

Challenges for the production of high quality organic seeds

By Steven P.C. Groot, Jan M. van der Wolf, Henk Jalink, Cees J. Langerak and Ruud W. van den Bulk
Plant Research International, Wageningen University and Research Centre

P.O. Box 16 6700 AA Wageningen, Netherlands,
E-mail: steven.groot@wur.nl



From left to right: Henk Jalink, Steven Groot, Ruud van den Bulk, Cees Langerak and Jan van der Wolf

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Figure 1. Seed researcher Steven Groot analysing a germination test

The world-wide need for a more sustainable agriculture has stimulated farmers and consumers to go for alternative production methods, including organic farming. Important aspects of organic crop production are the abandoning of chemical crop protectants, the use of organic manure instead of chemical fertilisers and the certifi-

cation of the organic production system. The latter is important for consumers, in justification for paying higher prices for organic products.

In the European Union the rules for organic production methods are laid down in EEC regulation 2092/91, which exactly states the kind of input and measures that are allowed for organic production, including certification. A prerequisite for organic farming is that seeds or other propagation material should also be produced under organic farming conditions. For several crops, such as potato and tomato, this works quit well. For some other vegetable or arable crops it is very difficult to produce organic seeds using the same quality standards as for conventional farming, while for ornamental crops there is hardly any organically produced propagation material available. Especially with biennial vegetable crops, as cabbages, carrot and onion, difficulties are encountered with production of high quality organic seeds. For these crops, the two seasons needed for seed production make the risk of diseases and pathogen contamination very high. With respect to cereals, organically produced wheat seeds are available, but the emergence of the seeds is often less than that of conventionally produced seeds, which normally is treated with fungicides. *Fusarium* infections are mostly causing this problem. In Denmark, for instance, it is debated whether the threshold for *Fusarium* infection in wheat seed should be increased for organic wheat seed, since it is at this moment not, or hardly, possible to meet the quality standards (B.J. Nielsen, pers. comm.). Moreover, organic seed production

is at this moment often more expensive than conventional seed production, varying from a few percent till three fold, among others due to losses during seed production or insufficient quality of some seed productions (van der Zeijden, 2003). Research is needed to tackle these problems and aid seed companies in improving their organic seed production and seed treatment methods.

The frequent lack of available organically produced propagation material made the European Commission to introduce a temporary derogation system, under which the use of conventionally produced non-chemically-treated propagation material can be allowed. This under the condition that no organically produced seed was available of the variety the farmer intended to grow. The deadline for this derogation system was set at 1 January 2004. Nevertheless, several companies have put large efforts in the optimisation of organic seed production, in several cases with success. In practice, some organic farmers did choose, for economic reasons, a variety for which only cheaper conventionally produced seeds were available. Last year it became apparent that for various crops the supplies of organic produced seeds are still insufficient. The European Commission decided therefore that the deadline for derogation should be postponed again for some crops. Each EU country had to produce a national list of crops for which derogation of the use of organic propagation material is no longer allowed. In the Netherlands this list includes for 2004, for instance, wheat, oat, barley, ryegrass and potatoes, but for some vegetable crops derogations are still allowed. The

ongoing derogations are not stimulating for seed companies to invest in organic seed production.

Next to the difficulties regarding the production and availability of organic propagation material, organic farmers encounter other problems that are less relevant in conventional crop production. Because of the abandoning of the use of chemicals during seed production, organic seed has a greater risk of contamination with weed seeds and seedborne pathogens. Moreover, sowing of seeds in soils with organic manure, that has slower mineralisation rate in the cold spring, and a stronger competition from weeds may require a high seed vigour and seedlings with a faster developing root system. Increased risks of seed contamination with seedborne pathogens might theoretically also increase the risk of crop contamination with mycotoxin producing fungi. However, the few relevant studies in which a direct comparison between organic and conventional crop production systems was made with regard to contamination with mycotoxins, do not support this theory. At present an important sales point is the guaranteed non-GM nature of organically produced products. With a global increase of GMO crops, also in regions of seed production, the risk for GMO contamination also increases. Presently it is discussed at the international level whether organic seeds need lower thresholds for contamination with GMO seeds than non-organic seeds.

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These challenges urge for finding solutions, for a large part through research. Adequate methods for the detection of pathogens during seed production and determination of critical control points during production will provide the basis for disease monitoring activities and treatments. New seed sanitation treatments need to be developed as alternatives for the present use of fungicides. These treatments need not only be effective in elimination of the pathogen, but should also maintain the viability of the seeds. Such new treatments should also be in accordance to both the standards for organic farming and (inter)national regulations regarding the use of crop protection agents. Novel seed

sorting techniques may also be of use by sorting out diseased seeds from contaminated lots or discarding less vigorous seeds. At Plant Research International we are involved in a national research programme funded by the Dutch government and in two EC funded projects. In our research we collaborate with the seed industry, organic farmers and policy makers, to guarantee that solutions from research can be implemented in practice. Some examples of this research are presented below.

A healthy organic seed production

A consequence of the omission of chemicals in the organic production system is the increased risk of the occurrence of diseases during production of some crops, as long as disease resistant varieties are not available. This holds also for seed production, especially, for biennial crops, which are exposed to various diseases during two subsequent seasons. To find alternative measures for optimising organic seed production, we focused on gathering knowledge of "thresholds", describing the link between measured seed contamination levels of a pathogen and the potential disease risk in practice. The host-pathogen combination *Daucus carota* - *Alternaria radicina* was chosen as a model. Several field experiments were carried out under organic conditions, using basic seeds of six different cultivars with various levels of *A. radicina*. Disease transmission was studied and measured in all stages of the reproduction chain, from seed to seed. Important hereto is the detection method by which the presence of the pathogen can be demonstrated in basic seed and other kinds of plant material produced from that *viz.*, seedlings, leaves, roots, flower stems, flowers and the second generation seed. To detect also slight infections, we preferred to use the more sensitive ARSA method (Prior *et al.*,

1994) instead of the blotter or malt agar method recommended by ISTA (ISTA, 2003).

Infections found with the blotter method are mainly related to a bad emergence and occurrence of symptoms in the seedling stage and leaf stems. The slight seed infections, which could only be detected with the ARSA method, seem to be responsible for non-visible latent infections in the crown part of the carrot root. These infections may become visible as a black rot either at a high temperature (>20 °C) during maturation of the carrots or during cool storage of the carrots. When young carrot plants or mature roots are vernalised in order to induce flowering, latent infections mostly remain unnoticed. Such infections can finally result in infected flowers and diseased seeds, and may form a source of inoculum for secondary infection of seeds developing on healthy plants.

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Consequently, organic seed production requires a high degree of sanitation, e.g. disease freedom of the basic seed, roguing in any stage of plant development and a stringent isolation of production fields from other umbelliferae. Additional experiments have also shown that a hot water treatment of the basic seed can be a good start for such a protocol (as shown in the graph).

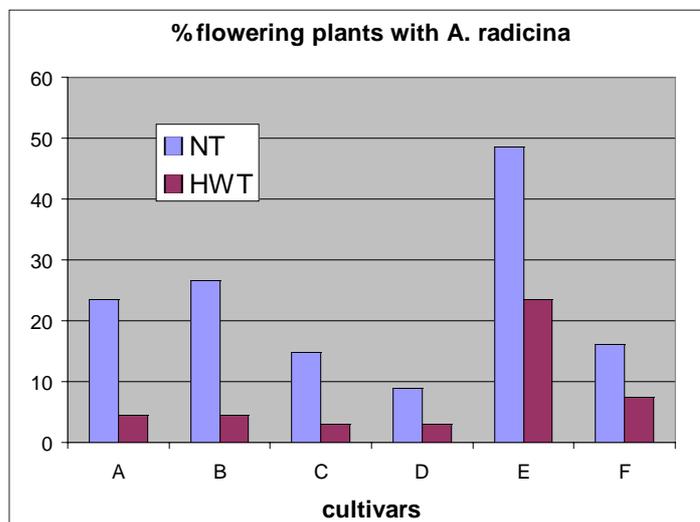


Figure 2. Hot water treatment (HWT) lowers the risk of transmission of *Alternaria radicina* to the flowering carrot plant. NT is the non-treated control

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Compounds of natural origin for seed treatment

Most commercially produced seed is treated nowadays with (synthetic) crop protection agents, in order to eliminate seedborne pathogens and to protect emerging seedlings from soil- and air-borne pathogens and insects. For organic agriculture physical treatments, such as hot water treatments, are used, but they involve the risk of seed damage. We are developing a combination therapy, by combining milder physical treatments, with treatments using compounds of natural origin.

Within this concept, different natural compounds are tested, including essential oils and organic acids. To evaluate natural compounds for activity against important seed transmittable plant pathogenic bacteria and fungi, we optimised *in vitro* microplate assays. From 30 essential oils tested, thyme oil exhibited the highest *in vitro* inhibiting activity against *Xanthomonas campestris* pv. *campestris* (*Xcc*) and *Clavibacter michigan-*

ensis subsp. *michiganensis*. Thyme oil also showed an inhibiting activity against *Botrytis aclada* and *Alternaria dauci*. Strong synergistic effects were found by adding a chelator and a natural detergent to the oil. Treatment of cabbage seed for 0.5 h with 0.25% thyme oil resulted in a strong decrease of seed-associated bacteria (> 99%) and saprophytic fungi. However, a negative effect on seed germination was found with an oil concentration exceeding 0.25%, when applied for at least 4 h. Ascorbic acid in a concentration of 2.5% also resulted in a strong decrease of seed associated bacteria without affecting seed germination. Presently we are investigating the effect of both types of components on pathogen infected seeds.

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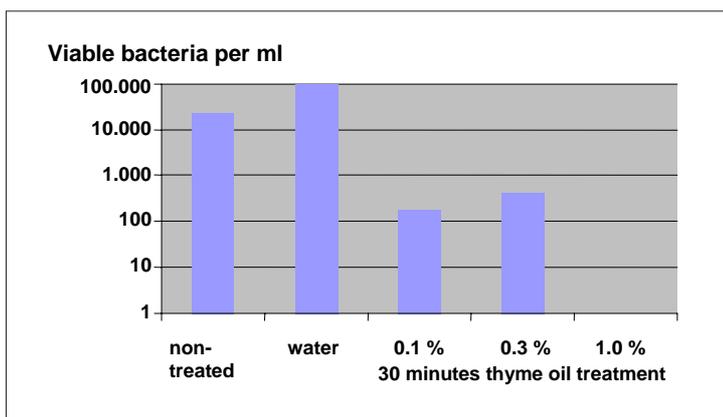


Figure 3. Effect of thyme oil treatment on the bacterial background of a cabbage seed lot



Figure 4. Organic onions growing from primed seeds

An important aspect for implementation in practice is that also the use of these natural agents should be allowed according to the national and international regulations for crop protectants, even if they are already used in food products. Products that are not yet registered for use as a crop protectant will need the submission of new dossiers, often requiring costly toxicological studies that are not feasible for the small market of organic seed treatment. Next to that, they should also be allowed for use in organic production systems (EEC regulation 2092/91).

In the Netherlands thyme oil fits both the criteria and may be used for treatment of seeds when mixed with water. Due to its hydrophobic properties treatments with thyme oil need to be further optimised. The use of ascorbic acid is presently not allowed for organic seed treatments, since it is not listed in annex IIB (EEC regulation 2092/91) describing the crop protection agents allowed for organic production. However, it is permitted as additive in organic food and fodder (annex IIC) and it could be worthwhile to submit a request to the EC to place this compound on Annex IIB as well.

Seed priming

Microbial activity is very important for the release of nutrients, when using organic manure. In the cold spring soil, microbial activity is low and nutrients become less readily available in comparison with the use of synthetic fertilisers in conventional farming. A vigorous seedling with a fast growing root system may improve the uptake of minerals and improve the establishment of the crop. In this respect vigorous, healthy seedlings may be even more important for the organic farmer than for the conventional farmer. Moreover, faster growing seedlings can improve competition with weeds for nutrients and light. The latter is relevant, because manual and mechanic weed removal are major costs in organic farming. We found that primed seeds from onion and carrot had a faster establishment in organic soils compared to non-primed seeds. Two months after sowing, the roots and shoots of plants from primed seeds were larger than of plants from non-primed seeds. In our field tests, however, we had a favourable growing season and the plants from non-primed seeds caught up. As a result there was no significant effect on the yield at the end of the growing season. We expect that under less optimal conditions, for instance when the crop is attacked by diseases during the season, the initial faster growth of primed seeds

can have strong benefits for the organic farmer. Dutch organic farmers will continue experimenting with primed seeds in 2004.

New seed sorting technologies to improve the health and quality of seed lots

As argued above, for organic farmers the use of seed lots with a high vigour may be even more important than for conventional farmers. Also alternative sanitation treatments with, for instance hot water, require a high degree of tolerance of the seeds. Commercial seed lots can be composites of seeds harvested over different periods of time and differing in quality. The environmental conditions constantly change during the production period and add to the heterogeneous nature of the seed lot. During maturation, seeds reach optimal physiological quality. A major cause of the heterogeneity is the variation in maturity, resulting in a seed lot with an overall lower seed quality. Seeds, which are not completely mature, germinate more slowly, have a lower germination capacity, produce less normal seedlings, can have higher contamination levels with pathogens, and can be more sensitive to diseases. In this respect seed maturity has a large influence on seed vigour.



Figure 5. Germination test for CF sorted white cabbage seeds; left low CF, right high CF and bottom control non-sorted seed.

In general, after the filling of the seeds has completed the colour of the seeds slowly turns from green to a colour that varies with the species or cultivar. This process is called degreening, due to chlorophyll breakdown, and is correlated with seed maturation. The maturation of the seed can be distorted by poor plant nutrition, poor weather conditions, the presence of pathogens or an early harvest. These are all factors known to influence seed vigour. Seed companies use different types of sorters, including colour sorters, for upgrading of their seed lots. However, the colour of high quality mature seeds may vary, because the colour is not only influenced by breakdown of chlorophyll but can also depend on the presence of other

pigments, related to the cultivar and production conditions. It is known that chlorophyll shows prompt fluorescence when the molecule is excited at the proper wavelength. The established chlorophyll fluorescence (CF) sorting method analyses the amount of chlorophyll in the seed by measuring the chlorophyll fluorescence signal in a very sensitive manner (Jalink *et al.*, 1998). Using CF sorting, one measures the intensity of CF signal of each individual intact seed at high speed. Based on the magnitude of the chlorophyll fluorescence signal, the seeds can be sorted into various classes of maturity and linked to seed performance. Cabbage seeds with the lowest amount of CF, and hence the most mature, provide indeed the highest percentage of germination, a more uniform germination, a higher speed of germination, a higher percentage of normal seedlings, and a lower amount of pathogens. Seeds from the high CF fraction, involving less mature seeds, showed a lower germination capacity and were more heavily infected than the seeds from the low CF fraction (Jalink *et al.*, 1998).

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Also for barley (*Hordeum vulgare* L.) seeds, a relationship was established between the CF signal and the level of contamination with *Fusarium* spp and *Cochliobolus sativus* pathogens (Konstantinova *et al.*, 2002). Seeds from the fraction with the highest CF signals were always the most heavily infected. CF sorting of barley seeds improved their germination quality by not only removing less mature seeds, but also by removing seeds with the largest fungal infection levels. This technology can therefore also contribute to improving the quality of organic seeds.

International collaboration

The need for a more sustainable agriculture is acknowledged world-wide and many governments support research for organic farming. Seed companies also invest in organic seed production, in spite of the general expectation that the organic seed market is hardly interesting for the main seed companies from a commercial point of view.

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Collaboration between private and public institutions is a must, both on the national and international level. As seeds are the basis of crop production, it is an important that the International Federation of Organic Agricultural Movements (IFOAM), the Food and Agriculture Organisation of the United Nations (FAO) and the International Seed Federation (ISF) have taken the initiative to organise together the 'First World Conference on Organic Seed'. This conference will take place from 5-7 July 2004 at the FAO Headquarters in Rome. As key player in the research on and analysis of seed quality, ISTA will also take part in this conference. ■

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