Healthy seeds, the basis for sustainable farming

Paper Series from the 4th ISTA PDC Symposium on Seed Health

Wageningen, Netherlands, April 29 - May 1, 2002

The ISTA Seed Health Committee continues with the new series in the *Seed Testing International.* The two papers 'Strategies for regulation of seed borne diseases in organic farming' by Anders Borgen, Scanagri Denmark, Denmark and 'Early harvest - a possible method for production of healthy seed for organic farming' by Hans Olvang, Swedish University of Agricultural Science, Sweden are the second in a series of papers related to the field of seed health and show the technical and scientific work of our association.

The papers are works which were presented at the 4th ISTA-PDC Seed Health Symposium 'Healthy seeds, the basis for sustainable farming' held in Wageningen, The Netherlands, April 29th to May 1st, 2002.

The ISTA-PDC Symposia are used as a platform to exchange ideas, new techniques, and information in the various topics of seed health. The high profile of seed health will be reflected in the future presentations in this series covering regional seed health issues, quality management, and innovations and new methods in seed health testing.

Strategies for Regulation of Seed Borne Diseases in Organic Farming

By Anders Borgen, Scanagri Denmark

Scanagri Denmark A/S, Vester Farimagsgade 6, 5th, DK-1606 Copenhagen V., Denmark.
E-mail: anders.borgen@scanagri.dk

Summary

The impact of seed borne diseases on organic cereal production in North-Western Europe is discussed as well as the potential of the possible control measures. It is concluded that it is essential for the organic seed production to put more focus on the control the seed borne diseases. Possible control measures exist, but only a few are used at present. Small seeds are statistically more infected by a number of seed borne diseases than larger seeds. Removal of these seeds by size and gravity separation could be used more frequently. Varieties resistant to the most significant seed borne diseases are available, and improved heat treatment techniques are being developed and are likely to be available for practice in the coming years. Some organic certifying bodies allow application of cupper-salts and bio-agents, but the use of these does to some extent conflict with the fundamental principles of organic diseases management.

Introduction

Through agriculture's history, seed borne diseases have been one of the most serious problems in cultivation. From ancient Greece and Rome and until the start of this century control of bunt diseases in cereals, in particular, has played an important role in the history of phytopathology. The development of organic mercury seed dressings in 1913 radically changed this situation within only a few decades. The mercury seed dressings were effective against most of the seed borne diseases - they were not costly and they were easy to use. By the end of the century the use of mercury dressings were prohibited and replaced by other disinfectants.

Many diseases can be transmitted both by seeds and through soil. In the end of last century as crop rotations became less diversified a range of seed borne diseases became more frequent. Also organic farming has become increasingly widespread and this cropping system rejects the use of conventional disinfectants. Organic farmers therefore now face similar challenges as farmers in previous centuries.

The rules applying to organic farming are based on a number of principles and the organic farming sector does not wish to simply replace the existing chemical agents with other agents from the organic positive list in Annex IIb in the EU regulation (EU 2000). In organic farming, pests and diseases should be dealt with through prevention rather than treatment. In the EU regulation this has been formulated in a way so that the agents listed in Annex IIb can only be used in case of acute risk to the crops. The regulation of seed borne diseases must, thus, be based on a systematic preventive strategy in the production of seeds combined with monitoring of the occurrence of diseases. Direct control must be limited to cases where diseases have been identified despite the preventive actions taken.

Preventive Methods

The most effective preventive method for control of seed borne diseases is to only introduce healthy seed into the system. Normally, organic seeds are produced by purchasing conventional non-treated seeds (C1), which have been grown organically for one season and then sold on to organic farmers as organic seeds (C2). It is of vital importance that the seeds purchased are free from diseases - this is not automatically the case even though it has been grown on the basis of disinfected plant material. Seed borne diseases occur equally often in conventional non-treated seed as in certified organic seed.

The choice of resistant varieties is also an important component in the preventive strategy. Loose smut of barley (*Ustilago nuda*) is mainly controlled by resistant varieties and in Sweden Stava is, thus, grown as the predominant winter wheat variety. This variety is resistant to common bunt (*Tilletia tritici*) and dwarf bunt (*Tilletia contraversa*), which are the most serious seed borne threats to this crop. To a large extent leaf stripe of barley (*Pyrenophora graminea*) and could also be controlled by choosing resistant varieties.

No cereal variety is, however, completely resistant to all diseases - this would probably also be contrary to the wish of maintaining biodiversity. All things considered, it will be advantageous to use mixtures of several varieties, but this strategy is difficult to implement in the multiplication phase of the propagation, due to practical reasons as well as due to the degree of purity required by the rules for certification of seed.

The cultivation conditions influence the occurrence of seed borne diseases, but we only have limited knowledge of this. It has been stated that row cropping may reduce the impact of some diseases, but the importance of this has not been determined (Borgen, 2001). Also early harvesting has an influence on some diseases (Olvång and Poulson, 2002).

Analysis Methods and Thresholds

In order to assess whether or not there is a need for seed treatment to control diseases, the seed has to be subjected to a phytopathological analysis. The method used for this analysis depends on the types of diseases investigated. Some of the analyses require up to two weeks. In winter cereals, where the time span from harvesting of the crop to the sale and sowing of the seed produced is very short, the considerable time required for analysis is a serious problem. For this reason, in particular, actions have been initiated in many countries focussing on the implementation of new and less time-demanding PCR analysis methods. The methods used until now for the analysis of glume blotch (*Stagonospora nodorum*) and seedling blight fungi (*Fusarium* spp., *Bipolaris sorokiniana*) have, to some extent, been dependent on the laboratory assistant's own evaluation of the differences in colour of roots and grains when applying ultraviolet reflection. Considerable differences have, thus, been registered in the results from the various laboratories. The PCR technology is much more reliable, objective and quick. On the other hand, it is species-specific, which is a disadvantage compared to the traditional analysis of the seedling blight fungi, where many different pathogens are concerned. The implementation of the methods and the evaluation of pros and cons will be investigated in a new research project, which is being carried out in Denmark and will last until 2005.

When the seed has been analysed, the results are evaluated. In conventional farming, thresholds have been developed i.e. guidelines on when dressing may be omitted. These thresholds have been applied until now also within organic farming as an indication of what is acceptable. The thresholds have, however, been determined based on the assumption that e.g. leaf blotch diseases (*Pyrenophora teres* and *Stagonospora nodorum*) can be treated through spraying with fungicides later in the season and that weed can be controlled by using herbicides in cases where the competitiveness of the weed has been improved in a thin plantation as a result of seedling blight. In organic farming where herbicides and fungicides are not used, the tolerance may, therefore, vary from conventional farming. This aspect will also be dealt with in more detail in the ongoing research project in Denmark.

Control

If the threshold is exceeded in a certain seed lot, action will be required and several possibilities are available. In the other Scandinavian countries Cedomon can be used for the control of seed borne diseases in barley, whereas this agent has not been approved yet for use in Denmark. In winter cereals and in pulse no means of control are used, at present, and consequently all organic seed lots exceeding the threshold are discarded. In some years up to 90% of the seed lots of certain crops have been discarded, which is naturally a totally unacceptable situation for the organic seed production.

The control of seed borne diseases is of vital significance for the organic production. There is a need for developing new methods for prevention, monitoring and control and more qualified thresholds are required.

Removal of the smallest seeds in a seed lot may, in some cases, limit the content or the significance of seed borne diseases. A series of diseases attack, in particular, the top grains in the ear and these are statistically smaller than the remaining grains. The attack itself often also results in a reduction in size of the infected grains. It is, therefore, possible to reduce the impact of the attack of diseases such as loose smut (*Ustilago nuda*), glume blotch (*Stagonospora nodorum*), leaf stripe (*Pyrenophora graminea*) and *Fusarium* by removing the smallest grains of a particular seed lot.

In the case of attacks of common bunt (*Tilletia tritici*) in wheat and stem smut (*Urocystis oculta*) in rye, the spores are placed loosely on the surface of the grains. The grain is as such healthy and not infected until germination. The spores can be removed by means of physical treatment using a brush cleaner of the type used in the production of grass seed. A Sigma cleaner where the grains are centrifuged at high speed is also efficient. These rough treatments will remove dust and hairiness from the grains and thereby also a great part of the fungal spores on the outer side of the grains. It is probably not possible to remove all fungal spores, but, in some cases, it will be possible to reach a level below the threshold.

Cereal and fungal spores tolerate a good deal of heat when dry, however, much less the moister they are. This factor can be used in to the control fungal diseases. If the grains are exposed to dry heat, the outer parts of the grains will dry out before the inner parts. As most of the fungus is found on or in the outer layer of the seed, the fungus tolerates dry heat better than the germ of the grains, which are better protected. On the other hand, if the grains are exposed to hot water or warm moist air, the outer parts and thereby also the pathogens will be become moist before the interior part of the grains. It is, therefore, possible to control a range of pathogens selectively without harming the germination of the grains.

Since the end of the previous century hot water has been used for controlling seed borne diseases, but the traditional hot water method where the grains are sub-merged in hot water is costly and complicated especially in the case of large quantities of cereals, which will require drying afterwards. This method is therefore now only used in certain crops with small and high value seeds.

Several institutions, therefore, concentrate on the development of different types of equipment for thermal treatment of seed in which the imbibition of the seed during treatment is reduced compared to the traditional submersion of the grain into water. At Göttingen University in Germany experiments are carried out using a combination of vapour and microwaves (Cwiklinski et al. 2001); at SLU in Sweden hot air with high air humidity has been tested (Forsberg 2001) and at PlanteForsk in Norway experiments are made with vapour treatment. In Denmark experiments based on this technology will also be carried out in the coming years using the so-called roller drum driers.

Thermal treatment is able to control all relevant diseases in cereal, but the various types of loose smut (e.g. *Ustilago nuda*) requires several hours' of treatment in order to be efficient (Winkelmann 1955) - therefore, it will probably not be economically justifiable to use this technique for these particular types of diseases.

In Germany experiments have been carried out during the last decade on the development of an irradiation installation, which irradiates the grains with electro-rays of the same type as those used in television tubes. This technique has been applied to a limited extent and seems to be able to control a series of diseases. The installation itself requires a considerable investment, which is only justifiable in the case of high capacity seed installations (>6,000 t/y) (Scröder et al. 1998).

Various seed dressings, which are permitted in organic farming, have been developed. In Germany Tillecur which is based on e.g. mustard flour is used. This agent is very effective against common bunt (*Tilletia tritici*) (Borgen and Kristensen 2001, Spiess 2000). In Denmark it is not permitted to use mustard as seed dressing as it is not listed in Annex IIb in the EU Regulation on organic farming. In Germany, however, the same regulation is interpreted differently allowing the use of mustard flour.

Experiments with vinegar as dressing have been carried out in organic farming and has proven to be effective against common bunt (*Tilletia tritici*) and leaf stripe (*Pyrenophora graminea*) (Borgen and Nielsen 2001). Due to the present interpretation of the EU regulation this agent is, however, not permitted either.

Biological treatments with bacteria or fungi are a potential mean of control. At present no organism or products are approved in Denmark, but in other countries products like Cedomon (*Pseudomonas chlororaphis*) and others can be used. In the coming years it is likely that more products will be approved, and these confirm with the EU regulation on organic farming.

The use of biological control of pathogens in organic agriculture implies a dilemma. On the one hand it is a pesticide-free control measure that promotes beneficial life-forms rather than actively kills pathogens. On the other hand there may be problems connected to the use of some biological control forms parallel to problems related with pesticides. In organic agriculture e.g. plants juices can be used in plant protection, but single chemical compounds isolated from plants or copies hereof are unwanted because they are not used in the concentration and in a chemical and organic environment of which they naturally occur. In the same way the use of a single or a very limited number of micro-organisms may disturb the existing balance in the soil flora, and the use of non-indigenes species not already present in the local soil is certainly questionable in organic agriculture (Borgen and Davanlou 2000). Nevertheless, bio-agents are listed in Annex IIb in the EU regulation and are accepted by a range of certifying bodies in Europe.

Milk powder can be used to control common bunt (*Tilletia tritici*), but a full control can only be reached at doses, where also the germination vigour of the seeds are reduced (Borgen and Kristensen, 2001). However, milk powder may pay a role in combination with bio-control agents, where the effect of both measures is improved by a synergistic effect (Borgen and Davanlou 2000).

In some EU countries copper-salts are used as seed dressing in organic farming. Cupper as a seed treatment is quit effective and have been used in Europe for 200 years. However, the use for plant protection in organic farming is controversial. Most wine producing countries allow the use, while the Scandinavian and some other countries have opposed the use of cupper in organic farming - therefore, the future of this agent in organic farming is uncertain.

Synthesis

The control of seed borne diseases is of vital significance for the organic production. There is a need for developing new methods for prevention, monitoring and control and more qualified thresholds are required.

In barley leaf stripe (*Pyrenophra graminea*) is the most serious disease. Effective sources of resistance are available against this disease, but there is often a lack of knowledge of which varieties are resistant and which are not. Removal of the smallest grains will reduce the frequency to a certain extent, but in non-resistant varieties, there will be a need for control. Cedomon can be used for this purpose and within a few years thermal treatment will probably also be an alternative. Net blotch (*Pyrenophra teres*) and scald (*Rhyncosporium secalis*) are often found in varying degrees, but it has not been established exactly what effect the seed borne infection has on the development of epidemics. Normally, seed analysis does not include scald. If the tolerance with respect to net blotch is exceeded, Cedomon and thermal treatment may be a possibility. Seedling blight fungi (*Fusarium, Bipolaris sorokiniana*) only seldom presents a problem in spring cereal in Denmark. If the threshold is exceeded a removal of the smallest seed fraction may solve the problem.

In winter wheat common bunt (*Tilletia tritici*) is the biggest problem. The variety "Stava" is resistant and is grown in organic farming in Sweden to a large extent. Several resistant varieties are expected on the market in the nearest future. If the threshold is only exceeded to a small extent, treatment by means of brush cleaner or Sigma cleaner may be an alternative. In some years glume blotch (*Stagonospora nodorum*) may harm the germination and possibly activate an epidemic if the proper climatic conditions are present. Removal of the smallest seed fraction may, in some cases, solve the problem by removing the most infected grains. Thermal treatment may, when more developed, be used in the future.

In rye there are seldom problems with seed borne diseases. Seedling blight fungi may occur, but often the germination will be reduced at the same time - the problem is, thus, not solved even though the pathogens are killed. Stem smut (*Urocystis oculta*) may occur, but only rarely develops into a problem in the cultivation. The spores may be removed in a similar way as for bunt spores in wheat. Thermal treatment is also a possibility, if the technique is available.

Triticale may, in principle, be attacked by both common bunt and stem smut. However, most varieties are resistant to both diseases. Triticale is a relatively new crop and it cannot be excluded that virulent races of these pathogens develop. The major problem with triticale is, however, seedling blight fungi. Increasing seed size and, in the future, thermal treatment and biological agents offer good possibilities of control.

In oat seed borne diseases are seldom a problem in Denmark, but the crop may be attacked by loose smut (*Ustilago avena*), leaf spots (*Drechslera aenae*) and seedling blight, which can be controlled according to the same principles as used for other crops. ■

List of References

Borgen, A. 2001: Regulering og bekæmpelse af udsædsbårne sygdomme i økologisk korn og bælgsæd. In: Vidensyntese økologisk såsæd. Ed: Nielsen, B. and L. Kristensen. FØJO-report.

Borgen, A and L. Kristensen 2001: Use of mustard flour and milk powder to control common bunt (*Tilletia tritici*) in wheat and stem smut (*Urocystis occulta*) in rye in organic agriculture. In: Seed treatment - challenges and opportunities (ed. A.J.Biddle) p. 141-150.

Borgen, A. and Nielsen B. J. 2001: Effect of seed treatment with acetic acid for control of seed borne diseases. Proceedings from BCPC Symposium No. 76: "Seed Treatment: Challenges & Opportunities", eds. A. J. Biddle. BCPC, Farnham, 135-140.

Borgen, A. and M. Davanlou 2000: Biological control of common bunt (*Tilletia tritici*) in organic farming. Journal of Crop Production 3(5):159-174

Cwiklinski, M., D. von Hörsten, W. Lücke, and G. Wolf 2001: Alternativen zur chemischen Beizung. Saatgutbehandlung mit Mikrowellen- und Hochfrequenzenergie. Landtechnik 56(1):28-29.

EU 2000: Regulation no. 2092/91 on organic agricultural methods and reference hereto on agricultural products and foodstuff. 1991 with later amendments.

Forsberg, G. 2001: Värmebehandling - et realistiskt sätt att uppnå friskt ekologiskt utsäde. Proceedings fra konferencen Ekologiskt Lantbruk, Ultuna 13-15/11

Olvång, H. and P. Person 2002: Early harvest a possible cultivation measure to imporove seed health in organic farming. Seed Testing International 127, 39-42

Schröder, T, O. Röder and K. Lindner 1998: E-dressing - a unique technology for seed. ISTA News Bulletin. 118:13-15.

Spiess, H. 2000: Aktuelle Versuchergebnisse zur Weizensteinbrandbekämpfung. Lebendige Erde 5:41

Winkelmann, A. 1955: Untersuchungen zur Bekämpfung des Gersten- und Weizenflugbrandes. Angewante Botanik 29:3-13