# The consequences of the concept of naturalness for organic plant breeding and propagation

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## Abstract

Organic agriculture is enhancing specific plant breeding activities to meet its requirements for varieties better adapted to the specific organic environment. In the past five years, therefore, attempts have been made to translate the principles of organic farming into rules, regulations and guidelines for organic plant breeding and propagation. These principles are based on the concept of naturalness, which includes three complementary approaches: the *non-chemical approach*, the *agro-ecological approach* and the *integrity approach*. Departing from the concept of naturalness, criteria have been developed to evaluate existing plant breeding and propagation techniques for their compliance to the principles of organic agriculture. Each of the three approaches of the concept of naturalness has major consequences. If these consequences are taken seriously, plant breeding and propagation strategies and techniques for organic farming will greatly differ from breeding and propagation for conventional farming. To better understand the choices to be made and to make them acceptable to the mainstream seed industry, it is necessary to further clarify the underlying framework. This paper provides this clarification by analysing the cognitive, emotive, and normative dimensions of the three approaches. Distinguishing the three different approaches of naturalness in organic agriculture, as well as their three dimensions, and analysing the consequences for the breeding and propagation strategies and techniques can also help to identify and prioritize short-term and long-term steps for the practical development of organic seed production and plant breeding.

*Additional keywords*: integrity, intrinsic value, ethical notions

## Introduction

Organic agriculture is increasingly gaining societal, political and scientific recognition for its contribution to sustainable agriculture. Therefore, new parties, such as the seed industry, are entering this production chain. At the same time, EU regulation 2092/91 (Anon., 1991) is putting pressure on closing the organic production chain and demands organically propagated seed and planting material to be used that has been produced according to organic production standards. Currently, the organic sector is in the process of making mandatory the use of organically produced seeds. For the time being these may be seeds from varieties produced by conventional breeding programmes. This practice is only a step in the process to come to organically bred, maintained and propagated varieties that are better adapted to the low-input, organic farming system. A logical, following step would be setting up breeding programmes to produce, select and propagate varieties under and for organic farming conditions.

When breeding companies are considering to invest in organic breeding programmes they require clear certification standards for organic breeding and seed production. They are aware that the organic sector has decided to exclude transgenic modification as a breeding technique, and that more restrictions may be imposed. Plant breeders need to know how other existing breeding and propagation techniques comply with the principles of organic agriculture. Lammerts Van Bueren *et al.* (1999) described a project in which they applied *ecological* criteria to evaluate existing plant breeding and propagation techniques, in a first attempt to identify the techniques complying with the organic principles. The results of that project have lead to the design of draft standards for organic plant breeding and propagation (Anon., 2002).

However, the principles of organic agriculture involve more than can be assessed using merely ecological criteria. In the international discussions on the assessment of breeding techniques for organic agriculture it soon became clear that besides the ecological criteria also ethical notions play a role in the underlying organic principles. These principles have been elaborated into the concept of *naturalness*, which includes three complementary approaches (Verhoog *et al.*, 2003):

1. the *non-chemical* approach,
2. the *agro-ecological* approach, and
3. the *integrity* approach, which means respect for the *integrity* of living entities.

The concept of naturalness as elaborated by Verhoog *et al.* (2003) has been recognized by the world umbrella organization for organic agriculture IFOAM (International Federation of Organic Agriculture Movements) and will be considered during the revision of the current IFOAM standards for organic farming.

## Naturalness

Verhoog *et al.* (2003) pointed out that the concept of 'naturalness', as used in the context of organic agriculture, not only refers to the avoidance of inorganic, chemical inputs, and to the application of organic, agro-ecological principles, but also implies

acknowledging the *autonomy* of living beings, or their 'integrity'. Integrity is the ethical element of naturalness. Including such an ethical element in plant breeding and propagation fits in a biocentric framework of action. Several bioethical frameworks can be distinguished: (1) anthropocentric (only humans have an ethical relevance), (2) zoocentric (both humans and animals have an ethical relevance), (3) biocentric (all living entities have an ethical relevance) and (4) ecocentric (all living entities and their natural habitats have an ethical value). A biocentric attitude towards nature – so characteristic for organic agriculture – leads to the consideration that not only humans and animals, but all living entities, including plants, have an intrinsic value and are ethically relevant.

From the biocentric perspective, plants have a value of their own, independent of the instrumental value for humans. That value should be taken into account in the decisions of actions such as (organic) plant breeding and propagation strategies. Accepting this value does not mean that the organic farmer cannot regulate the presence of plants in his agro-ecosystem. Because of his duty to take care of the crop, he has to remove undesirable plants (such as weeds or excessive crop plants) competing with the desirable crop plants for resources, to optimize crop growth. He can compensate this intervention by allowing weeds to grow as herbs in non-productive areas on his farm.

Verhoog *et al.* (2003) concluded that only if the non-chemical, the agro-ecological and the integrity approaches are taken together, the concept of naturalness can be used to distinguish organic agriculture from conventional agriculture. But the concept can also be used as a guideline for future developments in organic plant breeding and propagation.

The three approaches of the concept of naturalness have large consequences and make plant breeding and propagation strategies and techniques for organic agriculture different from those in conventional agriculture. To better understand why naturalness is of moral value in organic agriculture and how this leads to different breeding and propagation strategies and techniques, there is a need for further clarification of the underlying values. This paper provides such a clarification by analysing the different components involved in the process of moral valuation (feeling, thinking, communicating, choosing and acting). There are three dimensions involved in the processes of moral valuing:

1. A *rational (cognitive)* dimension related to the more theoretical concept of nature, and the relation between man and nature, in so far as these are connected with the valuation of nature.
2. An *emotive* dimension related to certain feelings towards nature. This is expressed in different attitudes towards nature: man as a ruler, as steward, as partner of nature or as participant in nature.
3. A *normative* dimension related to the question what we ought to do or not to do with nature.

These three dimensions are generally recognized in literature (e.g. Keulartz *et al.*, 2000). Here they will be discussed in qualitative terms in the light of the three approaches of the concept of naturalness. For an overview see Table 1. Table 2 summarizes to what extent plant breeding and propagation techniques at the level of plant,

Table 1. Consequences of the appreciation of the approaches of the organic concept of naturalness for organic breeding and propagation.

| Approach of naturalness | Cognitive dimension (view) |
|---|---|
| Non-chemical | • Applying substances derived from the living (organic) nature is healthier for mankind and environment than from the dead (inorganic) nature.<br>• Breeding is a genetic improvement of cultivated plants to obtain desirable traits for human use to maximize product quality and production within the accepted limits.<br>• Breeding should be as efficient as possible; modern strategies like quantitative genetics and DNA markers can be important instruments. |
| Agro-ecological | • Breeding is genetic adaptation of cultivated plants to the agro-ecological conditions in the farming system, with ecological variety traits, e.g.:<br>– Ability to perform under low input of organic fertilizers;<br>– Efficient in uptake of minerals and water;<br>– Deep-rooting characteristics;<br>– Ability to associate with beneficial soil micro-organisms;<br>– Weed suppressing;<br>– Disease resistance or tolerance;<br>– Stability in yield and quality;<br>– Ability to produce healthy seeds.<br>• Plant diseases can in many cases be considered as an expression of an imbalance between the crop and its environment, and solutions need interdisciplinary approach.<br>• Functional genetic diversity is important to stimulate the self-regulatory ability.<br>• Genotype × environment interaction has to be taken into account<br>• Farmer × breeder interaction has to be taken into account.<br>• Regulations need to be adapted to organic conditions. |
| Integrity | • Organic plant breeding and propagation allow a plant-worthy development of our cultivated plants based on insight into the meaningful interdependence of the plant and its ecological and socio-economic environment.<br>• Development of an art- and respectful breeder's eye as an important instrument for perceiving the phenotypic integrity of plants.<br>• Organic plant breeding and propagation enable optimal expression of species-specific potential of self-regulatory/adaptive ability and quality characteristics.<br>• Organic plant breeding and propagation result in genetic diversity in varieties and in fostering the self-regulatory capacity and the specific regional and cultural qualities.<br>• Organic breeding techniques should aim at a sustainable use of varieties (among different breeders or farmers). |

Adapted after Lammerts Van Bueren (2002).

| Emotive dimension (attitude) | Normative dimension (do's and don'ts) |
|---|---|
| • Mankind has the right to cultivate plants as long as one does not use artificial substances.<br>• Cultivated plants are perceived as (living) production units to which one can add useful traits.<br>• Fear of chemicals.<br>• Organic seeds should be untreated and should have a natural resistance 'by themselves'; they should not depend on chemical protectants.<br>• Transgenic modification is unnatural. | • Intervention with chemical substances is accepted, and crop nutrition and crop protection should be carried out with organic substances and conditions.<br>• Varieties may be derived from conventional breeding programmes but their seeds should at least be propagated organically.<br>• Seed treatment is permitted provided it is non-chemical.<br>• *In vitro* techniques are not logic, but can be made acceptable by using natural substances for the growing media.<br>• Transgenic modification is not accepted because chemicals and artificial growing media are used.<br>• DNA markers can be used. |
| • Respect for nature and the complexity of living entities, including agro-ecosystems.<br>• Responsibility for maintenance and development of genetic diversity as cultural inheritance of mankind.<br>• Robust varieties are needed.<br>• Cultural diversity is to be respected. | • Organic, adapted varieties are not only organically propagated but also have traits that make them ecologically fit to organic farming.<br>• Selection, maintenance and propagation should occur under organic conditions.<br>• No *in vitro* techniques because they represent an ecological detour.<br>• Transgenic modification is rejected because it is a product of reductionist science with possible environmental and health risks.<br>• No patents on life because it threatens cultural and genetic diversity.<br>• Participatory approach involving farmers and breeders.<br>• Adapted regulation for variety testing protocols and threshold values for seed-borne diseases. |
| • Respect for breeding as an art.<br>• Respect for the autonomy and wholeness of plants; consequently, breeding refrains from forcing/ manipulating plants, but elicits the plant's potentials (respect for integrity of life and plant integrity).<br>• Respect for the reproductive barriers (respect for genotypic integrity).<br>• Respect for the coherence of a plant's appearance, growth dynamics, species-specific balance between quantitative and qualitative aspects (respect for phenotypic integrity)<br>• Farmers want to be involved in the total life cycle and development of cultivated plants.<br>• One does not 'make' plants and cannot therefore 'own' plants. | • Organic varieties are bred, maintained and propagated under organic conditions.<br>• Only techniques that allow pollination, fertilization and seed formation on the (whole) plant itself are acceptable.<br>• The plant's potential for natural reproduction should not be affected, so no cytoplasmic male sterility-hybridization without restorer genes.<br>• *In vitro* techniques are not accepted out of respect for plant integrity.<br>• Transgenic modification is not accepted because it violates all levels of the integrity of plants.<br>• Fostering of participatory plant breeding strategies.<br>• No patents on life, out of respect for autonomy of life. |

Table 2. The extent to which plant breeding and propagation techniques at plant, cell or DNA level are compatible with the three approaches of the concept of naturalness. Note that arguments from non-chemical, via agro-ecological to integrity approaches can be cumulative.

| Level[1] | Approach of naturalness | | |
|---|---|---|---|
| | Non-chemical | Agro-ecological | Integrity |
| Plant or crop | +[2] | + + | + + + |
| Cell or tissue | +/– | +/– – | – – – |
| DNA[3] | – | – – | – – – |

[1] The techniques for variation induction, selection, maintenance and propagation can be applied at three levels: plant or crop; cell or tissue (*in vitro*), and DNA. The latter includes techniques that go beyond the level of the organized cell.

[2] + = compatible; + + = very compatible; + + + = most compatible; – = incompatible; – – = very incompatible; – – – = most incompatible with the principles of organic farming; +/– = compatible, but there are arguments for rejection; +/– – = there are arguments for compatibility, but even more arguments for rejection.

[3] DNA-marker technology may be of value in the selection process of organic breeding programmes and can be used if methods without radioactivity are applied and carcinogenic substances are avoided.

cell or tissue, and DNA are compatible with the three approaches of the concept of naturalness.

## Non-chemical approach

Within the concept of naturalness, the non-chemical approach is the best known aspect of organic agriculture that is communicated to the public: no inorganic fertilizers, no chemical pesticides, no transgenic modification (GMOs). This is based on the rational view (cognitive dimension) that components of the living (organic) nature are healthier for humans and the environment than components of the dead (inorganic) nature. Consumers react to this with a fear for chemical residues in food and in the environment (emotive dimension). The normative dimension shows that in organic agriculture (bio)chemical-synthetic or inorganic substances have to be replaced by natural, organic ones. This implies that also for seed production and seed treatments chemical treatments have to be replaced by applying natural substances (e.g. neem oil), using physical (e.g. hot water) treatments, or involving biological agents (e.g. antagonists). As for the *in vitro* techniques used in breeding programmes, such as embryo culture, it may be clear that using artificial growing-conditions does not comply with the organic production methods using organic substances. However, one can argue that tissue culture remains within the (lowest) level of organized life. In

Table 2 this is indicated with +/–. To make it really compatible with the non-chemical approach, one can suggest designing growing media by using natural substances for a substrate and natural plant growth regulators.

This non-chemical approach is often experienced as the first phase in the conversion process from conventional tot organic agriculture. With respect to the area of seed production, the use of conventionally bred varieties but propagated in the last year in a non-chemical way is considered as a first step in the process to come to better adapted, organically bred, maintained and propagated varieties. Meanwhile, this approach still remains rational and is based on the conventional strategy of suppressing symptoms and on the idea to create a highly controlled environment in which pests and diseases have to be eliminated. With respect to breeding, this non-chemical approach refers to the view that plants are a sum of traits that can be improved by (classical) plant breeding to maximize the use for humans within accepted boundaries of the organic standards.

## Agro-ecological approach

In organic farming, solutions are based on rational, experiential and experimental ecological knowledge (cognitive dimension). In organic farming, agricultural activities (culture) are integrated in nature. Nature is defined as an ecosystem, and the organic farmer acts according to the conditions for a sound agro-ecosystem.

During the conversion period from conventional to organic farming, farmers experience that a sustainable farming system can only be created by co-operating with nature and stimulating its self-regulatory capacity, e.g. through biodiversity, and not by merely eliminating inorganic fertilizers and pesticides. A new attitude is needed based on respect for nature (emotive dimension).

With respect to the normative dimension of organic plant breeding and propagation, one should go a step further than within the non-chemical approach and select those (existing) varieties for organic seed production that have traits that make them ecologically fit to organic farming conditions. Examples of required traits are: broad field tolerance to diseases, ability to perform under low input of organic fertilizers, deep-rooting characteristics, the ability to associate with beneficial soil micro-organisms and the ability to produce healthy seed (Lammerts Van Bueren *et al.*, 2002). Selection, maintenance and propagation should occur under organic conditions. To include the experiential knowledge of organic farmers (the farmer's eye) a participatory approach in plant selection and breeding is recommended.

Compared with the non-chemical approach there are even more arguments to avoid *in vitro* techniques in organic plant breeding schemes, based on the agro-ecological approach. In Table 2 this is indicated with +/– –. From an agro-ecological point of view it is important that production is soil-bound. *In vitro* techniques can be considered as an ecological detour with the risk of losing traits associated with growth in natural (soil-bound) environments if the *in vitro* phase is used over a long period.

From an agro-ecological point of view transgenic modification is rejected because it is a product of reductionistic science with possible environmental and health risk.

## Integrity approach

The concept of naturalness as used in the context of organic agriculture not only refers to the avoidance of inorganic, chemical inputs and to the application of organic, agro-ecological principles, but also implies acknowledging the integrity of living entities. Integrity is the ethical element of naturalness, determined by a biocentric framework of action. In the biocentric theory all living entities are considered ethically relevant, which means that the intrinsic value is taken into account in decisions on the exploitation of nature. The intrinsic value of plants is a reflection of their integrity at different levels (Lammerts Van Bueren *et al.*, 2003). Plants have an integrity

– as a living being (*integrity of life*);
– as a plant with the typical nature associated with it (*plant-specific integrity*);
– as a species or genotype, with a potential to have a unique expression of the combined characteristics of the species (*genotypic integrity*);
– as a phenotype, with a coherent appearance being in balance with its environment (*phenotypic integrity*).

At all these levels the notion is that a plant is more than a functional quantity of genes or pathways. So the plant can play part in the cyclic nature of the system and in the system's capacity to naturally reproduce, to adjust to its environment and to regulate itself and to be resilient. Organic agriculture will take these elements of integrity into account and will refrain from violation of integrity. Organic agriculture therefore accepts and cherishes the characteristic nature or way of being of living entities, their wholeness, completeness, their species-specific characteristics and their being in balance with the species-specific environment. Only from a holistic perspective integrity of plants makes sense. From a purely reductionistic perspective there is no reason for acknowledging integrity, because plants merely have extrinsic values for the utility of mankind.

## Consequences of organic principles for plant breeding, selection and propagation

In Table 1 the consequences of naturalness for organic plant breeding and propagation are elaborated in detail, following the three value dimensions in horizontal direction and the three approaches of naturalness in vertical direction.

The consequences of acknowledging the intrinsic value of plants and respecting their integrity in organic agriculture are more drastic than those merely departing from the non-chemical and agro-ecological approach. Including the ethical values implies that the breeder or the seed producer also takes the integrity of plants into account in his choices of breeding and propagation techniques. It implies that one not merely evaluates the result and consequences of an intervention, but in the first place questions whether the intervention itself affects the integrity of plants.

Table 2 shows that adding ethical criteria results in a different assessment of *in vitro* (cell and tissue culture) techniques commonly used in conventional breeding and propagation, or leads at least to additional arguments to reject these techniques. More-

over, the reasons for rejection are more specific and unambiguous. For example, in contrast to the non-chemical and agro-ecological principles, the principles of integrity more clearly lead to rejection of the *in vitro* techniques because these techniques are not compatible with all levels of the integrity of plants.

Immediate banning of the *in vitro* techniques sets back development at least 30 years as many modern varieties have been bred or multiplied using a technology involving *in vitro* culture. In due time, the organic sector wants to refrain from unacceptable, conventional outputs and therefore the development of alternatives is necessary before a total ban can be implemented. By accepting the concept of integrity, the organic movement should realize that it has also accepted the need to search for such alternatives. Meanwhile, the use of material produced with current *in vitro* techniques can be temporarily accepted.

Also with respect to breeding techniques at DNA level, such as protoplast fusion and transgenic engineering, there are additional arguments against such techniques being incompatible with the non-chemical, agro-ecological and integrity approach. Moving from a non-chemical (+) to an agro-ecological (++) and integrity approach (+++), techniques at (whole) plant level are more appreciated, as the focus moves from an analytical to a more holistic perception of plants.

## Discussion

Integrating the concept of naturalness and intrinsic value of plants is explicitly a concern of organic agriculture, but connects to a broader tendency in society. Several authors refer to an increasing awareness in society that all living creatures, including plants, are to be respected on the basis of a value of their own (Kockelkoren, 1993; Meyer-Abbich, 1997; Anon., 1999; Hofmeister, 1999; Heaf & Wirz, 2001). This shows a shift in society from a merely anthropocentric towards a more biocentric attitude. Organic agriculture responds to this awareness of ethical notions and looks for caring responsibility in agriculture, also for plants. In this way organic agriculture may identify relevant new plant-man relationships.

From the above we can distil three types of development. First of all we see that the organic sector is expanding its domain and is still in the process of closing the production chain with organically produced seeds, albeit of conventionally bred varieties. The second step is the optimization of the farming system by developing varieties that are better adapted to organic farming conditions and therefore requires breeding strategies focused on organic agriculture. The third step is the development of the concept of naturalness by not only adapting to the already existing non-chemical and agro-ecological approaches but by also integrating the integrity approach. The practical consequences of the concept of integrity are not immediate, because breeding and seed production activities specifically for organic agriculture (even those merely based on the principles of the non-chemical and agro-ecological approaches) are still in their infancy. Making the criteria of intrinsic value and integrity of plants more explicit and adding this approach to the already established non-chemical and agro-

ecological approaches will assist breeders who are willing to participate in organic plant breeding and to develop adequate breeding strategies for organic varieties.

Distinguishing the three different approaches of naturalness in organic agriculture and the consequences for the breeding and propagation strategies can also help to identify and time short-term and long-term steps for the practical development of organic seed production and plant breeding. Some breeding companies start with the non-chemical approach, other ones include the agro-ecological approach, and some accept the more challenging integrity approach in breeding. Taking all three approaches of naturalness into account, the aim of organic plant breeding can be summarized as follows: *Plant breeding for organic agriculture produces varieties with a good nutritional value and taste, enhances the potential for a sound organic seed production and farming system, and enhances biodiversity. Organic plant breeding follows the concept of naturalness, by avoiding the use of chemical inputs, by stimulating the agro-ecological self-regulatory ability of organic farming systems, and by respecting the integrity of plants based on respect for their natural reproductive ability and barriers, and their relationship with the living soil.*

From a conventional, anthropocentric point of view, these aims merely restrict the tools for breeders. From an organic, biocentric point of view, however, they challenge the life sciences to participate in the discussion and to develop new and additional breeding and propagation strategies within the framework of the principles of naturalness to gain the desired progress for organic production.

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