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Alternatives to chemical dressing

Seed treatment with microwave and high-frequency energy

Thermal seed dressing treatments using microwave or high-frequency energy offers a possibility for complete killing of fungus pathogens both on the surface and inside the seed without affecting germination potential. As physical treatments, they are also suitable for application in organic systems. Contrary to conventional thermal systems, dielectric treatments feature short treatment times and therefore represent an interesting solution. Results of trials on the killing of Fusarium ssp. in wheat indicate the possibility of practical applications for both systems.

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Keywords

Microwave heating, radio-frequency electric heating, wheat seed, thermal seed treatment

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Currently, seed is protected from disease pathogens by the application of chemical dressings. However, organic farms are not allowed to use such substances and therefore have only the possibility of applying physical seed treatments. Further, reducing the introduction into the soil of pollutants is a theme of public discussion. In some north European countries action has already been taken through the application of pollutant substance thresholds, and bans on seed dressing substances. Thus the development of alternatives to chemical dressing is a task for science. Thermal seed treatments enable the killing of pathogenic fungi on both the surface and inside the seed. Systems using convection heating are seldom used because of poor results and different processing-technological and economic disadvantages [1 to 4]. The question of the suitability of dielectric heating systems using microwave or high-frequency energy for seed treatment is therefore the subject of this investigation.

Application of electromagnetic energy

Contrary to conventional heating systems, the heat produced from the application of the dielectric system is released in the subject interior. Through this, an even temperature distribution is released within the product and therefore a high treatment reliability achieved. The dielectric properties of the material to be treated are of great importance for heating within electromagnetic fields. The moisture content of the seed has also outstanding influence on the material's reaction to heating [5].

Microwave energy
Microwaves have a frequency between 300 MHz and 300 GHz and wavelengths in the centimetre range. They are produced in magnetrons and channelled into a treatment area through appropriate hollow conductors. The waves penetrate the subject material whereby the material's field strength is reduced with the depth of the penetration. Because of wave overlapping in the treatment room, the electrical field in the treatment area must be evenly formed. This is achieved through injecting vapour into the treatment area. To achieve an improved temperature distribution in the product, the material is additionally moved within the electromagnetic field [6].

High frequency energy
High frequency fields are produced as a rule in a condenser between two parallel-plane electrodes. Hereby frequencies between 1 MHz and 100 MHz are used whereby waves with lengths in the metre range are produced. As dielectric subject, the seed is a part of the electrical alternate current circuit within the condenser. In total, the field strength in the complete material which is positioned between the electrodes is consistent in height during the condenser field

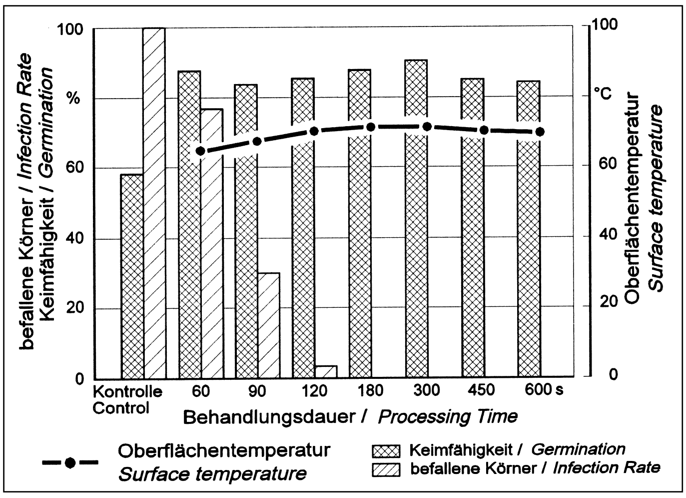

Fig. 1: Microwave steam treatment of wheat seed infected with Fusarium culmorum. Influence of processing time on germination and infection rate (mass: 100 g, seed moisture content (w.b.): 15 %)

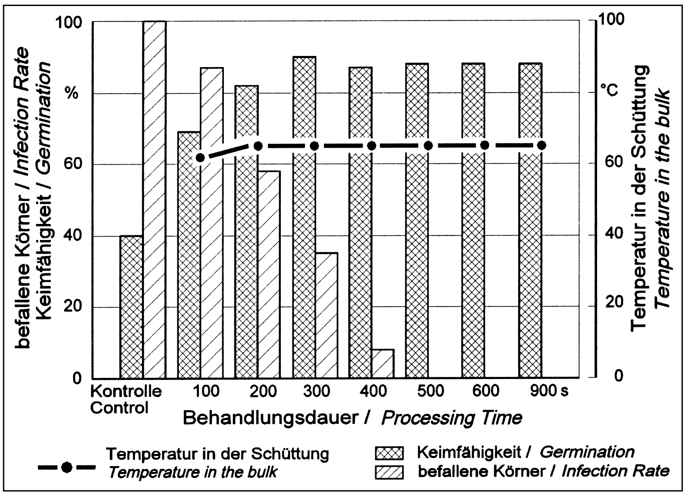

Fig. 2: Radio-frequency electric heating of wheat seed infected with Fusarium graminearum. Influence of processing time on germination and infection rate (mass: 455 g, seed moisture content (w.b.): 16 %)

heating. The temperature distribution in the material is therefore homogeneous when it shows relatively consistent dielectric properties. The phytosanitary effect of the dielectric heating process depends solely on the thermal affect. There is no known scientifically-proven evidence for the production of athermic effects.

Trial plant

The microwave-vapour treatment took place in a microwave experimental plant comprising a steplessly-adjustable magnetron with a performance of 120 to 1200 W and worked at a frequency of 2450 MHz. Among other things, the plant was equipped with a vaporising system and a heating chamber with heatable walls. During the treatment the seed samples were placed on a Teflon sample plate coupled to a turntable drive. The plant also featured a wide range of measuring equipment for the continuous measurement of the process-relevant parameters – product weight, product temperature, transmitted and reflected performance, treatment time and vapour content.

The heating of the condenser field took place in a high frequency plant comprising an infinitely-variable generator with 2800 W output performance with constant output resistance as well as an automatic adaptation network for performance adaptation, and heatable electrodes. The plant worked at a frequency of 27.12 MHz. The seed samples were treated in a closed container of Teflon. During treatment, the transmitted and reflected performance, the electrode voltage, product temperature and treatment time were continually recorded. Product weight and moisture content were determined before and after the treatment.

Both plants were computer-controlled which automated the heating process and ensured recording of relevant process parameters during the treatment. The temperature in the interior of the seed sample was determined with the fibre optic temperature measurement method which is noted for very high measuring accuracy and very short delivery time. The surface temperature was additionally determined in the microwave vapour treatment with a radiation pyrometer [6].

Wheat seed treatment

Microwave-vapour system

Wheat (15% moisture content) infected under artificial conditions with *Fusarium culmorum* and then treated with the microwave-vapour system resulted in a complete killing of the pathogen. Through this, the germination of the sample could be increased to 85% compared with 58% for control. *Figure 1* shows the influence of the length of treatment on the Fusarium infection and the germination capability of the seed. A complete killing of the pathogen fungus was achieved after 180 s. The germination capability was not affected up until 300 s treatment and up to 600 s was only slightly reduced. A complete killing F. culmorum in wheat could be achieved with a seed moisture content of 15%, a surface temperature from 70 to 75 °C and a treatment time of from 150 to 180 s.

Condenser field heating

Presented in *figure 2* is the influence of the treatment time on the Fusarium infection and germination capability after the condenser field heating of wheat seed inoculated with *Fusarium graminearum* under artificial conditions. A complete killing of the fungus was achieved at a seed moisture content of 16% and 65 °C bulk temperature after 500 s treatment time. With this, the germination capability was raised from 40% to 88%. Available from further trials was the information that the pathogen can also be completely killed in seed with a moisture content of 14%, 70 °C bulk temperature and a treatment time of 500 s. In this case the germination capability was increased from 40% to 83%.

The trials showed clearly that a complete killing of seedborne pathogen fungi with simultaneous increasing of germination capability is possible. Dielectric heating systems allow an even heating without notable drying out or moistening of the seed. Thus, this also allows treatment of moisture-sensitive products [7, 8]. The treatment requirements (temperature, treatment time, heating rate) must be individually matched to respective seed characteristics of each type of grain. A combined microwave-vapour treatment led to short treatment times. With a microwave treatment on its own, a killing of pathogens in seed with germination capability retained is not possible through the uneven heating process and rapid drying-out of the product. The condenser field heating, on the other hand, enabled the heating of greater depths of grain with only slightly longer treatment times.

Outlook

The treatment of wheat seed with microwave and high frequency energy showed that seed dressing with these technologies is possible and represents an alternative to chemical treatment. As physical procedures, microwave and condenser field heating are also suitable for seed treatment in organic production systems. Through the application of electromagnetic heating systems seedborne pathogen fungi could be killed in future – without use of chemical dressing materials. Hereby it can be emphasised that the pathogen inside the seed is also killed. Microwave-vapour treatment could be carried out in a continuous-flow plant. Larger depths of seed could be treated by high-frequency energy in batch or continuous-flow systems. Before a technical realisation of the system is able to be achieved there are still some fundamental investigations necessary, in particular trials featuring seeds from other plants and also looking at continuous-flow plants.