain varieties that are optimally adapted to the organic environment. For most private breeding companies the organic sector is just a small (new) niche market. For economical reasons they prefer to select under conventional conditions, with some additional evaluation criteria, and test the new lines under organic conditions in the last few years of the breeding program. The subject of this study is to search whether selection under organic conditions gains better adapted varieties for the organic sector, than selection under conventional conditions. Together with a Dutch onion breeding company we investigated the effects of the two different selection environments from 2004-2007.
To compare the selection progress under conventional and organic conditions selection in the open pollinated variety Bastora and two broad, newly made, base populations of onion was conducted: Round Rijnsburger Group, and the Yellow Flat Rijnsburger Group, from 2004-2007. Standardized Selection Differential (S) was determined as a measure for selection effort. S = (mean new selection – mean original population)/sed_{or} whereas sed_{or} is the standard deviation of the original population. Seeds were produced from the selected bulbs in isolation cages. The new selections (organic and conventional) were sown at two organic locations in three replicates together with the original populations to compare with each other in the field for plant traits as well as for bulb characteristics after storage. Response to selection (R) was determined (R = mean selection – mean original population).
2007: in an additional pilot experiment the potential rooting ability of the bulbs was evaluated by growing the bulbs in hydro-culture for 2½ weeks.
Most selection effort (S) was made for the traits bulb shape and bulb size, independently of the selection environment. Although, the selection criteria of the breeder were the same for both selection environments, S differed for some traits between the organic and the conventional selections. In the populations grown in the organic field S was zero for the position of maximum diameter, the number of dry skins, the shape of the base of the onion and the intensity of basic colour of dry skin. For the conventional selections no selection effort was found for skin retention. For the other traits S was more or less the same for the organic and the conventional selections. For the traits earliness and root potential the Response to selection (R) was affected by the selection environment. The conventional selection of Balstora was much earlier than the organic one. In the root experiment we found a striking difference between the organic and the conventional selection in the Yellow Flat Rijnsburger Group. The bulbs of the organic selection formed proximately 60% more roots (number and dry weight) than the conventional selection. In the other populations we did not find this phenomenon. For the other traits R was not affected by the selection environment, although S was found different for the respective characteristics.

Genetic diversity of an emmer population grown under organic farming in Central Italy

Renzo Torricelli, Mario Falcinelli
Plant Biology, Agro-environmental and Animal Biotechnology Dept., University of Perugia, Italy

Emmer (*Triticum dicoccum* Schubler, 2n= 4x= 28) is a predominantly self pollinated crop widespread throughout the Mediterranean Basin. The cultivation of this hulled wheat species has survived only in a few marginal mountainous areas of central and southern Italy. In central Italy the area cultivated with emmer increased during the last decade due to renewed interest in natural and healthy food and in organic agriculture. Since this species has not been bred with modern strategies, landraces are the only genetic material available. Hence the acreage of emmer has increased especially in marginal areas because it is well-suited to low input agronomic systems. Emmer landraces are still maintained and managed on-farm because of their resistance to harsh climatic conditions, cultural reasons, or organoleptic aspects which make them highly valuable. The objective of this study was to characterize the genetic structure of a central Italian landrace of emmer named "Monteleone di Spoleto". 106 randomly chosen spikes were collected from an organic field in Monteleone di Spoleto, 1000 m a.s.l. (Perugia – Italy). The physiological and morphological traits of progenies of each genotype were evaluated. The following characteristics were recorded: growth habit (GH), stem colour (SC), heading time (HT), plant height (PH), seed yield/plant (SY) and score of naked seed (SNS). Univariate and multivariate analysis showed wide genetic diversity within landrace of Monteleone di Spoleto emmer. The Principal Component Analysis (PCA) showed that the first three components accounted for 34.8%, 18.4% and 18.1% of variance, respectively (cumulative = 70%). On the basis of the eigenvector values, the traits responsible for maximum separation along the first component, were: heading time, plant height and seed yield/plant. The PCA has allowed to group the 106 lines of emmer in a restricted number of different families. These homozygous families differ one another for at least one trait. We concluded that the emmer "Monteleone di Spoleto" can be considered like a natural composite variety originated by continuous on farm conservation; it is genetically heterogeneous and is well adapted to the local environmental conditions.

Participatory Approaches

Changes in the concept of genotype x environment interactions to fit agriculture evolution: multidisciplinary points of view.

D. Desclaux, J.M. Nolot, Y. Chiffoleau, E. Gozé, C. Leclerc
INRA - UMR Diversité et Adaptation des Plantes Cultivées, France

The homogenization of environments (E) encouraged by modern society and by the productivist model of agriculture has resulted in the homogeneity of genotypes (G) thereby reducing GxE interaction to a parasitic source of inaccuracy (a residual).
As this model is called into question and new societal values are affirmed, agriculture is diversifying to fit contrasted environments and may be represented by four models defined by two axes, one socio economic (individual logics vs. collective governance), and the other agro-ecological (analytical vs. systemic approaches). Models differ by (i) the objectives (from yield improvement to farmers empowerment), (ii) specific expectations concerning genotypes (from inherited genetic resources to varieties that represent genetic, ethical and social progress), (iii) a specific representation of the environment (from E, a simple interaction between the agro-ecological environment (M) and cultivation system (C), to E including a range of socio-economic components (Actors competences (A), Outlets (O), Legislation (L), , Society (S)) and (iv) particular relations between G and E (from GxE to GxMxCxA under evolving constraints represented by LxOxS).
Taking these diverse objectives into account has changed the way plant improvement is envisaged. Thus depending on the model concerned, the order, interest and status of the five classic stages of plant improvement (setting objectives, creating variability, selecting, evaluating and disseminating) may be called into question. Between the existing analytical model and a holistic model that remains to be developed, lies the challenge of ensuring the sustainability, efficiency and acceptability of plant breeding and resulting innovations. From a simple « noticing » that we attempt to reduce the GxE interaction has become an « objective » that we try to predict and valorize. Structuring the different components of E, G and GxE, enables us to extend the basic concept of representativeness both of the cultivation conditions and of the socio-economic « positions » of the involved actors.

Evolution of diversity during 20 years of mass selection on 'Pigarro', a Portuguese improved maize population with fasciation.

Pedro Mendes Moreira[1], *Carlota Vaz Patto*[2] *Silas E. Pêgo*[3], *Arnel R. Hallauer*[4]
[1]Escola Superior Agrária de Coimbra, Departamento de Fitotecnia, Coimbra, Portugal;
[2]Instituto de Tecnologia Química e Biológica, Universidade Nova de Lisboa, Portugal;
[3]Instituto Nacional de Recursos Biológicos/EAN, Oeiras, Portugal;
[4] Iowa State University, USA.

Maize was introduced in Portugal, after America's discovery by Columbus. Maize adaptation to a diversity of landscape, climate conditions and people's needs, took place during five centuries. These adaptations led to flint-type open pollinated landraces with technological ability for production of the traditional maize bread called "broa". "Broa" production still has an important economic and social role in Central and Northern Portuguese rural communities and this is probably why traditional maize landraces have not been yet totally replaced by hybrids.
In 1984, Pêgo started, with the CIMMYT support, an on-farm participatory maize breeding project at the Portuguese Sousa Valley region (VASO). This project was intended to answer the problems of small farmers; i.e., increasing yield without loosing the parameters defined by farmers for bread making quality, potential for polycropping systems, and use in sustainable agriculture. During 20 years of participatory maize breeding (PMB) at Sousa Valley, mass selection and recurrent selection were applied on 'Pigarro', a maize landrace from VASO. Concern has been expressed that genetic diversity might be reduced by natural and artificial (human) selection. Our present objective is to compare mass selection data of Pigarro's diversity and erosion over an interval of 20 years, using: morphological data and SSR molecular markers. Morphological data evaluation (*e.g.* yield gain, ear length, fasciation level) was conducted in Portugal (3 locations in 2 years) and in the USA (4 locations in one year) using seven different mass selection cycles. ANOVA comparisons and regression analyses on the rate of direct response to selection was done.
Samples from three different mass selection cycles were fingerprinted with SSR molecular markers. Thirty randomly selected individuals per cycle were fingerprinted with a set of 10 SSR markers uniformly distributed across the maize genome.
The results from morphological data revealed that: ear length significantly decreased and simultaneously, ear diameter, kernel row number and fasciation significantly increased. This selection also led to significant increase of days to silk and anthesis.
The results from SSR molecular markers revealed that no effective loss of genetic diversity has occurred during the selective adaptation to the farmer's needs and the regional growing conditions. 96.26% of variation was attributable to within-selection cycles diversity indicating that a great proportion of the genetic diversity is maintained in each selection cycle.
Besides morphological and SSR molecular markers comparison; an insight of PMB on VASO project (*e.g.* location, germplasm, farmer) will be discussed.

New F1 and open-pollinated spinach varieties for organic systems: a farmer, seed company, and non-profit model of participatory breeding.

Micaela R. Colley, John P. Navazio,
Organic Seed Alliance, Port Townsend, USA.

Organic farming, a system which strives for reduced inputs and optimized ecological health, requires plant varieties adapted to organic growing conditions. While organic producers primarily plant varieties bred by and for conventional systems, new models of participatory plant breeding (PPB) are emerging in which populations may be continually selected on-farm for adaptation to diverse and evolving ecological conditions. Organic growers in the US serving fresh baby leaf and bunch markets desire varied spinach (*Spinacia oleracea* L.) types yet conventional breeders have focused on smooth leaf varieties for packaged baby spinach salad over the last decade. Organic growers and breeders would benefit from new, more erect, semi-savoy spinach varieties for fresh market, selected and produced under organic conditions. F1 and open-pollinated spinach varieties are being developed through a PPB model involving a commercial organic seed company (Seeds of Change, New Mexico), a non-profit research and education organization (Organic Seed Alliance (OSA)), and nine organic farms in Washington, U.S.A.

OSA staff, including a PhD plant breeder, developed initial breeding populations in western Washington, designed breeding methodologies, conducted statistical analysis, and trained farmers in selection, seed production, and trial layout procedures. Farmers identified desired traits, managed crops on-farm, and participated in on-farm selections and evaluations. All project partners were invited to participate in evaluations as an educational opportunity and to garner broad farmer-input. Nine open-pollinated breeding populations were mass selected over four generations for general adaptation to organic growing conditions along with desired phenotypic traits including savoyed texture, dark color, erectness, bolt resistance, and uniformity. These genetically diverse populations were crossed to create twelve experimental F1s in 2005 and eight in 2006. These were not inbred lines, but phenotypically refined, genetically elastic populations which can be further selected. This approach differs from traditional hybrid breeding of cross-pollinated species which aims for mono-genotypic populations through crossing of static, homozygous inbred lines. The resulting F1s were evaluated spring and fall on a single organic farm in two-replicate observation plots in 2006 and replicated complete block design trials in 2007 along with ten commercially available F1 and five open-pollinated varieties.

Two of the experimental F1s, 509 and 515, identified as commercially promising semi-savoy varieties, will be further evaluated on larger-scale organic farms in varied regions in 2008. Of twenty seven varieties compared 515 and 509 were significantly more erect than twenty six and twenty one varieties respectively ($p=0.05$). 515 and 509 were significantly more uniform than seven and three of the commercial varieties respectively. Positive outcomes of this participatory model include new, adaptive organic varieties, new releases for an organic seed company, non-profit support, improved farmer skills and education, and improved open-pollinated populations for future production and breeding activities.

Bread wheat variety testing in organic farming in France: contributions to organic breeding programmes

Laurence Fontaine[1], Bernard Rolland[2], Marie-Hélène Bernicot[3]
[1]ITAB (Institut Technique de l'Agriculture Biologique), Angers, France.
[2]INRA UMR APBVLe Rheu, France
[3]Arvalis – Institut du végétal, Guyancourt, France

The acreage of bread wheat is considerable in French organic agriculture (about 30 000 ha in 2006). The question of the kind of varieties organic farmers should be using is therefore very important. As most of varieties available on the market were bred for conventional farming systems (with high inputs of mineral fertilizers and chemicals for crop defense), it is important 1) to screen current varieties to find the best suited for organic conditions, and 2) to rapidly obtain suitable varieties that are specifically bred for organic farming conditions.
A ringtest of bread wheat variety trials has been set up under organic conditions in France since year 2000. The aims of this ringtest are not only to compare varieties, but also to support organic breeding. During the last few years, about 30 trials were included from the north to the south of France, characterized by numerous climatic and soil conditions. Different varieties are tested for agronomic performances, but also for quality traits since 2004:

- conventional varieties with traits that are supposed to best answer organic constraints (good response to low level of nutrients, good competitive ability against weeds, etc.),
- foreign varieties, with priority to those specifically bred for organic agriculture (Swiss, Austrian, German and Italian varieties are tested),
- advanced lines from French breeders from specific organic breeding programs.

The processed results are published each year, including longterm results over the years. Currently, varieties such as Renan (compromise between yield and proteins), Attlass (for yield) or Saturnus (for proteins) perform well, even in the south. Besides, network of trials gives the opportunity to evaluate the ability of lines bred for organic farming to meet the farmers and millers demand (in terms of agronomic and quality traits). Breeding company Lemaire-Deffontaines and the national research institute INRA used the network to screen promising lines. Some of them may be proposed for registration next year. Moreover, the network is used to study specific traits required for organic farming (such as weed competition), to transfer them as selection criteria in specific breeding programs.
Organic farmers need bread wheat varieties suitable for both organic conditions (agronomic traits) and organic market demand (quality traits). Already in France some initiatives exist to set up specific organic breeding programs to meet the requirements for adapted genotypes. Besides the screening of conventional varieties, national network of variety trials in organic farming complete those breeding programs, as they give information of performances of advanced lines and help to improve selection criteria. A problematic issue which needs more attention is the registration system, not being adapted to lines for very low input and organic conditions. Lemaire-Deffontaines did not register his organic line because of the high cost involved for special experiments. Therefore another value of the national network would be, to transform for some of the trials into official VCU trials. This still has to be discussed.

On-farm conservation of cereal landraces on the Outer Hebrides, Scotland – is participatory crop improvement the best approach?

Maria Scholten
Scottish Agricultural College, University of Edinburgh, Scotland, UK

The Outer Hebrides off the North West coast of Scotland are the largest remaining area of cereal landraces in the UK, possibly in north-western Europe. Bere barley, a local rye and *Avena strigosa*, have been home seed saved over generations and their cultivation forms a low-input low-input system on the nutrient deficient light and very alkaline soils. Because of the high freight costs, fodder cereal production is locally still important as cheap home produced winterfeed. Cereal producers deliver an important ecological service in the maintenance of the machair coastal grasslands habitat, an Annex 1 habitat on the EU directive, important for the conservation of threatened bird species such as corncrake and corn bunting. Several bottlenecks in crop and seed production have been observed over the last decades. Seed crop failures caused by adverse weather or diseases have been recurrent in the history of the islands. In recent decades an additional problem in the form of a large greylag geese population has shown up, which attacks and destroys the (seed) crop. Associated with the threat of geese is the increase in the use of silage. Smut has been a persistent disease problem while ergot was frequently observed in rye fields. As with other landraces for example in Italy, the landraces are grown by an ageing and declining farmer's population.

On farm conservation projects in Europe, more specifically the UK, are rare. Some forms of indirect conservation are however in place, funded and managed by wildlife conservation organizations such as the Royal Society for the Protection of Birds (RSPB) and Scottish Natural Heritage (SNH). These projects aim at maintaining traditional cereal cropping methods as means of maintaining the Machair grasslands as a bird habitat. This strictly conservationist approach tends to focus on tradition. Is landrace conservation based on a participatory approach such a better approach for local seed management to safeguard continued cereal cultivation? This option will be discussed in the poster.

Farmer`s eye and breeder`s eye – fields of knowledge exchange as a condition of a participatory cereal breeding approach

Martin Timmermann
Cereal Breeding Research Darzau,Germany

With the change to organic agriculture, the diversity of local conditions becomes more important. Local adapted varieties are necessary. But breeding for this demand is not profitable for the conventional breeding strategy. An alternative can be a participatory breeding approach. Evolved in the context of international development cooperation, this approach is increasingly discussed in the European context. Communication between farmers and breeders is a key issue in participatory breeding. Farmer`s and breeder`s eye have different perspectives on the plants and different knowledge gained through experience. Those perspectives and experiences need to be exchanged. As an outcome of the investigation of "The breeder`s eye" on the example of the crossbreeding of self-fertilizing cereals from a knowledge sociology perspective three levels of consciousness could be described: vegetational consciousness, generational consciousness and consciousness in hereditary flow (Timmermann, 2006). The framework of these three levels allows to understand the various levels of breeding behaviour and how the breeders learn and develop their breeding practices. Based on this results, fields of knowledge exchange between farmer and breeder, their limits and possibilities for further development can be worked out. There are three kinds of exchange fields of knowledge in the context of PPB: a field of correspondence and agreement, a field of learning and a sphere of competence, which is more or less inaccessible for each other.
a) A correspondence of knowledge between farmer and breeder can be found for agronomic tasks. About these topics and how to realize it technologically farmer and breeder can communicate and cooperate very well. Both, farmer and breeder are familiar in thinking about sowing, cultivation and harvesting in the context of seasons and vegetation.
b) Fields of learning: In the process of selection, the farmer has to learn in which breeding generation and context useful decisions can be made, finding a step into the consciousness of the different breeding generations, while the breeder is broadening his knowledge about the possible reactions of breeding lines to a new environment.
c) There are spheres of competence for the farmer concerning his intimate knowledge about his localities, its development over years and about the special demands of the markets where he sells. On the part of the breeder there is a deep knowledge about the breeding material, about the relevance of the different traits, about their realization in the breeding material and about the practical breeding know how. In planning of crossings lies a field of knowledge and competence, that only can be achieved by proceeding professionally.
The design of a PPB program should consider these aspects. Farmers and breeders are experts in their fields of knowledge. With a clever integration, both parts can profit from each other and increase the entire knowledge. From this perspective, a participatory approach is not a one way matter. Knowledge will be gained through experience by farmers and breeders, but on different levels. To consider this levels of knowledge exchange and above all of knowledge gained through experience is a measure to increase the success of participatory breeding programs.