Project No. R23033P
Date: May 2, 2025
Humboldt, Saskatchewan

Influence of Seed Moisture Content and Fan Speed on Air Seeder Damage of Dry Bean

TECHNICAL REPORT

Submitted To: **Manitoba Pulse and Soybean Growers**
Winnipeg, Manitoba

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ACKNOWLEDGEMENTS

Funders:

- Manitoba Pulse & Soybean Growers (MPSG)
- Funded in part by the Governments of Canada and Manitoba under the Sustainable Canadian Agricultural Partnership, a federal-provincial-territorial initiative.

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1. EXECUTIVE SUMMARY

In air-seeding operations, dry bean seed is susceptible to mechanical damage, which can markedly decrease germination rates and seedling vigor, ultimately compromising crop yield and quality. Two operator-adjustable parameters – seed travel speed, as governed by the air-seeder's fan settings, and seed moisture content – may influence the extent of this damage.

This study was conducted to evaluate the effects of moisture and air seeder fan speed on dry bean seed damage and to develop guidelines to minimize bean seed damage. Windbreaker pinto beans and Blackstrap black beans were tested at three targeted moisture levels (11%, 12.5%, and 14%) through a stationary air drill at three different target fan speeds (2,950 rpm, 3,200 rpm, and 3,850 rpm for pinto beans and 2,800 rpm, 3,000 rpm, and 3,600 rpm for black beans) for a total of nine trials per seed variety. An 18.3-m (60-ft) Bourgault Paralink Hoe Drill 3320, equipped with 254-mm (10-inch) opener spacings and paired with a 6550ST air cart was used for testing. This air seeder uses a Type-A distribution system consisting of one primary and six secondary distributors. Target simulated seeding rates were 129 kg/ha (115 lb/ac) for pinto beans and 105 kg/ha (94 lb/ac) for black beans.

For each moisture level and each fan speed trial, three composite samples were collected by combining seeds from all 72 drill openers. Each sample was tested for pure seed, germination, vigor, and seed coat damage (smoothness). A between-between 4x3 univariate ANOVA with Bonferroni correction was used for each bean variety to assess the effects of four fan-speed conditions (pre-test, low, medium, and high) and three moisture levels (low, medium, and high). Pairwise differences were also reported. Statistical significance was defined at $p < 0.05$.

Distinct patterns of significant differences were observed between fan speed and moisture content in pinto beans for both low, medium, and high moisture contents and fan speeds. Many significant differences between groups show that both seed moisture and fan speed influenced germination, vigor, and seed smoothness percentages in the pinto beans. Test outcomes infer that high moisture conditions (14%) in combination with the lowest possible fan speed (2,950 rpm) will demonstrate the lowest amount of seed damage. Even in these more ideal conditions, percentage germination and percentage vigor are still only around 70%. Increasing the fan speed to the manufacturer's recommended minimum (3,200 rpm), was found to lower germination and vigor values to around 60%, even with the high-moisture seed. Significantly poorer results were observed under conditions of increased fan speeds or reduced seed moisture contents, with some germination and vigor values as low as less than 10%.

For black beans, differences across moisture levels and fan speeds were less distinct but still provide valuable information. The combination of high moisture conditions (14%) and low-to-medium fan speeds (2,800 to 3,000 rpm) was associated with the least seed damage. Again, under these more optimal conditions, germination and vigor percentages were significantly reduced, to around 60%, while seed coat smoothness was found to be as low as 45%.

Significantly poorer results were again seen with either increased fan speeds or lower seed moisture contents.

These findings suggest that care should be taken to minimize fan speed and maximize seed moisture content when seeding dry beans with an air seeder. Bean seed should be at least 14% moisture content to minimize seed damage. Fan speed should be set as low as possible to maintain product distribution. If possible, operating at a fan speed lower than the manufacturer's recommended minimum is likely to help minimize seed damage. Furthermore, producers should adjust seeding rates to compensate for the reduced germination and vigor, even when operating under conditions that minimize seed damage.

2. INTRODUCTION

Dry bean seed is vulnerable to damage during passage through air seeders. This damage may significantly reduce germination and vigor, ultimately hindering crop yield and quality. Seed travel speed, determined by air seeder fan settings, and seed moisture content are two parameters within the producer's control that may reduce seed damage. The aim of this project is to investigate the influence of these factors (air seeder fan speed and seed moisture content) and to develop guidelines for minimizing bean seed damage.

3. TESTING METHODS

This section describes the test methods used to evaluate the effects of seed moisture content and air-seeder fan speed on dry bean condition. It includes an overview of testing parameters, followed by a description of the air-drill set-up and sampling protocols.

3.1 Testing Parameters

Two varieties of certified bean seed – Windbreaker pinto beans and Blackstrap black beans – at three targeted moisture contents were passed through a stationary air drill at three fan-speed settings (low, medium, and high) for a total of nine trials per seed variety.

The Prairie Agricultural Machinery Institute (PAMI) conditioned both seed varieties to represent three seed moisture contents. This was done by drying or adding moisture to the seed as required to reach the low (ML), medium (MM), and high (MH) moisture targets of 11%, 12.5%, and 14%, respectively. Aeration was used to condition the beans through the introduction of dry or humid air to remove or add moisture (**Figure 1**).

Figure 1. Aeration tube placed in plastic tote of pinto beans to condition product to appropriate moisture level for testing.

Three fan speeds were used for testing: the lowest speed (FL), defined as the minimum at which the distribution tubes remained clear (no plugging); the medium speed (FM), corresponding to the air seeder manufacturer's recommended minimum in the operator's manual (for the target seeding rate); and the high fan speed (FH), representing a 20% increase in speed above the manufacturer's recommended minimum. The target test seed moisture content and fan speeds are summarized in **Table 1**.

Table 1. Seed moisture contents and test fan speeds.

	Seed Moisture Contents (%)		Fan Speed Targets (rpm)		
Target Level	Pinto and Black Beans			Pinto Beans	Black Beans
Low	ML	11	FL	2,950	2,800
Medium	MM	12.5	FM	3,200	3,000
High	MH	14	FH	3,850	3,600

All variables other than seed moisture content and fan speed remained constant through all test trials. Seeding rate targets were based on plant populations of 85,000 plants per acre for pinto beans and 145,000 plants per acre for black beans (Barker, 2019). These targets were adjusted for an expected 85% seed emergence rate and then increased by 25% to account for expected seed damage when seeding with an air seeder. The thousand-kernel weight of the seed used was 416 g for the pinto beans and 200 g for the black beans. The resulting target seeding rates that were used for testing were 129 kg/ha (115 lb/ac) for pinto beans and 105 kg/ha (94 lb/ac)

for black beans. Seeding times were based on a drill width of 18.3 m (60 ft) travelling at a ground speed of 6.4 km/h (4.0 mph). A target seeding area of 0.2 ha (0.5 ac) was used, resulting in a test time of 62 seconds per trial. The total product required for each trial was 26.1 kg (57.5 lb) for pinto beans and 21.3 kg (47.0 lb) for black beans.

For each variety, nine total trials were conducted to represent each moisture content with each fan speed. The trials are listed in **Table 2**.

Table 2. Moisture content and fan speed trial breakdown for each bean variety.

Windbreaker Pinto Beans			**Blackstrap Black Beans**		
Moisture Level	**Fan Speed Level**	**Test Name**	**Moisture Level**	**Fan Speed Level**	**Test Name**
ML	FL	Pinto-ML-FL	ML	FL	Black-ML-FL
	FM	Pinto-ML-FM		FM	Black -ML-FM
	FH	Pinto -ML-FH		FH	Black -ML-FH
MM	FL	Pinto -MM-FL	MM	FL	Black -MM-FL
	FM	Pinto -MM-FM		FM	Black -MM-FM
	FH	Pinto -MM-FH		FH	Black -MM-FH
MH	FL	Pinto -MH-FL	MH	FL	Black -MH-FL
	FM	Pinto -MH-FM		FM	Black -MH-FM
	FH	Pinto -MH-FH		FH	Black -MH-FH

Following seed conditioning, three 500 g (1.1 lb) subsamples of each moisture level of each bean variety were taken for pretest evaluation of baseline pure seed, germination, vigor, and seed coat damage (soak test).

3.2 Test Equipment

An 18.3-m (60-ft), 2018 Bourgault Paralink Hoe Drill 3320, equipped with 254-mm (10-inch) opener spacings and paired with a 2011 6550ST air cart, was used to simulate machinery typical to Manitoba producers. This air seeder uses a Type-A seed distribution system in which seed initiates as a single metered stream and is then divided into sectional streams in a primary distributor and is finally further divided into individual streams for each soil-opener in secondary distributors. The drill was equipped with six secondary distributors, each servicing 12 openers for a total of 72 outlets (**Figure 2**).

Figure 2. Primary distributor (left) and secondary distributer (right) of the air seeder.

As per Bourgault's recommendation for dry beans, and with the Client's approval, the factory air-cart metering auger was removed and replaced with a new F1X Steel PDM Pro 6000 Series A/S aftermarket meter auger kit (**Figure 3**).

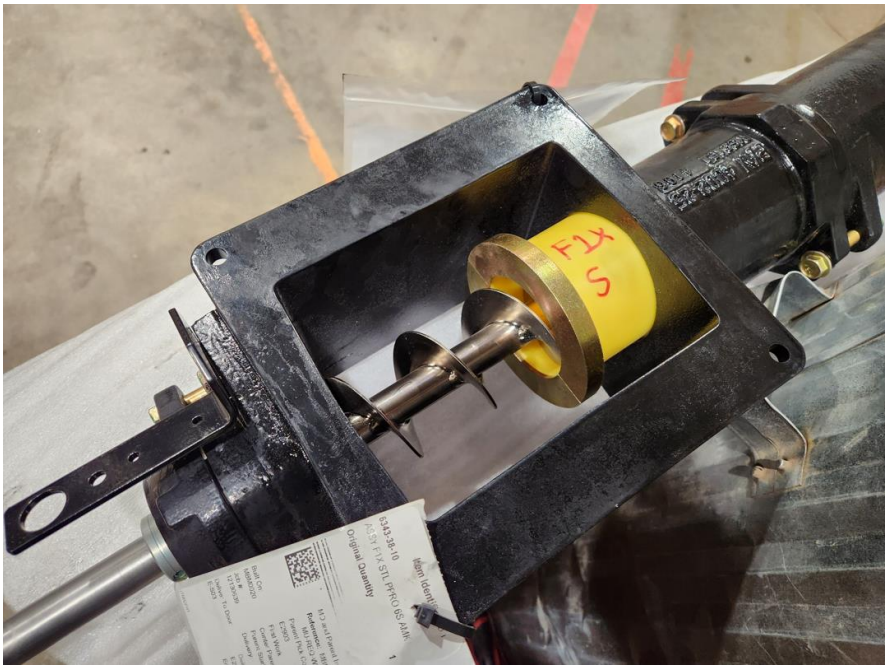

Figure 3. Bourgault F1X Steel PDM Pro 6000 Series A/S meter auger installed on air cart and used for testing.

All trials were conducted indoors with stationary equipment (**Figure 4**). The air cart's hydraulic calibration motor was used to drive the seed metering auger. Each trial simulated the seeding of 0.2 hectares (0.5 acres) at the target seeding rate and a ground speed of 6.4 km/h (4.0 mph).

Figure 4. Bourgault PHD 3320-10 toolbar with 6550ST air cart assembled in PAMI shop for testing.

To fill the air cart, while minimizing potential seed damage prior to distribution through the seeding system, the required amount of seed was lowered into the designated air-cart tank via a 20-L (5-gallon) pail suspended by two ropes (**Figure 5**).

Figure 5. 20-L (5-gallon) pail suspended with ropes (left) and filled with bean seeds being carefully lowered into the air cart to prevent any bean seed damage (right).

3.3 Sampling and Analysis

Before each trial, woven poly bags were clamped to each opener to ensure all seed is captured, while allowing air to vent through the bag and minimizing back pressure (**Figure 6**).

Figure 6. Bags clamped on individual openers to capture seed during testing.

Upon the completion of each trial, all bags were collected and their contents carefully emptied into a 65-L (17-gallon) plastic tote to create a composite sample of discharged seed (**Figure 7**). From this composite, three subsamples of approximately 750 g to 1000 g (1.6 lb to 2.2 lb) were collected per trial. If a high incidence of split or damaged beans was observed, subsample weights were increased to 1250 g (2.6 lb) to ensure adequate seed amounts for germination and vigor testing. Each subsample was photographed in-bag before being sent to Discovery Seed Lab for testing (pure seed, germination, vigor, and seed soak test).

Figure 7. Collection bag being carefully emptied into a plastic tote to ensure appropriate mixing prior to sampling.

4. RESULTS

Testing was conducted at PAMI in Humboldt, Saskatchewan, from January 10 through January 16, 2025. Results found during testing are discussed in the following subsections.

4.1 Fan Speeds, Seed Moisture Contents, and Ambient Test Conditions

The target for the low fan speed was determined through experimentation. It was set to the lowest value at which the distribution tubes throughout the drill remained clear and did not plug while continuing to meter and distribute seed at the target seeding rate and simulated ground speed. Prior to running trials, this value was found to be 2,950 rpm for pinto beans at the target seeding rate of 129 kg/ha (115 lb/ac) and 2,800 rpm for black beans at the target seeding rate of 105 kg/ha (94 lb/ac), while simulating a ground speed of 6.4 km/h (4.0 mph). During the trials at these low fan speeds, several plugged distribution tubes were observed. This may indicate that it is not feasible to operate the air seeder at these low fan speeds in the field. The target for medium fans speeds were from charts in the air seeder's operator's manual that recommend the minimum fan speed at different product application rates and ground speeds. Based on these charts, and the desired seeding rates and ground speed, the target medium fan speed was found to be 3,200 rpm for pinto beans and 3,000 rpm for black beans. The target for high fan speed was set 20% higher than the medium speed, equating to 3,850 rpm for pinto beans

and 3,600 rpm for black beans. Actual fan speeds during each test trial varied slightly from target values; actual values can be found in **Appendix A**.

Target seed moisture content for the low, medium, and high levels were 11%, 12.5%, and 14%, respectively. The seed was conditioned in six batches – low, medium, and high moisture of each pinto and black beans – with the goal of reaching the target seed moisture levels, but some variance occurred. After conditioning the beans, actual seed moisture contents for each batch of seed are shown in **Table 3.**

Table 3. Target and actual seed moisture contents of pinto and black beans.

		Seed Moisture Contents (%)		
Target Level		**Target**	**Actual – Pinto Beans**	**Actual – Black Beans**
Low	ML	11	11.1	10.4
Medium	MM	12.5	12.8	12.6
High	MH	14	14.2	14.3

Ambient conditions were relatively consistent throughout all trials, as testing was conducted indoors. Ambient temperatures ranged from 16°C to 19°C (61°F to 66°F), while relative humidity ranged from 29% to 30%. Specific conditions for each test trial may be found in **Appendix A**.

4.2 Qualitative Outcomes

Each sample was photographed prior to submission to Discovery Seed Labs to document visible seed damage (e.g., splitting, loss of seedcoat). **Figure 8** shows pinto bean samples and **Figure 9** includes black bean samples.

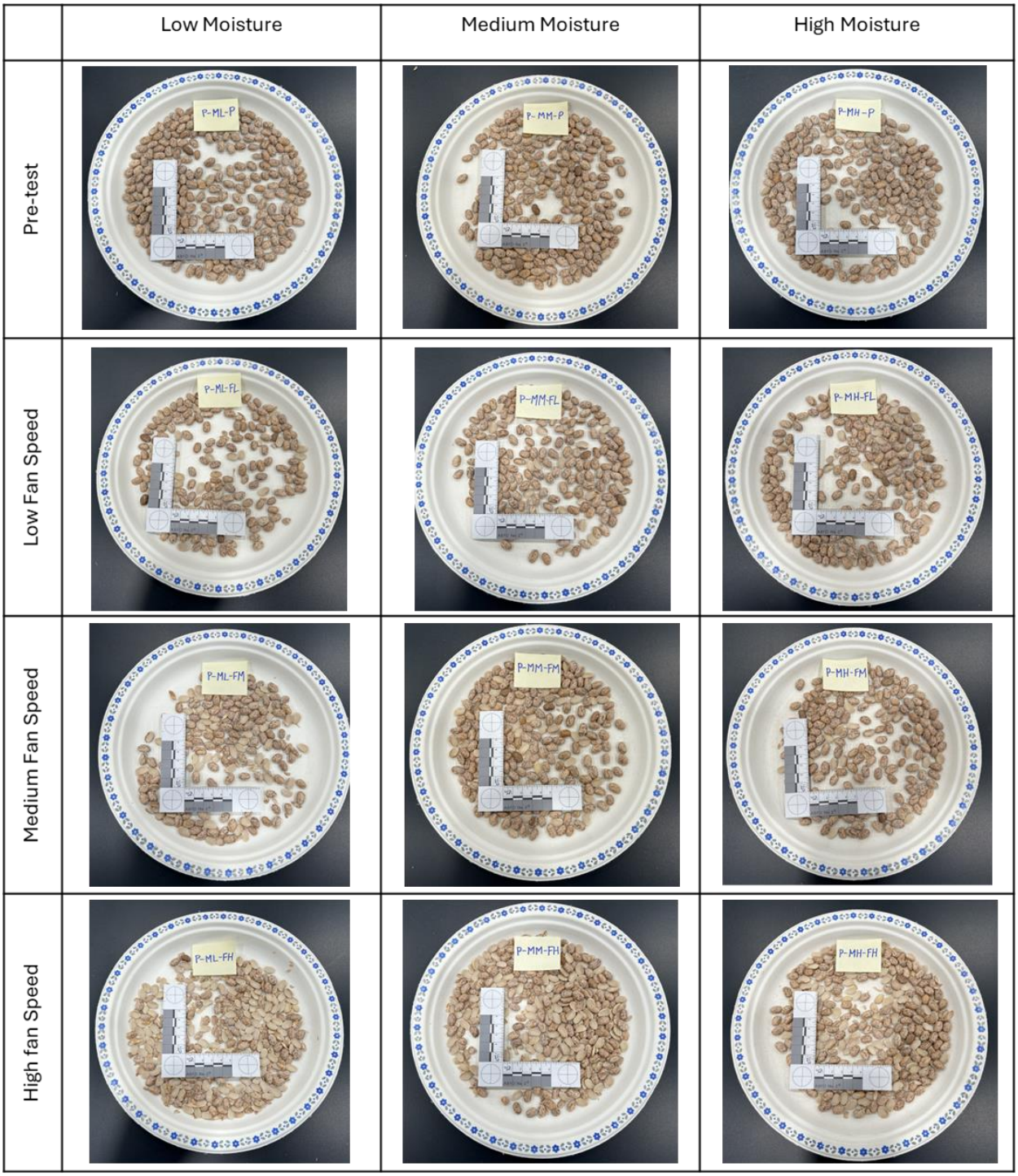

Figure 8. Representative samples of pinto beans collected from each test with columns representing low (left), medium (middle), and high (right) moisture contents and rows representing pre-test samples (top), low fan speed (second row), medium fan speed (third row), and high fan speed (bottom row).

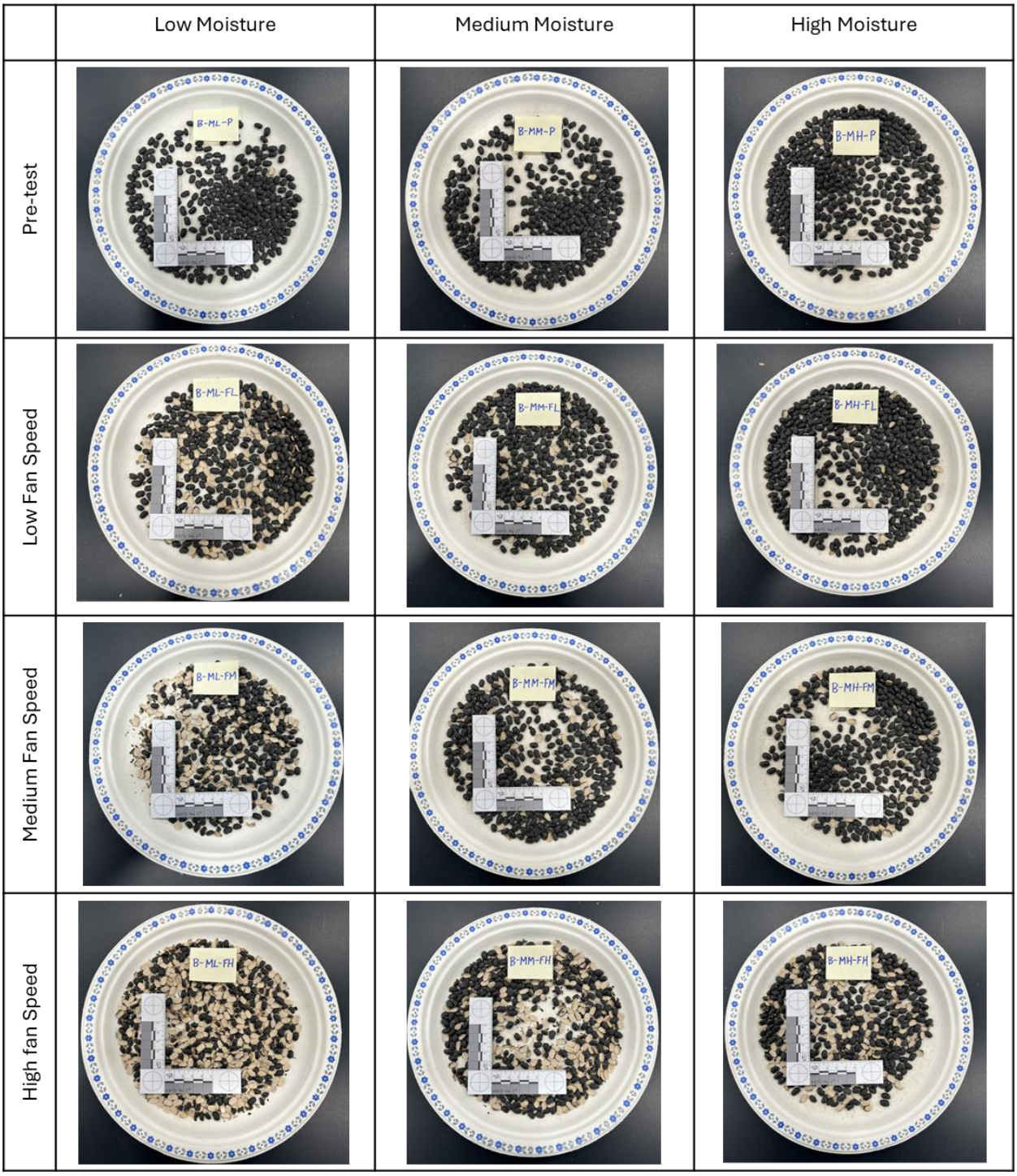

Figure 9. Representative samples of black beans collected from each test with columns representing low (left), medium (middle), and high (right) moisture contents and rows representing pre-test samples (top), low fan speed (second row), medium fan speed (third row), and high fan speed (bottom row).

4.3 Seed Condition Results

Pure seed, germination, vigor, and seed coat damage (soak test) data, as received from Discovery Seed Labs, was compiled into a single dataset. Raw percentage germination,

percentage vigor, and percentage smooth seed were normalized according to the percentage of pure seed for each sample. This means that all percentage germination, percentage vigor, and percentage smooth seed data that follows is presented as a percentage of the entire sample, not just of the intact seeds. Descriptives, including mean and standard deviation, were reported for all groups and all bean types. Differences between fan speed (pre-test, low, medium, and high) and moisture level (low, medium, and high) for each bean type were evaluated using a between-between 4x3 univariate ANOVA with Bonferroni correction. Pairwise differences were also reported. The level of statistical significance was set at $p < 0.05$, and all statistical analyses were performed using SPSS 30. Interaction effects between fan speed and moisture levels are noted by parallel lines between moisture groupings across fan speed levels in the plots that follow in each section.

4.3.1 Pinto Beans

Pretest Samples

The pretest pinto bean seed samples collected from conditioned seeds were tested for pure seed, germination, vigor, and seed coat damage (smoothness). Three subsamples per moisture treatment were collected. Averages and standard deviations for all moisture conditions are presented in **Table 4**. No differences in percentage of pure seed, germination, vigor, or smoothness between any moisture contents were found.

Table 4. Mean and standard deviation of pre-test samples at all moisture levels in pinto beans.

	Pure seed (%)	Germination (%)	Vigor (%)	Smoothness (%)
Low Moisture	98.9 ± 0.3	81.8 ± 2.3	80.2 ± 4.6	97.3 ± 1.8
Medium Moisture	99.3 ± 0.3	87.1 ± 3.7	83.8 ± 2.0	93.7 ± 2.9
High Moisture	99.0 ± 0.4	81.8 ± 5.0	79.5 ± 3.9	91.1 ± 6.9

Pure Seed

Descriptives and between group comparisons for pure seed outcomes are found in **Appendix B**.

Germination

Mean and standard deviation of percentage germination between the nine trials are presented in **Table 5**. A significant interaction between the effects of fan speed and moisture level, $F(6,24) = 76.101$, $p < 0.001$ was found. There were also significant main effects between fan speeds, $F(3,24) = 107.76$, $p < 0.001$ and moisture levels, $F(2,24) = 28.61$, $p < 0.001$. Significant differences were found between all tests, with the exception of those between moisture levels in the pre-test samples and between the medium and high moisture levels at low fan speed (**Figure 10**). An interaction between fan-speed and moisture-level effects was observed across all moisture outcomes at low, medium, and high fan speed, with significant differences between groups (noted by an asterisk [*]).

Table 5. Mean and standard deviation of percentage germination outcomes in pinto beans.

	Low Fan Speed	Medium Fan Speed	High Fan Speed
Low Moisture	34.7 ± 3.0	18.9 ± 2.2	5.8 ± 0.6
Medium Moisture	58.1 ± 7.7	39.0 ± 4.7	15.4 ± 2.6
High Moisture	69.3 ± 4.0	60.6 ± 3.3	28.8 ± 3.4

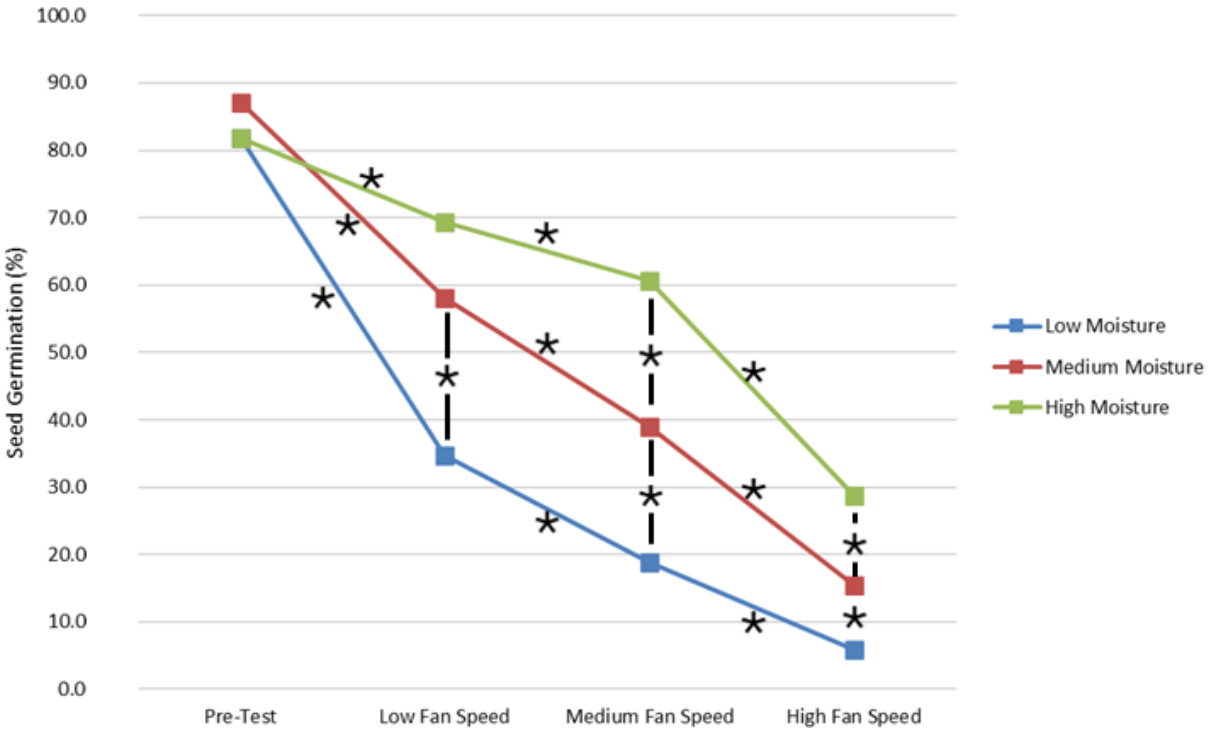

Figure 10. Mean differences in percentage germination of pinto beans between all moisture and fan speed groups. Significant differences ($p < 0.05$) are noted with an *.

Vigor

Table 6 summarizes the mean and standard deviation of percentage vigor between the nine trials. There was a significant interaction between the effects of fan speed and moisture level, $F(6,24) = 25.31$, $p < 0.001$. There were also significant main effects between fan speeds, $F(3,24) = 603.58$, $p < 0.001$, and moisture levels, $F(2,24) = 174.09$, $p < 0.001$. Significant differences were observed between all tests, all moisture levels, and all fan speeds (**Figure 11**). An interaction between fan speed and moisture level effects was observed across all moisture outcomes when evaluated at low, medium, and high fan speeds. Significant differences between groups are noted by an asterisk (*).

Table 6. Mean and standard deviation of percentage vigor outcomes in pinto beans.

	Low Fan Speed	Medium Fan Speed	High Fan Speed
Low Moisture	33.1 ± 3.7	19.2 ± 3.6	4.3 ± 1.8
Medium Moisture	56.8 ± 3.7	41.2 ± 3.5	15.0 ± 3.8
High Moisture	69.7 ± 2.7	61.5 ± 3.3	27.1 ± 2.4

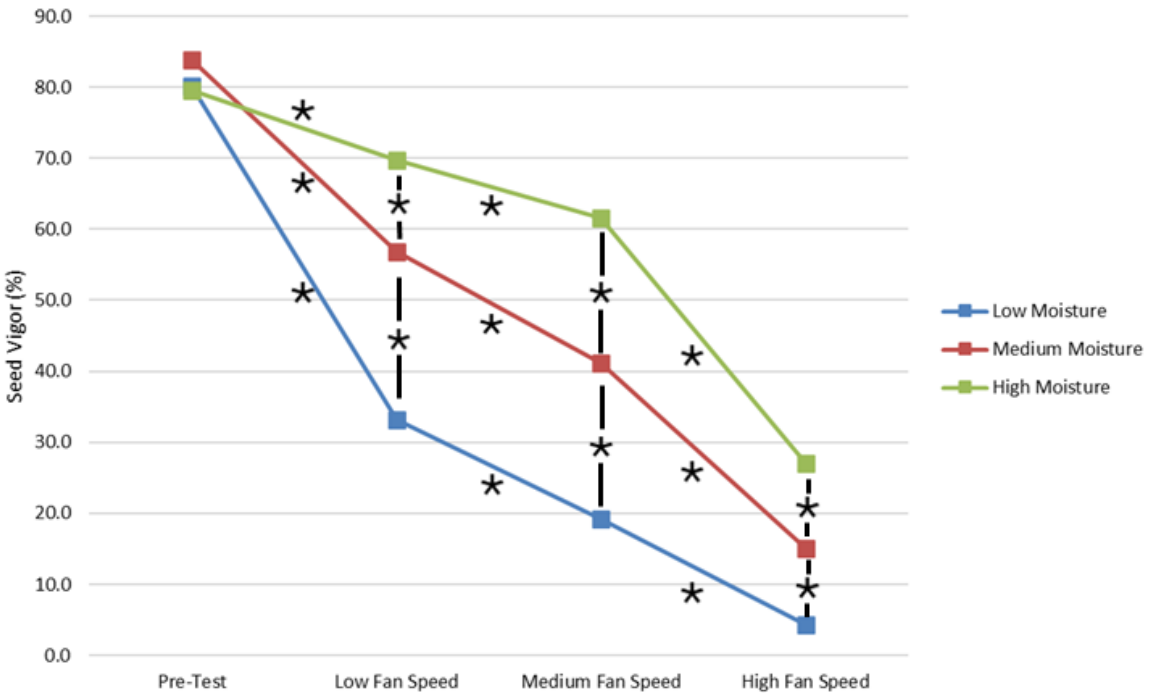

Figure 11. Mean differences in percentage vigor of pinto beans between all moisture and fan speed groups. Significant differences ($p < 0.05$) are noted with an *.

Seed Coat Damage (Smoothness)

Table 7 shows the mean and standard deviation of percentage in seed smoothness between the nine trials. There was a significant interaction between the effects of fan speed and moisture level, $F(6,24) = 15.77$, $p < 0.001$. There were also significant main effects between fan speeds, $F(3,24) = 249.05$, $p < 0.001$, and moisture levels, $F(2,24) = 59.14$, $p < 0.001$. At high moisture, there were only significant differences between medium and high fan speeds (**Figure 12**). At medium moisture, there were significant differences between pre-test and low fan speed, and medium and high fan speed, but not between low and medium fan speed. At low moisture, significant differences between all fan speeds was observed. There was also an interaction between fan speed and moisture level effects between all moisture outcomes at low, medium, and high fan speed. Significant differences between groups are noted by an asterisk (*).

Table 7. Mean and standard deviation of percentage seed smoothness outcomes in pinto beans.

	Low Fan Speed	Medium Fan Speed	High Fan Speed
Low Moisture	72.3 ± 4.7	54.7 ± 3.0	24.8 ± 2.8
Medium Moisture	76.9 ± 6.2	74.4 ± 2.1	44.5 ± 6.5
High Moisture	87.4 ± 2.9	82.6 ± 0.7	59.9 ± 2.6

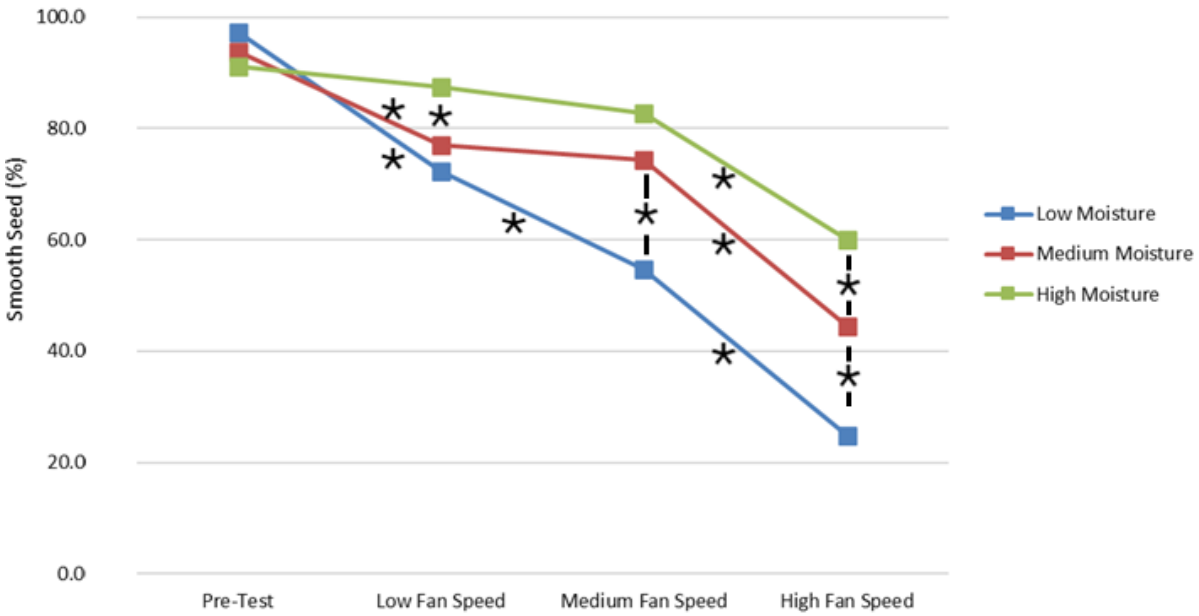

Figure 12. Mean differences in percentage seed smoothness of pinto beans between all moisture and fan speed groups. Significant differences ($p < 0.05$) are noted with an *.

4.3.2 Black Beans

Pretest Samples

The pretest black bean seed samples collected from conditioned seeds were tested for pure seed, germination, vigor, and seed coat damage (smoothness). Three subsamples per moisture treatment were collected. Averages and standard deviations for all moisture conditions are presented in **Table 8**. There were no significant differences in percentage pure seed and percentage germination between any moisture groups. There were significant differences in percentage vigor between low and medium moisture groups (p =0.023) and in percentage smoothness between low and medium moisture (p = 0.026) and low and high moisture (p < 0.001).

Table 8. Mean and standard deviation pre-test samples at all moisture levels in black beans.

	Pure seed (%)	Germination (%)	Vigor (%)	Smoothness (%)
Low Moisture	99.6 ± 0.1	85.3 ± 5.0	76.7 ± 3.7	93.9 ± 1.2
Medium Moisture	99.6 ± 0.1	94.3 ± 1.1	89.9 ± 1.1	79.7 ± 8.9
High Moisture	99.5 ± 0.6	84.9 ± 5.3	79.6 ± 5.0	69.9 ± 7.8

Pure Seed

Descriptives and between group comparisons for pure seed outcomes are found in **Appendix C**.

Germination

Mean and standard deviation of percentage germination between the nine trials are presented in **Table 9**. Significant interaction between the effects of fan speed and moisture level, $F(6,24) = 71.27$, p <0.001, were observed. There were also significant main effects between fan speeds,

$F(3,24) = 102.41$, $p < 0.001$, and moisture levels, $F(2,24) = 24.56$, $p < 0.001$. There were significant differences between all tests except between low fan speed and medium fan speed across all moisture levels, and between medium moisture and high moisture at medium fan speed (**Figure 13**). There was also an interaction between fan speed and moisture level effects between all moisture outcomes at low, medium, and high fan speed. Significant differences between groups are noted by an asterisk (*).

Table 9. Mean and standard deviation of percentage germination outcomes in black beans.

	Low Fan Speed	Medium Fan Speed	High Fan Speed
Low Moisture	27.0 ± 4.3	18.3 ± 4.8	6.1 ± 1.8
Medium Moisture	48.5 ± 8.1	37.9 ± 3.5	15.6 ± 1.6
High Moisture	66.2 ± 2.6	55.9 ± 11.0	30.2 ± 5.8

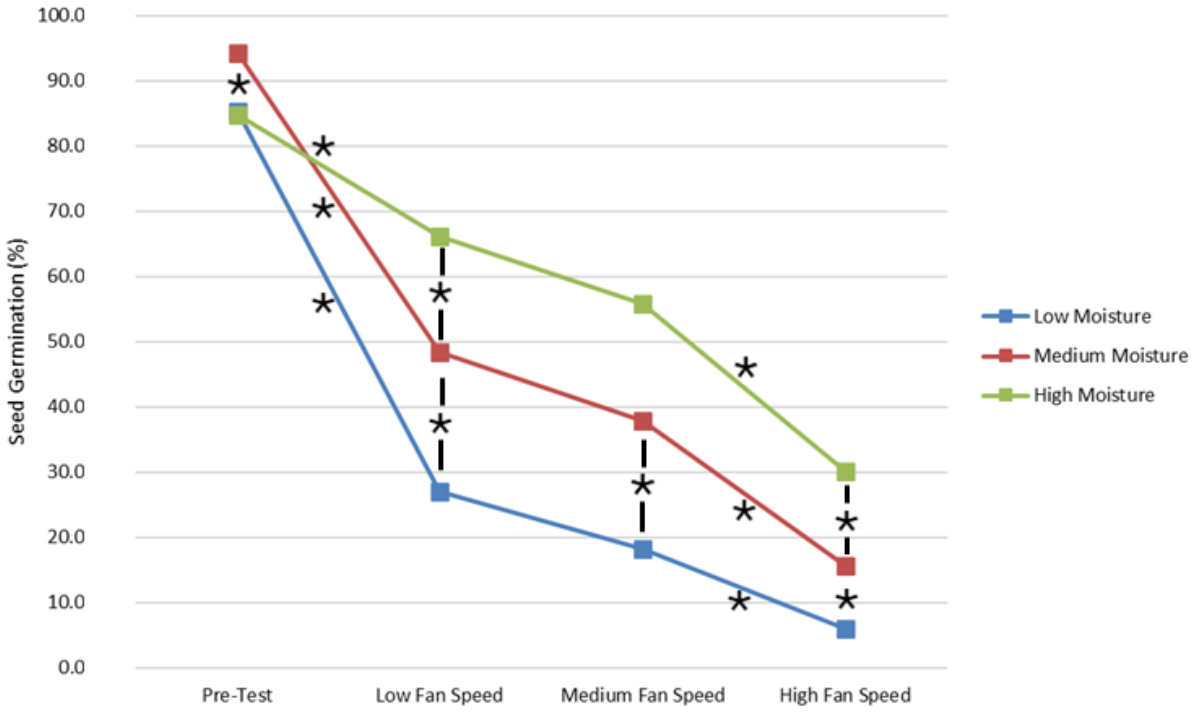

Figure 13. Mean differences in percentage germination of black beans between all moisture and fan speed groups. Significant differences ($p < 0.05$) are noted with an *.

Vigor

Table 10 shows the mean and standard deviation of percentage vigor between the nine trials. There was a significant interaction between the effects of fan speed and moisture level, $F(6,24) = 11.30$, $p < 0.001$. There were also significant main effects between fan speeds, $F(3,24) = 214.79$, $p < 0.001$, and moisture levels, $F(2,24) = 76.61$, $p < 0.001$. At the pre-test level, there were differences in percentage vigor between low moisture and medium moisture, but no differences between medium moisture and high moisture bean seed samples (**Figure 14**). At high moisture, there were only differences between medium fan speed and high fan speed groups. There were no differences in mean percentage vigor between low fan speed and

medium fan speed across any of the moisture groups. There was also an interaction between fan speed and moisture level effects between all moisture outcomes at low, medium, and high fan speed. Significant differences between groups are noted by an asterisk (*).

Table 10. Mean and standard deviation of vigor (%) outcomes in black beans.

	Low Fan Speed	Medium Fan Speed	High Fan Speed
Low Moisture	27.6 ± 9.6	19.6 ± 2.1	5.7 ± 1.3
Medium Moisture	47.0 ± 7.1	37.4 ± 5.4	14.3 ± 0.4
High Moisture	69.4 ± 11.8	65.6 ± 4.1	27.9 ± 1.4

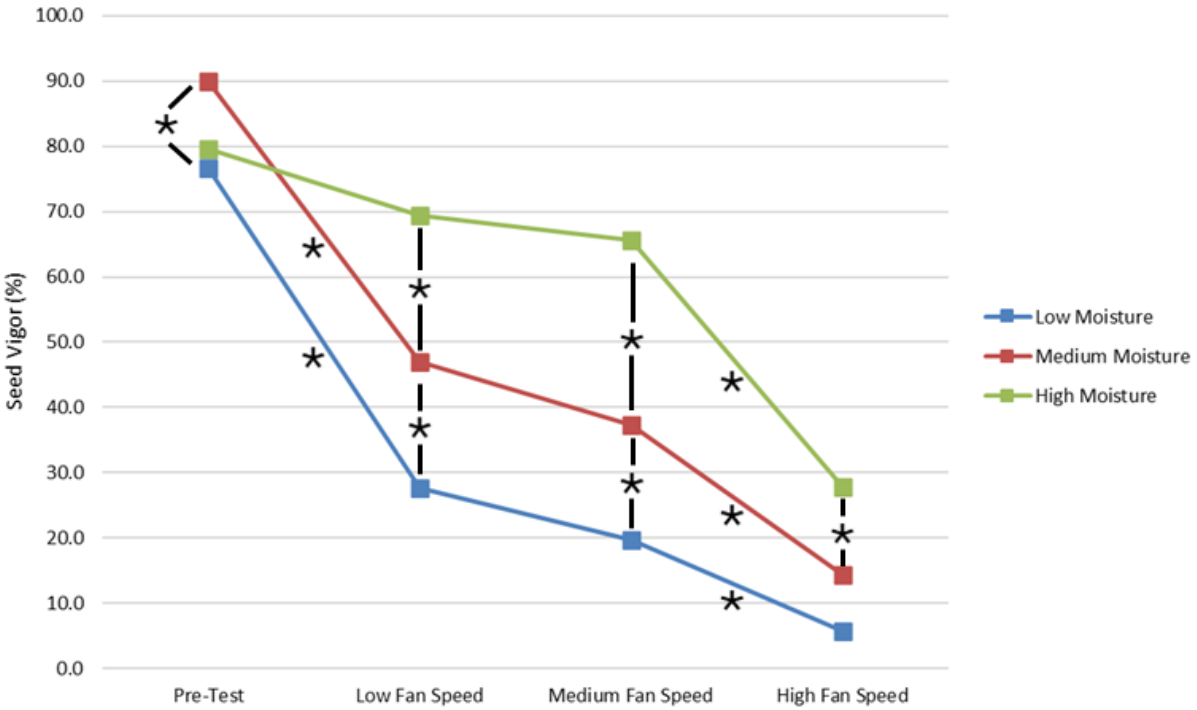

Figure 14. Mean differences in percentage vigor of black beans between all moisture and fan speed groups. Significant differences ($p < 0.05$) are noted with an *.

Seed Coat Damage (Smoothness)

Table 11 summarizes the mean and standard deviation of percentage in seed smoothness between the nine trials. There was a significant interaction between the effects of fan speed and moisture level, $F(6,24) = 10.69$, $p < 0.001$. There were also significant main effects between fan speeds, $F(3,24) = 160.45$, $p < 0.001$ and moisture levels, $F(2,24) = 8.29$, $p = 0.002$. There were differences in percentage seed smoothness between low and medium moisture contents in pre-test conditions, at low fan speed, and at medium fan speed, but not at high fan speed (**Figure 15**). There were significant differences between pre-test and low fan speed conditions and between medium fan speed and high fan speed across all moisture levels. There were no differences between low fan speed and medium fan speed for any tested moisture levels. There were significant interaction effects across all moisture levels between medium and high fan speed. Significant differences between groups are noted by an asterisk (*).

Table 11. Mean and standard deviation of seed smoothness (%) outcomes in black beans.

	Low Fan Speed	Medium Fan Speed	High Fan Speed
Low Moisture	32.8 ± 5.7	25.6 ± 5.4	9.8 ± 1.2
Medium Moisture	53.6 ± 4.6	45.1 ± 5.2	21.9 ± 1.7
High Moisture	46.7 ± 0.5	50.9 ± 13.8	25.6 ± 0.4

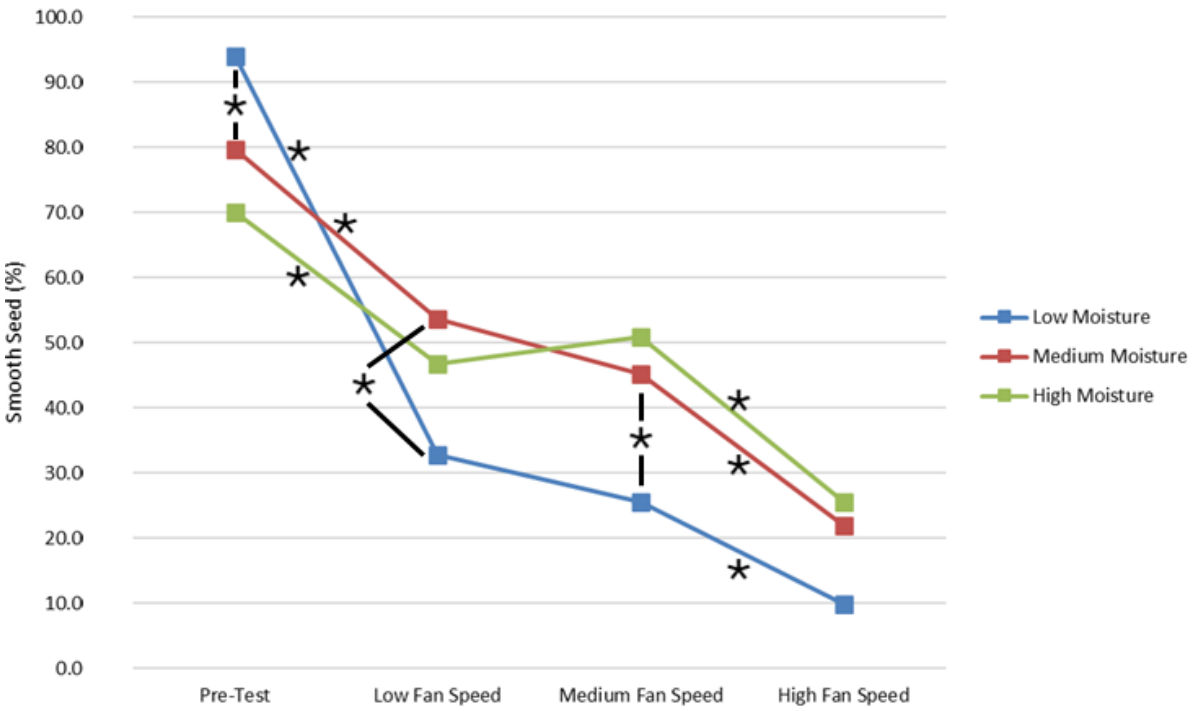

Figure 15. Mean differences in percentage seed smoothness of black beans between all moisture and fan speed groups. Significant differences ($p < 0.05$) are noted with an *.

5. CONCLUSIONS AND RECOMMENDATIONS

Distinct patterns emerged in the significant differences in pinto beans across fan speed and moisture groups for both low, medium, and high moisture contents and fan speeds. Many significant differences between the groups show that both seed moisture and fan speed are important factors in determining the percentages for germination, vigor, and seed smoothness (coat damage) in pinto beans. The outcomes from testing infer that high moisture conditions (14%) in combination with low fan speed (as low as possible while avoiding plugging) demonstrates the lowest amount of seed damage. Even in these more optimal conditions, percentage germination and percentage vigor are reduced to near 70%. Seeding in real-world conditions while using this low fan speed may not be feasible, as some plugging of distribution tubes occurred during testing. Increasing the fan speed to the minimum recommended by the manufacturer (medium fan speed) lowered germination and vigor levels to around 60% for high

moisture (14%) seed, 40% for medium moisture (12.5%) and below 20% for low moisture (11%) seed. Further increasing fan speed by 20% (high fan speed), resulted in very low germination and vigor values of below 30% for all seed moisture levels.

For black beans, patterns in differences between moisture levels and fan speeds were less distinct but still provide valuable information. The outcomes from this test infer that high moisture conditions (14%) in combination with low to medium fan speed will demonstrate the lowest amount of seed damage. Again, percentage germination and percentage vigor, even in these more optimal conditions, are only around 60%, with seed coat damage as low as 45%. Higher fan speed and lower seed levels were again seen to significantly lower germination and vigor values, with values as low as less than 10% for high fan speed and low moisture content conditions.

Based on these findings, it is recommended that when seeding dry beans with an air seeder, producers use high moisture content seed and minimize fan speed. Bean seed should be at least 14% moisture content, and fan speed should be set as low as possible to distribute the product. If possible, operating at a lower fan speed than the manufacturer's recommended minimum is likely to be beneficial. It is also recommended that producers increase seeding rates to account for the expected seed damage.

6. REFERENCES

Barker, B. (2019). *Saskatchewan Pulse Growers - Pulse Knowledge.* Retrieved from Narrow-Row Dry Bean Production: https://manitobapulse.ca/wp-content/uploads/2019/03/190214_Dry_Bean_Production_fact_sheet-compressed.pdf

APPENDIX A

TEST DATA

Table A-1. Test data for pinto beans trials.

Test Trial	Date and Time	Ambient Temperature (^{o}C)	Ambient Relative Humidity %	Bean Moisture Content %	Actual Fan Speed (rpm)	Actual Meter Shaft Speed (rpm) (Target 257 rpm for 115lb/ac)
P-ML-FL	Jan 14, 2025 8:55am	17	30	11.1	2960-2990	256-264
P-ML-FM	Jan 14, 2025 9:40am	16	30	11.1	3190-3200	259-268
P-ML-FH	Jan 14, 2025 11:00am	16	30	11.1	3850	250-262
P-MM-FL	Jan 10, 2025 4:06pm	17	30	12.8	2950-2960	260-268
P-MM-FM	Jan 10, 2025 11:50am	17	30	12.8	3190-3200	247-268
P-MM-FH	Jan 10, 2025 2:25pm	16	30	12.8	3860-3890	251-257
P-MH-FL	Jan 13, 2025 11:15am	16	30	14.2	2970-2990	258-271
P-MH-FM	Jan 13, 2025 1:40pm	16	29	14.2	3220-3230	248-269
P-MH-FH	Jan 13, 2025 2:30pm	16	30	14.2	3830-3850	251-283

Table A-2. Test data for black bean trials.

Test Trial	Date & Time	Ambient Temperature (^{o}C)	Ambient Relative Humidity %	Bean Moisture Content %	Actual Fan Speed (rpm)	Actual Meter Shaft Speed (rpm) (Target 183 rpm for 94lb/ac)
B-ML-FL	Jan 15, 2025 2:30pm	18	30	10.4	2820	180-183
B-ML-FM	Jan 15, 2025 4:00pm	19	30	10.4	3000-3010	185-190
B-ML-FH	Jan 15, 2025 4:30pm	19	30	10.4	3580-3590	176-179
B-MM-FL	Jan 16, 2025 11:10am	18	30	12.6	2780	178-185
B-MM-FM	Jan 16, 2025 1:20pm	18	30	12.6	3000-3010	185-189
B-MM-FH	Jan 16, 2025 2:10pm	19	30	12.6	3600	178-182
B-MH-FL	Jan 15, 2025 9:35am	18	30	14.3	2790	178-183
B-MH-FM	Jan 15, 2025 10:50am	18	30	14.3	3000-3020	174-188
B-MH-FH	Jan 15, 2025 1:15pm	18	30	14.3	3590-3600	186-189

APPENDIX B

PURE SEED DESCRIPTIVES AND BETWEEN-GROUP DIFFERENCES FOR PINTO BEANS

Table B-1. Mean and standard deviation of pure seed (%) outcomes in pinto beans.

	Pre-Test	Low Fan Speed	Medium Fan Speed	High Fan Speed
Low Moisture	98.9 ± 0.3	79.4 ± 3.0	69.9 ± 3.1	29.7 ± 3.2
Medium Moisture	99.3 ± 0.2	91.1 ± 1.5	82.9 ± 3.5	50.9 ± 4.5
High Moisture	99.0 ± 0.4	94.6 ± 1.6	89.2 ± 2.3	64.4 ± 1.6

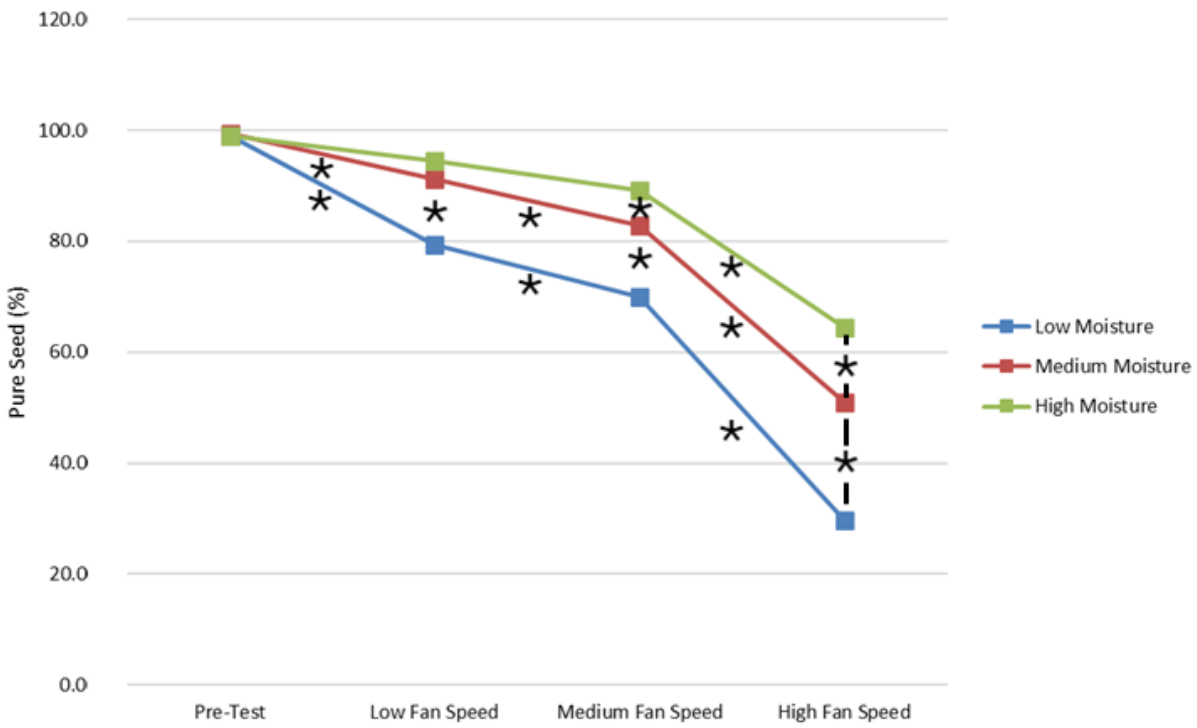

Figure B-1. Mean differences in percentage pure seed of pinto beans between all moisture and fan speed groups. Significant differences ($p < 0.05$) are noted with an *. No significant differences were noted between any moisture level in the pre-test samples and between medium and high moisture at low fan speed. No significant differences were noted at high moisture between pre-test and low fan speed; and between low fan speed and medium fan speed.

APPENDIX C

PURE SEED DESCRIPTIVES AND BETWEEN-GROUP DIFFERENCES FOR BLACK BEANS

Table C-1. Mean and standard deviation of pure seed (%) outcomes in black beans.

	Pre-Test	Low Fan Speed	Medium Fan Speed	High Fan Speed
Low Moisture	99.6 ± 0.1	73.6 ± 7.0	57.7 ± 2.5	19.7 ± 1.5
Medium Moisture	99.6 ± 0.1	88.0 ± 2.1	85.5 ± 0.9	44.8± 1.3
High Moisture	99.5 ± 0.6	95.9 ± 0.3	90.7 ± 1.0	61.6 ± 8.1

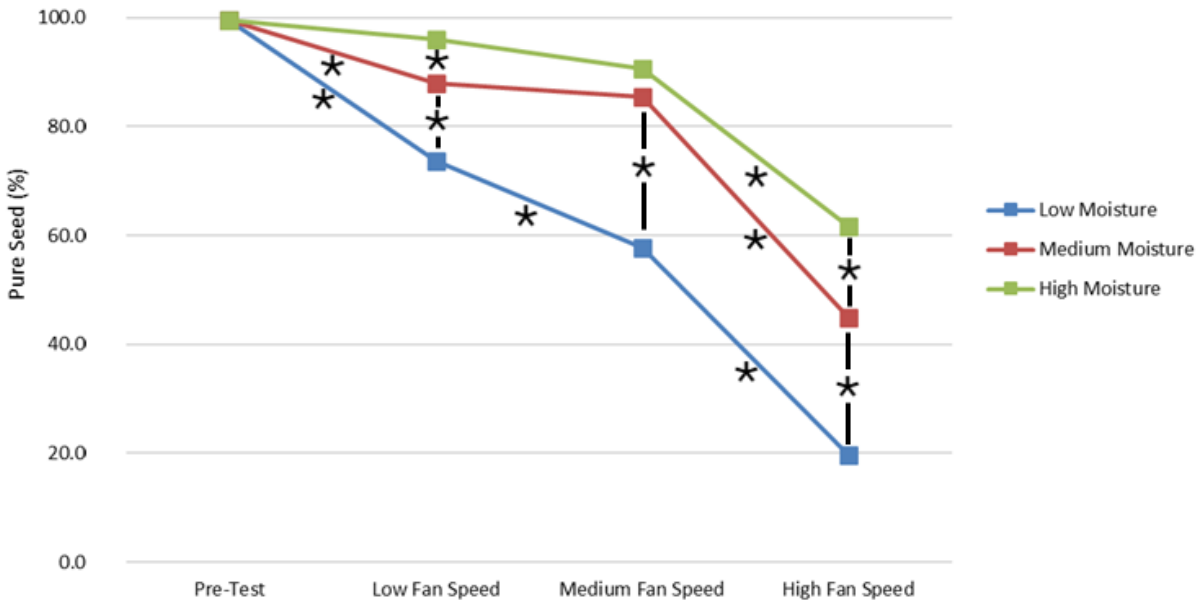

Figure C-1. Mean differences in percentage pure seed of black beans between all moisture and fan speed groups. Significant differences ($p < 0.05$) are noted with an *. No significant differences were noted between any moisture level in the pre-test samples and between low and medium fan speeds across medium and high moisture groups. No significant differences were noted at medium fan speed between high and medium moisture groups. There was an interaction effect between fan speed and moisture across all levels.

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