# Challenging new concepts and strategies for organic plant breeding and propagation

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**Abstract**: Organic agriculture is a growing sector and needs variety improvements for further optimisation of its farming system. The EU regulation 2092/91 for organic agriculture is aimed at closing the organic production chain which means that after 2003 seed and planting material for organic farming should be organically propagated. The first step is to identify the best existing, conventionally bred varieties for organic practices and for organic propagation. Crop ideotype is an instrument to improve the communication of farmers with seed companies on the variety requirements. Organic agriculture is not only focussed on varieties with ecologically better adapted traits but on varieties bred and propagated with techniques that comply with the ethical principles of organic agriculture. The International Federation for Organic Agriculture Movements (IFOAM) has set draft standards to give direction to organic plant breeding on the whole plant level. The ecological and ethical principles challenge the breeding sector to develop new or additional concepts and strategies for organic, low-input farming systems.

**Keywords:** organic agriculture, crop ideotype, variety concept

## Introduction

Organic agriculture is increasingly gaining social, political and scientific recognition for its contribution to sustainable agriculture. On a world scale, 17 million ha are grown organically. Australia is leading with 7.7 million ha, followed by Argentina (2.8 million ha) and Italy (1 million ha) (Yussefi and Willer, 2002). The area (ha) with organic agriculture in Europe has grown between 1998 and 2001 by 1300000 ha. The average of the proportion of the organic area in total agricultural land use among the EU countries was 2.8%; for the Netherlands, it was 1.9% in July 2002. As most European governments strive for a growth in organic agriculture of up to 10% by 2010 there is a need for improvement of varieties, not only by improving organic seed production but also through the development of organic plant breeding programmes for better adapted varieties.

Organic farmers have long depended on conventional variety and seed production, and have accepted it until other aspects of organic farming got established first. Organic farmers profit from the improvements of conventional breeding, but this does not imply that those are the best varieties for use in organic farming systems. Varieties supplied by conventional seed companies are developed for farming systems in which high levels of artificial fertilisers and agro-chemicals are applied. Organic farming, however, aims at a low input system and at refraining from agro-chemical inputs. To be able to avoid those kind of inputs, development and application of agro-ecological strategies are necessary. This has resulted in a fundamentally different farming system compared to the conventional one, especially with regard to soil fertility and disease and pest management. Therefore, organic farmers require (new) varieties with characteristics that are better adapted to this kind of farming to be able to further optimise the organic farming system.

However, the first step to plant breeding for organic farming systems is organic propagation of the most suitable, existing varieties. To date, conventionally produced but (post-harvest) chemically untreated seed has been allowed due to the lack of organically produced seeds. To be consistent and to gain more credibility from consumers by no longer relying on conventional inputs produced with chemical treatments, the organic sector needs to close the organic chain, and thus to develop efficient schemes for producing adequate quantities of organically produced seeds and planting materials. The EU regulations 2092/91 define organic seed (planting material) as seed (planting material) that is produced by a crop which is planted and raised organically for at least one generation in the case of annual crops, and for two growing seasons in the case of biennial and perennial crops. The EU regulation 2092/91 for organic agriculture will allow no more general derogation in the use of conventionally propagated seed from 2004 onwards. Only the use of organically propagated seed will be permitted for those listed crops of which sufficient varieties and quantities are already available. Some pioneering organic farmers and breeders in different European countries started propagating the varieties free of breeders' rights and also begun organic breeding programmes several decades ago. However, it is now necessary for the conventional seed sector to make a commitment to scale up and supply the organic market with a sufficient quantity and an adequate quality of organically propagated seed of current varieties.

In this paper a short overview will be given of the state of the art, the main challenges, obstacles and prospects for organic seed production and plant breeding, complying with both the ecological and the ethical principles of organic agriculture.

## Material and methods

This paper is based on several research and development projects that were conducted since 1993 at the Louis Bolk Institute, a specialised research institute for organic agriculture, human health care and nutrition (Lammerts van Bueren, 1994; Lammerts van Bueren et al., 1999; Lammerts van Bueren et al., 2001; Lammerts van Bueren et al., 2002a). These projects included an investigation of the obstacles of seed companies to begin organic propagation of varieties for organic farming systems, and a process of developing criteria and leading the national and international discussion on the assessment of breeding and propagation techniques compatible with the principles of organic agriculture. To prepare for the 'famous' date of 2004, in the past few years several variety trials have been set up with organic farmers to assess varieties under organic conditions and to define crop ideotypes. The aim has been to identify the desired variety traits in order to better communicate the requirements of organic farming to conventional seed companies that are not yet familiar with the possibilities and limitations of organic farming systems (Lammerts van Bueren et al. 2001, 2002b). These results and view points have recently been brought together in a PhD thesis at Wageningen University (Lammerts van Bueren, 2002).

## Results and discussion

### *Variety traits*

Organic farming systems aim at lowering the disease pressure by avoiding stress during crop development. Organic farmers thus aim at resilience and buffering capacity on all levels of the organic farm-ecosystem (farm, crop, variety level), by stimulating an internal self-regulation through functional agrobiodiversity in and above the soil, instead of the external regulation by chemical protectants. Comparing to conventional farming systems, this implies a greater need for 'reliable' varieties, which means varieties with a greater flexibility to cope with such conditions. Organic farmers currently put more emphasis on higher yield stability over the years rather than on higher yields with the risk of losing the extra kilos' because of disease susceptibility. This implies more than just a sum of potential resistance traits against pests and diseases. The way organic farmers assess varieties shows that they focus on a diversity of agro-ecological aspects resulting in an organic crop ideotype with several additional plant architectural and growth dynamical properties that can directly and indirectly contribute to yield stability and reduce the risks of quality and yield loss. For leafy vegetables, for example, it is important that they have the ability to grow in early spring conditions when the soil temperature is low and so is the mineralisation of organic nutrients. More attention needs to be paid to the development of a better root geometry (deeper and finer rooting system), for more efficient water and nutrient uptake and the ability to maintain steady plant growth without stress under fluctuating water and nutrient availability.

The consequences of losses due to pests and diseases in organic farming systems differ considerably, depending on region, crop, farm structure or market demands. In general, yields in organic agriculture are 20% lower due to a lower nitrogen-input (up to 50% less nitrogen) and in some cases due to pests and diseases (Mäder et al. 2002). Further optimisation of the organic production can be supported if the yield stability is raised through a better control of diseases and pests.

From comparative studies between conventional and organic/reduced-input systems, Van Bruggen (1995) concluded that in organic or reduced-input farms root diseases and pests are generally less of a problem than foliar diseases, because foliar disease development is much more determined by climatic factors. Many root diseases can be eliminated by the broad rotation in organic systems. For most air-borne diseases a good crop management which avoids stress will improve the tolerance of a crop. Therefore, an essential element in organic farming systems is to gain and maintain soil fertility with an active soil life contributing to the nutrient availability, good soil structure and crop specific manuring for buffering and resistance to unbalanced plant growth. The organic sector lacks a large availability of 'natural' sprays. Only a few sprays are permitted in the organic sector on the basis of e.g. *Bacillus thuringiensis*, *Pyrethrum*, and are not the main focus of organic farming systems.

Since an organic grower has hardly any curative and quick corrections available he, in contrast to his conventional colleague, will have to give more priority to varietal disease resistance, even if this is associated with a lower productivity. Because in many cases, organic growers can keep the disease pressure low with ample rotation and low nitrogen input, the focus is not merely on varieties with an absolute disease resistance; in many cases field resistance can be sufficient. This will be difficult to achieve on leafy vegetables when the whole product is to be harvested and sold. However, in case of *Bremia*, for example, it is worthwhile researching the possibilities of selecting for those types of lettuce that allow this fungus at a stage where it will only infect the older, outer leaves that are not to be harvested.

***Organic propagation***

With some crops like cereals and potato, the organic sector has already gained many years of experience with organic propagation, and since the beginning of the nineties nearly 100% organically produced seeds and tubers have been available. The situation is quite different with organic propagation of vegetable seeds. Several conventional seed companies have only recently started a division for organic propagation of some varieties. In particular, biennial crops with hybrid varieties are most difficult to propagate, and a shift in assortment is to be expected. Without chemical protectants, some parental lines are too susceptible to propagate. For several seed companies, practical experience has shown that for the annual, open pollinating leafy vegetable crops the problems are less complicated.

There are, of course, market problems related to the limited area under organic cultivation and thus the area of seed production per variety resulting in higher costs compared to conventional seed production. This implies that the organic assortment of varieties per crop will be limited. Because there is still limited experience in the formal seed sector with organic seed production without chemical inputs many technical problems occur. Organic propagation strategies require development of the right way of coping with organic nutrient availability, the right rotation to control weeds and soil related disease problems, and finding the best locations with low pressure of air-borne diseases for optimal results. Especially seed-borne diseases and seed quality require attention and more research efforts. Furthermore, a great effort is needed to develop adapted varieties for healthy seed production, developing protocols for seed health testing, assessing threshold values, and designing organic seed treatments.

The expectations resulting from an enquiry set up in 2002 by the European Seed Association (ESA) among 10 European vegetable seed companies showed that by 2004 the sufficient quantities of adequate quality organic seed and planting material for different market segments will be available for the most important crops (80%). The Green Seed Guide, yearly edited by the Louis Bolk Institute, shows a steady growth of available varieties. Some seed companies are waiting until the final date of January 2004 before selling their complete organic assortment, so the number of varieties will surely expand (Lammerts van Bueren et al. 2002a).

It can be expected that organic seed production will become realistic when more experience and research results are gained for optimising organic propagation of seed and planting material. Moreover, it is necessary to allow the development of alternative and adequate seed treatments. Examples of hot water or steam treatment, the use of antagonists, or the application of natural compounds like mustard powder are already available (Groot 2002). Important for ensuring the commitment of seed companies is a good communication and mutual commitment of farmers, traders, breeders and governments. At this moment, however, the most important aspect for the commitment of both the seed companies and the organic growers are strict EU-regulations. For those crops with sufficient assortment, quantity and quality of seed or planting material derogation for the use of conventional seeds should no longer be allowed after 2003.

***Organic plant breeding***

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

Along with the search for new breeding strategies for organic farming systems, there is an ongoing discussion about which breeding techniques are compatible with both the ecological and the ethical principles in organic agriculture. This discussion started at the time when genetic engineering became important in breeding and organic farmers realised that they are not only concerned about variety traits but also about how varieties are bred and propagated. In 1997, the Dutch Ministry of Agriculture asked the Louis Bolk Institute to set criteria and assess all breeding techniques compatible with the ecological principles in organic agriculture (Lammerts van Bueren et al. 1999). In Lammerts van Bueren et al. (2002c) breeding and propagation techniques are assessed from ethical principles of the organic agriculture respecting the integrity of plants based on their natural reproductive ability and barriers, and their viable relationship with the living soil. The world umbrella organisation for organic agriculture IFOAM (International Federation for Organic Agriculture Movements) has recently presented official draft definitions and standards for organic plant breeding and techniques, and has set a direction for further development and discussion (IFOAM, 2002). In short, these standards indicate that organic breeding programmes should not be based on *in-vitro* techniques or genetic modification.

***Outlook***

The organic sector challenges the conventional seed sector to develop additional and new approaches for organic plant breeding and propagation. Organic plant breeding should not be considered a strategy which only excludes certain techniques, but the one that can open new perspectives for the improvement of organic varieties in directions that to date have hardly received attention.

The limited area of organic agriculture will be the bottleneck of economic interest in establishing specific breeding programmes for organic farming systems, especially in relation to small crops and low-yielding but important crops such as cereals.

The organic sector needs the support of public-private research and pre-breeding activities investing in strategies that renew the genetic base for breeding programmes and for (re)new(ed) variety concepts. Co-operation at the European level should be the basis for regional diversification and adaptation. Although one can hope that 'organically bred' varieties will increase in number in the future, it is realistic to assume that for the next decades the organic sector will largely depend on organically propagated, but 'conventionally bred' varieties.

The EU regulation 2092/91 now agrees on the definition of organic seed as seed being produced by a crop that is planted and raised organically for at least one generation for annual crops, and for at least two growing seasons for biennial and perennial crops. This means that untreated, conventionally produced basic seed can be used to produce organic market seed. For further closing of the organic production chain it can be expected that in due time the organic maintenance of varieties suitable for organic farming systems will also be required, as a step towards organic plant breeding.

I hope that the organic crop ideotype and variety concept may in the future benefit not only organic farming systems, but also conventional systems moving away from high inputs in nutrients and chemical pesticides.

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