ORGANIC SEED DISINFECTION

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INTRODUCTION

Seed disinfection can be a valuable tool for many producers, including field crop farmers, market gardeners, and sprout producers. Although the majority of microorganisms on seeds have a neutral or positive effect on plants, some can cause disease. Seedborne diseases can affect germination, growth, and yield of the crop. For sprout producers, however, food safety is top of mind since poor management of sprouts has been linked with foodborne diseases, such as *E. coli* O157:H7, *Listeria*, and *Salmonella*.

For organic producers, having clean seed is particularly important because if a crop becomes infected with a seedborne disease it will delay growth, competitiveness and productivity of the crop. Organic producers are also limited in their options to control the disease because they can't rely on the synthetic pesticides commonly used in non-organic production. However, the choice of methods to disinfect seeds organically is also limited and the rate of contamination of organic seed can be high (See resources). For example, in Denmark, about half of all seed lots destined for organic use have been discarded because of high levels of seed-borne disease[i].

OSC RESEARCH: DISINFECTING SEEDS FOR SPROUT PRODUCTION

In 2013, as part of the Organic Science Cluster 2, a team of researchers led by Dr. Siyun Wang of the University of British Columbia (UBC) evaluated organic seed disinfectants.

They focussed on controlling human pathogens in seed used to produce sprouts. The scientists partnered with Eatmore Sprouts and Greens, a certified sprout operation in BC to find a way to inhibit *Salmonella enterica, Listeria monocytogenes, and E. coli 0157:H7.*

The team investigated various combinations of methods, such as hot water followed by, or mixed with, acetic acid and/or hydrogen peroxide (H_2O_2). **They found that a mixture of hydrogen peroxide, acetic acid, and hot water was more successful at disinfecting seeds than chlorine.**

The method not only addresses concerns about food safety but also leads to improved germination rates, faster growth, and higher quality of sprouts. This seed treatment can potentially be adopted by vegetable and field crop growers to improve crop germination and emergence. This may boost yields because crops that emerge quickly in even stands are more likely to establish well and outcompete weeds.

Unfortunately, one type of seed treatment does not work on all types of seeds without negative effects on germination rates. By adjusting the water temperature, soaking time, and concentrations of acetic acid and hydrogen peroxide, the seeds could be disinfected without being damaged. In a second phase of research, the scientists specified the optimal treatments for three species commonly used in sprout production.

Alfalfa seeds: soak in 50˚C water for 10 minutes then soak in a mixture of 2% H_2O_2 (prepared from 30% solution) and 0.1% acetic acid (prepared from 5% distilled white vinegar) for 10 minutes.

Radish seeds: soak in 55˚C water for 10 minutes then soak in a mixture of 4% H_2O_2 and 0.2% acetic acid for 10 minutes.

Mung beans: soak in 60˚C water for 20 minutes then soak for 15 minutes in a mixture of (i) 4% H_2O_2 and 0.2% acetic acid or (ii) 1% acetic acid.

MAKING A DILUTED SOLUTION

If you want to dilute one bottle of a concentrated solution with water to form a diluted solution of a specific strength, use the following formula:

(% concentration of concentrated solution / % concentration of the desired diluted solution) x volume of concentrated solution = total volume of diluted solution

If you have a concentrated solution and want to add water to create a diluted solution of a specific strength, use the following formula:

((% concentration of concentrated solution / % concentration of the desired diluted solution) x initial volume of concentrated solution) – initial volume of concentrated solution = volume of water to be added to create the diluted solution

The study successfully identified and verified an organic method to effectively disinfect seeds. Although the treatment was aimed at controlling human pathogens, it also destroyed plant pathogens, thereby leading to improved germination rates, sprout health, and yields. Soaking seeds in warm water also helps to soften seeds and stimulate germination, particularly for 'hard' seeds.

Carmen Wakeling, co-owner of Eatmore Sprouts and Greens, explained that the treatment led to an increase in alfalfa sprout yields by 25-43%. Before using the treatment, one pound of seed would produce seven to eight pounds of alfalfa sprouts. Now, one pound of seed produces ten pounds of sprouts. Also, after using the treatment, they no longer have patches of rot in their sprout trays, and the whole sprouting process from seed to marketable product is shorter. The OSC researchers are continuing to explore more options for sprout producers.

Carmen Wakeling, co-owner of Eatmore Sprouts and Greens (Photo by Karen McKinnon)

WHY DISINFECT SEED?

- **Reduce plant disease**. Many bacterial and fungal plant diseases are seedborne. By disinfecting the seed, growers can reduce or even eliminate the incidence of such diseases, including aster yellows, Anthracnose, Alternaria, Ascochyta blight, Ascochyta blight, bacterial blight, bacterial canker, Botrytis (grey mould), bunt, ergot, Fusarium wilt, scald, Sclerotinia (white mould), Septoria, and smut.

- **Improve food safety**. Seed can be a reservoir for human disease-causing organisms, including *E. coli* O157:H7, Listeria, and Salmonella. The potential risk of transmitting disease from the seed to the consumer is particularly high in sprouts, where sprouting conditions are conducive to microbial growth and consumers are actually consuming the seed. Disinfecting the seed creates a safer food product.

- **Improve crop quality and yields**. Disinfected seeds have been found to have greater germination rates and faster emergence than non-disinfected seeds. This can lead to faster growth, greater competition with weeds, and potentially higher yields.

However, there are potential disadvantages to disinfecting seeds used in crop production. Seed treatments can impair germination, particularly if the recommended procedure for that species is not followed, and can reduce the longevity of seed.

Seed is a reservoir for a variety of microbes; some of these may inhibit root diseases or facilitate symbiotic interactions with soil fungi that improve access to soil nutrients and water. In the process of killing pathogens, beneficial microorganisms will be killed. Microbial biodiversity may have important benefits for organic growers and seed disinfection might be best used for seeds that are likely to be carrying pathogenic microbes. Growers can send seed samples to seed testing labs to learn about the seed's germination rate and disease load.

To reintroduce beneficial microorganisms, growers can 'bioprime' disinfected seed using compost tea or commercial inoculants containing mycorrhizal fungi, plant growth promoting rhizobacteria (PGPR), *Bacillus subtilis*, or other beneficial microbes[ii] .

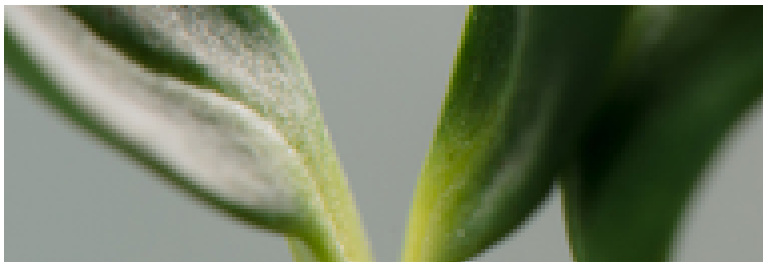
WAYS TO DISINFECT SEED

Conventional growers and seed companies often use a concentrated chlorine solution to disinfect seed. However, organic farmers are restricted to the products in the Permitted Substances List (specifically substances in Table 4.2 (Column 2) or Table 7.3 of CAN/CGSB-32.311). Bleach, in the form of sodium hypochlorite, is permitted in organic production but only if the levels do not exceed the maximum levels for safe drinking water, concentrations too low to effectively disinfect seeds. Common organic seed disinfectants include hot water, hydrogen peroxide, acetic acid, and essential oils (Table 1).

Table 1: Crop Specific Seed Treatments

Method	Suitability	Crops
Hot water treatment	High	Many small-seeded vegetables, particularly brassicas, carrots, tomatoes, peppers.
	Moderate	Celery, lettuce, spinach; cereals
	Low	Large-seeded vegetables including peas, beans, cucurbits, corn, beets; pulses
Hot water + hydrogen peroxide + acetic acid	High	Sprouting seeds and likely effective on many small-seeded vegetables and cereals
Essential oils/extracts	Varies depending on the disease	A wide range of vegetable and field crops.
Hydrogen peroxide, acetic and other acids	Varies depending on the disease	A wide range of vegetable and field crops.
Phages	High	A wide range of vegetable and field crops.
Compost tea	High	A wide range of vegetable and field crops.
	Inappropriate	Sprouting seeds

"Suitability" reflects efficacy of controlling pathogens without adverse effects on crop germination.



Hot Water Treatment

Hot water treatment is a traditional way to control seedborne diseases, particularly bacterial pathogens, but also certain fungal and viral diseases. Studies have found that hot water treatment reduces the incidence of various diseases including leaf stripe and smut in cereals; Septoria and Alternaria in a variety of crops; and Stemphylium leaf spot, Cladosporium leaf spot, and Verticillium wilt in spinach. For vegetables, hot water treatment is particularly effective on brassicas, carrots, tomatoes, and peppers, and somewhat effective on celery, lettuce, and spinach.

Hot water seed treatment is often not recommended for peas, beans, cucurbits, corn, and beets. Seed treated with hot water should be used within a year since the process reduces long-term viability.

While hot water can kill pathogens, it can also reduce the viability of the seed. The temperature of the water and the duration of the treatment is critical - and the ideal method varies with the species (see Table 2). Seed treated with hot water should be used within a year since the process reduces long-term viability. An alternative to hot water treatment is the use of humid air or "aerated steam," however this requires specialized equipment.

Table 2: Crop Specific Hot Water Treatment Protocols

Crops	Hot water	
	Temp (°C/°F)	Time (mins)
Vegetables		
Brussels sprouts, cabbage, eggplant, spinach, tomato	50°C/122°F	25
Broccoli, carrot, cauliflower, Chinese cabbage, collards, cucumber, kale, kohlrabi, rutabaga, turnip	50°C/122°F	20
Cress, mustard, radish	50°C/122°F	15
Celeriac, celery, lettuce	48°C/118°F	30
Pepper	51.5°C/125°F	30
Field crops		
Barley[i] , Safflower[ii]	44.5°C/112°F	30
Bean[1],[iii]	50°C/122°F	45
Pea[2],[iv]	See footnote	
Wheat[3],[v]	55°C/131°F	10

The vegetable information is reprinted with permission from McGrath, MT et al (2016) Managing Pathogens Inside Seed with Hot Water. https://www.vegetables.cornell.edu/pest-management/disease-factsheets/managing-pathogens-inside-seed-with-hot-water/

HOT WATER SEED TREATMENT

1. Put seeds in bags made of a permeable material (muslin, cheesecloth or coffee filters stapled shut).
2. Soak seed in warm water, such as 38-43°C (100.5-109.5°F) for 5-10 minutes.
3. Put seed in hot water for the crop-specific time (see Table 2).
4. Transfer seed to cold water and let cool for five minutes.
5. Pre-dry seed (e.g., spread on screens or towels, or put in spin cycle of washing machine with no heat).
6. Unless seed is going to planted immediately, dry seed thoroughly (e.g., 29.5°C (85°F) overnight in a dehydrator or in a warm room with air circulation).

Essential oils and extracts

Applications of essential oils can inhibit certain pathogens, including Alternaria, Botrytis, and Xanthomonas campestris (which is responsible for certain types of bacterial blight, black rot and black spot in vegetables, pulses, and cereals).

Treating cabbage seed for 30 minutes with a concentration of 0.1-1.0% of certain essential oils eliminated more than 99% of seedborne bacteria and substantially reduced seedborne fungi [iii]. Longer exposure had no effect whereas higher concentrations reduced germination rates. The most effective essential oils were those from thyme, oregano, cinnamon, and cloves.

Garlic extract has effectively reduced seedborne bacteria and fungi in vegetables, wheat, and rice, and led to an increase in crop yields in Bangladesh. Mustard powder is another seed treatment that can control diseases, such as bunt and smut in cereals.

Organic acids

Acetic, ascorbic, and lactic acids at concentrations of 2.5% or higher can reduce the level of pathogenic bacteria on seed. [iv] Acetic acid is both readily available and safe to use. One study found that an application of 20 ml of 5% acetic acid per kg of seed led to a reduction of 92-96% of seed-borne bunt of winter wheat; higher concentrations had negative effects on germination. [v] However, another study found 20 ml acetic acid per kg seed at 20% and 35% concentrations significantly reduced barley leaf stripe and oat loose smut with only slight effects on germination from the 35% concentration. Simply soaking carrot seeds in vinegar has controlled *Alternaria dauci* effectively.

Bacteriophages

Bacteriophages are viruses that can inactivate bacteria. As described by Catherine Wong and Dr. Siyun Wang, phages "are abundant and easily located in the ecosystem, [and]…an affordable antimicrobial agent. Phages are naturally occurring, are highly specific, can self-replicate, and are generally nontoxic to humans. Due to the self-replicating nature of phages, the concept is that phages can continually reduce pathogen populations introduced on sprouts by using the pathogen as hosts." [vi] Following the Organic Science Cluster study, the UBC team found that application of bacteriophages to seeds can reduce the pathogen load of seeds, but repeated applications are necessary to ensure food safety.

Compost tea

Rather than disinfect seed, compost tea introduces beneficial microorganisms which can potentially displace, outcompete, or destroy the pathogens. Although compost tea applications are not suitable in sprout production, this may be a promising option for other crops. Compost tea seed treatments can improve germination rates, reduce damping off, and inhibit various fungal diseases that cause root rot. [vii]

CONCLUSION

OSC researchers have identified effective and safe ways to disinfect seed organically. However, it appears there is no one simple solution to organic seed disinfection. Rather, the best way to disinfect seeds may involve using a combination of techniques, such as hot water followed by hydrogen peroxide and acetic acid solutions. The ideal disinfection method varies depending on the type of seed and type of production, such as whether the seed will be planted in the field or used for sprouting.

DID YOU KNOW

- Seeds can be a vector for disease. Seedborne diseases can destroy crops and, in the case of sprouts, cause foodborne illness in humans.
- You can build your own hot water treatment system for less that $200 (US) in materials. Check out Small-Scale Cost-Effective Hot Water Seed Treatment in Resources.
- Hot water treatments can damage the seeds of cucurbits (squash, gourds, pumpkins, watermelons, etc.). Other options should be used for these crops.
- Coating wheat seed with thyme oil can make the crop more drought-tolerant. Seeds treated with thyme oil had better germination and seedling growth, which led to deep roots, better carbon assimilation, and improved nitrogen uptake, which in turn improved the crop's resilience to drought.[viii]
- Biopriming involves inoculating seed with beneficial organisms, often while hydrating seed at the same time. It can improve a plant's resistance to seedborne and soilborne diseases.

RESOURCES

1 Gatch, E. (2009) Organic Seed Treatments and Coatings. https://eorganic.org/node/749

2 Keeping Our Seeds Pathogen-Free: A Small-Scale Seed Producer's Guide to Managing Seed-borne Diseases with Dr. Lindsey du Toit. 150-minute webinar. https://youtu.be/DNub-iJXbHo

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ABOUT THE ORGANIC SCIENCE CLUSTER

organic SCIENCE CLUSTER

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