Germination in Spring Grains Treated with Organic Seed Amendments and Aerated Steam

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GERMINATION IN SPRING GRAINS TREATED WITH ORGANIC SEED AMENDMENTS AND AERATED STEAM

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Small grains are often planted early in the spring when the soil is cool and wet creating ideal conditions for soilborne pathogens. Seed-borne pathogens that cause root rot and damping-off during germination and early seed growth, can often be prevented by treating seeds with conventional fungicides. Organic production does not allow conventional fungicide seed treatments and organic approved seed treatments may help farmers establish better stands of crops. The goal of this project was to compare the impact of various seed protectants and treatments on germination rates of spring wheat and barley.

MATERIALS AND METHODS

August 2017 Trial

Spring wheat seeds (var 'Prosper') (Albert Lea Seed House, Albert Lea, MN, 2016) were treated on 8-Aug 2017 with six organic biofungicide seed treatments, which included white mustard, skim milk power, aerated steam, K5 and K5AS2, (New York Advanced Biological Marketing, ABM, Geneva, NY) and an untreated control. K5 and K5AS2 are two proprietary seed treatment products in development by ABM. K5 includes strains of *Trichoderma* and K5AS2 contains strains of *Trichoderma* and *Bacillus*. There were four replicates (Table 1).

Table 1. Organic seed amendment germination trial specifics, 2017.

	UVM Greenhouse
Prosper spring wheat treatment date	8-Aug
Prosper spring wheat planting date	9-Aug
Robust spring barley treatment date	16-Aug
Robust spring barley planting date	18-Aug
Replications	4
Seeds per replication	50
Potting medium	Sungro Professional Growing Mix

The aerated steam treated seeds were treated at 65°C by High Mowing Organic Seeds (Wolcott, VT) for 90 seconds in 1" deep trays. After steam treatment, the seeds were dried to their original moisture over a period of 1 hour in a dehydrator at 30°C. The skim milk treatment consisted of 1.3g skim milk powder (Organic Non-fat Dry Milk Powder, NOW Foods, Bloomington, IL) for 10 g seed per 10 ml water. The mustard treatment (*Brassica hirta, or Sinapis alba*) consisted of 10 g mustard per 1000 g seed per 1000 ml water. The K5 treatment consisted of 0.19 ml per 454 g seed (1 lb seed) per 10 ml water. The K5S2 treatment consisted of 0.19 ml K5AS2 per 454 g seed (1 lb seed) in 10 ml water, as recommended by ABM. After treatment, the 50 seeds were spread on paper towels to dry for 24 hours. Water used in the seed treatments was distilled, sterile water. Aerated steam treated seeds and the non-treated control were also suspended in water before being spread to dry. Treatment concentrations, when applicable, are shown below in Table 2.

Table 2. Organic seed treatment concentrations, 2017 and 2018.

#	Treatment	Treatment concentration
1	White mustard (*Sinapis alba*)	10g/1000g seed/1000ml H_2O
2	Skim milk powder	1.3g/10g seed/10ml H_2O
3	Aerated steam	Steamed at 65°C
4	K5	0.19ml/454g seed/10ml H_2O
5	K5AS2	0.19ml/454 seed/10ml H_2O
6	Untreated control	N/A

50 seeds per replicate were planted on 9-Aug 2017 into Sungro Professional Growing Mix in 128 cell trays of 8 x 16 in the UVM Main Campus Greenhouse in house #6. The temperature was 68-74°F during the day, and 60-64°F at night, with a 15.5 hour photoperiod. Seed germinations were counted for 5 days by counting the number of sprouts. The percent germination as of day 5 was used for analysis. Seeds were marked with toothpicks when they were recorded as germinated to prevent seeds from being counted more than once. The trial was repeated with spring barley (var 'Robust') (Albert Lea Seed House, Albert Lea, MN, 2016) which were treated on 16-Aug 2017 and planted 18-Aug 2017.

February 2018 Trial

The second germination trial took place in February 2018 with a higher number of seeds per replication. The same seed source was used. The steam treatment methods above were repeated (Table 2) while the amount of the replications, length of trial, the amount of seeds per replication, and the potting media were altered. The potting media used was Fafard® #2 potting mix. Spring barley (var 'Robust') seeds were planted in UVM Greenhouse house #7 on 9-Feb 2018 (Table 3). There were 5 replications of 72 for 5 of the 6 treatments, except for the aerated steam treatment, which was 4 replications of 72 due to a shortage of aerated steam treated 'Robust' barley. On 16-Feb 2018, the non-germinated seeds were counted (the 7th day of the trial) and the trial was terminated. The methods were repeated with spring wheat seed (var 'Prosper'), which were planted on 16-Feb 2018 in UVM Greenhouse house #7 in 5 replications of 72 seeds per treatment. Greenhouse temperature for both spring barley and spring wheat was 70-75°F during the day and 60-64°F at night, with a 16-hour photoperiod.

Table 3. Organic seed amendment germination trial specifics, 2018.

	UVM Greenhouse
Robust spring barley planting date	9-Feb
Prosper spring wheat planting date	16-Feb
Replications	5*
Seeds per replication	72
Potting medium	Fafard® #2 potting media

*With the exception of the spring barley aerated steam treatment, which had 4 replicates.

Data from the 2017 trial were analyzed with a one-way analysis of variance (ANOVA) with JMP (JMP®, Version 13. SAS Institute Inc., Cary, NC, 1989-2019). Mean comparisons were made using the Least Significant Difference (LSD) procedure where the F-test was considered significant at $p<0.05$. Data from the 2018 trial were analyzed using a general linear model procedure of JMP (JMP®, Version 13. SAS Institute Inc., Cary, NC, 1989-2019). Mean comparisons were made using Tukey's Honest Significant Difference (HSD) to find the least significant differences where the F-test was considered significant at $p<0.05$.

Variations in project results can occur due to variation in genetics, soil, and other growing conditions. Statistical analysis makes it possible to determine whether a difference between treatments is significant or whether it is due to natural variations in the plant or field. At the bottom of each table, a LSD value is presented for each variable (i.e. germination). Least Significant Differences (LSDs) at the 0.05 level of significance are shown. This means that when the difference between two treatments within a column is equal to or greater to the LSD value for the column, there is a real difference between the treatments 95% of the time. In the example to the right, treatment C was significantly different from treatment A, but not from treatment B. The difference between C and B is 1.5, which is less than the LSD value of 2.0 and so these treatments were not significantly different in yield. The difference between C and A is equal to 3.0, which is greater than the LSD value of 2.0. This indicates the yields of these treatments were significantly different from one another. Treatments with the same letter indicate they are statistically similar, and the top yielding treatment is indicated in bold.

Treatment	Yield
A	6.0[b]
B	7.5[ab]
C	**9.0[a]**
LSD	2.0

RESULTS

August 2017 Trial

The 2017 trial results are displayed below in Table 4. The 'Robust' spring barley was noted to be vigorous during germination. The aerated steam treatment had the highest germination percentage of all the treatments (99.0%). Although it was not significantly different from the control (96.5%), the aerated steam treatment performed significantly higher than the skim milk powder (95.5%) and K5 (90.0%). K5 had a significantly lower germination rate than all other treatments. While there were significant differences between germination rates for 'Robust' spring barley ($P = 0.0010$), 'Prosper' spring wheat treatments were statistically similar ($P = 0.6658$) to each other.

Table 4. Spring barley and spring wheat germination results, August 2017.

Treatment	Spring barley germination %	Spring wheat germination %
White mustard (*Sinapis alba*)	96.5^{ab}†	96.0
Skim milk powder	95.5^{b}	**98.0**
Aerated steam	**99.0^{a}**	97.0
K5	90.0^{c}	96.0
K5AS2	96.5^{ab}	**98.0**
Untreated control	96.5^{ab}	97.5
LSD (0.05)	2.83	NS
Trial Mean	95.7	97.0

†Treatments within a column with the same letter are statistically similar. Top performers are highlighted in **bold**.
LSD – Least significant difference.
NS- Not significant.

February 2018 Trial

In the 2018 trial, the spring barley treatments again showed significant differences between the seed treatments (P = 0.0215) while the spring wheat treatments were statistically similar (P = 0.9188). The spring barley aerated steam treatment (92.0%) was significantly higher than the skim milk powder, K5 (78.6%) and K5AS2 (78.9%) but was statistically similar to the white mustard (80.8%) and the control (80.8) (Table 5).

Table 5. Spring barley and spring wheat germination results, February 2018.

Treatment	Spring Barley Germination %	Spring Wheat Germination %
White mustard (*Sinapis alba*)	80.8^{ab}†	96.1
Skim milk powder	79.2^{b}	95.8
Aerated steam	**92.0^{a}**	96.7
K5	78.6^{b}	95.8
K5AS2	78.9^{b}	**97.5**
Untreated control	80.8^{ab}	96.1
LSD (0.05)	11.2	NS
Trial Mean	81.7	96.3

†Treatments within a column with the same letter are statistically similar. Top performers are highlighted in **bold**.
HSD- honest significant difference from Tukey LSD.
NS- Not significant.

DISCUSSION

In both 2017 and 2018, the aerated steam treatment consistently had the highest germination rates in the spring barley and outperformed the skim milk powder and K5. While the top-performing treatments did not differ from the control, the results of these trials indicate that spring barley treated with skim milk powder and K5 may have decreased germination rates in comparison to other organic biofungicide treated seed or untreated seed. The lack of significant differences between spring wheat treatments in both trials suggests these methods of preventing seedborne pathogens with organic seed amendments and aerated steam treatments are less impactful on spring wheat germination.

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