Protecting organic seeds: Research on seed treatments for organic farming

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Introduction to seed health

Seeds are the foundation of agricultural production, but they can also serve as a vehicle for the transmission of pathogens that disseminate within fields, often surviving in the soil for extended periods. In conventional agriculture, seeds are treated with chemicals to prevent pathogen infections, whereas organic agriculture demands alternative approaches that avoid artificial inputs. These alternative treatments primarily involve natural compounds (e.g., plant extracts, plant oils, chitosan, minerals), physical methods (e.g., mechanical, thermal), and beneficial microorganisms[1,2]. While these treatments can be highly effective against certain diseases, specific crop-pathogen systems still require tailored solutions. Moreover, treatments that successfully eradicate seed pathogens may sometimes have unintended consequences for seed health. Consequently, further research is necessary to identify novel seed treatments targeting specific diseases that affect organic crop production. Here, we present research on new organic seed treatments that could protect seeds from soil-borne infections or sanitize seeds infected by soil-borne pathogens.

Seed treatments to limit "common bunt" and "snow mold" wheat infections from soil (SeednSoil project, funded by Fenaco)

Common bunt: caused by the fungi *Tilletia caries* and *Tilletia laevis*. It can lead to significant yield loses in organic wheat production[3].

- Symptoms: seeds filled with pathogen spores and a characteristic fishy odor (Figure 1).
- Transmission: through infected seeds or via soil.

Figure 1: wheat seeds filled with *T. caries* spores.
Source of image: pflanzenkranheiten.ch

Snow mold: caused by the fungi *Microdochium nivale* and *Microdochium majus*. It affects winter cereals such as wheat, rye and triticale, causing considerable yield losses in organic production[4].

- Symptoms: reduced seed germination, and both pre- and post-emergence death of seedlings. Secondary spread of the pathogen through fungal spores causes disease symptoms on wheat leaves and ears (Figure 2).
- Transmission: through infected seeds or via soil.

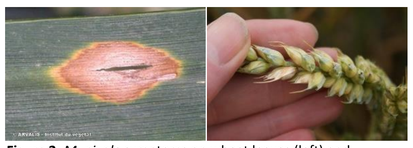

Figure 2: *M. nivale* symptoms on wheat leaves (left) and wheat ears (right)spores.
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Ear picture: https://www.fas.scot/crops-soils/crop-health/cereals/wheat/diseases-in-wheat/fusarium-microdochium-nivale/.

New protocols developed to test seed treatments against infections from soil:

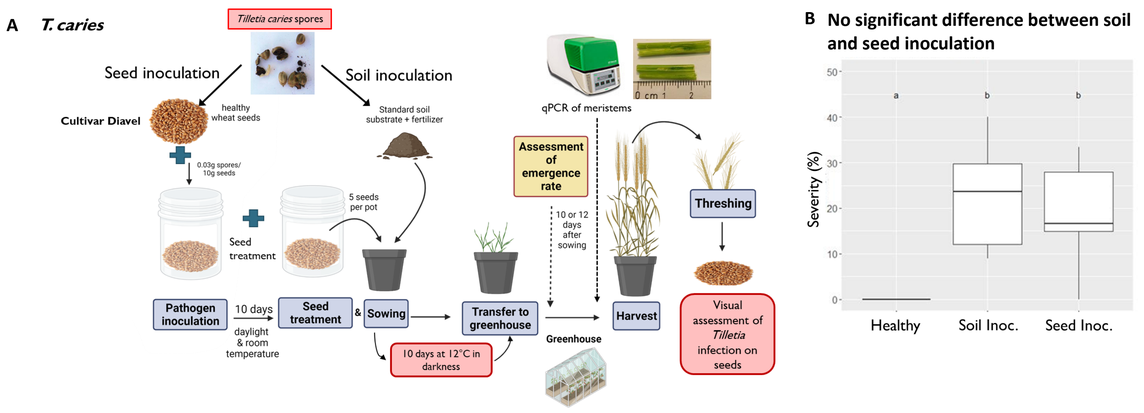

Figure 3: *T. caries* infection. A) Protocol. B) Comparison of *T. caries* disease severity levels on wheat grain by soil or seed inoculation. Letters indicate significant difference, Anova + Tukey's test (α=0.05).

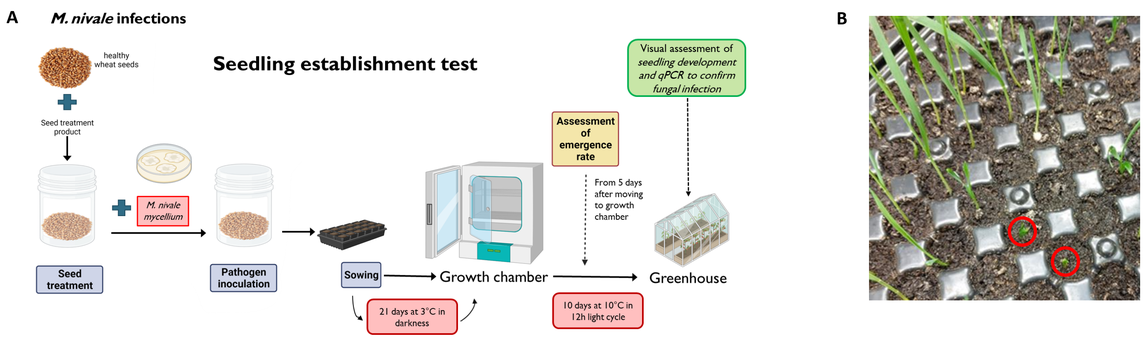

Figure 4: *M. nivale* infection. A) Protocol B) Seedling establishment test showing defected wheat seed establishment by *M. nivale* inoculation. Highlighted with red circles.

Results on products with potential to protect wheat against infections from soil:

Out of 18 products tested, two products (MicroB and Extract-1) showed significant effect against common bunt, while 11 resulted in a non-significant reduction in pathogen levels. Similarly, one out of the six products tested against snow mold (Sufrostar) showed significant effect, and three additional products led to a non-significant reduction (Table 1). None of the products with a significant effect had a negative impact on seed germination.

Name	Active ingredient	Effective against common bunt	Effective against snow mold	Sign. Delayed germination?
RhizoVital®42	*Bacillus amyloliquefaciens*	No	NA	No
Tillecur®	Yellow mustard powder	Not significant	NA	No, but lower
Cerall®	*Pseudomonas chlororaphis*	Not significant	NA	No
MicroA	*Clonostachys spp.*	Not significant	Not significant	No
Ceramax	Natamycin	Not significant	NA	No
MicroB	*Bacillus spp.*	Yes	Not significant	No
Extract-1	extracts from plants and bacteria & micronutrients	Yes	Not significant	Yes, but not always
AbioK	plant nutrients, including K	Not significant	No	No
AbioChit	Chitosan	Not significant	NA	No
Biostim	Microbial (unknown)	Not significant	NA	No
Biostim + AMF	Unknown + AMF	Not significant	NA	No
Vinegar	Acetic acid	Not significant	NA	Yes
Coconut oil	?	No	NA	Yes
Sunflower oil	?	No	NA	No
European Gall	?	No	NA	No
Extract-2	Plant extract	Not significant	No	No
Sufrostar	Elemental Sulphur	Not significant	Yes	No
Ginger powder	?	No	NA	No

Table 1: result seed treatments against common bunt and snow mold. "Yes" indicates significance difference observed in 2 or more trials. "Not significant" indicates that the product showed reduction, but not significant, or in only one trial. Significant difference by Anova + Tukey's test (α=0.05).

Seed treatments to disinfect seeds infected by seed-borne pathogens (LiveSeeding project, EU-funded)

Validation trials with candidate seed treatment products identified in previous projects were conducted at seed companies facilities (Sativa Rheinau, Oikos Seeds, and Bingenheimer Saatgut) by using naturally infected seeds:

Product	Composition	Target Pathogen/Crop	Control treatment
Koncia KMS1943	*Bacillus sp. + Trichoderma sp. + Glomus sp.*	*Alternaria brassicicola* / kale	HDB 65° 90s
		Alternaria dauci / carrots	HDB 65° 90s
		Xanthomonas campestris / kale	HDB 65° 90s
		Xanthomonas euvesicatoria / pepper	HDB 65° 90s
Koncia XP200EV	*Streptomyces sp. + Pseudomonas sp. + Glomus sp.*	*Alternaria brassicicola* / kale	HDB 65° 90s
		Alternaria dauci / carrots	HDB 65° 90s
		Xanthomonas campestris / kale	HDB 65° 90s
		Xanthomonas euvesicatoria / pepper	HDB 65° 90s
CH193EV	Chitosan based	*Xanthomonas campestris* / kale	HDB 65° 90s
		Xanthomonas euvesicatoria / pepper	HDB 65° 90s
MicroF	*Bacillus amyloliquefaciens*	*Cercospora beticola* / beetroot	HDB 68° 120s
MicroA	*Clonostachys sp.*	*Tilletia caries* / wheat	HDB 68° 180s
MicroB	*Bacillus sp.*	*Tilletia caries* / wheat	HDB 68° 180s

Table 2: Products tested as seed treatments to sanitize naturally infected seeds. HDB = Hot steam treatment, used as control treatment.

Figure 5: Pictures of the equipment used for seed coating (A) and soaking (B), and of seed germination test to evaluate germination capacity and speed (C). Images provided by Sativa Rheinau.

Results seed sanitation tests

Microbial adhesion to seeds was significantly higher by coating, using maltodextrin as adjuvant, than by soaking for the Koncia products (Figure 6).

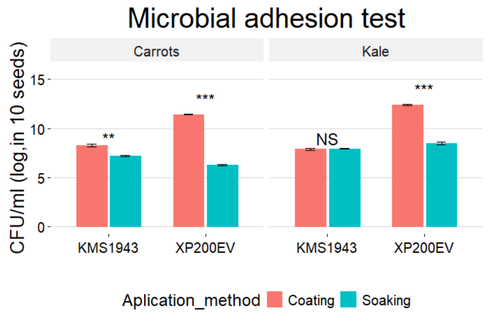

Figure 6: Comparison of bacteria recovered from seeds treated by soaking or by coating (maltodextrins as adjuvant). Statistical significance by Wilcoxon test, **p<0.001, ***p<0.0001.

Significant reduction of *A. brassicicola* on kale seeds by KMS1943 and XP200EV (Figure 7A), but no effect against *A. dauci* on carrot seeds (Figure 7B). Also reduction of *X. campestris* levels on kale seeds by all products tested, but only KMS1943 soaking is significant (Figure 7C). No significant reduction of *C. beticola* levels on beetroot seeds by MicroF (Figure 7D). Significant reduction of *T. caries* on wheat seeds by MicroA (Figure 7E). No negative effect on seed germination by any of the products tested.

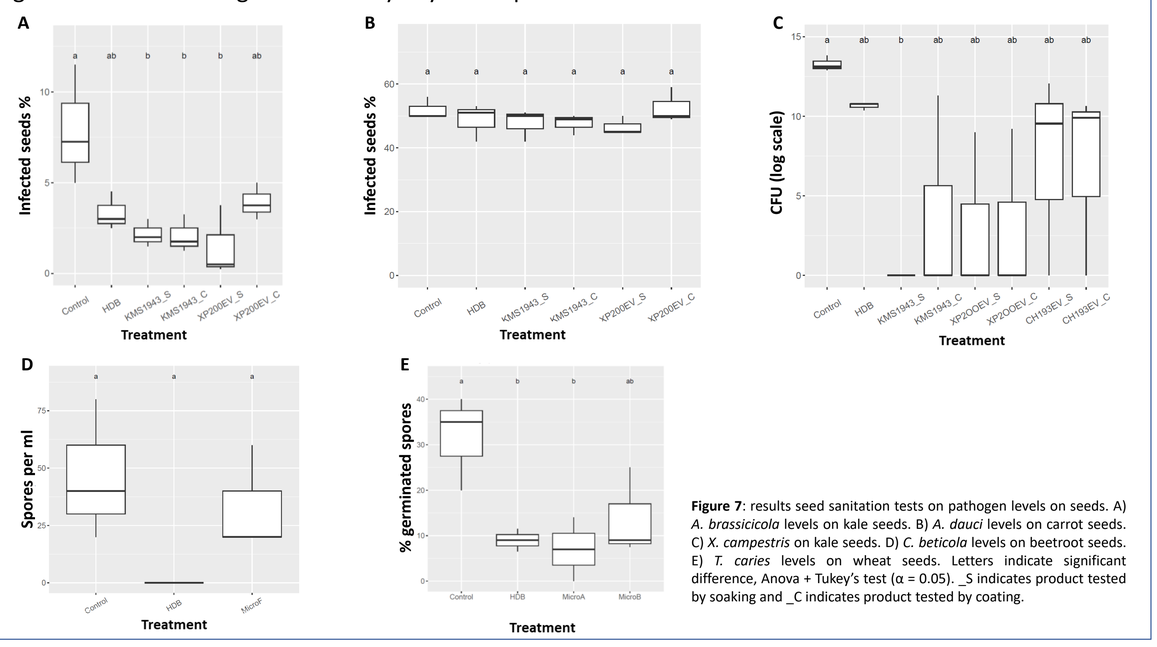

Figure 7: results seed sanitation tests on pathogen levels on seeds. A) *A. brassicicola* levels on kale seeds. B) *A. dauci* levels on carrot seeds. C) *X. campestris* on kale seeds. D) *C. beticola* levels on beetroot seeds. E) *T. caries* levels on wheat seeds. Letters indicate significant difference, Anova + Tukey's test (α = 0.05). _S indicates product tested by soaking and _C indicates product tested by coating.

Conclusions

- New protocols have been developed to test seed treatment products against soil infections by *T. caries* and *M. nivale.*
- Promising seed treatments have been identified that provide protection both from soil infections and/or from seedborne pathogens. The products vary on efficacy among pathosystems. In some cases the efficacy is higher than the control treatment.

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