Wheat and Barley Grain Hot Air Treatment Temperatures and Durations and *Fusarium* Control on Barley. Short Report

February 2026. Report number 2-2026

Dr Charles N Merfield. MRSNZ

The BHU Future Farming Centre

Permanent Agriculture and Horticulture Science and Extension

www.bhu.org.nz/future-farming-centre

Live, like you'll die tomorrow;
Farm, like you'll live for ever.

Disclaimer

This report has been prepared by The BHU Future Farming Centre, which is part of The Biological Husbandry Unit Organics Trust. While every effort has been made to ensure that the information herein is accurate, The Biological Husbandry Unit Organics Trust takes no responsibility for any errors, omissions in, or for the correctness of, the information contained in this paper. The Biological Husbandry Unit Organics Trust does not accept liability for error or fact or opinion, which may be present, nor for the consequences of any decisions based on this information.

Copyright and licensing

Citation Guide

Merfield, C. N. (2026). Wheat and barley grain hot air treatment temperatures and durations and *Fusarium* control on barley. Short report. Report number 2-2026. The BHU Future Farming Centre, Lincoln, New Zealand. 7.

1. Introduction

Fusarium is a large and diverse genus of fungi some of which are plant pathogens. This includes a range of species that infect cereal grains, i.e., are seed borne pathogens. For decades infected grain has been treated with synthetic agrichemicals fungicide treatments, which have been largely effective. However the number of fungicides is increasingly restricted through legislation and customer pressure coupled with evolved resistance. Non-chemical means of treating *Fusarium* and other seed borne pathogens are therefore becoming increasingly important.

Heat treatment of crop seeds was widespread before the advent of agrichemical based fungicides in the 1950s (Merfield, 2006). With the challenges facing fungicides the use of heat treatment is again becoming more common. Heat treatment of *Fusarium* infected cereal grains could potentially be an effective treatment.

Merfield (2006) used hot water to successfully treat carrot seed for *Alternaria* infection. However, cereals lack the hard seed coat of dicotyledons which makes them largely waterproof over short durations, e.g., < 60 minutes, such that cereals could absorb too much water during hot water treatment. Cereal grains are also much larger than carrot and many other vegetable seeds, such that the volumes of hot water required for water bath based batch treatments would be very large. Further the value per kilogram of cereal grain is vastly lower than vegetable seed, meaning the energy used and the cost of that energy, would have to be much lower to economically treat cereal grain.

One potential approach could be to use hot air instead of hot water and use two counter-flow heat exchangers in series, one to heat the grain up, the second to cool it back down and recover the heat into the air which can then be recycled. This approach of heating and then immediately cooling is also beneficial in allowing more precise control of amount of heat the seed or grain is exposed to. As counter flow heat exchangers can achieve very high efficiencies this could be an exceptionally energy efficient system. This approach was also explored for heating soil to kill the intrarow soil weed seedbank in (Merfield, 2012a, 2012b, 2013).

Therefore, a simple, non-replicated pilot study of the effect of hot air on wheat and barley grains was undertaken, to determine optimum treatment temperature × duration. Then barley grain with high levels of *Fusarium* was hot air treated to see if *Fusarium* levels could be reduced.

2. Methods

Wheat and barley grain was obtained from The Foundation for Arable Research (FAR www.far.org.nz) in May 2025 that had been collected from field trials and was considered to have low grain borne pathogen levels. A hot air treatment system using heat guns and an insulated retort with removable fine wire baskets as described in (Merfield, 2013) was used to heat treat the grain. Grain was treated in 100 g batches that created a layer of grain about 1 cm thick across the whole bottom of the basket such that all grain received the same heat treatment and bypass flow was minimised. Immediately after treatment grain was cooled down by placing in a cooling system using a vacuum cleaner to draw ambient air at volume through the grain in the treatment basket as described in (Merfield, 2013).

In experiment one on 2025-04-03 treated both barley and wheat grains at 200°C at time durations of 0 (null control) 10, 20, 30, 60, 100 and 180 seconds. After mixing, a one hundred grain sub-sample was removed from the 100 g batches of treated grain. These were placed in a sealed moist blotter germination trays, which were kept in a heated room with a target temperature of 21°C under artificial light and indirect sunlight. Germinated grain was counted at five and eight days to give total germination. The experiment was not statistically replicated and relied on the one hundred individual grains to account for variability.

As the 200°C treatment temperature used in experiment one resulted in rapid reduction in germination as duration increased lower temperatures were tested on barley. The second experiment was undertaken on 2025-05-02 using two temperatures of 100°C and 150°C and the same treatment durations and methods as experiment one. The results from experiment one for barley were combined with these results. Again, no replication was used.

The third experiment on 2026-01-16 used barley grain considered to have high levels of *Fusarium* provided by AsureQuality in June 2025. *Fusarium* levels were tested by comparing the barley used in experiments one and two and the infected grain, using blotter trays to compare the germination and number of grains displaying the pink *Fusarium* mycelium grown. The two barley lines were also compared by sowing grains in horticultural modular propagation trays in seed raising media, i.e., each grain was sown in an individual plug to minimise cross contamination, and then kept in an unheated propagation polytunnel. Based on the results of experiments one and two, three treatment temperature × durations were used to treat the infected barley:

- Untreated control
- 100°C × 30 seconds
- 150°C × 20 seconds
- 200°C × 10 seconds

using the same methods as prior experiments. As the germination in propagation trays showed a much clearer difference than on blotters, 104 grains were taken from each treatment after mixing and placed in individual plugs in the propagation trays on grain growing media.

3. Results

Experiment 1

The results are presented in Figure 1. Germination for both wheat and barley rapidly declined to zero by 100 s treatment duration. However, there was a 16% point increase in barley germination for the 10 s treatment compared with the control. It has been suggested that the heat may of helped break residual dormancy in the barley (Drummond, J. & Straathof, J. pers. comm.).

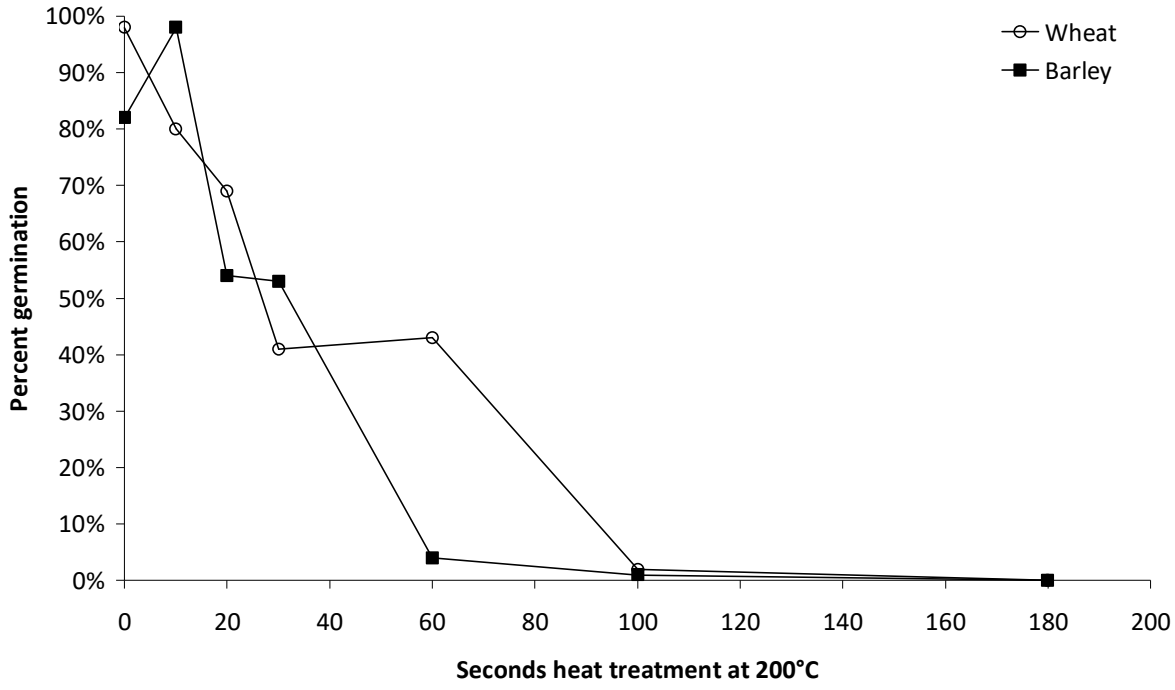

Figure 1. Results of experiment one, hot air treating wheat and barley grain at 200°C.

Experiment two

The results of experiment two are presented in Figure 2. There was a clear difference in germination between the 100°C treatment and the 150°C and 200°C treatments which followed a similar trajectory. Both new temperatures showed an initial increase in germination before decreasing as per experiment one. Again the 100°C treatment differed from the other two with having peak germination at 30 s compared with 10 s. The optimum treatment durations for barley at each temperature, i.e., maximum germination, are thus 30 s at 100°C and 10 s at 150°C and 200°C.

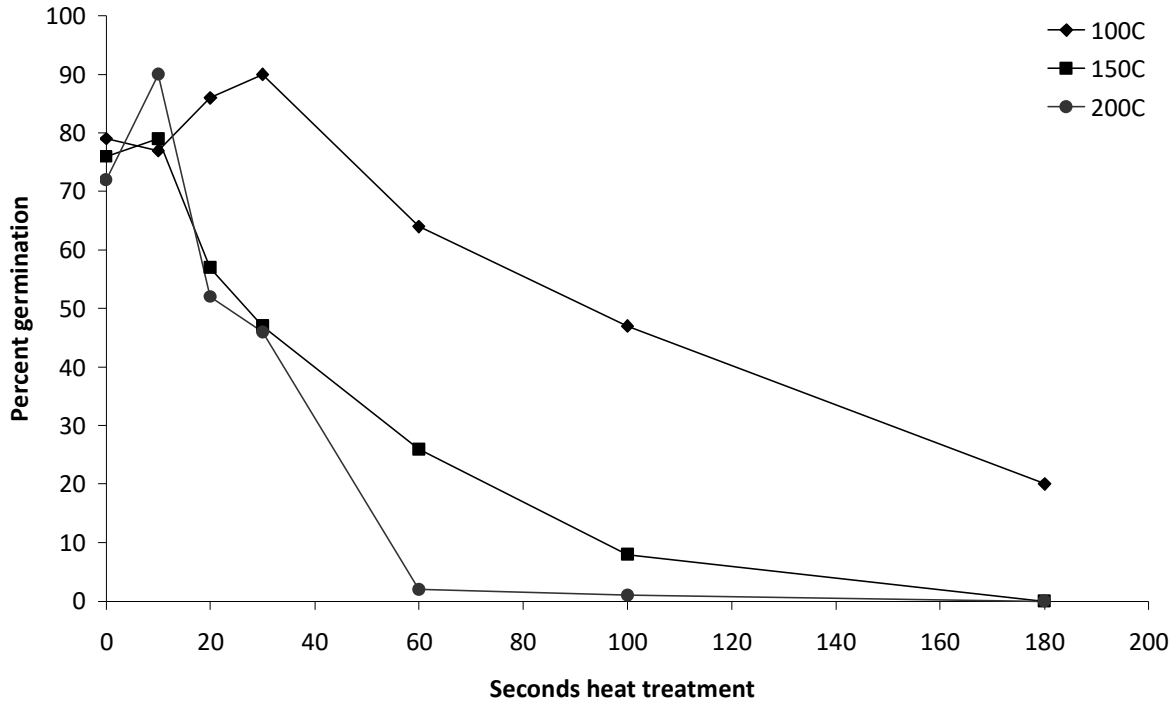

Figure 2. Results of experiment two, hot air treating barley grains at three temperatures.

Experiment 3

The blotter germination tests of the 'low' and 'high' *Fusarium* grains was 91% for low and 71% for high. The levels of *Fusarium* were 2% for low and 11% for high. While the differences between barley lines were plain, there were issues counting the number of *Fusarium* infected grains as the pink mycelium grew across the blotter. In comparison there was a very clear difference in the high and low *Fusarium* barley in the propagation trays Figure 3. Propagation trays were therefore used as a surrogate for direct measurement of *Fusarium* on individual grains. Germination in seed raising media is also closer to real-world conditions so could be considered a more accurate measure of the effect of heat treatment.

Figure 3. Barley seedlings from low (left) and high (right) *Fusarium* infected grains.

The results of the hot air treatment of the are presented in Table 1.

Table 1. Results from experiment three, treating *Fusarium* infected barley grains.

Treatment	Germ %
Control	42%
100°C × 30 s	38%
150°C × 10 s	24%
200°C × 10 s	24%

The 150°C and 200°C treatment temperatures had a large negative impact on germination with a 43% reduction in germination. Clearly the treatments did not control the *Fusarium*, rather it had a negative effect on overall germination. With just four percentage points between the 100°C treatment and the untreated control, it is unlikely the reduction would be statistically significant. However, as the aim of treatment was to improve germination through reducing *Fusarium* infestation this clearly has not happened.

4. Discussion

Experiments one and two successfully identified optimum treatment temperatures and durations for barley that did not negatively impact germination. The initial increase in germination possibly due to dormancy breaking is interesting and if heat treatment is successful it might improve field emergence. For wheat 200°C treatment resulted in a decrease in germination at all durations, thus, testing of lower temperatures, as was done for barley is considered important.

For experiment three, the reduction in germination for all heat treatments compared with the control indicates that this is not a viable treatment for grain borne *Fusarium*. The higher germination at 100°C indicates that there could be a trend and this could be identified if a larger number of temperatures were tested between 100°C and 200°C. Due to high demand on the propagation house there was a delay of approx. seven months between obtaining the infected barley grain and undertaking the heat treatment, which may have impacted the results. However, grain being stored from one season to the next could be stored for this length of time, so the delay is not unrealistic. Treatment immediately post harvest may still have a different result.

For heat treatment to be successful the seeds or grains need to have considerably higher heat tolerance than the pathogen. As grasses, barley and wheat lack the tough seed coat of the dicotyledons so they may be less tolerant of heat treatment. Ideally the pathogen is only on the seed or grain surface as that will be exposed to the heat first, be heated the longest and hottest while heating of the inside of the grain or seed is kept to a minimum. The choice of 200°C as a starting temperature is based on this logic - a high temperature, short duration treatment with immediate cooling should kill pathogens on the seed or grain surface before heat gets into the seed. In comparison, pathogens inside the seed or grain are likely to be much harder to kill as the plant embryo will also be exposed to the same heat and it is expected that it will be more likely to be harmed. As *Fusarium* does infect the inside of cereal grains (Drummond, J. pers. comm.) it appears unlikely that high temperature heat treatment will be effective. The alternative is to use much lower temperatures and longer durations, e.g., just at the start of lethal temperatures, e.g., 40 - 70°C for potentially tens of minutes, even hours, with the hypothesis being that the grain will be fully heated throughout but the embryo is just able to withstand such temperatures for such durations but the *Fusarium* is not. More research is therefore required.

5. Conclusions

This pilot study is indicating that cereal grains are much more susceptible to short duration high heat treatments than seeds of dicotyledons, and therefore such heat treatment is probably not a successful approach for grain borne pathogens. Low temperature long duration treatments may be effective, and should be investigated. A literature search to see if heat treatment of cereal grains has been tried before would therefore be valuable. The results also indicate that short duration high temperature treatment is unable to reduce *Fusarium* grain infection, indeed it reduced germination rates in seedling trays, so it is not a viable approach. As this initial test of heat treatment was not effective, other non-chemical grain borne pathogen treatment systems also need to be investigated.

6. References

Merfield, C. N. (2006). *Organic F1 hybrid carrot seed (Daucus carota L.) production: the effect of crop density on seed yield and quality, thermal weeding and fungal pathogen management.* PhD Thesis, Lincoln University http://www.merfield.com/research/2006/phd/index.htm

Merfield, C. N. (2012a). *Intrarow soil thermal weeding: A synthetic literature review and analysis of the potential for using hot air in place of steam*. Lincoln, New Zealand: The BHU Future Farming Centre https://merfield.com/research/2012/intrarow-soil-thermal-weeding-a-synthetic-literature-review-and-analysis-of-the-potential-for-using-hot-air-in-place-of-steam-2012-merfield-ffc.pdf

Merfield, C. N. (2012b). *Intrarow soil thermal weeding: Air and soil, heat exchange systems*. Lincoln, New Zealand: The BHU Future Farming Centre https://merfield.com/research/2012/intrarow-soil-thermal-weeding--air-and-soil,-heat-exchange-systems-2012-merfield-ffc.pdf

Merfield, C. N. (2013). *Intrarow soil thermal weeding research report: Research experiments report*. Lincoln, New Zealand: The BHU Future Farming Centre https://merfield.com/research/2013/intrarow-soil-thermal-weeding-research-report-research-experiments-report-2013-merfield-ffc.pdf