STORAGE AND ELECTRONIC MOLD ODOR

DETECTION OF WINTER CANOLA SEED WITH

SAFETY IMPLICATIONS FOR QUALITY LOSS

By

KEVIN GERALD MOORE

Bachelor of Science in Chemical Engineering
Oklahoma State University
Stillwater, OK
1995

Master of Business Administration
Oklahoma State University
Stillwater, OK
2001

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Dissertation Approved:

Dr. Carol Jones – Dissertation Adviser

Dr. R. Scott Frazier – Committee Member

Dr. Ning Wang – Committee Member

Dr. Niels Maness – Outside Committee Member

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For Suzanne. Every Frodo needs a Sam.
The heart of man plans his way, but the Lord establishes his steps. Proverbs 16:9 (ESV)

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Abstract: Winter canola has seen increasing adoption as a rotational crop with small cereal grains in the southern United States. Considerable effort has been devoted to the development of new canola varieties suited to this region, but less effort has been placed on understanding issues related to post-harvest storage and handling of the crop. This study investigates three such issues. First, lining the inside of unaerated grain bins with polyethylene material in an attempt to improve storage quality in secondary storage facilities. There was not a significant difference between canola seed stored with and without the liner. If low quality grain bins must be used for short-term storage, the bottom of the bin can be lined with grain bag material for the purpose of sealing and moisture exclusion. Second, the development of a low-cost electronic nose capable of detecting mold in stored canola seed. This device was able to classify canola seed as moldy or clean with a 3% error rate. Third, measurement of the pressure on the torso of a grain entrapment victim in canola, corn, soybeans, and wheat to provide information to first responders and health professionals in the event of a grain storage accident. This pressure was found to range from 1.6 to 4.0 kPa (0.23 to 0.57 psi). This does not appear sufficient to limit respiration in an otherwise healthy adult male.

TABLE OF CONTENTS

Chapter Page

I. INTRODUCTION 1

1.1 Overview of Canola 1
1.2 Research Objectives..5
1.3 References..6

II. IMPACT OF A POLYETHYLENE LINER ON THE STORAGE OF WINTER CANOLA SEED IN UNAERATED STEEL BINS 7

2.1 Abstract..7
2.2 Introduction..8
2.3 Materials and Methods..9
2.4 Results..12
2.4.1 Year one results..12
2.4.2 Year two results 15
2.5 Discussion 18
2.6 Conclusions..23
2.7 References..25

III. DEVELOPMENT OF A LOW-COST ELECTRONIC NOSE FOR THE DETECTION OF MOLD IN STORED WINTER CANOLA SEED 27

3.1 Abstract..27
3.2 Introduction..27
3.3 Materials and Methods..29
3.3.1 Development of electronic nose..29
3.3.2 Preparation of mold spore suspension 31
3.3.3 Inoculation of seeds with mold spore suspension..................................33
3.3.4 Testing procedure with electronic nose 34
3.3.5 Data analysis 35
3.4 Results and Discussion 35
3.4.1 Reference air regression analysis..35
3.4.2 Mean comparison of treatments..37
3.4.3 Classification of samples 40
3.4.4 Evaluation of sensor stability..42

Chapter Page

3.5 Conclusions....45
3.6 References....47

IV. GRAIN ENTRAPMENT PRESSURE ON THE TORSO: CAN YOU BREATHE WHILE BURIED IN GRAIN?....49

4.1 Abstract....49
4.2 Introduction....49
4.3 Materials and Methods....51
4.4 Results and Discussion....54
4.5 Conclusions....59
4.6 References....60

V. CONCLUSION....62

5.1 Summary....62
5.2 Future work....63

APPENDICES....65

LIST OF TABLES

Table Page

Table 2.1. Canola properties at the time of loading 11
Table 2.2. Year 1 overview of seed quality during final visual inspection and grade progression. 14
Table 2.3. Post-hoc germination rates for canola seeds in year 1............................14
Table 2.4. Year 2 overview of seed quality during final visual inspection and grade progression 17
Table 2.5. Germination rates for canola seeds in year 2..17
Table 3.1. Metal oxide sensors and gas sensitivity..30
Table 3.2. Treatment levels for seed inoculations 34
Table 3.3. Comparison of classification model error rates for canola data 42
Table 4.1. Measured physical properties of tested grains..52
Table 4.2. Comparison of mean contact pressure (kPa) by depth for each grain 55

LIST OF FIGURES

Figure Page

Figure 1.1. Production of canola in the United States is dominated by North Dakota. Oklahoma has led the expansion of canola production in the south and has been the number two producer of canola since 2009 2
Figure 1.2. The embryo dominates the interior of a canola seed and the cotyledons contain 90% of total fatty acids in the seed 3
Figure 1.3. A triglyceride molecule is formed by three fatty acid chains attached to a glycerol backbone 4
Figure 2.1. The Stored Products Research and Education Center (SPREC) at Oklahoma State University 9
Figure 2.2. One of the 170 bushel bins used during the project 10
Figure 2.3. View of the top of a sealed grain bin liner. The silage bag vent that was used for sample collection can be seen at the top of the image. The temperature cable can be seen entering the bag on the lower right 10
Figure 2.4. 170 bushel bins used during year one and year two testing. Bins are numbered 1-6 from west to east 11
Figure 2.5. The average temperature in lined and unlined grain bins followed trends in the air temperature, with slightly higher temperatures recorded for the unlined bins in year one. The maximum temperatures occurred in late August and early September 13
Figure 2.6. Free fatty acid content increased rapidly in year one during the first four months of storage. After this the FFA value stabilized and did not exceed 1% during the study 15
Figure 2.7. Average bin temperatures in year two continued to follow ambient temperature trends as seen in year one. However, there was no evidence of a temperature increase after binning 16
Figure 2.8. Free fatty acid increased moderately during year two and was lower than observed in year one 18
Figure 2.9. Comparison of free fatty acid values for lined versus unlined bins in year 1 and year 2 19
Figure 2.10. A triglyceride molecule 19
Figure 2.11. Canola seed storage guidelines published by the Canola Council of Canada (2014) based on the work of Mills and Sinha (1980) 21
Figure 2.12. Canola seed storage recommendations for Australia based on 60% equilibrium relative humidity and oil content. – Adapted from Cassells, Caddick, Green, and Reuss (2003) 22

Figure Page

Figure 3.1. Basic measurement circuit for Figaro gas sensors. V_C is the voltage supplied to the sensor, V_H is the voltage supplied to the heater, V_{RL} is the voltage measured across the load resistor R_L 30
Figure 3.2. Sensor array for electronic nose 31
Figure 3.3. Sensor array and sampling system for electronic nose..........................34
Figure 3.4. Influence of relative humidity on sensor response. Note the increase in data spread at lower RH 36
Figure 3.5. Regression curves used to calculate the sensor response R_0 for normalization of sensor output 37
Figure 3.6. Figure 3.6. Mean sensor response for each treatment at 6, 12, and 18 days post inoculation (dpi). Means with the same letter are not significantly different from other means within each graph 38
Figure 3.7. Comparison of 18 days post inoculation (dpi) and 16% moisture content samples prepared post hoc. Means with the same letter are not significantly different from other means within each graph 39
Figure 3.8. Graph of the first two principal components for the combined data set (6, 12, and 18 days post inoculation)..40
Figure 3.9. Plot of the first two linear discriminants to evaluate separation between inoculation levels 41
Figure 3.10. Baseline sensor value in air for all test runs. Dotted lines represent mean response for each sensor 43
Figure 3.11. Influence of temperature on baseline sensor response for 6, 12, and 19 days post inoculation (dpi) 44
Figure 3.12. Influence of relative humidity on baseline sensor response for 6, 12, and 19 days post inoculation (dpi) 45
Figure 4.1. The 1.83 m (6 ft) diameter steel bin used during measurement of entrapment pressures 52
Figure 4.2. Rescue manikin outfitted with sensor mats prior to testing in soybeans 54
Figure 4.3. Calibration of sensor mat with universal testing machine prior to testing. Force is applied through a layer of grain to approximate testing conditions 54
Figure 4.4. Mean contact pressure (MP) on the torso of a manikin at varying grain depths (D)...55

CHAPTER I

INTRODUCTION

1.1 Overview of Canola

Canola is a member of the mustard (Brassicaceae) family. Canola (*Brassica napus*) was originally developed in Canada through traditional breeding of the rapeseed plant. Production of vegetable oil is the main use of the seed, with the leftover meal used as a protein supplement for livestock. (Boyles, Bushong, Sanders, & Stamm, 2012) According to the Foreign Agricultural Service (2016), canola (including edible rapeseed) is the second largest global oilseed crop after soybeans, with production of 70.2 million metric tons in 2015/16. In addition to its use as an edible oil, canola can be used in the production of biodiesel, lubricants, surfactants, paints, and polymers (Walker, 2004).

Hundreds of varieties of canola have been developed during the past 40 years through a combination of traditional breeding and genetic modification. Canola can be broadly divided into spring and winter varieties. Winter varieties are typically planted in September and harvested in June. These can produce a higher yield than spring varieties, but must be grown in regions that will not produce excessive winter kill. Spring varieties are planted in spring and harvested in late summer or early fall. Spring varieties are typical for Canada and the northern United States, while winter varieties are common in the southern United States (Canola Council of Canada, 2014). North Dakota dominates production in the U.S. with 87% of the canola crop in 2015. But canola acreage has also been growing in the southern United States. For example, Oklahoma has been the number two producer of canola in the U.S. since 2009 (figure 1.1) (USDA, 2015). Canola has performed well as a rotational crop for wheat in the southern Great Plains. It provides a significant increase in wheat yields following canola and herbicide tolerant varieties help combat problematic weeds such as Italian ryegrass and feral rye (Bushong, Griffith, Peeper, & Epplin, 2012). The southeastern United States faces similar challenges with weeds due to wheat monocropping and could also benefit from canola rotation. (Bishnoi, Zurres, Cebert, & Mentreddy, 2007; Kumar, Bishnoi, & Cebert, 2007).

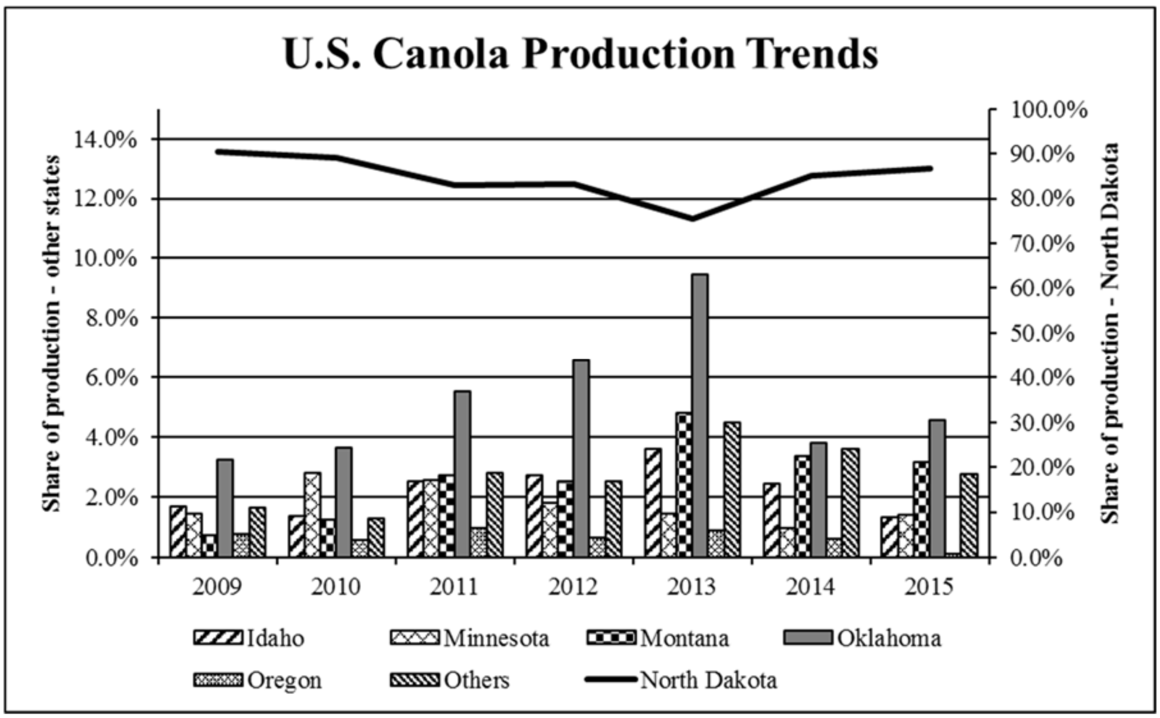

Figure 1.1. Production of canola in the United States is dominated by North Dakota. Oklahoma has led the expansion of canola production in the south and has been the number two producer of canola since 2009.

Canola has potential throughout the southern U.S. as a rotational crop for small grains. However, there is limited information available concerning the long-term storage of winter canola in the southern U.S.

Controlling moisture is the most critical factor for storage of canola. Most storage guidelines for canola recommend moisture content (MC) between 7 and 10%. Storage fungi are adapted to grow in grains with an equilibrium relative humidity (ERH) of 65-90%. Most grow best at a temperature of about 30°C. (Christensen & Meronuck, 1986) For canola stored at 20-30°C, an ERH of 65% equates to a moisture content of 8.5-9.0%. As the MC increases, fungal growth will begin to deteriorate the seed. Common storage fungi for canola are *Aspergillus glaucus, Aspergillus candidus, Penicillium* spp., and *Eurotium* spp. (Pronyk, Abramson, Muir, & White, 2006; Pronyk, Muir, White, & Abramson, 2004).

Fungal damage to canola seed is accompanied by degradation of lipids in the seed. This causes a loss in germination potential, the formation of free fatty acids (FFA), and the onset of rancidity and associated odors. Storage fungi attack the seed embryo, causing a loss in germination ability (Farrell, Hodges, Wareing, Meyer, & Belmain, 2002). Brassica plants like canola store large amounts of oil in the embryo. For *Brassica napus*, 90% of fatty acid storage is in the cotyledons. The embryo makes up the majority of the canola seed, as seen in figure 1.2 (Baud & Lepiniec, 2010).

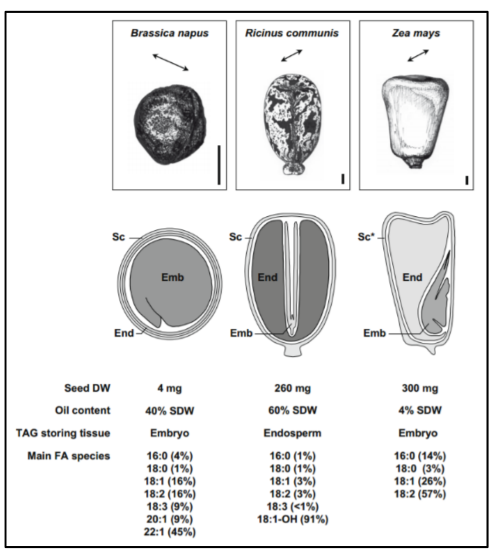

Figure 1.2. The embryo dominates the interior of a canola seed and the cotyledons contain 90% of total fatty acids in the seed (Baud & Lepiniec, 2010).

FFAs are formed by the breakdown of triglycerides due to oxidation or hydrolysis. Triglycerides are the main component of fats and oils. 95-99% of the fatty acids in canola are present as triglycerides. A triglyceride molecule is formed by three fatty acids joined to a glycerol molecule (figure 1.3). Canola oil contains a high concentration of unsaturated fatty acids. Unsaturated fatty acids contain at least one double bond in the carbon chain. While this is considered a "healthy fat", it is more susceptible to oxidation at the double bond locations (Ratnayake & Daun, 2004). Hydrolysis (enzymatic oxidation) of the triglyceride can also occur due to the presence of fungal lipases. A lipase is an enzyme that promotes the reaction between water and triglycerides, progressively cutting the glycerol/fatty acid bonds. Di- and mono-glycerides are formed as intermediate products until finally three fatty acids and glycerol remain (Swetman et al., 2002). Fatty acids are broken down further by oxidation to form alcohols, aldehydes, ketones, acids, hydrocarbons, and esters. These compounds lead to numerous odors and flavors, both pleasant and unpleasant (Barnes & Galliard, 1982; Rousseau, 2004). Excessive off-odors will cause a reduction in grade and commercial value.

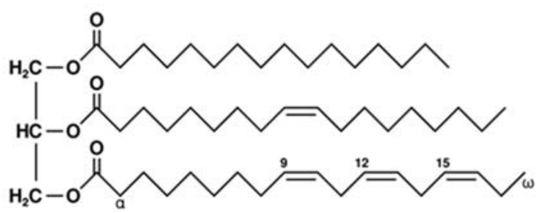

Figure 1.3 A triglyceride molecule is formed by three fatty acid chains attached to a glycerol backbone.

In addition to losses in product value, the formation of mold and associated degradation of stored grain can lead to health and safety issues for grain workers. Moldy grain does not flow easily out of storage structures and this often requires a worker to enter the storage structure to break up the moldy chunks of grain so it can be removed. This is a dangerous situation, as workers run the risk of becoming trapped in the grain when proper safety measures are not followed. This can be especially problematic for on-farm grain storage structures. Over two-thirds of grain storage capacity in the United States is on farms that are exempt from the Occupational Safety and Health Administration's grain handling regulation 29 CFR 1910.272 (Issa, Cheng, & Field, 2016). Historically about 70% of reported grain entrapments have occurred in these exempt facilities (Issa, Roberts, & Field, 2013).

1.2 Research Objectives

The objectives of this study are: 1) Investigate the impact on storage quality of winter canola seed of lining unaerated grain bins with polyethylene grain bag material, 2) develop an inexpensive electronic nose to detect mold odors in stored canola seed, and 3) measure the pressure applied to the torso of a simulated grain entrapment victim and determine if this is likely to limit respiration.

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CHAPTER II

IMPACT OF A POLYETHYLENE LINER ON THE STORAGE OF WINTER CANOLA SEED IN UNAERATED STEEL BINS

2.1 Abstract

Winter canola has potential as a rotational crop for small cereal grains throughout the southern United States. However, canola is typically harvested just before wheat and is not yet considered a primary crop in the south. This combined with already tight storage capacity has led producers and facility managers to look for ways to press older, low-quality storage bins into service. One idea has been the use of grain bag material as a liner for older bins that lack functional aeration systems. This project compared the storage quality of canola in lined and unlined steel grain bins without aeration during two harvest periods. There was not a significant difference in storage quality between the lined and unlined bins in either year. High moisture content canola seed (9.1%) was stored without loss in grade for six weeks, while low moisture content canola seed (5.4%) was stored without loss in grade for eleven months. However, the liner material was effective in preventing moisture intrusion at the bottom of the grain storage bins. The use of polyethylene grain bag material to prevent moisture intrusion in the bottom of older grain storage bins shows potential and may provide another option for the temporary storage of dry winter canola seed. Canola storage guidelines published in Australia recommend a lower moisture content than those published in Canada and also recommend adjustments based on the seed oil content. Australian guidelines should be utilized for canola storage in the southern United States.

2.2 Introduction

Canola has potential throughout the southern United States as a rotational crop for small grains. However, there is limited information available concerning the long-term storage of winter canola seed in the southern U.S. Most research concerning the storage of canola seed has been performed in cooler climates and with spring varieties that are harvested in early fall. Storage guidelines from the Canola Council of Canada recommend that canola be cooled to at least 15°C (59°F) if it is to be stored for 5 months or longer (Mills, 1996). This agrees with the recommendation of Foster and Tuite (1992) that grains should be cooled with aeration as quickly as possible to 15-20°C to prevent mold and insect growth. However, this can be difficult to achieve during the summer in southern states. Bin temperatures increase quickly during the summer in this region, especially without aeration. Canola is not a primary crop in the southern U.S. and is harvested just a few weeks before wheat. This has led producers and grain facility managers to look for alternative storage options for canola so that their primary storage capacity is ready for wheat harvest. Grain bags are a possible alternative, but space considerations and the specialized loading and unloading equipment they require can be a deterrent. Many facilities have older, leaky bins that lack functional aeration systems. While these bins are not ideally suited for canola storage, producers and managers have looked for ways to press these bins into temporary storage for canola seed. Placing grain storage bags inside existing grain storage structures has been considered by facility managers in the southern Great Plains. There are numerous technical challenges involved in making this a practical storage solution, such as keeping the liner in place during loading and properly sealing and unsealing the bag for unloading. However, there is no point in addressing these issues if storage quality is not maintained. The goal of this project was to determine if there is a difference in storage quality for winter canola seed placed in unaerated steel bins with and without the use of a polyethylene grain bag liner.

2.3 Materials and Methods

Testing was completed at Oklahoma State University's Stored Product and Research Education Center (SPREC) (figure 2.1). Six 170 bushel bins were utilized during testing. These are steel bins without aeration and they show signs of deterioration due to rust at the base of the bins. Access to the bins was possible through a manway hatch located at the top of each bin (figure 2.2). This hatch was used for the periodic collection of seed samples with a grain trier. A single StorMax temperature cable was located in the center of each bin (OPIsystems Inc., Calgary, Canada), which allowed temperature readings to be collected at six elevations. Three of the bins received the treatment of a 9.3 mil thick polyethylene liner made from grain bag material provided by Delta Grain Bag Systems, Inc. (Monette, AR). The liner was closed with a heat sealer and duct tape. A silage bag vent (Ag-Bag, St. Nazianz, WI) was installed at the top of each liner to allow for periodic sample collection (figure 2.3).

Figure 2.1. The Stored Products Research and Education Center (SPREC) at Oklahoma State University.

Figure 2.2. One of the 170 bushel bins used during the project.

Figure 2.3. View of the top of a sealed grain bin liner. The silage bag vent that was used for sample collection can be seen at the top of the image. The temperature cable can be seen entering the bag on the lower right.

Canola seed was purchased directly from a local farmer and delivered to SPREC during harvest. In year one, bins 1, 2, and 5 received the liner treatment and bins 3, 4, and 6 were unlined. In year two, bins 2, 4, and 6 received the liner and bins 1, 3, and 5 were unlined. Figure 2.4 shows the orientation of the bins and the numbering sequence. The seed was graded by Enid Grain Inspection (Enid, OK) at delivery and the initial conditions are indicated in table 2.1. During year two, excessive rain delayed the loading of canola into the 170bu bins for 2 1/2 weeks. It was stored in two 500bu bins at SPREC until it could be transferred. Before the seed was loaded in year two, repairs were made to address excessive water infiltration at the base of the bins. This involved recoating the base of the bins with elastomeric roof paint. A layer of plastic grain bag material was also added to the bottom of the unlined bins and extended up the sidewall approximately 200mm. A single 60mm vent cap was also added to the top of each bin to prevent condensation in the head space of the bins during storage.

Figure 2.4. 170 bushel bins used during year one and year two testing. Bins are numbered 1-6 from west to east.

Table 2.1. Canola properties at the time of loading.

	Variety	Moisture Content	Oil Content	Dockage	Grade
Year 1 (2014-15)	Croplan 115W	9.1%	35.1%	3.7%	U.S. No. 1
Year 2 (2015-16)	DeKalb DKW 44-10	5.4%	38.4%	2.03%	U.S. No. 1

Temperatures were collected two to three times per week for ten months in year one and twelve months in year two. Seed samples were collected prior to storage and at intervals throughout the storage period. Samples were collected from near the center of the bins with a five-foot-long grain trier. During year one, samples were graded at binning and then at approximately six weeks, six months, and ten months. During year two, samples were graded at binning and then approximately monthly. Analysis of free fatty acid (FFA) was completed by North Dakota State University by titration (AOCS Ca 5a-40). During year one this was completed weekly for eight weeks, bimonthly for two months, and then monthly for six months. In year two, this was completed monthly for the duration of the project. Seed germinations were evaluated monthly during year two. Several post-hoc germinations of year one seed samples that had been stored at 5°C were also completed. Germination tests were performed by adding 5ml of distilled water to a 90mm petri dish containing a filter paper disk. Fifty seeds were added and counts of germinated seeds were made after three days and five days. Additional water was added at day three as needed. At the end of each storage period, a visual inspection of the stored canola was conducted during unloading. Data were analyzed with SAS software version 9.3 (SAS Institute Inc., Cary, NC, USA), using analysis of variance to test mean differences and the MIXED procedure to evaluate trends based on time in storage. All measures of significance were evaluated for $\alpha=0.05$.

2.4 Results

2.4.1 Year one results

Year one temperatures increased during the first 90 days of storage, with the unlined bins showing the highest average temperatures. The mean grain temperature in the unlined bins was significantly higher during the first six months of storage ($p=0.0038$). Once temperatures dropped and the grain was quiescent, there was not a significant difference in temperature between the lined and unlined bins ($p=0.2506$) (figure 2.5). The average grain temperatures appeared to follow the general trend of ambient daily maximum air temperatures from Oklahoma Mesonet data (Brock et al., 1995; McPherson et al., 2007). The unlined bins show evidence of self-heating based on the higher mean bin temperature compared to the lined bins and the departure from the ambient air temperature. This is especially evident between 60 and 120 days of storage as shown in figure 2.5.

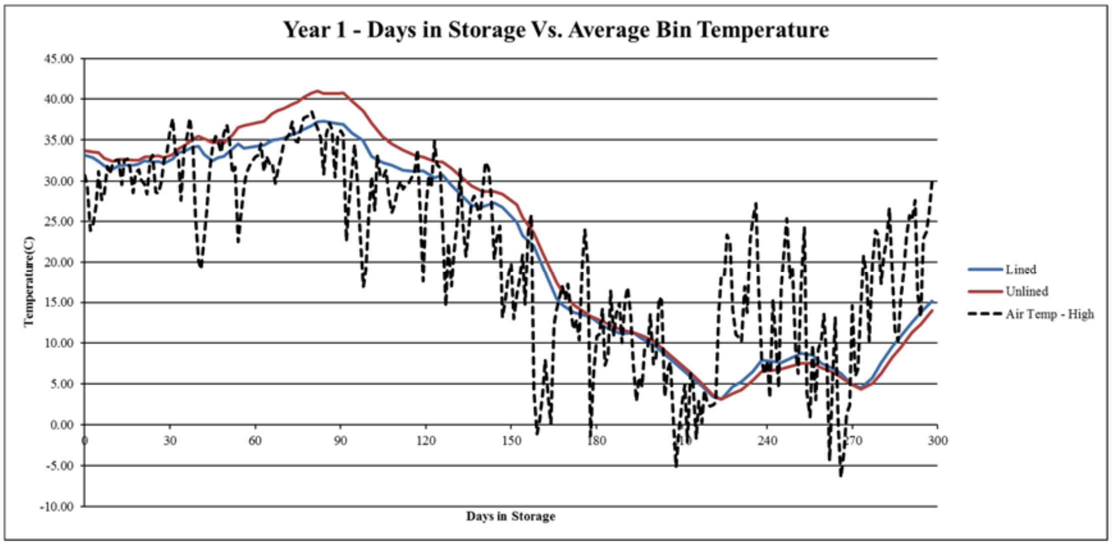

Figure 2.5. The average temperature in lined and unlined grain bins followed trends in the air temperature, with slightly higher temperatures recorded for the unlined bins in year one. The maximum temperatures occurred in late August and early September.

Upon emptying the bins at the end of the project, heavy mold infestation was evident in four of the six bins. This was found in two of the unlined bins and two of the lined bins. All of the unlined bins had mold at the bottom perimeter of the bin due to water infiltration. Bin 6 had three to six inches of moldy grain on the south and east walls. Bin 4 was in the worst condition, with six to twelve inches of mold on the south side and six to eight inches of wet, moldy grain at the bottom. This bin also experienced a soldier fly infestation. Soldier flies are known to lay eggs in damp grain and other decaying organic material (Bondari & Sheppard, 1981). A previous repair to the base of this bin failed and allowed excessive moisture to enter the bottom of the bin. Bin 3 was in good condition, with the exception of some light surface mold and mold along the bottom perimeter as discussed previously. The surface mold was likely caused by condensation at the top of the bin. For the lined bins, Bin 1 and Bin 5 had four to six inches of mold at the top of the bag. This appears to be caused by moisture migration to the top of the bag. This is in agreement with other studies of grain bags which found spoiled grain and/or increased moisture content at the perimeter of the grain bag due to moisture migration (Darby & Caddick, 2007; Gaston, Abalone, Bartosik, & Rodriguez, 2009; Jian, Chelladurai, Jayas, & White, 2015; Ward & Davis, 2012). Bin 2 was generally in good condition and did not have the thick mold layer associated with the other two lined bins. All samples were graded as U.S. No. 1 after six weeks of storage. After six months of storage, only Bin 2 and 3 were still U.S. No. 1 grade. After ten months of storage, all six bins were sample grade (Table 2.2).

Table 2.2. Year 1 overview of seed quality during final visual inspection and grade progression.

	Visual Inspection Upon Unloading	**Grade at 6 weeks**	**Grade at 6 months**	**Grade at 10 months**
Bin 1 (lined)	Heavy mold at top of bag, 4-6 inches thick. After this, some light clumping but generally in good condition.	U.S. No. 1	Sample	Sample
Bin 2 (lined)	Some very light clumping but no heavy mold. No mold at bottom of the bag.	U.S. No. 1	U.S. No. 1	Sample
Bin 3 (unlined)	Good condition. Light surface mold at the top. Bottom had mold at 45 degree angle around the perimeter.	U.S. No. 1	U.S. No. 1	Sample
Bin 4 (unlined)	Very poor condition. 6-12 inches mold on south side. Bottom was 6-8 inches of wet, moldy grain. Soldier fly infestation.	U.S. No. 1	Sample	Sample
Bin 5 (lined)	Heavy mold at top of bag, 4-6 inches. Sides and bottom did not appear moldy.	U.S. No. 1	Sample	Sample
Bin 6 (unlined)	Light surface mold at top. 3-6 inch mold south and east walls.	U.S. No. 1	Sample	Sample

Post-hoc germination tests were completed on samples that had been stored at 5°C. Prior to storage, a germination rate of 94% was measured. Germination rates dropped quickly and were below 10% for all samples except Bin 3 after three months of storage (table 2.3).

Table 2.3. Post-hoc germination rates for canola seeds in year 1.

	Initial	**9 weeks**	**11 weeks**	**13 weeks**
Bin 1 (lined)	94%	44%	16%	2%
Bin 2 (lined)		66%	38%	4%
Bin 3 (unlined)		66%	56%	34%
Bin 4 (unlined)		10%	2%	0%
Bin 5 (lined)		32%	14%	8%
Bin 6 (unlined)		20%	0%	0%

The free fatty acid content of the canola seed samples rose throughout the storage period, but stayed below 1% for all six bins. This is generally considered the upper limit for high quality seed due to the additional processing required for removal of excess free fatty acids (Barthet & Daun, 2005). There was no significant difference in the FFA between the lined and unlined bins ($p=0.6826$) so the values were pooled for trend analysis. There was a significant linear ($p<0.0001$) and quadratic ($p<0.0001$) trend in the FFA value with respect to the time in storage (figure 2.6).

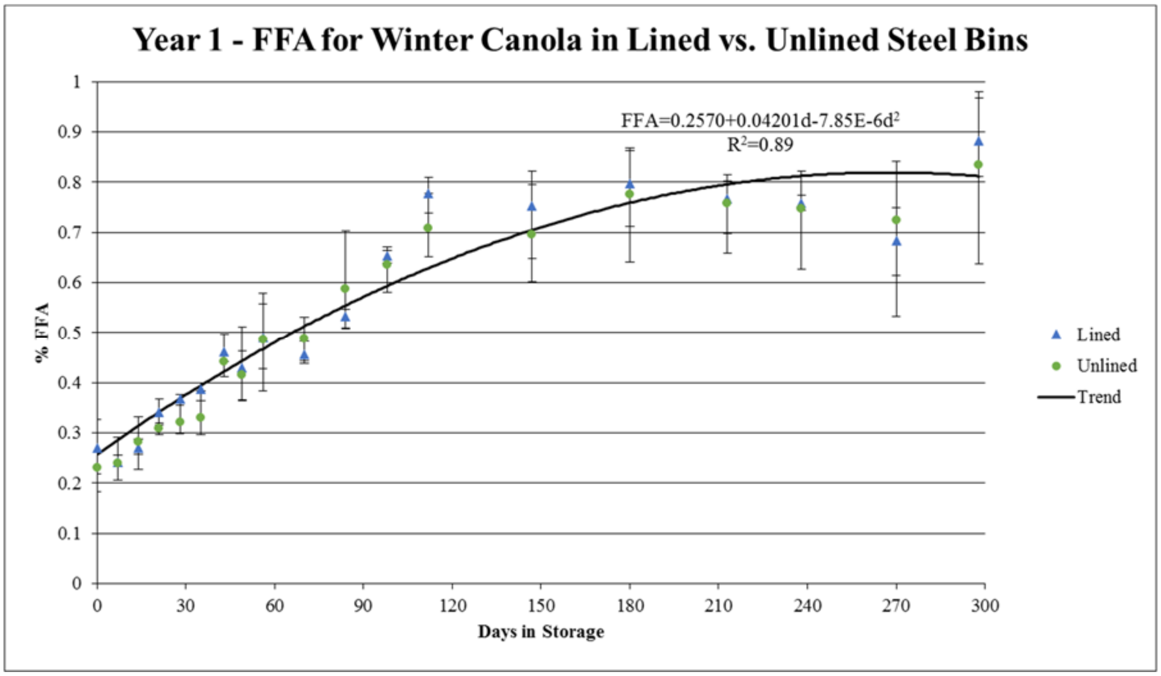

Figure 2.6. Free fatty acid content increased rapidly in year one during the first four months of storage. After this the FFA value stabilized and did not exceed 1% during the study.

2.4.2 Year two results

Year two temperatures began to drop immediately after being placed in storage. There was not a significant difference in mean temperature between the lined and unlined bins ($p=0.9921$), and the bin temperatures appeared to track the ambient daily maximum air temperature from Oklahoma Mesonet data (Brock et al., 1995; McPherson et al., 2007) throughout the storage period (figure 2.7). This is in direct contrast with the year one temperature profiles, which appeared to show self-heating of the unlined bins in the first 120 days of storage. This difference may be attributed to the higher moisture content of the seed in year one (9.1%) versus year two (5.4%) and improved sealing at the bottom of the bins. Lower moisture content will suppress the growth of mold in the seed during storage (Christensen & Meronuck, 1986).

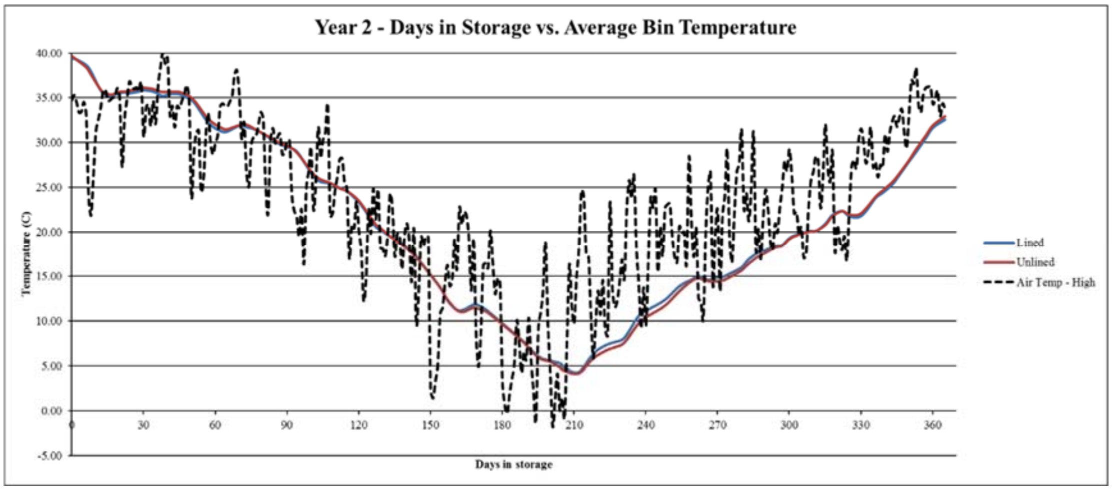

Figure 2.7. Average bin temperatures in year two continued to follow ambient temperature trends as seen in year one. However, there was no evidence of a temperature increase after binning.

As the bins were emptied, only a minor amount of mold was found in any of the bins. For the unlined bins, the surface mold that was present in year one was not found in year two. This was likely due to the addition of a small vent in the top of the bin to allow any moisture in the head space to evaporate instead of condensing on the surface of the grain. The mold that formed at the bottom perimeter of the bin in year one was not present in year two. The plastic material placed at the bottom of the bin was effective in preventing moisture intrusion at the bottom of the bin. A very thin layer of moldy grain was located at the bottom of Bin 1 and Bin 3 in the center. Bin 5 had some light clumping on the south side of the bin. For the lined bins, the grain was in good condition with no evidence of mold present in any of the bins. When the liner was completely removed, standing water could be seen at the bottom of the bins. During installation of the liner, a plastic box was placed underneath the liner in Bins 2, 4, and 6 to protect the liner from a metal bracket at the bottom of the bin. The air space created by this box may have promoted condensation under the liner. The water did not appear to have come in contact with the seed. Bins 1 and 3 (unlined) were also damp at the bottom, but did not have standing water. Seed samples were graded on a monthly basis. All six bins remained U.S. No. 1 during the first eleven months of storage. During the final month of sampling, Bin 3 was reduced to U.S. No. 2 due to heat damage (table 2.4).

Table 2.4. Year 2 overview of seed quality during final visual inspection and grade progression.

	Visual Inspection Upon Unloading	**Grade at 6 months**	**Grade at 11 months**	**Grade at 12 months**
Bin 1 (unlined)	Good condition. Small patch of moldy canola at the bottom center.	U.S. No. 1	U.S. No. 1	U.S. No. 1
Bin 2 (lined)	Good condition. No evidence of mold.	U.S. No. 1	U.S. No. 1	U.S. No. 1
Bin 3 (unlined)	Good condition. Small patch of moldy canola at the bottom center.	U.S. No. 1	U.S. No. 1	U.S. No. 2
Bin 4 (lined)	Good condition. No evidence of mold.	U.S. No. 1	U.S. No. 1	U.S. No. 1
Bin 5 (unlined)	Good condition. Slight clumping on the south side approximately halfway down.	U.S. No. 1	U.S. No. 1	U.S. No. 1
Bin 6 (lined)	Good condition. No evidence of mold.	U.S. No. 1	U.S. No. 1	U.S. No. 1

Germination testing was completed on a monthly basis. A control was stored at 5°C and tested monthly as well. Germination rates maintained above 70% for all samples with the exception of Bin 6, which dropped to 66% in month 11 (not shown.) Quarterly data is presented in table 2.5.

Table 2.5. Germination rates for canola seeds in year 2.

	Initial	**3 months**	**6 months**	**9 months**	**12 months**
Control	100%	96%	98%	98%	99%
Bin 1 (unlined)	92%	94%	96%	94%	82%
Bin 2 (lined)	82%	92%	90%	90%	85%
Bin 3 (unlined)	80%	90%	84%	100%	90%
Bin 4 (lined)	94%	88%	86%	94%	85%
Bin 5 (unlined)	92%	84%	84%	92%	72%
Bin 6 (lined)	84%	84%	82%	94%	72%

The free fatty acid content of the canola seed samples rose throughout the storage period, but stayed below 0.4% for all six bins. There was no significant difference in the FFA between the lined and unlined bins ($p=0.8057$) so the values were pooled for trend analysis. There was a significant linear ($p<0.0001$) trend in the FFA value with respect to the time in storage (figure 2.8).

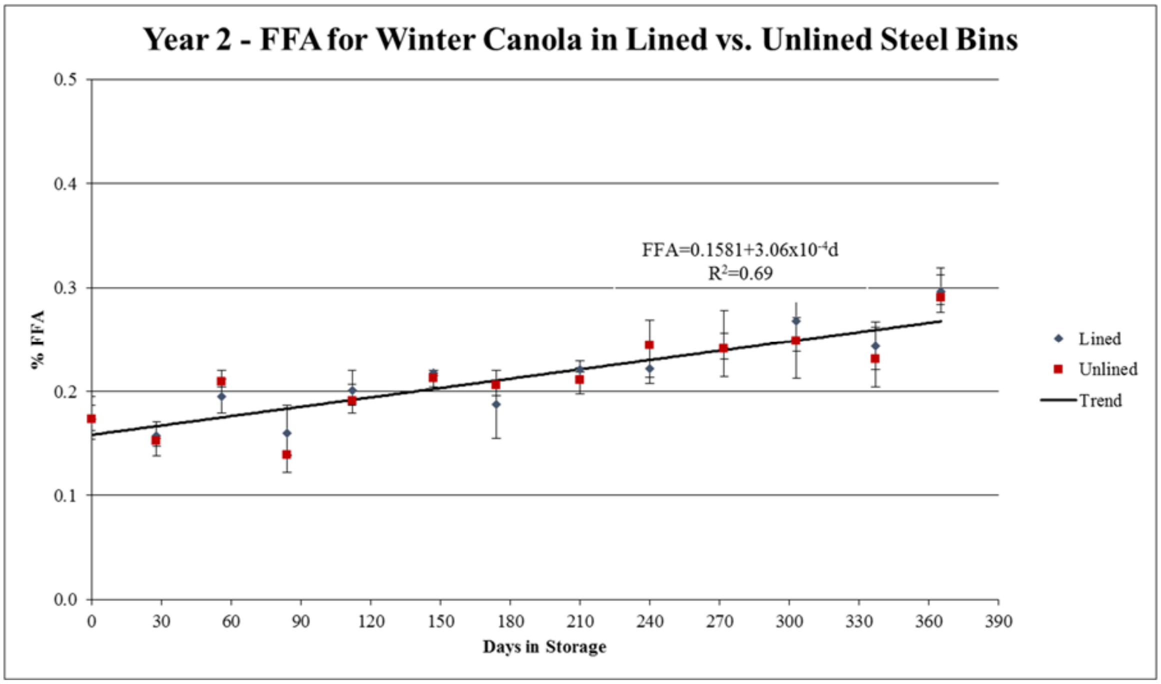

Figure 2.8. Free fatty acid increased moderately during year two and was lower than observed in year one.

2.5 Discussion

Comparing the results in year one and year two of the study, the polyethylene liner did not appear to impact the storage quality. There was not a significant difference in the free fatty acid levels between the lined and unlined bags in year one (p=0.6826) or year two (p=0.8057) (figure 2.9). Additionally, the deterioration in grade during year one was spread evenly between the lined and unlined bins. In each case, two were sample grade and one was U.S. No. 1 at the end of six months and all were sample grade at the end of ten months. However, there was a significant difference in the mean temperature between the lined and unlined bins during the first six months of storage (p=0.0038). This is likely due to biological activity within the bins. An increase in temperature is generally indicative of fungal growth and/or insect activity (Tipples, 1995). The difference in moisture content between year one (9.1%) and year two (5.4%) is the most likely cause of this biological activity.

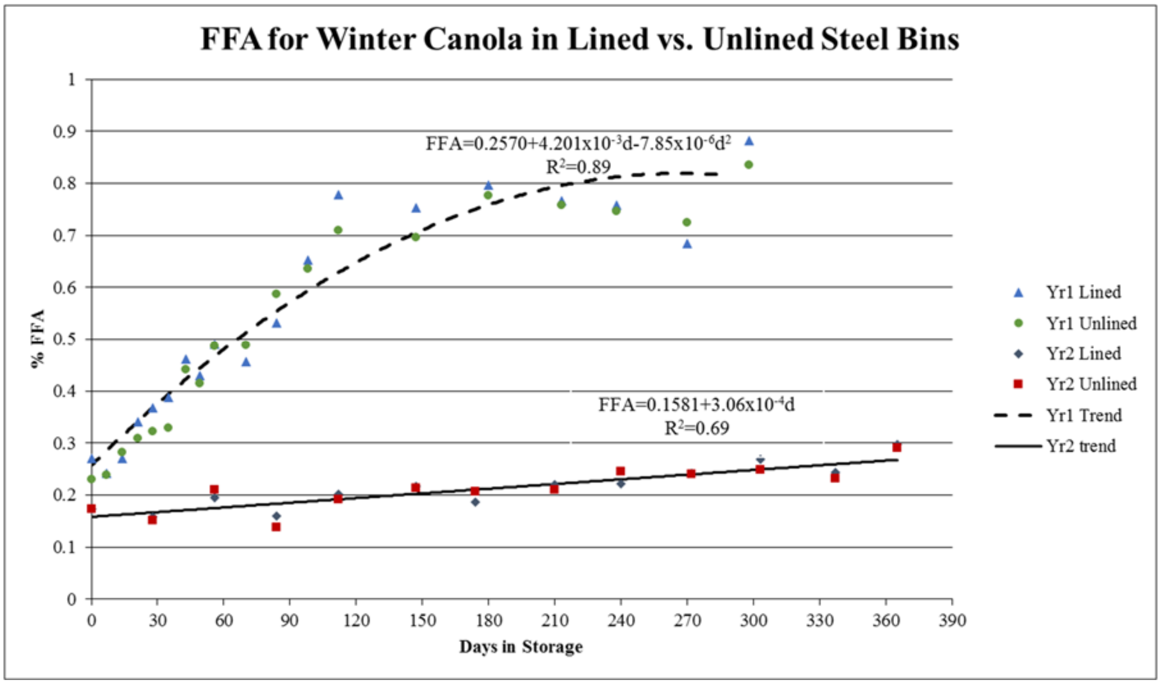

Figure 2.9. Comparison of free fatty acid values for lined versus unlined bins in year 1 and year 2.

The difference in FFA between year one and two is indicative of the poor storage quality experienced in year one. FFA is commonly used as a measure of grain deterioration and generally increases with moisture content and storage time (Sathya, Jayas, & White, 2009). FFAs are formed by the breakdown of triglycerides due to oxidation or hydrolysis. Triglycerides are the main component of fats and oils. 95-99% of the fatty acids in canola are present as triglycerides. A triglyceride molecule is formed by three fatty acids joined to a glycerol molecule (figure 2.10).

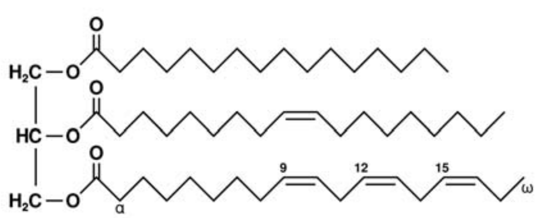

Figure 2.10. A triglyceride molecule.

Canola oil contains a high concentration of unsaturated fatty acids. Unsaturated fatty acids contain at least one double bond in the carbon chain. While this is considered a "healthy fat", it is more susceptible to oxidation at the double bond locations (Ratnayake & Daun, 2004). Hydrolysis (enzymatic oxidation) of the triglyceride can also occur due to the presence of fungal lipases. A lipase is an enzyme that promotes the reaction between water and triglycerides, progressively cutting the glycerol/fatty acid bonds. Di- and mono-glycerides are formed as intermediate products until finally three fatty acids and glycerol remain (Swetman et al., 2002). Fatty acids are broken down further by oxidation to form alcohols, aldehydes, ketones, acids, hydrocarbons, and esters. These compounds lead to numerous odors and flavors, both pleasant and unpleasant (Barnes & Galliard, 1982; Rousseau, 2004). Excessive off-odors will cause a reduction in grade and commercial value. Odors and free fatty acids must be removed from the oil during refining and this increases processing costs. *Aspergillus* spp. and *Penicillium* spp. are common storage fungi associated with cereal grains and oilseeds (Sauer, Meronuck, & Christensen, 1992). These fungi are highly lipolytic and are responsible for the breakdown of fatty acid molecules during storage. In year one the rapid increase in FFA, decrease in germination, decrease in grade, evidence of self-heating, and visible mold formation were all indicative of a reduction in seed quality. These were not present in year two, which exhibited only a moderate increase in FFA, a moderate decrease in germination, a decrease in grade for only one bin after twelve months of storage, and minimal evidence of visible mold formation.

There was a considerable difference in moisture content between year one (9.1%) and year two (5.4%). Moisture content and temperature are the most critical factors contributing to the degradation of stored seeds (Jayas & White, 2003). Most storage guidelines for canola are based on the work of Mills and Sinha (1980) in Manitoba, Canada. They developed a safe storage region based on the seed temperature and relative humidity at the time of binning (figure 2.11). Mills and Sinha considered a maximum equilibrium relative humidity (ERH) of 70% to limit mold growth in storage bins, but allowed higher ERH values at lower temperatures due to suppression of mold growth. While the Canadian Grain Commission (2016) allows canola seed to be sold as straight grade (not tough or damp) at moisture contents up to 10%, best management practice in Canada for long term storage calls for a moisture content below 8% and temperature below 15°C (Canola Council of Canada, 2014).

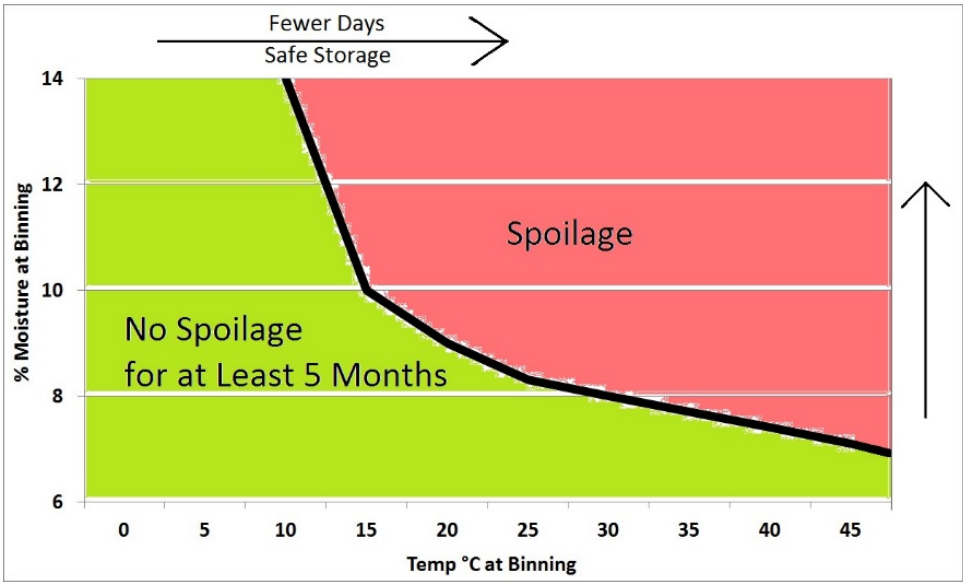

Figure 2.11. Canola seed storage guidelines published by the Canola Council of Canada (2014) based on the work of Mills and Sinha (1980).

In southern climates where winter canola is typically grown, harvest temperatures are often 30 or even 35°C. Under these conditions, the Canadian guidelines recommend a moisture content of approximately 7.5-8%. This reflects an equilibrium relative humidity (ERH) of 70%. Storage fungi are adapted to grow in grains with an ERH of 65-90% and most grow best at temperature of about 30°C (Christensen & Meronuck, 1986). Australian producers must also deal with high temperatures during harvest. Storage guidelines for Australia typically recommend a lower moisture content than Canada. Cassells, Caddick, Green, and Reuss (2003) recommend a maximum ERH of 60% for canola seed in Australia. Caddick (2002) stressed the importance of considering the oil content of canola seed when determining safe storage conditions. For example, at 30°C, canola at 35% oil content can be safely stored at 7.5% moisture content while canola at 45% oil content should be stored at 6.5% moisture content (figure 2.12). This is because less dry matter is available to absorb water. Based on the Australian study, the year one canola

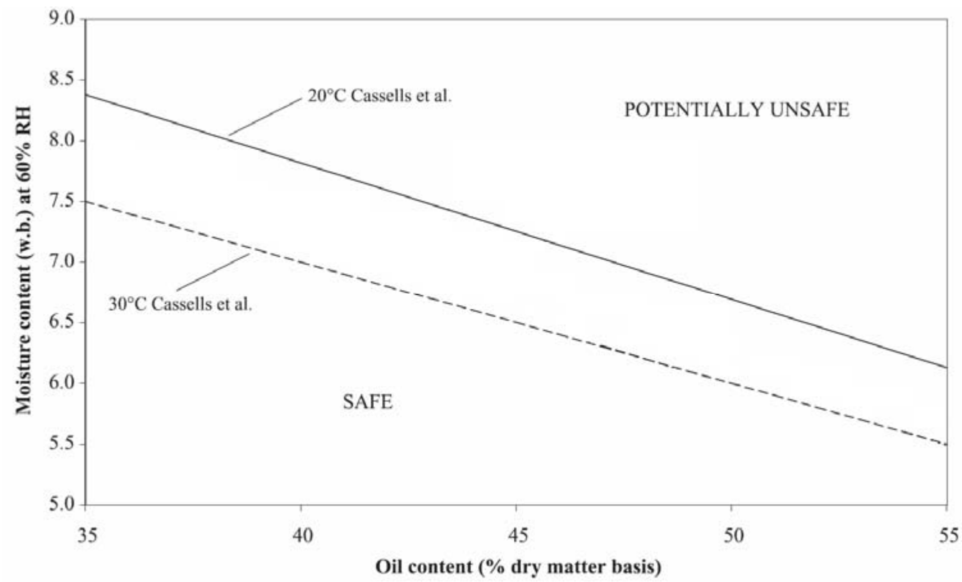

Figure 2.12. Canola seed storage recommendations for Australia based on 60% equilibrium relative humidity and oil content. - Adapted from Cassells, Caddick, Green, and Reuss (2003).

seed at 35.1% oil content and 30°C temperature should have been stored at a moisture content of no more than 7.5%. Since the measured bin temperatures were as high as 41°C, the moisture content should have been closer to 6.5-7% for safe storage. This is based on an extrapolation of the Cassells et al. data. The canola seed was at 9.1% during year one and four of the six bins did not maintain good storage quality after six months of storage. During year two, the canola seed was 38.4% oil content and bin temperatures began at nearly 40°C. Similar to year one, a safe moisture content would have also been approximately 6.5-7%. The canola seed moisture content was 5.4% in year two and suffered no loss in quality after 11 months of storage.

Based on this information, the moisture content of our canola seed was clearly too high in year one for safe storage without aeration to help reduce the temperature and moisture content of the seed. The seed quality was still acceptable at six weeks, but by six months four of the six bins were reduced to sample grade. This is in agreement with the storage guidelines of Cassells et al. (2003), Mills and Sinha (1980), and Sathya et al. (2009). Water infiltration at the bottom of the bins exacerbated this problem in the unlined bins, where mold was present at the bottom and along the south facing wall. For the lined bins, moisture migration led to mold formation at the top of the bags while the rest of the canola appeared to be in good condition. It is possible that in a larger storage bin without aeration the liner would provide some benefit in maintaining the quality of the bulk of the canola seed, especially if steps were taken to manage moisture migration to the top of the bag. One possibility would be the installation of liner material only near the bottom of the bin to prevent moisture infiltration at the base of older, leaky bins. This, combined with vents in the headspace, could allow older bins to be pressed into service when needed for short-term storage of canola or other grains. Of course it would be important to leave an opening at the discharge so that grain can be removed. Also the grain should be clean and dry since aeration would not be possible with the liner in place. Additional research is needed to determine how long grain could be safely stored in this manner and what the maximum moisture content should be. Until this data can be obtained, grain should be stored drier than what would normally be considered a safe moisture content with aeration.

2.6 Conclusions

A two-year study to investigate the impact of a polyethylene grain bag liner in small, low-quality grain bins without aeration for the storage of canola seed was completed. There was not a significant difference in storage quality between the lined and unlined bins. A moisture content of 9.1% is too high for long term storage of winter canola seed in the southern United States. However, low moisture content (5.4%) canola seed can be stored without aeration for 11 months without losing grade and with minimal loss in germination. Guidelines developed for the storage of canola seed in Australia appear to be more appropriate for the southern United States than Canadian storage guidelines. Grain storage facilities should target a maximum equilibrium relative humidity of 60% and should consider adjusting the target moisture content based on the oil content of the seed. The acceptable moisture content of canola seed should be reduced by 0.1% for every 1% increase in oil content. The moisture content of canola seed in unaerated grain bins in the southern United States should be 6-7% for long term storage. If the temperature can be quickly reduced below 20°C with aeration then moisture contents up to 8% may be possible if the oil content is less than 40%. In circumstances where low quality grain bins must be used for short-term storage, the bottom of the bin can be lined with grain bag material for the purpose of sealing and moisture exclusion. Canola seed should be monitored closely for temperature increases or mold formation. Further study concerning the use of grain bag material to line the bottom of low quality storage bins for other oilseed crops and cereal grains would be beneficial.

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CHAPTER III

DEVELOPMENT OF A LOW-COST ELECTRONIC NOSE FOR THE DETECTION OF MOLD IN STORED WINTER CANOLA SEED

3.1 Abstract

Mold development is a key cause of grain deterioration during storage and reduces the commercial value of the product. The characteristic earthy, musty odor of mold is caused by numerous volatile organic compounds produced as the mold grows. Electronic nose technology has been broadly utilized to detect odors in food, medical, and industrial applications. Expanding canola production in the United States has led to interest in improved monitoring of stored canola seed. The goal of this project was to develop a low-cost electronic nose to detect the presence of mold in canola seed. An electronic nose utilizing an array of metal oxide semiconductors was developed that is capable of identifying moldy canola with an error rate of less than 3%. The electronic nose could clearly distinguish between moldy and not moldy samples but could not distinguish between three different levels of mold inoculation. Additional development of the electronic nose for commercial testing and application is warranted.

3.2 Introduction

Objectionable odors have a significant negative effect on the commercial grade of canola seed. According to 7 CFR §810.304 canola seed is discounted to "U.S. Sample Grade" if it has a "musty, sour, or commercially objectionable foreign odor." Because of this, the odor of stored canola seed is an important quality characteristic. The off-odor characteristic of canola seed indicates past or ongoing microbial deterioration. It also makes canola less palatable. Rapid characterization of canola seed odor is a potential way to quickly and cheaply determine whether it should be accepted (or rejected) for human consumption (Borjesson, Eklov, Jonsson, Sundgren, & Schnurer, 1996). Previous studies have attempted to develop an "electronic nose" to detect and classify mold in grain. These projects have utilized metal oxide semiconductors (MOS) (Falasconi et al., 2005), MOS sensors coupled with metal oxide semiconductor field effect transistors (MOSFET) (Borjesson et al., 1996; Jonsson, Winquist, Schnurer, Sundgren, & Lundstrom, 1997), and several commercially available electronic noses utilizing MOS (Gobbi, Falasconi, Torelli, & Sberveglieri, 2011), surface acoustic wave (Keshri & Magan, 2000), and quartz crystal microbalance sensors (Paolesse et al., 2006). The basic operating principle of all these devices is the same. The response of a sensor array varies in a predictable way with exposure to different volatile compounds. Then neural network pattern recognition or multivariate statistical techniques such as principle component analysis, discriminant analysis, and partial least squares regression are used to classify the samples.

Numerous studies have investigated the volatile organic compounds (VOCs) that are produced by molds in stored grains and other food products. Early work by Kaminski, Stawicki, and Wasowicz (1974) identified 1-octen-3-ol (mushroom alcohol) as the main VOC present in a study of 12 mold strains. This alcohol is formed by the degradation of lipids, specifically, linoleic and linolenic acids (Bennett & Inamdar, 2015). Ketones, terpenes, pyrazines, and esters are other chemical groups associated with *Aspergillus* and *Penicillium* molds (Jelen & Wasowicz, 1998). These fungal VOCs can be detected before visual signs of mold are present (Borjesson, Stollman, Adamek, & Kaspersson, 1989). However, VOC production can be influenced by the fungal species, growth media, moisture content, temperature, and growth time (Pasanen, Lappalainen, & Pasanen, 1996). This information is useful in selecting potential sensors for mold detection, but the inherent variability of biological processes presents challenges in the use of VOCs for monitoring stored grain.

The goal of this project is to develop an inexpensive electronic nose that can accurately detect the presence of mold in stored canola seed.

3.3 Materials and Methods

3.3.1 Development of electronic nose

An electronic nose was constructed using metal oxide semiconductor gas sensors. This type of sensor was initially developed in the 1960's and exhibits a change in the resistance of the semiconductor material (often SnO_2) when exposed to reducing or oxidizing gases. As the semiconducting metal oxide is exposed to the air, free electrons on the surface of the metal oxide bind to oxygen molecules, leaving an electron-depleted region at the surface of the metal oxide. This loss of free electrons increases the electrical resistance of the metal oxide material. When exposed to a reducing gas, oxygen molecules are released from the metal oxide and free electrons are made available again. This causes a reduction in the electrical resistance of the material. Measurement of this change in resistance is utilized to detect the presence of certain gases. These sensors are simple, inexpensive, and robust and have been widely applied in carbon monoxide detectors and other residential and industrial gas detectors (Miller, Bakrania, Perez, & Wooldridge, 2006).

Four metal oxide sensors were selected and purchased from Figaro Engineering, Inc. Since the exact nature of the volatile gases produced by the moldy canola was unknown, sensors were selected that would respond to a variety of VOCs associated with mold. The selected sensors are sensitive to alcohols, organic solvents, and light hydrocarbons as shown in Table 3.1.

Table 3.1. Metal oxide sensors and gas sensitivity.

Sensor Type	**Sensor I.D.**	**Gases detected**
TGS 2620	Sensor 1 (S1)	sensitive to alcohol and organic solvent vapors
TGS 2602	Sensor 2 (S2)	sensitive to VOCs and odorous gases
TGS 822	Sensor 3 (S3)	sensitive to organic solvent vapors
TGS 813	Sensor 4 (S4)	sensitive to combustible gases

The manufacturer recommends the use of a voltage divider to measure the change in resistance of the sensor when exposed to the target gases. The basic measurement circuit is shown in Figure 3.1. Four voltage divider circuits were constructed for development and testing of the electronic nose.

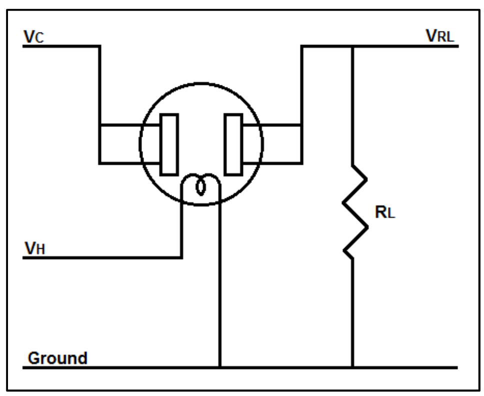

Figure 3.1. Basic measurement circuit for Figaro gas sensors. V_C is the voltage supplied to the sensor, V_H is the voltage supplied to the heater, V_{RL} is the voltage measured across the load resistor R_L.

A suitable load resistor was selected for each circuit (R_L) to provide a similar voltage output for each sensor in clean air. The resistance of each sensor was determined by equation 1:

$$R_S = \left(\frac{V_C}{V_{RL}} - 1\right) \times R_L \quad \text{(Eq. 1)}$$

MOS sensors are sensitive to changes in temperature and relative humidity, so relative humidity and temperature sensors were added to the sensor array. A HIH-4030 (Honeywell, Morris Plains, NJ) humidity sensor was selected for the project. The sensor comes calibrated by the manufacturer and the temperature compensated relative humidity is calculated based on equation 2:

$$RH = \frac{V_{out} - 0.16}{0.0326926 - 0.00006696 \times T} \quad \text{(Eq. 2)}$$

Temperature is obtained from a TMP-36 temperature sensor (Analog Devices, Norwood, MA).

A USB-6008 data logger (National Instruments, Austin, TX) was selected for data acquisition. A regulated 5V power supply and breadboard power supply strip (Sparkfun, Niwot, CO) provided a consistent voltage to the sensors. Data collection was controlled with a LabVIEW (National Instruments, Austin, TX) program which also provided an interface during test runs. The completed sensor array is pictured in figure 3.2.

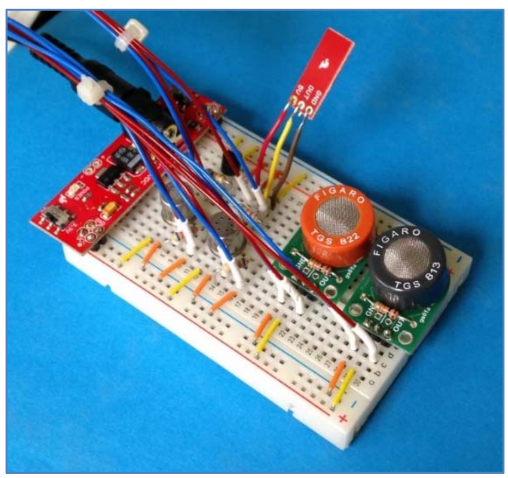

Figure 3.2. Sensor array for electronic nose.

3.3.2 Preparation of mold spore suspension

Mold spores were harvested from Croplan 115W winter canola seed that was heavily infested with mold. Mold spores were cultured and isolated for DNA identification. The culture was started by inserting a sterilized loop into a moldy seed sample and streaking a 90mm Petri dish containing a yeast-peptone-salt (YPS) media with chloramphenicol-rifampicin-ampicillin added to control bacterial growth and danitol to control mites (CRAD). This was incubated at 28°C overnight and then a single spore was identified under magnification and transferred to a fresh YPS-CRAD plate and placed back in the incubator. After five days the plates were inspected to confirm that they contained a single mold species. Spores were collected from the margin of a colony using a sterilized loop and transferred to potato dextrose broth (PDB) and incubated at 28°C for seven days to provide mycelia for DNA identification. Liquid broth was utilized to suppress sporulation. Additional spores were transferred to Czapek-yeast-agar (CYA-CRAD) media to produce a working culture for development of a spore suspension. After seven days the mycelia from the PDB was harvested, lyophilized, and stored at -20°C until needed for DNA analysis.

DNA was isolated from the mycelium using ZR Fungal/Bacterial DNA MiniPrep™ kit (Zymo Research Corporation, Irvine, CA, USA). DNA identification was performed using the method outlined by Samson et al. (2014). Briefly, sequencing of the internal transcribed spacer (ITS) region with primers ITS1 and ITS4 as developed by White, Bruns, Lee, and Taylor (1990) with secondary sequencing of calmodulin (CaM) with primers CMD5 and CMD6 as developed by Hong, Go, Shin, Frisvad, and Samson (2005). Comparing these two sequences to reference databases RefSeq and GenBank using BLAST allows identification of *Aspergillus* samples to the species level. The mold obtained from the Croplan 115W canola was identified as *Aspergillus* chevalieri (L. Mangin) Thom & Church. A. chevalieri is a xerophilic mold typically found in grain and animal feed. It is mycotoxigenic, producing sterigmatocystin and echinulin (Greco, Kemppainen, Pose, & Pardo, 2015; Meurant, 2012). Sterigmatocystin is closely related to aflatoxin B1 and is considered carcinogenic (Dickens, Jones, & Waynforth, 1966; Meurant, 2012; Schroeder & Kelton, 1975). Echinulin has been demonstrated as toxic in rabbits (Ali, Mohammed, Alnaqeeb, Hassan, & Ahmad, 1989) and feed containing echinulin was refused by swine and resulted in decreased milk production (Vesonder, Lambert, Wicklow, & Biehl, 1988).

Following positive identification of the mold species a standard spore suspension was prepared by flooding the agar plates containing mold cultures with 3-4ml of autoclaved water and scraping the cultures gently with a sterilized spreader to dislodge the spores. The liquid was filtered through sterilized cheesecloth into a 50ml centrifuge tube. This process was repeated five times. The spore suspension concentration was quantified with a hemocytometer and adjusted to $1x10^7$ spores/ml. This suspension was stored at 5°C and used for inoculations within one week.

3.3.3 Inoculation of seeds with mold spore suspension

Seed lots from two different years were collected for testing. The first lot was harvested in Oklahoma during the summer of 2016 and the second was harvested during the summer of 2015. Both lots were Dekalb DKW 44-10 winter canola seed. Samples were cleaned to remove foreign matter and the moisture content was adjusted to a final value of 9.2% for the 2016 lot and 9.1% for the 2015 lot. Samples weighing 10.00g were placed into sterilized 50ml plastic centrifuge tubes. The seeds were inoculated with 0.75ml of liquid spore suspension diluted to 10^0 (water only), 10^5, 10^6, and 10^7 concentrations, capped, and vortexed until the liquid was absorbed by the seeds. This brought the final moisture content of the samples to approximately 15%. While this moisture content is high for storage of canola seed, it was selected to promote rapid mold growth in the samples. An untreated sample was also prepared for each seed variety. Five seed replications were prepared for each treatment (table 3.2). The samples were then placed in an environmental chamber at 30°C to promote mold growth. Samples were tested with the electronic nose after six, twelve, and eighteen days in storage.

Table 3.2. Treatment levels for seed inoculations.

	No treatment	Water only	0.75ml 10^5	0.75ml 10^6	0.75ml 10^7
4410 - 2016	5 replications	5 replications	5 replications	5 replications	5 replications
4410 - 2015	5 replications	5 replications	5 replications	5 replications	5 replications

3.3.4 Testing procedure with electronic nose

The electronic nose consisted of the sensor array and the sampling unit (figure 3.3). Laboratory air was regulated to approximately 100Pa and passed through a combination gas dryer / activated carbon scrubber. Valves were manually opened and closed to direct the air to either the sample chamber or a bypass container for purging the sensor array after each test. Once a sample was loaded air was directed across the sample in the centrifuge tube and carried into the chamber containing the sensor array. Ninety seconds of sensor data was collected using a 2Hz sampling rate. Following data acquisition, the sample was removed and air was directed through the bypass chamber to the sensor array for four minutes to allow the sensors to return to their baseline values.

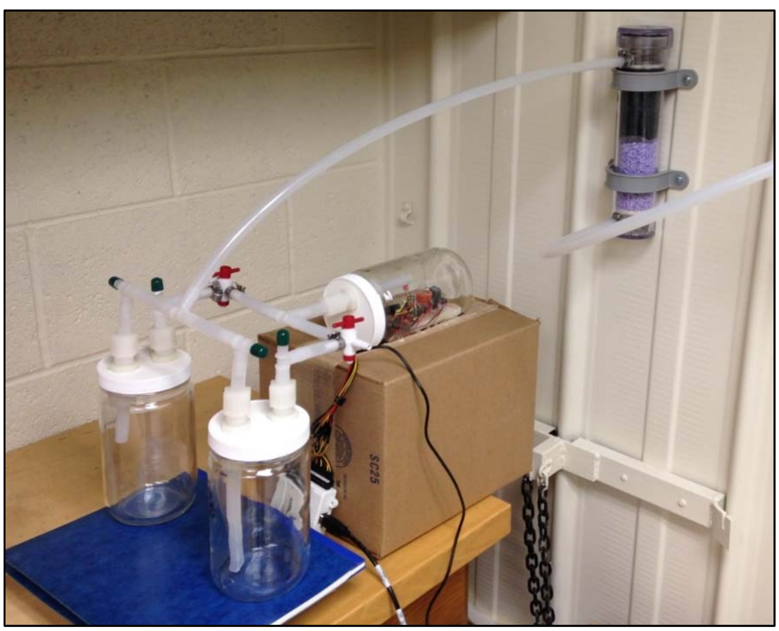

Figure 3.3. Sensor array and sampling system for electronic nose.

3.3.5 Data analysis

Following data acquisition, MATLAB (MathWorks, Natick, MA, USA) was utilized for preprocessing of the data. A large number of sensor measurements (4x180 data points per sample) are collected for each sample and it is necessary to reduce the amount of data for statistical analysis. To accomplish this, the 10 maximum sensor responses were identified for each sensor and averaged. The temperature and relative humidity associated with these responses were also recorded and averaged. During another set of experiments, the response of the sensor to changes in temperature and relative humidity for reference air were measured and regression curves were prepared. Based on these regression curves, the sensor response for reference air at the temperature and relative humidity corresponding to the maximum sensor response was calculated. The response of the sensor to the sample was adjusted based on this reference air value by R/R_0, where R was the maximum sensor response and R_0 was the sensor response to the reference air. Using these values, statistical analysis was performed in SAS software version 9.4 (SAS Institute Inc., Cary, NC, USA). PROC GLM was utilized for regression analysis of the reference air. Principal component analysis was performed using PROC GLM and PROC PRINCOMP to determine if the treatment levels could be discriminated. Discriminate analysis was performed using PROC DESCRIM and PROC CANDISC to test classification techniques. PROC STEPDISC was used to determine if the number of sensors in the array could be reduced without sacrificing classification quality. All measures of significance were evaluated for α=0.05.

3.4 Results and Discussion

3.4.1 Reference air regression analysis

During preliminary sensor testing it became clear that the sensor response was confounded by relatively small changes in temperature and relative humidity. Of particular concern was the amount of spread in the data observed at relative humidity values below 23-24% (figure 3.4).

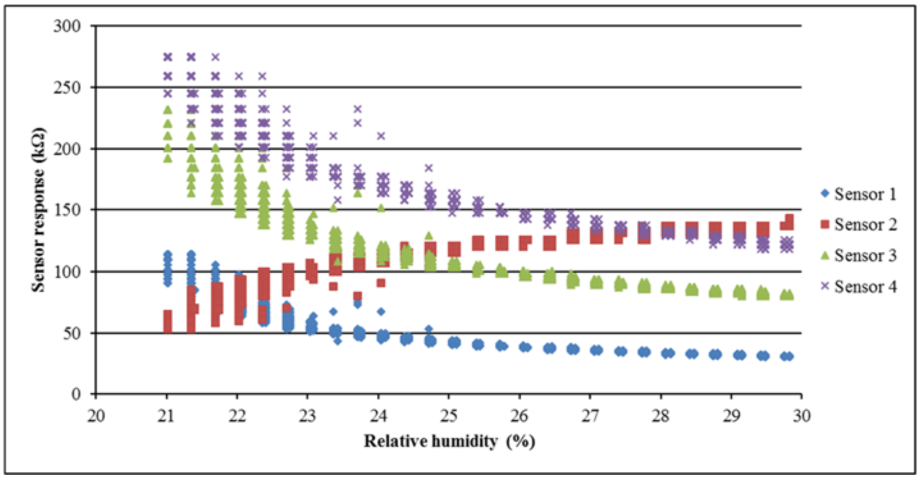

Figure 3.4. Influence of relative humidity on sensor response. Note the increase in data spread at lower RH.

These values were commonly encountered in the relatively dry air used to purge the sensor array prior to the introduction of each sample. The sensor response at time zero is often used as R_0 to adjust the sensor response. This provides an indication of the amplitude of the sensor response. One advantage of this approach is that it helps to correct for drift that may occur in the sensor over time. However, the ultimate goal of this project was to develop a sensor that could be deployed continuously in a grain storage facility. Therefore, the decision was made to develop a regression curve for clean air in order to adjust the sensor response. Data were collected for clean air at three temperatures (35, 36, and 39°C) and relative humidity levels between 25 and 30%. All of the maximum sensor responses during testing fell within these relative humidity values and the majority of responses fell within these temperature values. There was not a significant difference in the regression at 35 and 36°C ($p=0.1086$) so these data were pooled. There was a significant difference in the regression between the 35-36 and 39°C data ($p<0.0001$). A graph of the regression lines for each sensor is presented in figure 3.5. Values were interpolated between these two regression lines to calculate R_0 for each sample. For any samples below 35°C the 35-36°C regression curve was utilized. Likewise, for any samples above 39°C the 39°C regression line was used. Additional work is needed to expand the family of regression curves used for the reference air prior to commercial deployment of the electronic nose.

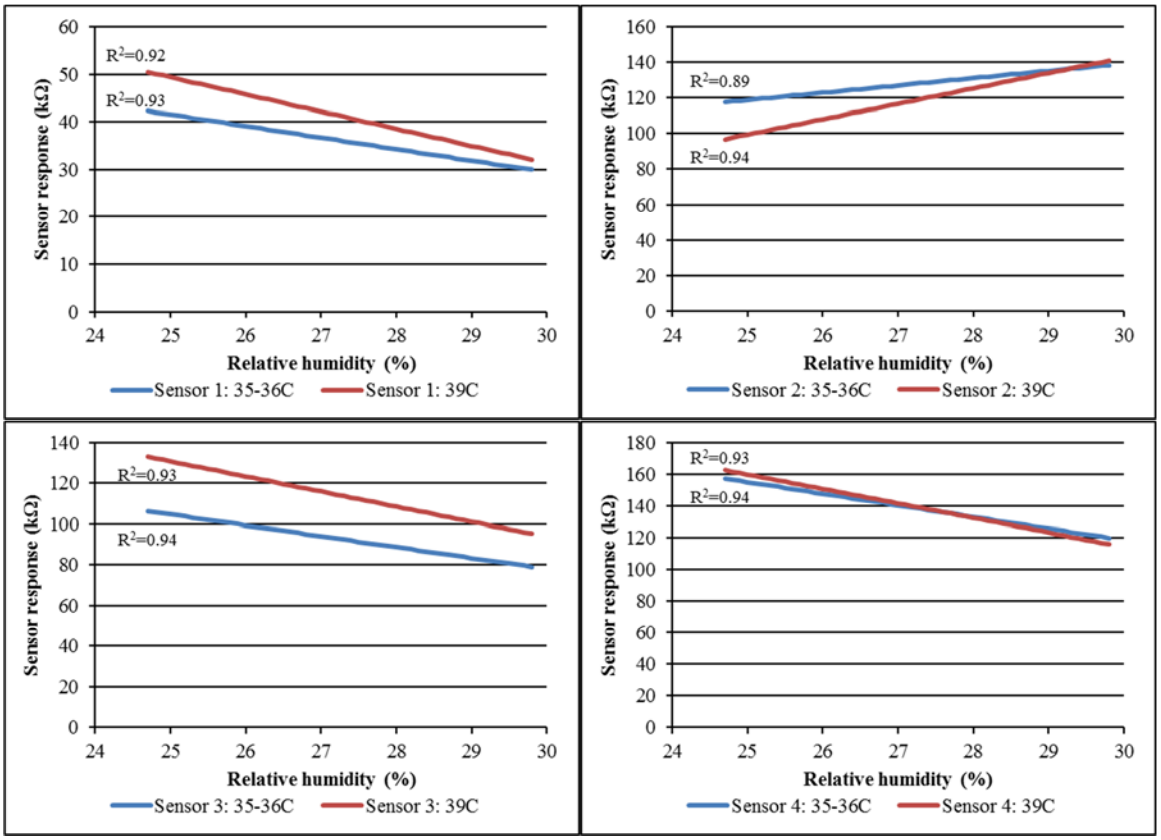

Figure 3.5. Regression curves used to calculate the sensor response R_0 for normalization of sensor output.

3.4.2 Mean comparison of treatments

The mean sensor response for the five treatments at 6, 12, and 18 days post inoculation (dpi) shows a clear separation between the treated and untreated samples (NT) (figure 3.6). The magnitude of the sensor response for the NT samples is fairly consistent across the two sample years and the three sample dates. The response of the other treatments appear to be generally higher for 2015 than 2016 and also appear to decrease as the dpi increases. There may be some evidence of a trend from the 10^7 inoculation to the 10^5 inoculation for the 12 and 18 dpi time frames, especially for sensors 1 and 3. The water (10^0) samples appears to be more similar to the inoculated samples than the NT samples. Upon inspection, the 10^7, 10^6, 10^5, and 10^0 all contained visible mold. The samples that only received the water treatment evidently contained surface

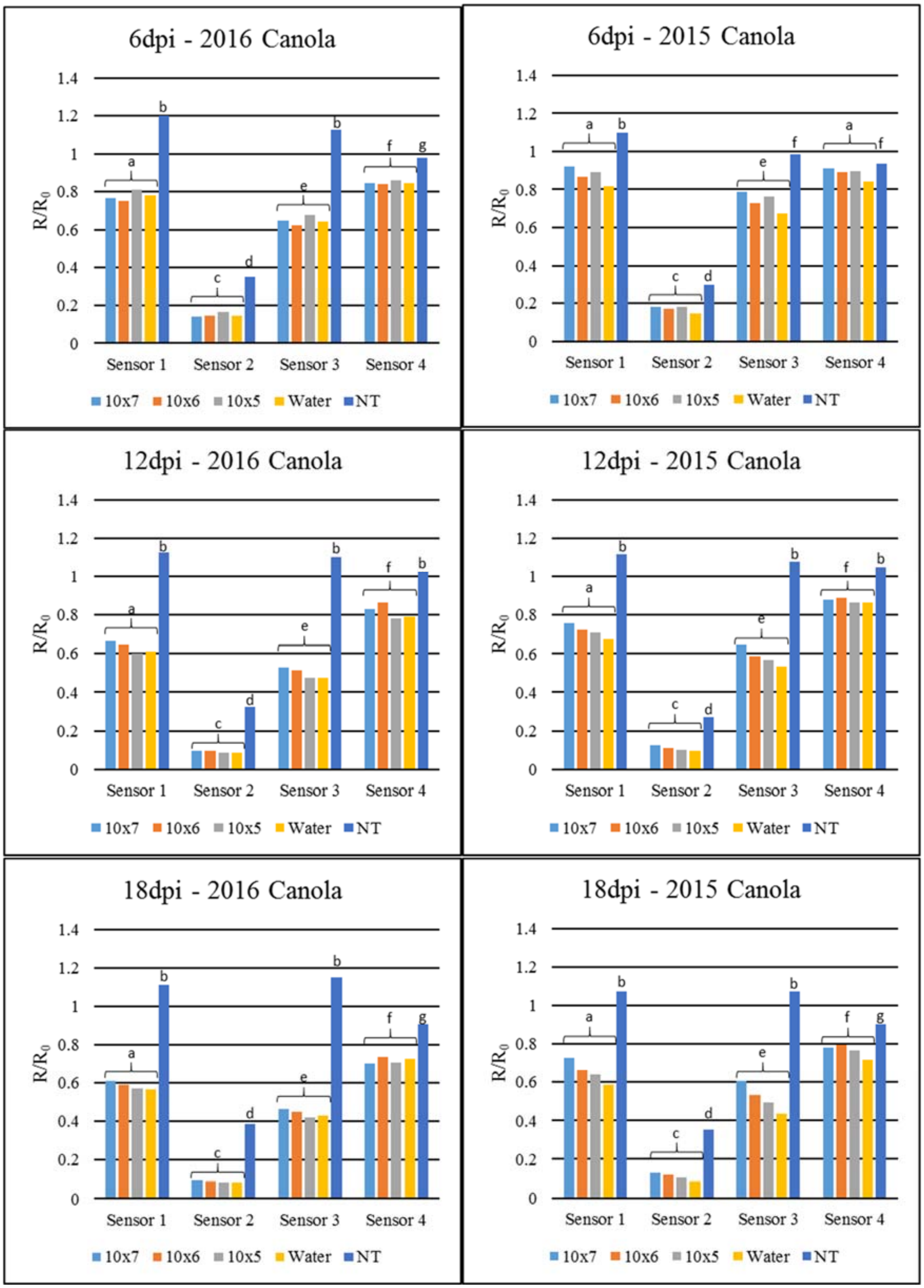

Figure 3.6. Mean sensor response for each treatment at 6, 12, and 18 days post inoculation (dpi). Means with the same letter are not significantly different from other means within each graph.

mold that developed when the moisture content was increased to 15%. Surface disinfection of the samples prior to inoculation should be considered for future tests.

Since the NT samples were a lower moisture content than the treated samples, it is possible that the difference in the mean response is due to the moisture content and not the presence of mold in the treated samples. To further investigate this, five additional samples of canola seed from each of the 2015 and 2016 lots were prepared post hoc and tested with the electronic nose. These samples had a final moisture content of approximately 16%. These are compared to the 18dpi mean sensor responses in figure 3.7. The mean response of the NT samples and the 16% moisture content samples are quite similar even though the 16% samples had a higher moisture content and were tested two weeks later. On this basis, it appears reasonable to compare the treated samples and the NT samples for classification. A clear distinction can be made between the moldy and not moldy samples but not the inoculation level. This was evident for the 6 and 12 dpi data as well (figure 3.6). This may warrant further investigation.

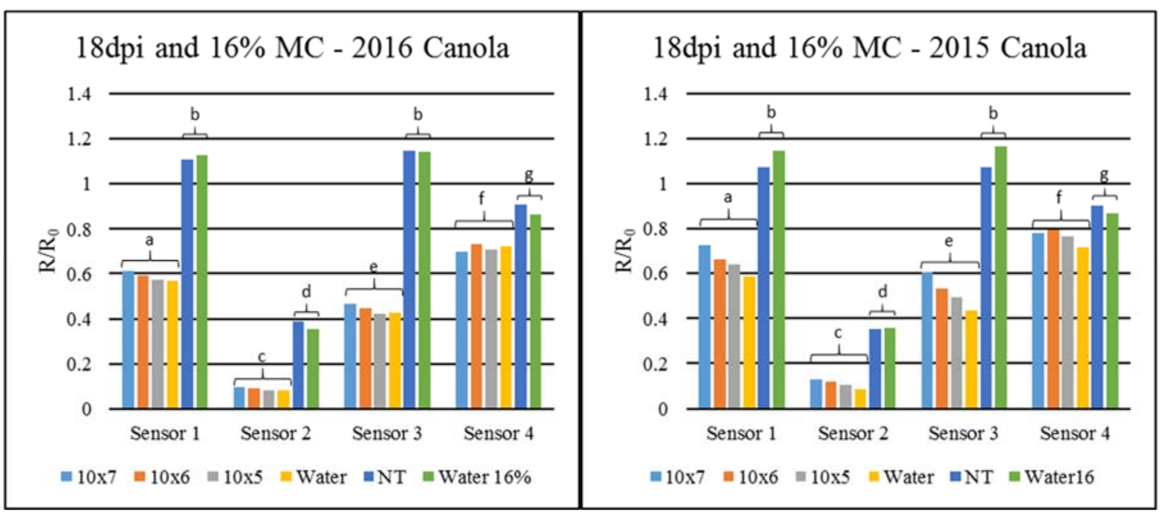

Figure 3.7. Comparison of 18 days post inoculation (dpi) and 16% moisture content samples prepared post hoc. Means with the same letter are not significantly different from other means within each graph.

3.4.3 Classification of samples

The goals of this analysis were to select a statistical model for classification of the canola samples as moldy or not moldy and to determine if the electronic nose could discriminate between the mold inoculation levels. Multivariate analysis of variation (MANOVA) was used to determine if the treatment levels could be discriminated. To assess the validity of the normality assumption, a plot of the first two principle components was prepared (figure 3.8). The first two principle components provide a good test of normality in this case as they capture 96.6% of the variability in the data. The data appear to be normal, as the plot does not reveal any obvious trends. The equal covariance assumption was confirmed with Box’s M test ($p<0.0001$).

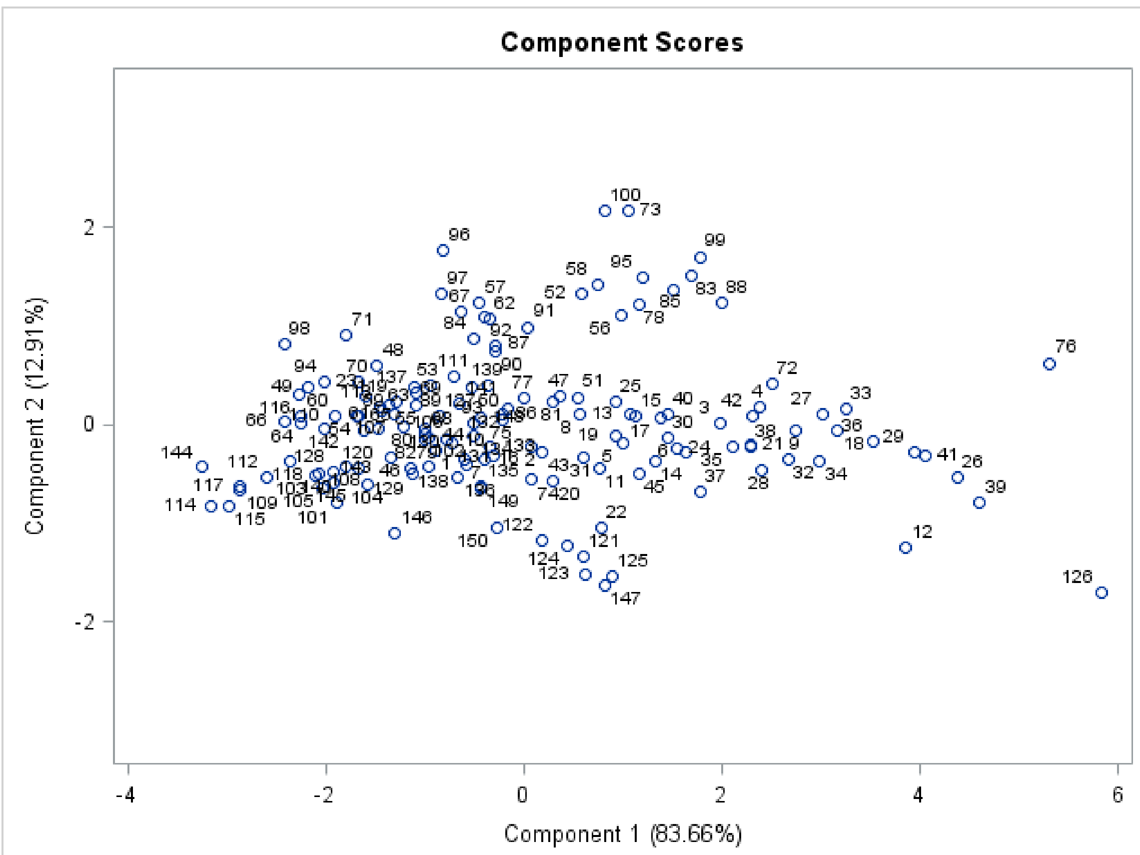

Figure 3.8. Graph of the first two principal components for the combined data set (6, 12, and 18 days post inoculation).

Test data were analyzed using MANOVA to determine if there is a difference between the inoculation levels. There are at least two discriminable groups in the data ($p<0.0001$ for Wilks' Lambda, Pillai's Trace, Hotelling-Lawley Trace, and Roy's Greatest Root). A plot of the first two linear discriminants does not show a clear separation between the inoculation levels or the dpi. However, there is a distinct separation between the inoculated samples and the untreated samples (figure 3.9). Classification tests were applied to the data to determine the best model for separating the moldy samples from the untreated samples.

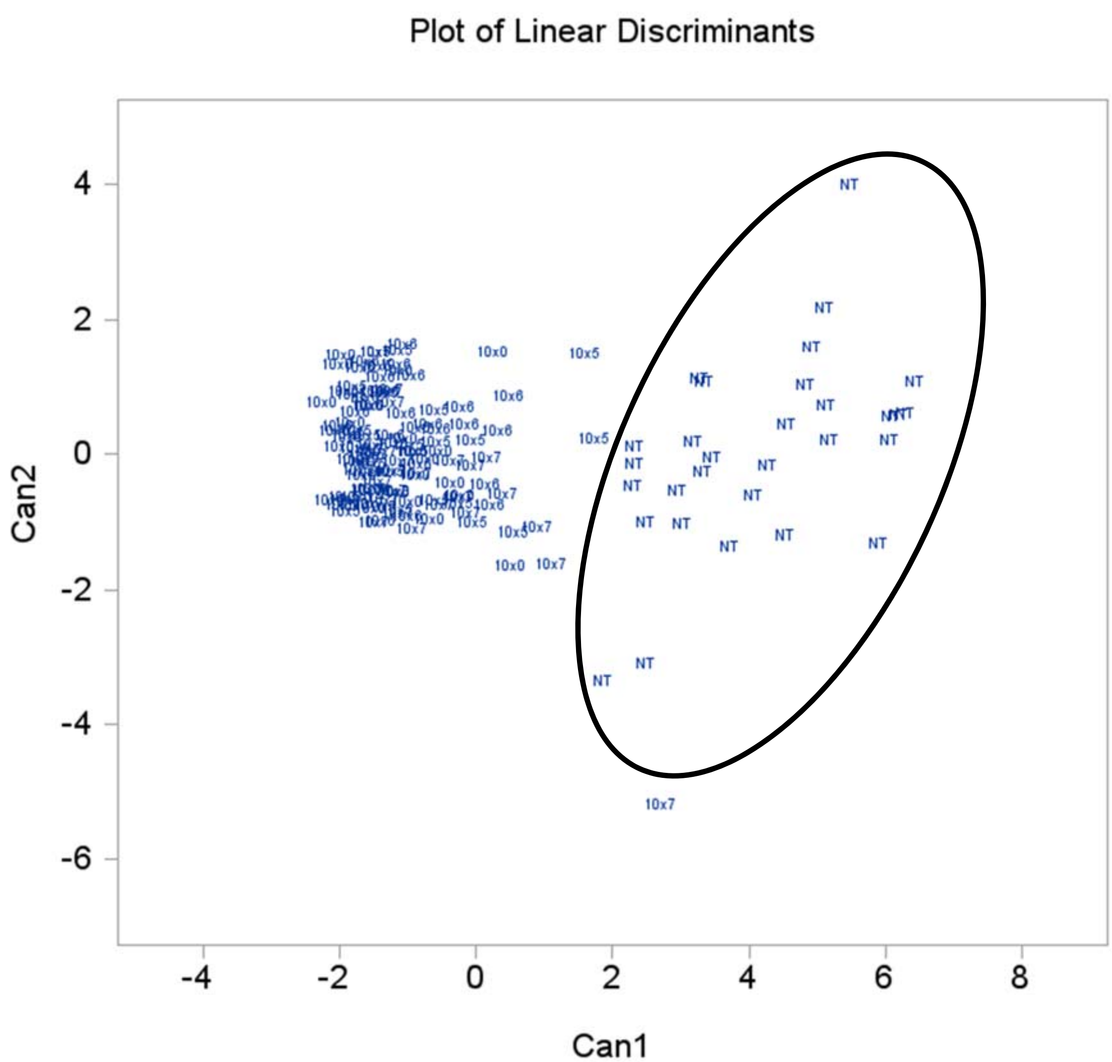

Figure 3.9. Plot of the first two linear discriminants to evaluate separation between inoculation levels.

Classification of the data was tested using linear, quadratic, and 3-nearest neighbor models. The lowest error rates were obtained with the quadratic and 3-nearest neighbor models (table 3.3). However, selecting a model requires consideration of the tradeoff between bias and variance. The bias reflects how accurately the model matches the training data. Variance reflects how sensitive the classification is to changes in the training data. More complex models (quadratic, quartic, etc.) will have a lower bias than a simple model (linear) but are sensitive to sample size. The linear model is the best choice in this case, even though it has a higher bias, because a simple model will help to control the variance and the difference in bias is minimal.

Table 3.3. Comparison of classification model error rates for canola data.

Model	**Cross Validation Error**
Linear classification	2.9%
Quadratic classification	1.7%
3-Nearest neighbor classification	1.7%

Stepwise discriminant analysis in the forward direction was utilized to determine if the number of sensors could be reduced. This resulted in the inclusion of sensor 2 ($p<0.0001$), sensor 1 ($p=0.0143$), and sensor 3 ($p=0.0721$). Sensor 4 can be removed from the sensor array without impacting the quality of the classification.

3.4.4 Evaluation of sensor stability

Sensor variability and drift is problematic for the long term performance of an electronic nose. Sensor stability was evaluated by computing the mean sensor response during the first 5 seconds of each test run before the sample was loaded. All four sensors exhibit considerable variation in the baseline value throughout the measurement period (figure 3.10). There also appears to be a slight negative slope to the baseline sensor values. As discussed previously, the sensors are influenced by changes in temperature and relative humidity. The majority of the baseline sensor data is found within +/- 20% of the mean sensor response. Sensor two exhibits the most variation, and also appears to be impacted the most by changes in temperature and relative humidity. In general, the baseline sensor response appears to be more strongly related to the relative humidity

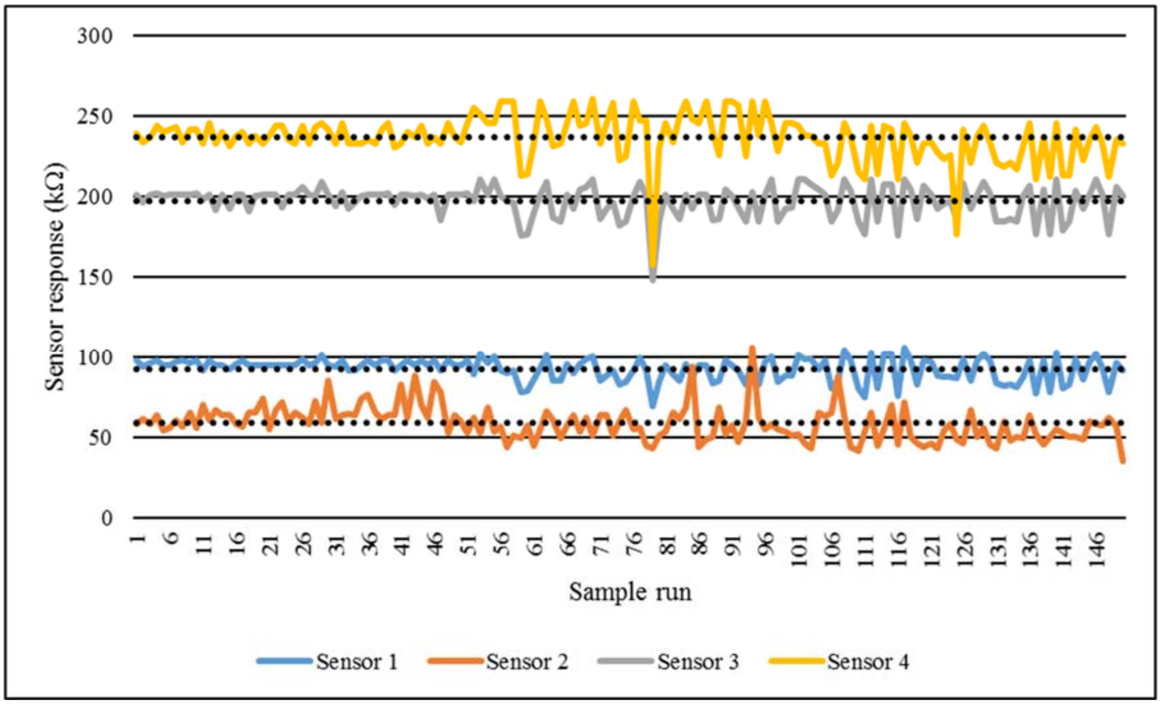

Figure 3.10. Baseline sensor value in air for all test runs. Dotted lines represent mean response for each sensor.

than the temperature (figures 3.11 and 3.12). This agrees with the work of Huerta, Mosqueiro, Fonollosa, Rulkov, and Rodriguez-Lujan (2016), who devised an energy band model to correct MOS sensors for variation in relative humidity and temperature. Their method requires at least three months of continuous sampling data to train the algorithm, but results in an R^2 greater than 90%.

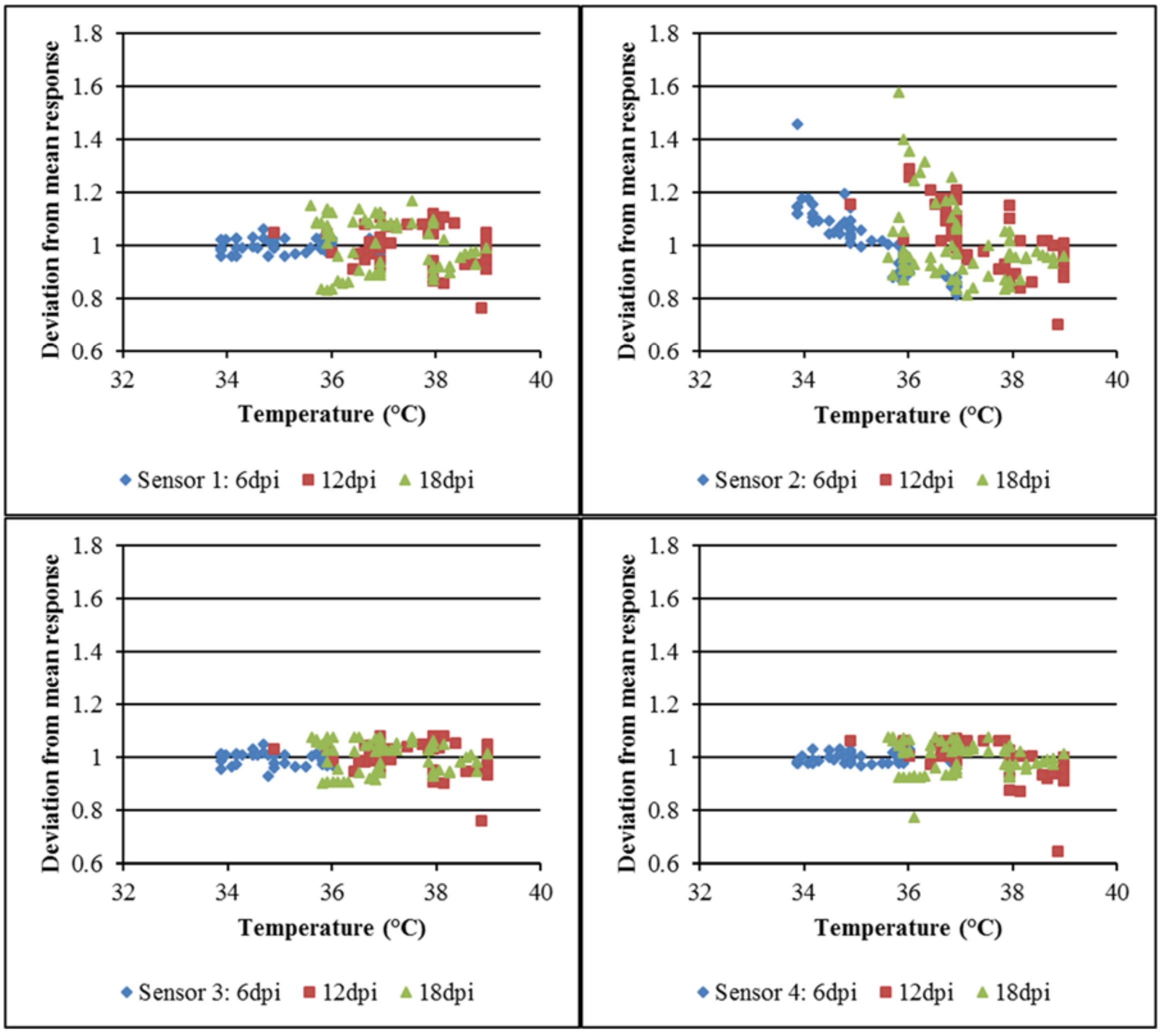

Figure 3.11. Influence of temperature on baseline sensor response for 6, 12, and 18 days post inoculation (dpi).

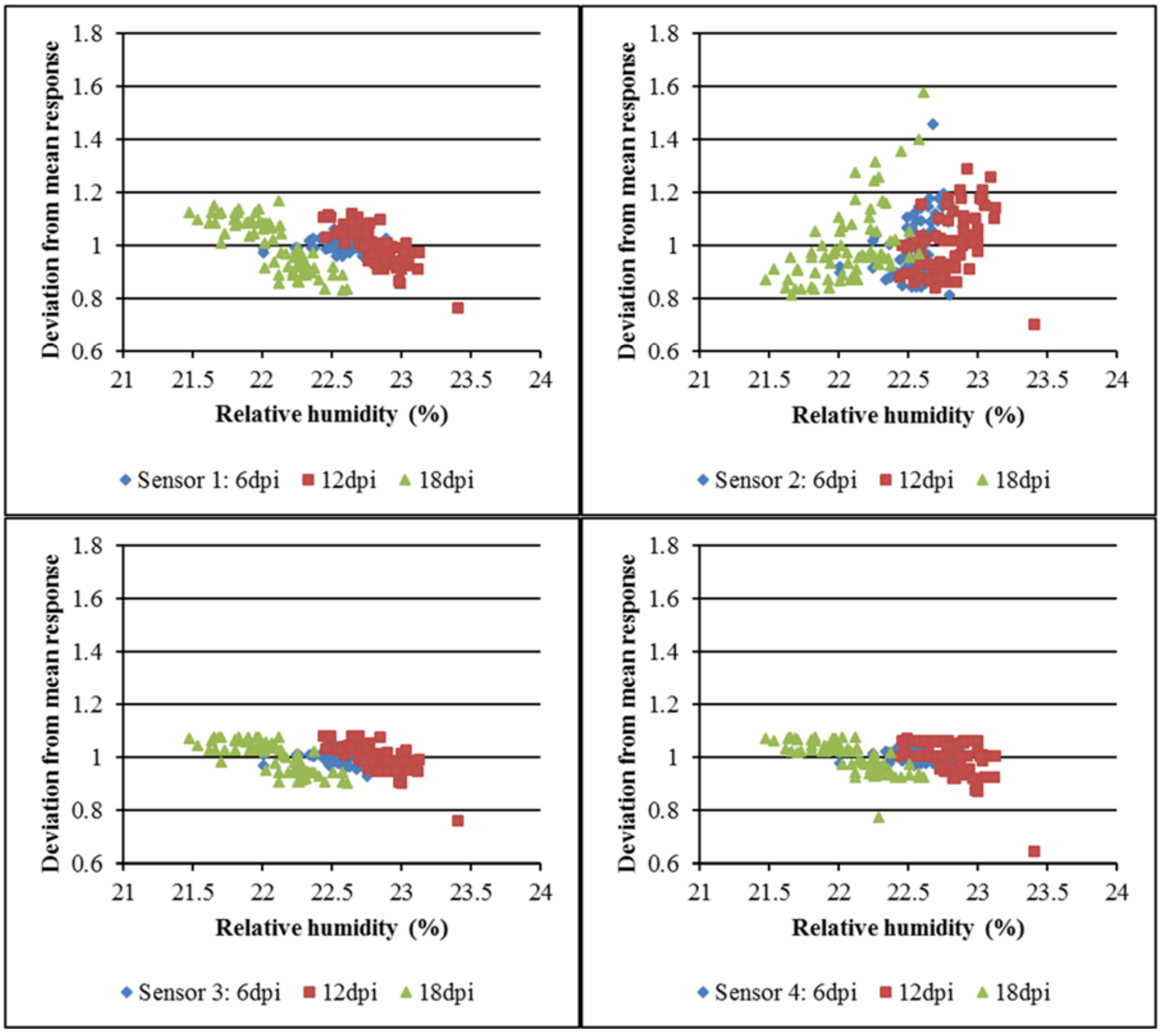

Figure 3.12. Influence of relative humidity on baseline sensor response for 6, 12, and 18 days post inoculation (dpi).

3.5 Conclusions

A metal oxide semiconductor based electronic nose system was developed that is capable of identifying mold in canola seed with an error rate of less than 3%. A clear distinction between the inoculation levels could not be made and this warrants further investigation. Additional testing to determine the lower detection limit is also desirable. The electronic nose was constructed from off the shelf components costing less than $100. There is potential for commercial application of the electronic nose for early detection of mold in storage. Ideally the electronic nose would be deployed in individual grain bins for continuous monitoring and communication to a central location. This will require packaging the sensor array with an integrated power supply and communication system. Alternatively, a handheld unit could be utilized periodically for sampling at one of the aeration exhaust vents. Additional development is needed to improve the ability of the electronic nose to adjust to changes in temperature and relative humidity. Field testing is also required to verify the ability of the nose to function long term in a dusty environment with considerable variation in temperature and humidity throughout the year. It is expected that the nose could be easily adapted for use in other grains. Ideally, an electronic nose can be developed that is effective at detecting mold in a wide variety of grain types.

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CHAPTER IV

GRAIN ENTRAPMENT PRESSURE ON THE TORSO: CAN YOU BREATHE WHILE BURIED IN GRAIN?[1]

4.1 Abstract

The pressure applied to the chest and back of a simulated grain entrapment victim was measured. Pressure sensors were attached to the chest and back of a manikin that was buried in grain in the vertical position. Measurements were made in four grain types at four grain depths ranging from the top of the manikin's shoulders to 0.61 m (24 in) over the head. The pressure ranged from 1.6 to 4.0 kPa (0.23 to 0.57 psi). Based on available physiological information, this amount of pressure is unlikely to limit the respiration of an otherwise healthy adult male victim. However, other factors, such as the victim's age, gender, and body position in the grain, may influence respiration. The aspiration of grain appears to be the most likely asphyxiation risk during grain bin entrapment. Due to the risk of grain aspiration during engulfment, the development of safety equipment that could help protect the airway of a victim should be investigated.

4.2 Introduction

Agriculture is consistently recognized as one of the most dangerous working environments. Fatalities in the industry sector of agriculture, forestry, fishing, and hunting rose by 14% in 2014 (BLS, 2015). One area of risk that has received significant attention recently is grain handling and

[1] Moore, K. G., & Jones, C. L. (2017). Grain Entrapment Pressure on the Torso: Can You Breathe while Buried in Grain? Journal of Agricultural Safety and Health, 23(2), 99-107.

storage. There were at least 38 grain entrapments in 2014, 17 of which resulted in death. Reported grain entrapments and deaths have risen during the past three years (Issa et al., 2015a). The term "entrapment" is often used to describe any event in which victims are trapped by a flowable agricultural material and unable to free themselves. However, the grain handling industry makes a distinction between grain entrapment and engulfment. An entrapment victim is still partially above the grain surface, while an engulfment victim is fully submerged in grain. This can result in a considerable difference in the final outcome for the victim. A review of grain rescue strategies in 2011 determined that of the cases where the depth of submersion was known, the survival rate of entrapment was 90% versus 18% for engulfment (Roberts et al., 2011). That study also identified suffocation as the most commonly reported cause of death.

Previous efforts to understand the impact of grain entrapment on a victim have involved measuring the force required to pull a victim from the grain. The earliest known study was completed by Schmechta and Matz (1971) in Germany. They investigated the ability of a human subject to extricate himself from grain when buried to the knees, waist, and top of the shoulders. When the grain reached the victim's waist, he could only escape with the assistance of others. When he was buried to the shoulders, he experienced difficulty breathing and could not escape without the removal of grain (Schmechta and Matz, 1971). Schwab et al. (1985) later measured the force required to extract a manikin from static and flowing grain. The vertical force required to extract the manikin from the grain ranged from 2000 to 8000 N (450 to 1800 lbf). This information has been used extensively in Extension publications and training materials, especially concerning the need to remove grain from around victims before attempting to pull them out. This has led to the common use of rescue tubes and cofferdams by first responders to a grain entrapment. In addition to blocking the inflow of additional grain around the victim, these devices were also believed to reduce the force experienced by the victim. This hypothesis was tested by Roberts et al. (2015) by placing a manikin in grain and measuring the force needed to pull it out of the grain with and without a rescue tube. The researchers found that the process of inserting the grain tube actually increased the required pull force by 22% to 26% depending on the grain depth. This was attributed to an increase in the bulk density of the grain during insertion of the rescue tube. However, the force decreased by 31% to 38% when the tube was installed and grain was removed to knee level inside the tube.

Although many anecdotal reports indicate that entrapment victims experience increased chest pressure and difficulty breathing, no published data could be identified concerning the magnitude of this pressure. This information would be valuable to first responders and medical personnel. It could also provide insight into recommended safety equipment for bin entry. The goal of this project was to estimate the pressure on the chest and back of a victim buried in grain.

4.3 Materials and Methods

Testing was performed in a 1.83 m (6 ft) diameter corrugated steel bin with a hopper bottom (figure 4.1) at Oklahoma State University's Stored Product Research and Education Center (SPREC) in Stillwater, Oklahoma. Four grain types were evaluated: corn, soybeans, wheat, and canola. Table 4.1 lists the measured physical properties of each grain tested. These properties are consistent with the range of values published by Boac et al. (2010). Each grain was tested at four depths above the shoulders of the manikin: 0 m, 0.28 m (11 in, head covered), 0.58 m (23 in), and 0.89 m (35 in). Three replications were tested for each grain and depth combination.

Pressure measurements were made using a pressure mapping system (CONFORMat, Tekscan, Inc., Boston, MA). This system consists of two thin, flexible panels measuring 0.471 m (18.5 in) on each side with a total of 2,048 sensing elements. The sensor mats were covered with ripstop material for protection from the grain and affixed to the chest and back of a rescue manikin during testing (figure 4.2). The top of the sensor mat was located at the middle of the shoulder such that the first row of sensing elements was located near the collarbone. The manikin was

Figure 4.1. The 1.83 m (6 ft) diameter steel bin used during measurement of entrapment pressures.

Table 4.1. Measured physical properties of tested grains.

Grain	Moisture Content (%)	Bulk Density (kg m^{-3})	Dimensions length / width / thickness (mm)	Static Angle of Repose (°)
Corn	12.6	798	11.6 / 8.5 / 4.6	30.5
Soybeans	13.0	696	7.2 / 5.8 / 4.8	32.9
Wheat	10.6	862	5.5 / 2.9 / 2.5	33.2
Canola	7.4	675	1.7	29.6

dressed in work clothes and boots and measured 1.85 m (73 in) tall with a weight of 90.7 kg (200 lb). The sensor mats were equilibrated and calibrated prior to testing for each grain per the manufacturer's instructions. During equilibration, the sensor mat is placed in a vacuum bladder and uniform loads of 30, 60, 90, 120, and 150 mmHg are applied. The manufacturer's software applies a scale factor to each of the 2,048 sensing elements to normalize the output across the sensor mat. Following equilibration a two-load calibration technique was utilized to develop a power law equation for sensor calibration. A universal testing machine (model 5966, Instron, Norwood, Mass.) was used to apply a uniform force of 206 N and 562 N to the sensor mat through a thin layer of the grain to be tested during calibration (figure 4.3). The force was applied to a contact area of 661cm^2 (102 in^2), approximately 30% of the total sensor area. The manufacturer recommends loading at least 25% of the sensor mat during calibration.

The manikin was placed in the grain bin in the vertical position. Grain was loaded into the top of the bin from a discharge spout until the specified fill height was reached. Marks were placed on the inside of the bin to facilitate consistent filling between measurements. Special care was taken to direct the discharge spout around the perimeter of the bin so that the grain filled evenly around the manikin. Pressure data were collected at a frequency of 3.3 Hz for one minute under static conditions. There was minimal variation during this time, so the mean contact pressure on the front and back sensor mats was calculated at the middle set of data points (time = 30 seconds). Following each measurement, the grain was removed from the bin with a grain vacuum and refilled prior to the next measurement. Data were analyzed by analysis of variance and tested for interactions using SAS (ver. 9.3, SAS Institute Inc., Cary, NC). Trends were evaluated based on grain depths. All measures of significance were evaluated for $\alpha = 0.05$.

Figure 4.2. Rescue manikin outfitted with sensor mats prior to testing in soybeans.

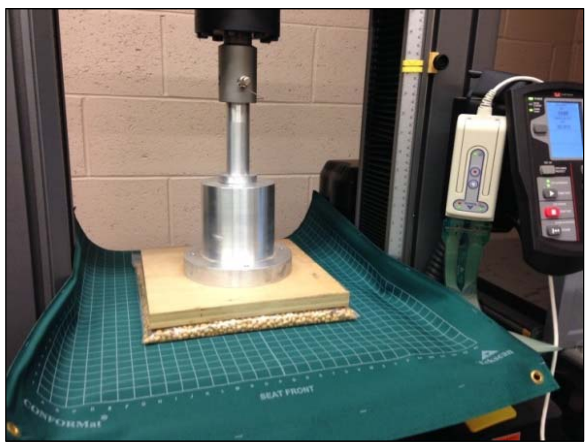

Figure 4.3. Calibration of sensor mat with universal testing machine prior to testing. Force is applied through a layer of grain to approximate testing conditions.

4.4 Results and Discussion

Mean contact pressures for each grain and depth combination are presented in table 4.2. There was a positive correlation between grain depth and pressure for all grains. There was no significant difference between corn and soybeans at any depth. There was a significant difference between canola, wheat, and corn/soybeans at all depths with the exception of wheat and corn at

0.28 m and 0.89 m. Wheat and corn/soybeans exhibited significant linear trends with depth, while canola exhibited a linear and quadratic trend (figure 4.4).

Table 4.2. Comparison of mean contact pressure (kPa) by depth for each grain.[a]

	Grain Depth above Shoulders (m)			
Grain	0	0.28	0.58	0.89
Canola	1.6 a	2.3 d	2.5 g	2.6 j
Wheat	1.9 b	2.8 e	3.2 h	3.7 k
Corn	2.8 c	2.9 ef	3.7 i	4.0 k
Soybeans	2.6 c	3.0 f	3.6 i	3.9 k

[a] Contact pressure values followed by different letters are significantly different within each depth.

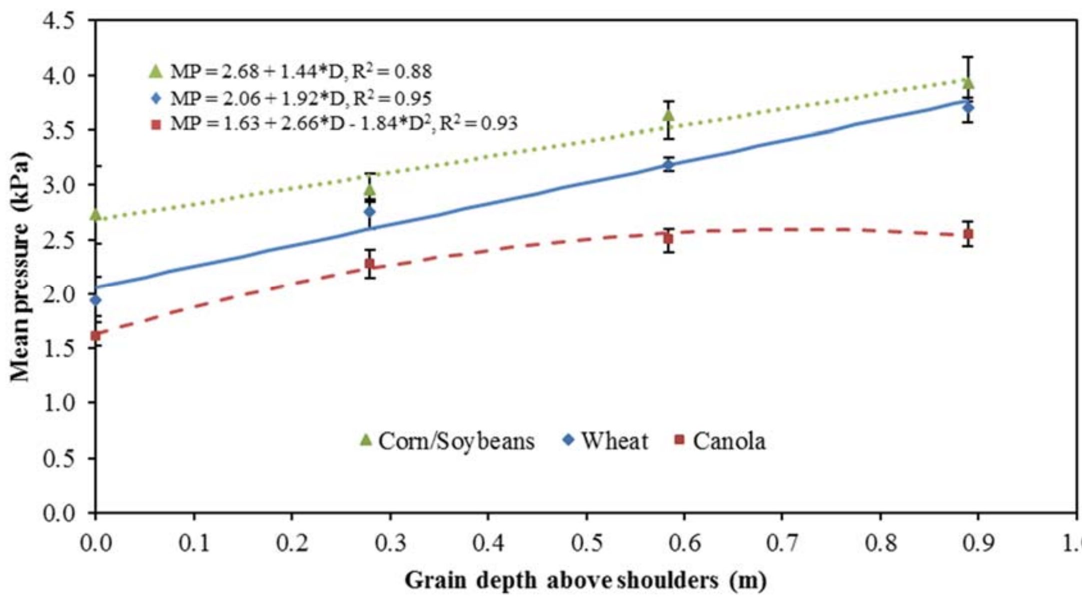

Figure 4.4. Mean contact pressure (MP) on the torso of a manikin at varying grain depths (D).

The behavior of canola was unexpected and may be attributed to the size and shape of the seeds. Considerable effort has been directed toward understanding the behavior of granular material. Early work by Janssen (1895) recognized that the force exerted by water at the bottom of a storage vessel increases linearly, while granular material such as grain approaches an upper limit. This is due to interactions between the particles, which translate a portion of the vertical stress horizontally to the wall of the vessel. These small-scale grain-to-grain interactions influence the macroscopic behavior of grains (Clement, 1999). Granular material can be placed in many stable configurations, with loosely packed material behaving more like a liquid, and tightly packed material behaving more like a solid. When a force is applied to granular material, it is distributed through contact points where particles touch one another. This leads to the formation of force chains, a branching network of high-stress particle interactions that carry the majority of the load while other particles experience little or no loading. Therefore, the force distribution in granular material is heterogeneous and will vary based on the loading history of the material (Hidalgo et al., 2004). An unexpected result of this phenomenon is illustrated by the "sand pile" problem, in which the vertical stress in a pile of sand reaches a minimum under the peak. Particle shape has been shown to impact the behavior of these force chains, with elongated particles resulting in longer force chains that involve fewer particles and have a higher concentration of force (Azéma and Radjaï, 2012; Estrada et al., 2008; Zuriguel et al., 2007). Canola seeds are essentially spherical, while corn, soybeans, and wheat are oblong. Canola seeds are also much smaller than the other three grains (table 4.1). It may be that this difference in the shape and size of the canola particles led to the non-linear trend. Additional study is needed to fully understand this phenomenon.

The Purdue Agricultural Confined Space Incident Database (PACSID) contains data on reported grain entrapments in the U.S. from 1962 to the present. Of the 1,028 documented entrapment cases, 70% were fatalities (Issa et al., 2015a). While information concerning the cause of death is not always available, suffocation is most commonly reported. Freeman et al. (1998) investigated 71 entrapment cases at commercial grain facilities and found that 86% were engulfments and 92% of these were fatalities. In contrast, of the ten cases that were partial entrapments, there was only one fatality. Death from asphyxiation can be caused in two ways: (1) aspiration of grain or (2) traumatic asphyxiation due to restriction of chest movement by grain.

Several cases of grain aspiration have been documented in the literature (Arneson et al., 2005; Bahlmann et al., 2002; Jurek et al., 2009; Slinger et al., 1997). During engulfment, grain can fill the mouth and throat and even enter the bronchi of the lungs. Protecting the airway during engulfment would prevent this type of asphyxiation. A fairly recent case of this was documented by a television program concerning the engulfment of Arick Baker in 2013 (Awes, 2015). Arick was working alone on the family farm and entered a grain storage bin to clear a blockage while the auger was still energized. This was clearly unsafe behavior and in violation of Occupational Safety and Health Administration (OSHA) guidelines for permit-required confined spaces (2016b) and grain handling facilities (2016a). He quickly became engulfed in grain and was unable to free himself. Fortunately, he did not become entangled in the auger or asphyxiate from grain inhalation. Arick typically wore an air circulating mask when entering the grain bin to help with his asthma. This mask covered his face and appears to have protected his airway during engulfment, allowing him to survive until he could be freed from the grain.

Traumatic asphyxia is caused when respiratory motion is limited by a heavy weight on the torso while the airway remains open. This can occur when an individual is pinned under an automobile or tractor, trampled or pressed against a door or wall by a large crowd, or buried during an avalanche or earthquake (Byard et al., 2006; Campbell-Hewson et al., 1997; Stalsberg et al., 1989; Williams et al., 1968). Expansion of the chest and abdomen is required for respiration. This motion increases the volume of the lungs, which lowers the pressure in the alveoli, allowing air at atmospheric pressure to enter. In one case study, the head of an avalanche victim was uncovered, and mouth-to-mouth resuscitation was attempted while the body was still buried in snow. This proved to be impossible until the torso was uncovered so the chest could expand (Gray, 1987). Issa et al. (2015b) postulated that the chest expansion and contraction of a grain entrapment victim packs grain particles around the chest and might eventually stop respiration.

The literature is unclear concerning the amount of pressure that a human can withstand on the chest before breathing becomes impossible. However, research on the human respiratory system indicates that maximum inspiration pressures range from 9.5 to 14.7 kPa (1.4 to 2.1 psi) for men. Two studies included data on females and reported values approximately 30% lower than for male subjects. Additional variation is expected based on the size, age, and physical condition of the victim (Agostoni and Rahn, 1960; Lausted et al., 2006; Milic-Emili et al., 1964; Wilson et al., 1984). The influence of age on respiratory strength may also be important in understanding the potential risk during engulfment, as 28% of reported grain entrapment victims were ages 1 to 20, and 20% were over the age of 60 (Issa et al., 2016). Wilson et al. (1984) measured the maximum inspiration pressures of children ages 7 to 17 as 7.4 kPa (1.1 psi) for boys and 6.2 kPa (0.9 psi) for girls. They also found a significant negative correlation between age and maximum respiratory pressures in adult males. Respiratory studies of guinea pigs and dogs applied a mass equal to 2, 3, 4, and 5 times the body weight of the animal to the chest. In these studies, the animal survived for over an hour with a mass of two times the body weight applied to the chest, while no animal survived longer than 10 min with a mass of five times the body weight (Furuya, 1981). Assuming similar results for a human, an otherwise healthy male should be able to withstand a pressure on the torso of 14 kPa (2 psi) for at least an hour. An individual trapped near the surface of grain will experience a much smaller pressure, roughly 2 to 4 kPa (0.3 to 0.6 psi). If the corn/soybean data from our study are extrapolated in a linear fashion, a pressure of 14 kPa would occur at a depth of 7 to 8 m (23 to 26 ft). However, the age, gender, and overall health of the victim should be considered when applying these results. Additionally, the stress of entrapment and asphyxia alone can lead to cardiac arrhythmias or cardiac arrest (Beynon, 2011). Body position during entrapment may also impair breathing. The pressure experienced by a victim in the horizontal position is expected to be higher than for a victim in the vertical position. In addition, when the arms are positioned above the shoulders, there is a small decrease in total lung capacity, which may be due to restriction of chest wall expansion (McKeough et al., 2003).

Other factors, such as the distribution of grain around the victim (flat, peaked, inverted cone) and the weight of rescue personnel standing on the grain, may increase the pressure experienced by the victim.

4.5 Conclusions

The amount of pressure applied to the torso of a simulated grain entrapment victim in the vertical position was measured at static grain depths of 0 to 0.89 m (0 to 35 in) above the shoulders for corn, soybeans, wheat, and canola. The pressure increased linearly with depth for all grains except canola, which exhibited a linear and quadratic trend. Pressures ranged from 1.6 to 4.0 kPa (0.23 to 0.57 psi).

The measured pressure on the torso does not appear to be high enough to limit respiration for an otherwise healthy adult male unless the entrapment depth is quite deep (over 7 m) or the duration of entrapment is long enough to cause respiratory fatigue. However, other factors, such as the victim's age, gender, and body position in the grain, may influence respiration. Based on this information, preventing the aspiration of grain during engulfment warrants further study. The use of a full-face respirator during bin entry has the potential to help protect the airway during engulfment. Future research should evaluate the ability of commercially available respirators to stay in place and prevent grain aspiration during engulfment. An appropriately designed respirator could be an important addition to grain bin entry safety equipment.

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CHAPTER V

CONCLUSION

5.1 Summary

Winter canola serves a valuable role as a rotational crop for small cereal grains in the southern United States. There is considerable potential for expansion of canola acres in this region. While significant effort has been invested in developing varieties that thrive in warmer climates, less focus has been placed on post-harvest storage and handling of the crop under these conditions. This study contributed to the understanding of these issues.

The storage of winter canola seed in low-quality grain bins was investigated to determine if lining these structures with polyethylene grain bag material would improve storage quality. There was not a significant difference in storage quality between the lined and unlined bins. If low quality grain bins must be used for short-term storage, the bottom of the bin can be lined with grain bag material for the purpose of sealing and moisture exclusion. Australian canola seed storage guidelines should be utilized for the southern United States. Grain storage facilities should target a maximum equilibrium relative humidity of 60% and should consider adjusting the target moisture content based on the oil content of the seed. The moisture content of canola seed in unaerated grain bins in the southern United States should be 6-7% for long term storage. If the temperature can be quickly reduced below 20°C with aeration then moisture contents up to 8% may be possible if the oil content is less than 40%.

An electronic nose system was developed that is capable of identifying mold in canola seed with an error rate of less than 3%. This nose was constructed using components costing less than $100. One of the four sensors could be removed from the array without impacting classification quality, further reducing the cost of the system. Additional development of the electronic nose will be required to improve its ability to operate under a wide range of temperature and relative humidity conditions. The system also needs to be packaged and tested under field conditions. This work is justified by the commercial benefit that an early mold detection system would have for a grain storage facility. It is expected that the nose could be easily adapted for use in other grains. Ideally, an electronic nose can be developed that is effective at detecting mold in a wide variety of grain types.

Once grain quality is degraded, the risks associated with bin entry to clean out moldy grain must be considered. The amount of pressure applied to the torso of a simulated grain entrapment victim was found to increase linearly with depth for corn, soybean, and wheat. Pressure in canola increased with a quadratic trend. Pressures ranged from 1.6 to 4.0 kPa (0.23 to 0.57 psi). This pressure does not appear to be large enough to limit respiration for an otherwise healthy adult male unless the entrapment depth is quite deep (over 7 m) or the duration of entrapment is long enough to cause respiratory fatigue. Other factors, such as the victim's age, gender, and body position in the grain, may influence respiration and must also be considered. The use of a full-face respirator during bin entry has the potential to help protect the airway during engulfment. Respirator usage should be encouraged during grain bin entry to protect workers from inhalation hazards as well as airway protection. Additional research is needed to determine which respirator designs are best suited for airway protection. An appropriately designed respirator could be an important addition to grain bin entry safety equipment.

5.2 Future Work

This study has addressed many issues related to the storage, monitoring, and safety of canola seed and other grains. Additional work in justified in several areas. Further study concerning the use of grain bag material to line the bottom of low quality storage bins for other oilseed crops and cereal grains would be beneficial. Out of necessity this must also address storage guidelines for grain in bins without aeration. Additionally, the development of best practices for the installation of grain bag material in storage bins is needed.

Concerning the electronic nose for mold odor detection, additional work is needed in support of commercial development. A clear distinction between the inoculation levels could not be made and this warrants further investigation. This may be a function of concentration level or other factors related to the nature of the individual sensors. The lower detection limit should also be determined. Compensation for a wider range of temperature and humidity conditions must also be integrated into a prototype. Ideally the electronic nose will be deployed in individual grain bins for continuous monitoring for mold odor. This requires packaging the sensor array with an integrated power supply and communication system. Testing with other grain types should also be explored.

Future grain entrapment research should investigate methods of protecting the airway of a victim during entrapment. Commercially available respirators should be tested to measure their ability to stay in place and prevent grain aspiration during engulfment. Collaboration with researchers in human factors to identify design features that would promote respirator use (such as cooling) would also be beneficial.

APPENDICES

APPENDIX 1

IMPACT OF A POLYETHYLENE LINER ON THE STORAGE OF WINTER CANOLA SEED IN UNAERATED STEEL BINS

	6/6/2014	top	Temp at Thermocouple							bottom
Bin1	days in storage	9	8	7	6	5	4	3	2	1	average temp (2-7)
6/6/2014	0	79.0	79.0	93.0	94.0	95.0	95.0	97.0	98.0	88.0	95.3
6/9/2014	3	82.0	76.0	89.0	93.0	94.0	95.0	96.0	92.0	80.0	93.2
6/11/2014	5	111.0	101.0	86.0	91.0	92.3	94.3	94.1	88.3	77.4	91.0
6/13/2014	7	106.0	98.0	87.0	90.0	91.0	92.0	91.0	86.0	77.0	89.5
6/16/2014	10	95.0	90.0	88.0	90.0	91.0	91.0	89.0	85.0	80.0	89.0
6/18/2014	12	95.0	89.0	90.3	90.5	91.0	91.6	89.2	86.2	82.8	89.8
6/20/2014	14	83.0	83.0	89.6	91.2	91.4	91.6	89.6	86.5	81.5	90.0
6/23/2014	17	73.0	76.0	91.0	91.0	91.0	91.0	89.0	86.0	82.0	89.8
6/25/2014	19	125.8	110.8	90.9	91.8	91.6	91.6	89.6	86.4	80.6	90.3
6/27/2014	21	83.5	82.4	91.4	92.3	91.9	91.6	89.6	89.4	81.9	91.0
6/30/2014	24	106.7	99.5	90.1	91.0	91.0	91.0	89.2	86.0	82.2	89.7
7/2/2014	26	99.7	95.9	90.5	91.6	91.4	91.0	89.1	86.2	81.7	90.0
7/4/2014	28	104.0	98.0	89.0	91.0	91.0	91.0	89.0	86.0	80.0	89.5
7/7/2014	31	117.0	107.0	93.0	92.0	91.0	91.0	89.0	87.0	85.0	90.5
7/9/2014	33	93.7	92.5	95.2	94.8	93.4	92.5	90.1	88.3	85.3	92.4
7/11/2014	35	100.8	91.4	92.3	95.2	93.7	93.0	91.0	88.3	82.0	92.3
7/14/2014	38	123.8	113.0	95.7	95.4	93.7	92.8	90.7	88.2	85.1	92.8
7/16/2014	40	68.7	71.6	93.4	96.4	94.6	93.7	91.2	88.0	81.7	92.9
7/18/2014	42	96.1	91.4	84.2	92.8	92.5	92.3	90.1	85.1	74.5	89.5
7/21/2014	45	96.1	92.5	86.9	88.9	89.4	89.2	86.9	82.4	77.9	87.3
7/23/2014	47	114.3	103.1	93.2	90.7	90.1	89.2	86.2	83.5	82.4	88.8
7/25/2014	49	110.0	102.0	95.0	94.0	92.0	90.0	87.0	84.0	82.0	90.3
7/28/2014	52	104.0	97.0	97.0	97.0	94.0	92.0	89.0	87.0	84.0	92.7
7/30/2014	54	73.0	76.6	97.7	98.8	95.9	93.6	90.3	87.6	83.8	94.0
8/1/2014	56	70.7	71.1	90.5	96.8	95.0	93.4	90.5	86.2	78.3	92.1
8/8/2014	63	77.0	80.0	98.0	98.0	96.0	93.0	89.0	86.0	83.0	93.3
8/11/2014	66	101.8	92.5	98.2	98.8	96.6	94.3	90.5	87.1	83.3	94.3
8/13/2014	68	84.0	79.0	96.4	99.5	97.3	94.8	90.9	87.1	82.0	94.3
8/15/2014	70	106.0	98.4	96.8	99.5	97.3	95.0	91.0	87.4	83.1	94.5
8/18/2014	73	79.3	80.8	100.0	100.0	98.2	95.7	91.6	88.3	85.3	95.6
8/20/2014	75	108.5	102.4	99.7	101.3	99.1	96.4	92.3	88.7	84.6	96.3
8/22/2014	77	126.0	117.7	100.4	101.8	100.0	97.3	93.2	89.4	86.7	97.0
8/25/2014	80	104.5	98.1	101.7	103.1	101.3	98.6	94.3	90.7	87.3	98.3
8/27/2014	82	105.1	95.9	102.7	104.2	102.4	99.5	95.0	91.6	87.8	99.2
8/29/2014	84	77.7	78.8	101.3	104.9	102.9	100.0	95.9	91.9	86.4	99.5
9/3/2014	89	91.0	86.5	97.2	102.7	101.8	100.0	95.7	90.7	83.3	98.0
9/5/2014	91	97.7	90.9	99.0	101.5	101.1	99.3	95.0	90.1	85.3	97.7
9/8/2014	94	85.8	80.8	91.9	98.8	99.1	97.9	94.1	87.8	78.4	94.9
9/12/2014	98	58.6	62.8	89.6	97.0	97.5	96.4	91.9	86.0	76.3	93.1
9/15/2014	101	80.1	77.4	82.8	90.1	92.5	92.5	88.9	81.7	73.8	88.1
9/19/2014	105	70.3	72.0	88.0	89.8	91.0	90.5	86.2	81.7	77.2	87.9
9/22/2014	108	75.6	69.1	86.2	90.9	91.4	90.5	86.4	82.0	76.3	87.9
9/26/2014	112	87.3	78.1	85.1	89.2	90.1	89.4	85.6	81.0	75.6	86.7
9/30/2014	116	74.8	70.5	86.9	90.0	90.7	89.2	85.3	81.0	75.7	87.2
10/3/2014	119	67.3	68.5	85.6	91.2	91.4	90.0	86.0	81.3	73.9	87.6
10/7/2014	123	76.6	72.1	83.3	87.4	89.1	88.2	84.4	78.4	72.5	85.1
10/10/2014	126	68.5	71.6	87.6	89.6	90.1	88.7	84.2	79.5	76.1	86.6
10/13/2014	129	60.4	62.6	77.4	85.6	87.4	87.3	83.5	76.6	68.2	83.0
10/20/2014	136	102.9	93.2	73.6	80.1	82.6	82.4	78.1	72.1	66.2	78.2
10/24/2014	140	107.1	104.9	77.2	81.1	82.6	82.0	77.7	73.0	68.5	78.9
10/28/2014	144	91.4	89.4	80.6	83.8	84.2	82.9	78.8	74.5	69.4	80.8
10/31/2014	147	46.6	50.0	74.8	82.4	83.5	82.6	79.0	73.4	64.6	79.3
11/5/2014	152	47.1	50.0	66.7	75.2	78.3	78.8	75.4	68.7	60.8	73.9
11/7/2014	154	61.7	57.7	61.7	71.1	74.5	75.4	72.0	65.7	56.5	70.1
11/11/2014	158	33.4	37.4	63.7	69.1	72.1	72.7	69.1	63.7	53.4	68.4
11/14/2014	161	36.3	32.2	49.6	64.6	68.2	69.6	66.4	57.2	43.3	62.6
11/19/2014	166	55.4	48.6	45.1	54.1	59.2	60.8	57.7	50.0	41.9	54.5
11/21/2014	168	42.8	43.7	48.9	53.8	57.7	59.0	55.4	49.6	45.1	54.1
11/25/2014	172	75.7	65.5	50.0	55.2	57.2	57.6	54.5	51.3	46.0	54.3
12/1/2014	178	24.6	29.1	53.6	56.3	57.0	56.7	54.0	51.4	43.7	54.8
12/5/2014	182	56.8	55.6	49.1	52.7	54.3	54.9	52.9	49.3	48.2	52.2
12/9/2014	186	49.3	43.7	49.1	51.1	52.3	52.9	51.4	49.3	46.4	51.0
12/12/2014	189	50.9	50.9	50.4	51.4	52.0	52.3	50.9	49.1	47.8	51.0
12/16/2014	193	64.4	64.2	50.2	52.7	52.7	52.7	51.4	50.4	45.9	51.7
12/19/2014	196	35.4	36.9	45.3	50.5	51.1	51.8	51.1	48.6	43.9	49.7
12/23/2014	200	47.7	48.4	46.0	48.0	49.1	49.6	48.7	47.1	44.8	48.1
1/5/2015	213	57.4	54.1	33.4	40.1	42.1	43.3	42.4	39.2	33.1	40.1
1/9/2015	217	43.0	42.1	31.8	38.5	40.5	41.5	40.3	36.7	31.6	38.2
1/13/2015	221	20.3	19.6	32.5	35.8	37.6	38.5	37.4	34.7	32.0	36.1
1/16/2015	224	41.5	33.3	35.2	35.8	37.0	37.8	36.5	34.7	33.8	36.2
1/20/2015	228	44.1	43.3	46.2	41.9	41.0	40.1	38.5	39.6	42.4	41.2
1/23/2015	231	32.0	28.2	43.0	44.4	43.3	42.4	41.4	41.5	40.6	42.7
1/27/2015	235	39.7	36.3	46.9	46.4	45.3	44.2	43.3	43.3	44.1	44.9
1/30/2015	238	60.4	59.0	49.3	50.5	48.9	47.3	46.0	46.4	45.5	48.1
2/3/2015	242	44.6	36.5	41.9	48.0	47.8	47.7	47.1	44.2	37.4	46.1
2/6/2015	245	71.8	69.8	43.9	46.2	46.8	46.9	45.7	42.1	40.6	45.3
2/13/2015	252	37.6	36.0	46.6	50.7	50.2	49.3	47.8	46.0	42.3	48.4
2/17/2015	256	41.2	34.5	41.9	49.3	49.3	49.3	48.0	44.8	37.6	47.1
2/20/2015	259	54.0	53.0	41.0	45.0	46.0	47.0	45.0	42.0	38.0	44.3
2/24/2015	263	61.9	60.4	38.5	43.7	44.8	45.5	44.2	40.3	33.4	42.8
2/27/2015	266	18.1	20.7	37.9	42.8	43.9	44.2	42.6	39.0	33.1	41.7
3/3/2015	270	78.8	73.0	36.1	38.5	40.3	41.2	39.7	36.7	35.8	38.8
3/6/2015	273	57.2	48.7	37.4	38.8	39.7	40.5	39.0	36.7	34.0	38.7
3/10/2015	277	45.7	45.9	46.6	44.2	43.3	42.4	40.6	41.0	43.5	43.0
3/13/2015	280	45.1	46.6	56.3	49.1	46.6	45.1	43.7	44.8	48.7	47.6
3/17/2015	284										50.6
3/20/2015	287	81.5		55.0	56.8	54.1	52.5	51.4	51.4	50.0	53.5
3/24/2015	291	69.1		64.0	57.9	55.6	54.1	52.9	53.2	56.8	56.3
3/27/2015	294	43.9	46.6	62.2	62.1	59.2	57.6	56.1	55.6	53.4	58.8
3/31/2015	298	108.9	no data	66.4	62.8	60.8	59.4	57.7	57.2	60.4	60.7

Bin 1 began having trouble with temperature cable on 3/17/15. Blank cells are due to no sensor data.

	6/6/2014	top	Temp at Thermocouple							bottom	
Bin2	days in storage	9	8	7	6	5	4	3	2	1	average temp (2-7)
6/6/2014	0	82.0	85.0	92.0	89.0	89.0	89.0	91.0	92.0	91.0	90.3
6/9/2014	3	80.0	79.0	91.0	91.0	90.0	91.0	92.0	90.0	84.0	90.8
6/11/2014	5	110.0	87.0	89.2	91.4	91.2	91.8	92.3	88.9	81.7	90.8
6/13/2014	7	104.0	87.0	88.0	90.0	91.0	91.0	91.0	87.0	81.0	89.7
6/16/2014	10	94.0	87.0	89.0	89.0	90.0	91.0	89.0	86.0	82.0	89.0
6/18/2014	12	92.0	87.0	90.0	90.0	90.5	90.5	89.4	86.4	84.9	89.5
6/20/2014	14	84.0	84.0	90.7	90.3	90.5	90.3	89.1	86.7	84.4	89.6
6/23/2014	17	75.0	81.0	91.0	90.0	90.0	90.0	89.0	86.0	85.0	89.3
6/25/2014	19	121.0	95.0	91.0	91.0	90.0	90.0	89.0	86.0	86.0	89.5
6/27/2014	21	82.6	85.1	92.3	91.6	91.0	90.7	89.4	86.9	84.4	90.3
6/30/2014	24	103.6	92.5	91.0	91.8	91.6	91.0	89.8	86.9	84.4	90.4
7/2/2014	26	98.6	89.6	91.8	91.6	91.6	91.2	89.8	87.1	85.1	90.5
7/4/2014	28	102.0	90.0	91.0	91.0	91.0	91.0	89.0	87.0	84.0	90.0
7/7/2014	31	113.0	98.0	93.0	92.0	92.0	91.0	90.0	87.0	86.0	90.8
7/9/2014	33	94.3	90.3	94.8	92.8	92.8	92.3	90.5	88.5	88.0	92.0
7/11/2014	35	95.4	86.0	94.3	94.1	93.7	93.2	91.4	89.2	86.2	92.7
7/14/2014	38	121.6	101.8	94.8	94.6	95.0	94.6	92.7	89.8	88.3	93.6
7/16/2014	40	70.0	77.9	95.0	95.4	95.7	95.4	93.2	90.1	86.5	94.1
7/18/2014	42	98.6	82.9	90.1	95.5	96.4	95.9	93.7	88.9	80.6	93.4
7/21/2014	45	95.2	87.1	87.4	93.4	95.9	96.1	93.4	87.1	80.8	92.2
7/23/2014	47	108.7	95.9	90.1	92.3	95.0	95.5	92.5	87.1	84.7	92.1
7/25/2014	49	105.0	95.0	92.0	92.0	94.0	95.0	91.0	87.0	85.0	91.8
7/28/2014	52	100.0	91.0	95.0	95.0	96.0	95.0	92.0	89.0	87.0	93.7
7/30/2014	54	74.3	82.2	96.1	97.0	97.2	95.9	92.8	89.6	87.4	94.8
8/1/2014	56	71.2	74.8	93.7	97.9	98.1	96.4	93.4	89.2	83.5	94.8
8/8/2014	63	78.0	84.0	97.0	98.0	98.0	96.0	93.0	89.0	87.0	95.2
8/11/2014	66	95.5	89.2	99.0	100.4	99.5	97.0	93.4	89.2	86.7	96.4
8/13/2014	68	81.5	81.1	99.5	101.1	99.7	97.0	93.4	89.6	86.4	96.7
8/15/2014	70	101.3	92.7	100.0	101.7	100.0	97.2	93.6	89.6	86.9	97.0
8/18/2014	73	79.9	86.9	102.2	102.4	100.6	97.3	93.7	90.1	88.7	97.7
8/20/2014	75	105.4	97.9	103.5	103.3	100.8	97.3	93.7	90.1	88.0	98.1
8/22/2014	77	124.0	109.9	104.4	104.2	101.7	97.9	94.1	90.5	88.9	98.8
8/25/2014	80	100.4	95.7	106.2	105.6	102.6	98.6	94.6	91.4	90.1	99.8
8/27/2014	82	100.4	94.6	107.2	106.3	102.9	98.8	95.0	91.9	91.0	100.4
8/29/2014	84	78.1	85.3	107.2	107.1	103.5	99.1	95.5	92.3	90.5	100.8
9/3/2014	89	87.4	86.9	104.4	106.9	104.5	100.4	96.1	92.1	87.8	100.7
9/5/2014	91	93.7	91.6	103.8	106.3	104.5	100.6	96.3	91.6	88.5	100.5
9/8/2014	94	81.1	80.6	99.7	104.9	103.6	100.0	95.9	90.1	82.6	99.0
9/12/2014	98	60.3	70.0	97.5	102.4	102.4	99.5	94.8	88.7	82.0	97.6
9/15/2014	101	79.3	77.5	90.5	99.5	100.8	98.6	93.7	85.6	77.0	94.8
9/19/2014	105	71.2	76.1	91.2	95.5	97.5	95.9	91.4	84.4	80.1	92.7
9/22/2014	108	70.9	70.7	91.6	95.0	96.1	94.1	89.8	84.2	80.6	91.8
9/26/2014	112	81.5	76.3	89.6	94.1	94.8	92.8	88.9	83.5	79.5	90.6
9/30/2014	116	71.2	73.0	90.0	93.4	93.7	91.6	88.0	83.1	79.9	90.0
10/3/2014	119	67.1	70.0	90.7	93.6	93.7	91.4	87.8	83.5	80.4	90.1
10/7/2014	123	71.8	72.3	86.4	92.3	93.2	91.4	87.8	81.9	76.3	88.8
10/10/2014	126	70.0	75.4	89.1	91.8	92.5	90.7	86.9	81.7	79.3	88.8
10/13/2014	129	61.3	65.7	83.8	91.6	92.3	90.5	86.7	80.2	72.3	87.5
10/20/2014	136	97.7	81.5	77.7	85.5	88.2	87.3	83.3	76.1	70.3	83.0
10/24/2014	140	106.9	93.0	79.3	83.8	86.2	85.3	81.7	76.1	72.1	82.1
10/28/2014	144	89.8	81.1	82.0	84.2	85.6	84.7	81.3	77.2	75.0	82.5
10/31/2014	147	47.5	55.0	79.0	84.6	86.0	84.7	81.7	76.8	71.4	82.1
11/5/2014	152	48.2	53.8	72.0	81.9	85.1	84.7	81.5	73.9	65.5	79.9
11/7/2014	154	56.5	53.2	68.2	78.4	82.8	83.3	79.7	71.6	61.9	77.3
11/11/2014	158	34.9	43.3	66.7	74.5	79.0	79.7	76.5	68.9	62.8	74.2
11/14/2014	161	34.3	34.3	59.9	72.3	76.6	77.4	74.1	64.9	50.5	70.9
11/19/2014	166	49.1	44.1	50.9	64.2	70.2	71.8	68.2	57.4	45.7	63.8
11/21/2014	168	43.2	44.4	51.4	61.2	67.1	68.7	65.1	55.6	47.8	61.5
11/25/2014	172	67.6	55.4	53.2	58.3	62.2	63.5	60.4	54.7	50.7	58.7
12/1/2014	178	26.1	33.6	54.7	56.3	58.6	59.2	57.4	54.1	52.0	56.7
12/5/2014	182	56.5	53.2	50.4	55.6	57.6	57.9	56.3	52.0	48.2	55.0
12/9/2014	186	42.8	41.9	50.2	53.6	55.6	56.3	54.7	51.4	49.1	53.6
12/12/2014	189	51.6	50.4	50.5	52.7	54.3	54.7	53.6	50.9	49.5	52.8
12/16/2014	193	67.6	57.2	51.8	52.7	53.6	53.8	52.9	51.8	50.5	52.8
12/19/2014	196	36.0	38.5	48.4	52.5	53.4	53.6	52.9	50.9	47.1	52.0
12/23/2014	200	48.4	47.5	47.5	50.4	52.0	52.5	51.8	49.3	47.1	50.6
1/5/2015	213	58.1	45.0	37.9	44.2	46.9	47.8	46.6	42.1	36.1	44.3
1/9/2015	217	46.6	39.2	35.8	42.1	44.8	45.7	44.4	39.9	33.1	42.1
1/13/2015	221	18.5	22.5	34.3	38.8	41.5	42.6	41.2	37.4	34.0	39.3
1/16/2015	224	33.4	31.1	35.2	37.8	40.1	40.8	39.6	36.5	34.7	38.3
1/20/2015	228	43.7	43.7	42.1	38.7	39.2	39.4	38.5	38.7	43.3	39.4
1/23/2015	231	27.5	29.3	43.3	41.2	40.3	39.9	39.4	40.6	43.5	40.8
1/27/2015	235	37.6	38.3	45.3	43.2	42.1	41.7	41.5	42.6	45.7	42.7
1/30/2015	238	61.5	54.1	49.1	45.5	43.9	43.2	43.2	45.3	48.7	45.0
2/3/2015	242	37.4	34.3	45.1	47.3	46.4	45.5	45.5	45.5	41.7	45.9
2/6/2015	245	75.2	63.1	43.9	46.6	46.8	46.6	46.2	44.2	39.9	45.7
2/13/2015	252	36.0	36.9	48.4	48.4	47.7	47.3	46.4	46.6	46.0	47.5
2/17/2015	256	35.4	32.9	46.4	48.9	48.7	48.4	47.8	46.6	41.9	47.8
2/20/2015	259	55.0	49.0	42.0	47.0	48.0	48.0	47.0	44.0	40.0	46.0
2/24/2015	263	67.3	54.5	41.0	45.9	47.3	47.7	46.8	43.3	36.9	45.3
2/27/2015	266	19.2	23.9	40.8	44.4	46.2	46.8	45.5	41.7	36.7	44.2
3/3/2015	270	78.4	61.5	36.9	42.1	44.2	44.8	43.5	39.2	34.9	41.8
3/6/2015	273	47.8	41.2	37.9	40.6	42.8	43.3	42.1	38.5	35.6	40.9
3/10/2015	277	45.7	46.0	44.4	41.2	41.5	41.7	40.6	40.3	43.7	41.6
3/13/2015	280	45.7	49.3	51.1	43.7	42.4	41.9	41.2	42.6	48.7	43.8
3/17/2015	284	57.7	59.2	55.9	48.6	45.7	44.2	44.2	46.9	54.5	47.6
3/20/2015	287	75.9	62.8	55.9	52.0	48.6	46.9	46.9	49.8	52.7	50.0
3/24/2015	291	66.6	64.9	59.4	54.0	51.4	50.2	50.2	52.0	56.8	52.9
3/27/2015	294	44.8	50.0	61.7	56.8	53.8	52.3	52.2	54.3	56.7	55.2
3/31/2015	298	113.2	96.4	63.1	59.4	56.8	55.6	55.2	56.3	59.4	57.7

	6/6/2014	top	Temp at Thermocouple						bottom	
Bin3	days in storage	9	8	7	6	5	4	3	2	1	average temp (2-7)
6/6/2014	0	87.0	81.0	91.0	90.0	91.0	91.0	91.0	88.0	78.0	90.3
6/9/2014	3	83.0	74.0	90.0	91.0	92.0	91.0	90.0	84.0	81.0	89.7
6/11/2014	5	82.0	75.0	89.8	91.6	92.3	91.9	90.0	83.5	108.0	89.9
6/13/2014	7	84.0	75.0	89.0	91.0	91.0	91.0	88.0	83.0	99.0	88.8
6/16/2014	10	87.0	79.0	89.0	90.0	91.0	90.0	87.0	83.0	91.0	88.3
6/18/2014	12	87.0	82.0	90.3	90.5	90.7	89.8	88.0	85.1	90.0	89.1
6/20/2014	14	86.0	80.0	90.5	90.5	90.7	89.8	88.0	84.9	82.0	89.1
6/23/2014	17	86.0	80.0	91.0	90.0	91.0	89.0	88.0	85.0	72.0	89.0
6/25/2014	19	88.0	79.0	91.0	91.0	91.0	90.0	88.0	85.0	116.0	89.3
6/27/2014	21	88.0	80.1	91.8	91.6	91.4	90.5	88.7	85.3	80.1	89.9
6/30/2014	24	89.6	81.7	91.6	91.8	91.8	90.7	88.9	85.5	101.1	90.1
7/2/2014	26	87.4	81.5	91.6	91.8	91.6	90.7	88.9	86.0	92.3	90.1
7/4/2014	28	87.0	80.0	91.0	91.0	91.0	90.0	88.0	85.0	98.0	89.3
7/7/2014	31	92.0	85.0	92.0	91.0	91.0	90.0	89.0	87.0	113.0	90.0
7/9/2014	33	89.8	85.1	93.2	92.5	92.1	91.0	89.8	88.3	89.6	91.2
7/11/2014	35	86.5	79.9	93.0	92.8	92.5	91.6	90.1	86.9	92.5	91.2
7/14/2014	38	93.4	85.3	94.1	93.6	93.2	92.3	90.9	88.7	118.2	92.1
7/16/2014	40	84.7	81.3	93.6	94.1	93.7	92.7	91.0	87.6	68.4	92.1
7/18/2014	42	81.7	72.5	91.0	93.7	93.9	92.8	90.5	83.5	89.4	90.9
7/21/2014	45	85.1	78.3	90.1	92.5	93.0	91.8	88.9	83.3	91.4	89.9
7/23/2014	47	90.5	83.8	91.2	91.9	92.3	91.0	88.5	85.3	113.0	90.0
7/25/2014	49	90.0	82.0	91.0	91.0	91.0	90.0	88.0	86.0	103.0	89.5
7/28/2014	52	88.0	85.0	93.0	93.0	92.0	91.0	89.0	87.0	97.0	90.8
7/30/2014	54	88.0	83.8	94.6	94.5	93.7	92.7	90.9	88.2	72.7	92.4
8/1/2014	56	81.5	77.5	93.7	95.5	95.2	93.7	91.4	85.8	69.1	92.6
8/8/2014	63	90.0	84.0	97.0	98.0	97.0	96.0	93.0	88.0	76.0	94.8
8/11/2014	66	90.1	84.2	99.7	100.6	100.0	98.2	94.8	89.4	100.4	97.1
8/13/2014	68	86.4	82.8	100.0	102.2	101.7	99.7	95.9	89.6	82.4	98.2
8/15/2014	70	91.0	83.8	101.1	103.3	103.1	100.9	96.8	90.1	98.8	99.2
8/18/2014	73	91.9	85.3	102.7	104.9	104.9	102.7	98.5	91.9	77.2	100.9
8/20/2014	75	94.8	84.4	103.5	105.8	106.0	103.8	99.1	91.9	101.8	101.7
8/22/2014	77	101.5	88.0	104.5	107.1	107.2	105.3	100.6	93.6	121.8	103.1
8/25/2014	80	94.3	87.4	105.3	108.5	108.9	107.1	102.7	95.0	98.1	104.6
8/27/2014	82	93.7	88.9	106.2	109.2	109.9	108.0	103.3	95.9	100.2	105.4
8/29/2014	84	90.9	86.2	106.2	109.9	110.7	108.7	104.0	95.5	75.0	105.8
9/3/2014	89	89.8	82.8	105.1	110.1	111.6	109.9	105.1	95.0	86.2	106.1
9/5/2014	91	92.3	86.7	104.9	109.8	111.4	109.9	105.4	96.3	95.5	106.3
9/8/2014	94	83.7	79.0	101.8	108.3	110.3	109.4	104.4	92.5	81.5	104.5
9/12/2014	98	78.1	74.8	99.1	105.6	108.0	106.9	102.4	91.2	57.5	102.2
9/15/2014	101	80.2	74.5	95.4	103.1	105.6	104.7	99.7	87.4	78.8	99.3
9/19/2014	105	80.2	78.6	93.6	99.0	101.3	100.6	96.4	87.8	69.1	96.5
9/22/2014	108	72.9	78.4	91.8	97.0	99.1	98.6	95.0	87.4	73.8	94.8
9/26/2014	112	75.4	77.9	90.3	95.2	97.3	96.8	93.4	86.4	82.8	93.2
9/30/2014	116	75.4	78.6	89.6	93.9	95.9	95.2	92.3	86.0	73.0	92.2
10/3/2014	119	72.3	75.2	88.7	93.4	95.2	94.6	91.8	85.5	65.5	91.5
10/7/2014	123	73.9	74.8	87.1	92.5	94.6	94.1	90.7	82.9	73.8	90.3
10/10/2014	126	78.4	77.9	87.8	91.6	93.6	92.8	89.8	84.2	67.3	90.0
10/13/2014	129	70.3	68.5	84.7	90.9	93.2	92.3	88.3	79.3	60.1	88.1
10/20/2014	136	70.3	68.2	79.3	85.8	88.5	87.4	83.1	75.4	96.4	83.3
10/24/2014	140	81.0	70.9	79.7	83.8	86.2	85.1	81.5	75.9	99.5	82.0
10/28/2014	144	72.7	70.9	79.7	83.3	85.1	84.2	81.3	77.2	82.0	81.8
10/31/2014	147	60.8	63.9	77.7	82.9	85.1	84.2	81.1	74.5	46.0	80.9
11/5/2014	152	60.1	59.9	74.1	80.8	83.5	82.6	78.4	69.8	46.9	78.2
11/7/2014	154	53.1	56.3	70.3	78.1	81.1	79.9	75.6	66.6	50.7	75.3
11/11/2014	158	51.8	50.9	68.0	74.5	77.2	76.3	72.0	63.9	32.4	72.0
11/14/2014	161	39.4	41.7	62.2	71.6	74.7	73.4	68.2	55.9	33.1	67.7
11/19/2014	166	41.7	42.4	55.8	64.6	68.0	66.6	61.0	50.5	44.1	61.1
11/21/2014	168	46.2	46.4	54.9	61.7	64.9	63.5	58.6	50.9	42.6	59.1
11/25/2014	172	42.3	46.9	53.1	57.7	60.1	59.2	55.9	51.4	68.5	56.2
12/1/2014	178	40.6	41.2	52.3	55.0	56.7	56.1	54.1	50.5	23.7	54.1
12/5/2014	182	51.4	50.0	51.4	54.0	55.4	54.9	53.1	50.0	56.5	53.1
12/9/2014	186	41.2	46.9	50.0	52.7	53.8	53.6	52.0	49.5	43.3	51.9
12/12/2014	189	49.3	49.1	50.5	51.8	52.9	52.5	51.4	49.8	50.0	51.5
12/16/2014	193	50.4	45.7	50.7	51.4	52.3	52.0	51.4	49.8	56.8	51.3
12/19/2014	196	41.5	43.0	48.9	51.1	52.2	51.8	51.1	47.8	35.2	50.5
12/23/2014	200	46.6	45.7	48.2	50.0	50.9	50.7	49.8	47.7	47.3	49.6
1/5/2015	213	34.5	31.8	39.6	43.9	45.7	45.3	43.2	37.9	48.7	42.6
1/9/2015	217	34.0	30.4	37.4	41.5	43.5	43.0	40.6	35.6	37.4	40.3
1/13/2015	221	26.1	30.0	35.4	38.5	40.3	39.9	38.1	34.3	18.1	37.8
1/16/2015	224	28.0	34.9	35.2	37.4	38.8	38.5	37.2	35.4	29.3	37.1
1/20/2015	228	40.6	45.0	38.8	37.4	37.9	37.8	38.1	41.0	44.1	38.5
1/23/2015	231	30.4	41.7	39.2	38.7	38.8	38.8	39.6	41.2	28.9	39.4
1/27/2015	235	38.1	45.7	41.7	40.6	40.5	40.6	41.5	43.7	39.7	41.4
1/30/2015	238	46.9	46.9	44.2	42.4	42.1	42.1	43.7	46.2	55.2	43.5
2/3/2015	242	31.6	36.7	42.6	43.9	44.2	44.2	44.6	42.3	39.2	43.6
2/6/2015	245	51.8	43.3	43.9	44.2	44.8	44.8	44.2	42.3	63.1	44.0
2/13/2015	252	37.0	42.1	44.8	45.1	45.5	45.3	45.5	45.1	35.6	45.2
2/17/2015	256	31.8	36.0	43.5	45.7	46.4	46.4	45.7	42.6	37.4	45.1
2/20/2015	259	45.0	40.0	43.0	45.0	46.0	46.0	45.0	42.0	53.0	44.5
2/24/2015	263	45.1	33.8	42.1	44.2	45.3	45.0	43.3	38.8	51.1	43.1
2/27/2015	266	28.0	30.2	40.1	43.3	44.6	44.1	42.3	37.4	17.1	42.0
3/3/2015	270	46.9	37.9	39.2	41.2	42.6	42.1	40.3	37.4	76.1	40.5
3/6/2015	273	33.4	34.0	37.9	40.1	41.4	40.8	39.2	36.5	55.2	39.3
3/10/2015	277	44.8	45.1	41.9	40.3	40.6	40.1	40.1	41.9	45.5	40.8
3/13/2015	280	48.0	50.7	46.0	42.1	41.5	41.2	42.1	45.7	44.4	43.1
3/17/2015	284	56.5	56.5	50.7	45.7	44.4	44.2	46.0	50.9	55.2	47.0
3/20/2015	287	50.5	50.0	50.9	48.4	47.3	46.9	48.4	50.7	76.1	48.8
3/24/2015	291	61.0	59.5	55.6	51.4	50.4	50.2	51.4	54.7	68.9	52.3
3/27/2015	294	52.0	53.1	56.5	53.8	52.7	52.3	53.6	55.0	43.3	54.0
3/31/2015	298	79.3	62.1	60.4	56.7	55.6	55.4	56.3	58.3	103.3	57.1

	6/6/2014	top	Temp at Thermocouple							bottom	
Bin4	days in storage	9	8	7	6	5	4	3	2	1	average temp (2-7)
6/6/2014	0	79.0	88.0	94.0	93.0	93.0	92.0	91.0	89.0	84.0	92.0
6/9/2014	3	77.0	82.0	93.0	95.0	94.0	93.0	91.0	88.0	81.0	92.3
6/11/2014	5	101.0	82.0	92.5	94.8	94.1	92.8	91.4	87.4	80.6	92.2
6/13/2014	7	96.0	84.0	91.0	94.0	93.0	92.0	90.0	86.0	81.0	91.0
6/16/2014	10	91.0	87.0	91.0	93.0	92.0	91.0	89.0	87.0	85.0	90.5
6/18/2014	12	89.0	88.0	91.8	92.5	91.9	91.0	89.4	87.8	87.6	90.7
6/20/2014	14	82.0	86.0	91.9	92.5	91.9	91.0	89.6	88.3	86.7	90.9
6/23/2014	17	75.0	85.0	92.0	92.0	91.0	91.0	90.0	89.0	87.0	90.8
6/25/2014	19	112.0	87.0	92.0	92.0	92.0	91.0	90.0	89.0	86.0	91.0
6/27/2014	21	81.9	87.4	92.8	93.0	92.5	91.6	90.7	89.4	87.4	91.7
6/30/2014	24	98.4	90.0	92.8	93.7	92.8	91.9	91.2	89.8	88.0	92.0
7/2/2014	26	92.8	87.3	93.7	94.1	93.0	92.1	91.4	90.1	88.2	92.4
7/4/2014	28	98.0	87.0	94.0	94.0	93.0	92.0	91.0	90.0	87.0	92.3
7/7/2014	31	106.0	94.0	96.0	96.0	94.0	92.0	91.0	90.0	89.0	93.2
7/9/2014	33	92.1	91.4	99.5	97.9	95.0	93.2	91.8	91.4	91.4	94.8
7/11/2014	35	88.7	88.2	101.1	100.4	96.6	94.1	92.5	91.9	88.9	96.1
7/14/2014	38	116.4	97.7	104.2	103.5	98.6	95.5	93.6	92.5	90.5	98.0
7/16/2014	40	71.8	86.5	105.1	105.1	100.0	96.4	94.3	92.7	89.1	98.9
7/18/2014	42	95.4	85.3	102.7	106.3	101.5	97.5	94.6	91.0	81.5	98.9
7/21/2014	45	92.5	89.1	101.5	105.8	101.5	97.5	94.1	89.2	83.5	98.3
7/23/2014	47	101.8	95.0	102.7	104.9	101.3	97.3	93.6	89.4	86.5	98.2
7/25/2014	49	100.0	95.0	103.0	104.0	101.0	97.0	93.0	89.0	86.0	97.8
7/28/2014	52	93.0	91.0	105.0	105.0	102.0	99.0	95.0	91.0	89.0	99.5
7/30/2014	54	76.1	89.6	105.8	106.9	104.2	100.4	96.4	92.7	87.8	101.1
8/1/2014	56	71.8	81.9	104.0	107.8	105.3	101.8	97.7	92.5	94.2	101.5
8/8/2014	63	78.0	89.0	104.0	106.0	105.0	103.0	99.0	93.0	87.0	101.7
8/11/2014	66	88.7	89.4	104.7	107.1	106.3	104.2	100.0	94.3	88.0	102.8
8/13/2014	68	79.0	84.0	104.2	107.2	106.7	104.9	101.1	95.2	88.3	103.2
8/15/2014	70	95.5	90.5	103.8	107.2	106.7	105.1	101.3	95.2	87.8	103.2
8/18/2014	73	79.9	90.3	104.5	107.1	106.9	105.4	101.8	95.9	89.6	103.6
8/20/2014	75	100.6	94.6	104.5	106.9	106.9	105.8	102.4	96.1	88.7	103.8
8/22/2014	77	118.2	102.9	104.9	107.2	107.2	106.3	103.3	97.2	90.5	104.4
8/25/2014	80	94.5	93.4	105.4	107.6	107.6	106.9	104.0	98.2	91.4	105.0
8/27/2014	82	93.6	91.9	105.8	107.8	108.0	107.2	104.4	98.6	91.8	105.3
8/29/2014	84	77.7	88.0	105.6	108.1	108.3	107.6	104.9	98.8	90.9	103.1
9/3/2014	89	84.6	87.6	104.0	108.0	108.3	107.8	105.4	99.1	89.2	103.0
9/5/2014	91	89.8	90.9	103.6	107.6	108.1	107.8	105.4	99.5	90.9	103.2
9/8/2014	94	77.7	81.0	100.6	106.5	107.2	107.2	105.1	97.7	84.6	101.4
9/12/2014	98	61.0	74.3	98.2	104.2	104.9	104.9	102.9	96.2	85.3	99.7
9/15/2014	101	78.1	78.4	94.1	102.2	103.1	103.1	101.3	93.9	82.0	97.6
9/19/2014	105	70.7	78.1	93.4	98.1	99.1	99.1	97.5	91.0	82.4	94.5
9/22/2014	108	67.5	69.8	92.5	96.4	97.0	97.3	95.5	90.1	82.6	93.2
9/26/2014	112	74.5	73.4	91.0	95.2	95.9	95.5	94.1	88.9	80.8	91.7
9/30/2014	116	68.4	73.0	90.7	94.3	94.5	94.3	92.5	87.6	80.4	90.6
10/3/2014	119	65.5	70.0	91.0	94.3	94.1	93.6	91.6	87.8	81.7	90.5
10/7/2014	123	67.6	72.3	89.2	94.6	94.1	93.2	91.4	86.4	77.9	89.6
10/10/2014	126	70.7	77.9	91.2	94.6	93.4	92.3	90.5	86.0	81.1	89.7
10/13/2014	129	61.9	69.1	88.7	95.5	93.7	92.3	90.0	84.4	75.2	88.5
10/20/2014	136	89.1	72.7	84.4	93.9	91.6	89.2	86.2	80.4	72.5	85.6
10/24/2014	140	98.6	84.7	84.9	92.5	90.1	87.4	84.4	79.2	72.7	84.4
10/28/2014	144	82.4	74.8	86.5	92.8	89.8	86.9	83.8	79.9	76.3	84.9
10/31/2014	147	47.8	58.3	84.6	93.4	90.5	87.1	83.8	79.9	72.5	84.5
11/5/2014	152	49.3	57.9	81.0	92.7	89.8	86.2	83.3	77.0	67.3	82.7
11/7/2014	154	51.8	51.3	77.2	90.1	87.8	84.4	81.0	74.1	63.7	80.2
11/11/2014	158	35.4	46.6	75.2	86.5	84.4	80.8	77.2	70.9	60.8	76.8
11/14/2014	161	33.1	36.1	68.7	83.5	81.5	78.1	74.1	65.5	49.8	72.1
11/19/2014	166	43.7	41.4	60.8	76.6	75.4	71.8	67.3	57.9	46.2	65.9
11/21/2014	168	43.2	45.7	59.7	73.4	72.3	68.9	64.6	56.3	48.9	64.1
11/25/2014	172	56.7	43.9	58.3	68.2	67.5	64.4	60.6	55.4	50.5	61.1
12/1/2014	178	26.4	35.8	57.2	63.9	63.3	60.8	58.3	54.5	48.6	58.2
12/5/2014	182	55.8	53.2	54.1	61.7	61.3	59.4	57.0	53.2	50.2	57.1
12/9/2014	186	39.9	39.7	53.2	59.2	59.0	57.4	55.6	52.7	49.8	55.6
12/12/2014	189	50.9	50.2	52.9	57.4	57.4	56.1	54.7	52.3	50.7	54.8
12/16/2014	193	57.7	51.8	52.9	55.9	55.9	55.0	54.0	52.7	49.8	53.9
12/19/2014	196	36.5	40.1	50.4	55.4	55.4	54.7	53.8	51.8	47.3	53.1
12/23/2014	200	47.7	47.1	49.6	53.6	53.8	53.4	52.5	50.5	48.0	52.0
1/5/2015	213	46.6	36.3	39.6	46.4	47.3	47.1	46.2	42.4	35.2	44.1
1/9/2015	217	38.1	34.7	37.0	43.9	45.0	44.8	43.7	39.7	33.1	41.7
1/13/2015	221	18.9	23.4	35.8	40.5	41.5	41.4	40.3	37.4	33.3	39.1
1/16/2015	224	29.1	26.8	35.8	38.8	39.7	39.7	38.8	36.9	35.8	38.3
1/20/2015	228	43.2	41.2	39.9	38.5	38.8	38.7	38.3	39.4	43.7	39.6
1/23/2015	231	24.6	27.3	40.3	39.7	39.4	39.4	39.4	41.0	43.0	40.3
1/27/2015	235	36.0	36.7	42.4	41.5	41.2	41.0	41.4	43.2	46.0	42.4
1/30/2015	238	57.4	49.6	45.0	43.3	42.6	42.6	43.0	45.5	48.2	44.2
2/3/2015	242	31.8	29.7	42.8	45.3	44.8	44.8	45.1	45.1	40.6	44.3
2/6/2015	245	64.6	55.6	42.8	45.5	45.5	45.5	45.5	44.2	41.4	44.6
2/13/2015	252	34.3	35.4	45.1	46.4	46.0	46.0	46.0	46.4	45.5	46.1
2/17/2015	256	32.0	30.0	43.7	47.3	46.9	46.9	46.9	46.0	40.8	45.8
2/20/2015	259	53.0	47.0	42.0	46.0	46.0	46.0	46.0	44.0	40.0	44.7
2/24/2015	263	54.7	47.5	41.0	45.7	46.0	45.9	45.5	42.8	36.9	43.8
2/27/2015	266	19.2	24.3	40.1	44.6	45.1	45.0	44.4	41.5	35.6	42.7
3/3/2015	270	71.8	52.9	37.9	42.6	43.3	43.2	42.4	39.4	36.7	41.3
3/6/2015	273	43.3	34.7	38.1	41.4	42.1	41.9	41.2	38.8	36.1	40.3
3/10/2015	277	45.7	45.3	42.6	41.0	41.2	41.0	40.6	41.0	44.2	41.5
3/13/2015	280	45.5	47.5	47.5	42.4	42.1	41.9	41.7	43.9	50.0	43.7
3/17/2015	284	57.2	57.4	52.0	46.0	44.8	44.6	45.0	48.4	55.2	47.3
3/20/2015	287	69.3	53.8	52.0	49.1	47.7	47.3	47.8	50.7	52.7	49.2
3/24/2015	291	64.8	52.2	56.8	52.3	50.9	50.5	50.9	53.6	58.3	52.8
3/27/2015	294	45.5	50.2	58.1	54.7	53.2	52.7	53.1	55.6	56.8	54.4
3/31/2015	298	104.9	86.5	60.8	57.7	56.3	55.8	56.1	58.3	61.7	57.7

	6/6/2014	top	Temp at Thermocouple							bottom	
Bin5	days in storage	9	8	7	6	5	4	3	2	1	average temp (2-7)
6/6/2014	0	82.0	81.0	89.0	89.0	89.0	89.0	90.0	91.0	92.0	89.5
6/9/2014	3	82.0	77.0	87.0	90.0	90.0	91.0	91.0	88.0	84.0	89.5
6/11/2014	5	115.0	103.0	86.0	90.1	91.0	91.6	91.4	86.4	81.5	89.4
6/13/2014	7	107.0	99.0	87.0	89.0	91.0	91.0	90.0	85.0	81.0	88.8
6/16/2014	10	98.0	92.0	88.0	89.0	90.0	90.0	88.0	84.0	82.0	88.2
6/18/2014	12	94.0	89.0	90.1	89.4	90.1	90.1	88.5	85.5	84.4	89.0
6/20/2014	14	84.0	83.0	89.8	90.0	90.3	90.1	88.5	86.0	84.9	89.1
6/23/2014	17	74.0	78.0	91.0	90.0	90.0	90.0	88.0	86.0	85.0	89.2
6/25/2014	19	125.0	111.0	91.0	91.0	91.0	90.0	88.0	86.0	84.0	89.5
6/27/2014	21	82.4	83.7	91.9	91.6	91.4	90.5	89.2	86.5	85.1	90.2
6/30/2014	24	105.1	100.0	91.2	91.8	91.9	91.0	89.6	86.5	84.7	90.3
7/2/2014	26	100.9	95.5	91.4	91.9	91.9	91.2	89.6	86.9	85.6	90.5
7/4/2014	28	107.0	101.0	91.0	92.0	92.0	91.0	89.0	86.0	84.0	90.2
7/7/2014	31	114.0	107.0	94.0	92.0	92.0	92.0	90.0	88.0	87.0	91.3
7/9/2014	33	95.2	93.6	95.5	93.9	93.4	92.7	91.0	89.4	89.1	92.7
7/11/2014	35	97.0	91.6	93.7	95.2	94.3	93.4	91.8	89.4	87.4	93.0
7/14/2014	38	125.1	114.3	96.8	95.9	95.5	94.3	92.5	89.8	88.5	94.1
7/16/2014	40	70.3	74.7	94.6	97.0	96.4	94.6	92.8	89.6	87.3	94.2
7/18/2014	42	99.1	90.5	87.3	96.8	96.8	95.2	92.8	87.1	81.3	92.7
7/21/2014	45	98.1	93.9	89.2	94.3	96.3	95.2	92.1	85.3	80.2	92.1
7/23/2014	47	109.4	103.6	94.5	93.7	95.2	94.3	91.0	86.0	83.7	92.5
7/25/2014	49	107.0	102.0	96.0	94.0	94.0	93.0	90.0	86.0	85.0	92.2
7/28/2014	52	104.0	97.0	97.0	96.0	95.0	92.0	90.0	87.0	87.0	92.8
7/30/2014	54	74.1	79.2	97.5	97.9	95.5	93.0	90.5	88.3	87.4	93.8
8/1/2014	56	71.8	72.3	91.8	98.2	96.4	93.7	91.0	87.1	83.8	93.0
8/8/2014	63	77.0	81.0	97.0	97.0	96.0	93.0	90.0	87.0	86.0	93.3
8/11/2014	66	97.7	93.4	98.2	98.2	95.9	93.6	90.9	87.8	86.5	94.1
8/13/2014	68	85.1	82.9	96.6	98.8	96.8	94.1	91.4	88.2	86.2	94.3
8/15/2014	70	106.0	99.7	97.3	98.8	97.0	94.3	91.4	88.2	86.0	94.5
8/18/2014	73	78.8	82.4	99.7	99.0	97.3	94.5	91.6	88.9	87.6	95.2
8/20/2014	75	106.7	101.8	99.5	99.5	97.5	94.6	91.9	89.1	87.6	95.4
8/22/2014	77	123.3	117.1	100.4	100.0	97.9	95.0	92.3	89.8	88.7	95.9
8/25/2014	80	103.6	98.2	100.9	100.6	98.2	95.2	92.7	90.7	89.8	96.4
8/27/2014	82	107.1	102.6	102.0	101.3	98.8	95.9	93.4	91.4	90.5	97.1
8/29/2014	84	77.2	80.4	100.8	101.8	99.1	96.1	93.7	91.6	90.0	97.2
9/3/2014	89	89.4	86.4	97.5	101.7	100.0	97.2	94.5	90.7	88.0	96.9
9/5/2014	91	96.4	91.9	98.8	101.1	100.2	97.2	94.3	90.5	87.0	97.0
9/8/2014	94	83.3	81.1	92.8	100.2	99.7	97.2	94.1	88.3	82.9	95.4
9/12/2014	98	59.5	65.7	90.5	97.9	98.2	96.1	92.8	86.9	82.4	93.7
9/15/2014	101	80.4	77.2	85.1	95.2	98.1	95.5	91.6	83.7	76.5	91.5
9/19/2014	105	70.5	73.4	89.2	91.9	93.6	92.5	88.5	82.8	79.3	89.8
9/22/2014	108	74.8	72.5	87.4	91.8	92.3	90.5	87.1	82.6	79.9	88.6
9/26/2014	112	83.5	80.1	86.5	90.7	91.4	89.4	86.2	81.5	77.9	87.6
9/30/2014	116	71.1	70.5	87.8	90.1	90.3	88.3	85.3	81.1	77.9	87.2
10/3/2014	119	69.8	70.0	86.7	90.5	90.1	88.0	85.1	81.1	78.8	86.9
10/7/2014	123	73.4	72.5	84.6	89.1	90.5	88.3	85.1	79.3	74.3	86.2
10/10/2014	126	69.6	73.6	88.3	89.1	89.2	87.3	83.8	79.7	77.0	86.2
10/13/2014	129	61.0	64.2	79.5	88.7	90.5	87.3	83.7	77.2	71.4	84.5
10/20/2014	136	104.9	91.4	75.7	83.1	85.6	84.4	80.2	73.4	68.0	80.4
10/24/2014	140	108.7	104.5	79.3	82.6	83.8	82.0	78.4	73.2	70.0	79.9
10/28/2014	144	91.4	86.2	81.9	83.3	82.9	81.0	77.7	74.5	72.7	80.2
10/31/2014	147	46.9	52.9	76.3	83.3	83.5	81.1	78.1	73.4	69.3	79.3
11/5/2014	152	47.5	52.2	69.1	80.1	83.1	81.5	77.5	70.0	63.5	76.9
11/7/2014	154	59.5	57.6	64.6	76.6	81.0	79.9	75.6	67.1	60.3	74.1
11/11/2014	158	34.7	41.4	65.7	73.2	77.7	77.0	72.7	65.3	60.4	71.9
11/14/2014	161	34.9	32.0	52.5	70.7	75.6	74.8	70.3	59.7	49.6	67.3
11/19/2014	166	53.8	49.6	47.5	62.2	69.4	69.8	64.4	53.1	43.5	61.1
11/21/2014	168	43.0	43.9	50.9	59.4	66.4	66.9	61.7	52.2	45.1	59.6
11/25/2014	172	74.3	67.8	51.6	57.7	61.9	62.1	57.9	52.2	49.1	57.2
12/1/2014	178	25.3	32.0	54.3	56.3	58.6	58.3	55.6	52.2	50.5	55.9
12/5/2014	182	56.7	55.4	50.2	55.4	57.9	57.2	54.7	50.0	46.6	54.2
12/9/2014	186	47.8	45.1	50.4	53.4	55.9	55.6	53.4	49.8	47.8	53.1
12/12/2014	189	51.8	51.1	51.4	52.7	54.5	54.3	52.5	49.6	47.8	52.5
12/16/2014	193	65.5	61.0	51.8	53.2	54.0	53.4	52.0	50.5	49.8	52.5
12/19/2014	196	35.6	37.8	46.6	52.5	53.8	53.2	52.0	49.1	46.4	51.2
12/23/2014	200	48.2	48.7	47.7	50.2	52.3	52.2	50.9	48.0	46.0	50.2
1/5/2015	213	57.2	50.9	35.6	43.5	47.1	47.5	45.7	40.6	35.8	43.3
1/9/2015	217	41.4	40.1	33.1	41.0	44.8	45.3	43.5	38.3	32.9	41.0
1/13/2015	221	20.1	21.2	33.8	38.3	41.9	42.4	40.5	36.3	33.3	38.9
1/16/2015	224	35.8	32.0	36.1	37.4	40.3	40.6	38.8	36.1	34.0	38.2
1/20/2015	228	43.9	43.9	46.4	39.6	39.6	39.2	38.3	39.2	41.2	40.4
1/23/2015	231	28.0	27.3	43.2	42.3	41.0	39.7	39.4	40.6	42.1	41.0
1/27/2015	235	41.2	39.4	46.9	44.4	43.0	41.7	41.4	42.4	43.7	43.3
1/30/2015	238	61.2	58.1	50.0	47.3	45.0	43.3	43.0	45.0	46.9	45.6
2/3/2015	242	40.5	36.9	43.0	48.2	47.5	45.9	45.1	43.9	41.5	45.6
2/6/2015	245	68.9	66.6	44.6	46.9	47.8	46.9	45.7	42.8	39.2	45.8
2/13/2015	252	37.9	37.0	47.3	49.6	48.7	47.3	46.0	45.5	44.6	47.4
2/17/2015	256	36.5	34.0	43.0	49.8	50.0	48.6	47.3	44.6	41.5	47.2
2/20/2015	259	55.0	53.0	42.0	47.0	49.0	49.0	47.0	42.0	38.0	46.0
2/24/2015	263	58.6	56.3	39.9	46.0	48.4	47.8	45.7	41.0	36.5	44.8
2/27/2015	266	18.9	22.6	39.2	44.6	47.1	46.9	44.8	40.1	35.8	43.8
3/3/2015	270	79.9	70.9	37.6	41.7	45.1	45.0	42.6	37.8	34.2	41.6
3/6/2015	273	55.6	50.9	38.5	40.6	43.0	43.3	41.2	37.6	35.1	40.7
3/10/2015	277	46.0	46.0	47.3	42.3	42.1	41.7	40.3	40.5	42.1	42.4
3/13/2015	280	45.5	48.2	57.0	45.7	43.0	41.9	41.4	43.7	46.9	45.5
3/17/2015	284	58.3	59.9	62.1	51.1	46.8	44.6	44.4	47.8	51.8	49.5
3/20/2015	287	81.5	72.7	56.5	54.5	50.0	47.3	47.3	49.6	52.0	50.9
3/24/2015	291	66.7	65.3	65.8	56.3	52.9	50.7	50.2	52.2	54.7	54.7
3/27/2015	294	44.6	49.3	64.4	59.5	55.4	52.9	52.5	54.3	56.1	56.5
3/31/2015	298	113.2	106.0	69.3	61.7	58.5	55.9	55.4	56.3	57.4	59.5

	6/6/2014	top	Temp at Thermocouple							bottom	
Bin6	days in storage	9	8	7	6	5	4	3	2	1	average temp (2-7)
6/6/2014	0	82.0	92.0	96.0	96.0	96.0	96.0	97.0	93.0	83.0	95.7
6/9/2014	3	79.0	89.0	96.0	97.0	97.0	97.0	96.0	89.0	75.0	95.3
6/11/2014	5	104.0	87.0	95.2	97.0	97.3	97.3	95.4	87.1	75.6	94.9
6/13/2014	7	98.0	89.0	94.0	96.0	96.0	96.0	93.0	85.0	75.0	93.3
6/16/2014	10	94.0	90.0	93.0	95.0	95.0	94.0	91.0	85.0	80.0	92.2
6/18/2014	12	90.0	91.0	93.9	94.6	94.8	94.1	91.0	86.5	82.8	92.5
6/20/2014	14	83.0	90.0	94.1	94.6	94.5	93.6	90.9	86.4	80.8	92.4
6/23/2014	17	75.0	91.0	94.0	94.0	94.0	93.0	90.0	86.0	80.0	91.8
6/25/2014	19	112.0	91.0	94.0	94.0	94.0	93.0	90.0	85.0	78.0	91.7
6/27/2014	21	81.7	92.1	94.6	94.8	94.3	93.4	90.7	86.4	81.3	92.4
6/30/2014	24	101.3	92.5	94.5	94.8	94.3	93.2	90.7	86.4	81.9	92.3
7/2/2014	26	93.9	91.0	94.3	94.6	94.1	93.0	90.7	86.5	81.5	92.2
7/4/2014	28	101.0	91.0	94.0	94.0	94.0	93.0	90.0	86.0	80.0	91.8
7/7/2014	31	109.0	95.0	95.0	95.0	94.0	93.0	91.0	87.0	85.0	92.5
7/9/2014	33	93.7	94.1	96.1	95.5	95.0	93.7	91.6	88.7	85.3	93.4
7/11/2014	35	90.1	91.4	96.6	96.6	95.9	94.6	92.5	88.0	80.4	94.0
7/14/2014	38	118.2	97.0	97.9	97.9	97.0	96.1	93.7	89.6	85.5	95.4
7/16/2014	40	72.3	91.2	98.6	99.0	98.2	97.0	94.6	89.1	81.3	96.1
7/18/2014	42	95.5	86.5	97.3	99.7	99.5	98.2	95.0	85.8	72.1	95.9
7/21/2014	45	93.6	90.0	96.4	99.3	99.3	98.2	94.3	85.8	78.4	95.6
7/23/2014	47	103.6	95.2	97.3	99.0	99.1	97.9	94.1	87.4	83.5	95.8
7/25/2014	49	103.0	95.0	98.0	99.0	99.0	98.0	94.0	88.0	84.0	96.0
7/28/2014	52	93.0	95.0	100.0	101.0	101.0	99.0	96.0	91.0	85.0	98.0
7/30/2014	54	76.1	95.4	102.4	103.5	102.7	101.3	97.7	91.6	84.6	99.9
8/1/2014	56	72.1	89.2	102.2	104.5	104.0	102.4	98.6	90.0	78.3	100.3
8/8/2014	63	79.0	97.0	104.0	105.0	105.0	103.0	98.0	91.0	84.0	101.0
8/11/2014	66	90.1	97.7	105.8	107.1	106.2	104.0	99.5	92.1	84.4	102.5
8/13/2014	68	80.2	95.0	106.2	107.8	106.9	104.9	100.4	92.3	83.5	103.1
8/15/2014	70	98.2	97.9	106.3	108.1	107.4	105.3	100.6	92.8	84.7	103.4
8/18/2014	73	80.6	100.0	107.2	108.7	107.8	105.8	101.3	94.1	86.4	104.2
8/20/2014	75	104.0	101.3	107.8	109.0	108.3	106.3	102.0	94.5	86.4	104.7
8/22/2014	77	122.9	105.1	108.7	109.8	109.0	107.2	103.1	95.9	89.6	105.6
8/25/2014	80	96.1	101.7	109.4	110.5	109.9	108.1	104.4	97.7	90.1	106.7
8/27/2014	82	96.4	101.7	109.6	110.5	109.9	108.1	104.5	98.2	90.7	106.8
8/29/2014	84	78.8	99.5	109.4	110.7	109.9	108.5	105.1	97.9	88.0	106.9
9/3/2014	89	86.0	97.3	108.5	110.5	110.3	108.7	104.9	96.1	83.8	106.5
9/5/2014	91	91.9	99.5	108.1	110.3	110.1	108.7	104.7	96.8	88.0	106.5
9/8/2014	94	79.3	92.3	106.0	109.0	109.4	107.8	103.6	93.2	79.2	104.8
9/12/2014	98	61.7	88.7	103.5	106.5	106.7	105.1	100.6	90.7	77.4	102.2
9/15/2014	101	79.3	86.9	99.9	103.8	104.2	102.6	97.3	86.5	75.4	99.1
9/19/2014	105	71.2	87.3	96.6	99.5	100.0	98.6	94.3	86.4	78.6	95.9
9/22/2014	108	69.6	82.4	95.2	97.7	98.2	97.0	93.2	86.2	78.1	94.6
9/26/2014	112	77.5	82.6	93.7	96.4	96.8	95.7	92.3	85.3	77.5	93.4
9/30/2014	116	69.4	82.6	92.8	95.2	95.5	94.5	91.0	84.6	77.5	92.3
10/3/2014	119	66.4	80.2	92.8	95.2	95.2	94.1	90.7	83.8	74.3	92.0
10/7/2014	123	68.0	80.6	91.6	94.8	95.0	93.7	89.8	82.0	74.5	91.2
10/10/2014	126	70.9	84.4	92.1	94.3	94.3	93.0	89.1	82.9	77.0	91.0
10/13/2014	129	61.9	77.2	90.7	94.3	94.5	92.7	88.0	79.2	68.0	89.9
10/20/2014	136	89.6	74.3	85.3	90.3	91.0	89.2	83.5	75.2	67.6	85.8
10/24/2014	140	102.4	80.8	84.7	88.3	89.2	87.3	82.4	75.4	69.4	84.6
10/28/2014	144	82.0	77.2	85.1	88.0	88.3	86.5	82.0	76.5	70.9	84.4
10/31/2014	147	48.2	69.4	84.0	88.0	88.3	86.5	82.0	75.0	66.4	84.0
11/5/2014	152	49.1	66.6	80.8	85.8	86.5	84.7	79.3	70.2	60.8	81.2
11/7/2014	154	51.3	59.9	77.0	82.8	84.0	82.2	76.6	66.9	56.1	78.3
11/11/2014	158	36.1	59.9	74.1	79.0	79.9	78.1	72.7	64.6	55.0	74.7
11/14/2014	161	31.8	47.7	69.1	75.6	76.6	74.5	68.7	57.6	43.5	70.4
11/19/2014	166	42.4	46.4	61.3	68.2	70.0	68.0	61.9	51.3	42.1	63.5
11/21/2014	168	43.2	49.3	59.2	64.9	66.7	65.1	59.4	51.1	45.5	61.1
11/25/2014	172	55.9	46.4	56.8	60.8	62.2	60.8	56.5	51.1	45.5	58.0
12/1/2014	178	27.3	46.6	55.0	57.4	58.3	57.4	54.5	50.5	44.2	55.5
12/5/2014	182	55.6	51.1	53.4	55.9	56.8	55.9	53.4	50.0	49.3	54.2
12/9/2014	186	38.3	45.5	52.2	54.3	55.2	54.5	52.3	49.3	46.6	53.0
12/12/2014	189	50.9	50.0	51.8	53.2	54.1	53.6	51.8	49.5	48.4	52.3
12/16/2014	193	56.8	50.0	51.8	52.7	53.2	52.9	51.4	49.5	45.7	51.9
12/19/2014	196	36.3	44.2	50.5	52.3	53.1	52.7	51.3	47.8	42.8	51.3
12/23/2014	200	48.2	46.9	49.3	50.9	51.8	51.4	50.0	47.5	45.0	50.2
1/5/2015	213	47.5	34.5	41.4	44.8	46.2	45.9	43.7	38.3	31.3	43.4
1/9/2015	217	37.4	33.6	39.2	42.4	43.9	43.7	41.2	36.1	30.7	41.1
1/13/2015	221	18.9	30.4	36.9	39.6	40.8	40.3	38.3	34.5	31.1	38.4
1/16/2015	224	26.4	31.6	36.3	38.1	39.2	38.8	37.0	35.2	34.9	37.4
1/20/2015	228	43.0	41.4	38.8	37.9	38.3	38.1	37.6	39.4	43.5	38.4
1/23/2015	231	23.4	35.1	39.6	39.2	39.2	38.8	39.0	40.3	40.8	39.4
1/27/2015	235	35.8	41.0	41.9	41.0	40.8	40.6	41.2	43.0	45.5	41.4
1/30/2015	238	57.9	45.7	44.1	42.6	42.3	42.3	43.0	45.1	46.0	43.2
2/3/2015	242	29.7	35.8	43.9	44.4	44.6	44.4	44.6	42.4	36.5	44.1
2/6/2015	245	63.5	47.3	44.1	44.6	45.0	44.8	44.2	42.1	41.2	44.1
2/13/2015	252	34.5	40.5	45.5	45.7	45.7	45.5	45.0	44.2	41.5	45.3
2/17/2015	256	30.6	35.6	45.0	46.4	46.6	46.4	45.8	42.8	36.7	45.5
2/20/2015	259	54.0	42.0	44.0	45.0	46.0	46.0	44.0	41.0	38.0	44.3
2/24/2015	263	54.9	42.6	43.2	44.8	45.7	45.3	43.3	39.2	33.8	43.6
2/27/2015	266	19.8	33.1	41.9	43.9	44.8	44.2	42.3	37.4	30.6	42.4
3/3/2015	270	73.0	41.9	39.9	41.9	42.8	42.4	40.1	37.0	37.0	40.7
3/6/2015	273	42.8	35.6	39.4	40.8	41.7	41.2	39.2	36.3	33.8	39.8
3/10/2015	277	45.7	44.8	41.7	40.8	41.0	40.5	39.6	40.8	44.6	40.7
3/13/2015	280	45.1	50.7	45.5	42.6	41.9	41.4	41.4	44.6	49.6	42.9
3/17/2015	284	57.7	57.0	49.8	46.0	44.8	44.2	45.1	49.3	55.4	46.5
3/20/2015	287	69.6	51.3	51.3	48.9	47.7	47.1	47.8	49.6	49.3	48.7
3/24/2015	291	65.1	61.5	55.2	52.0	50.5	50.2	50.9	53.4	57.9	52.0
3/27/2015	294	45.9	57.0	57.0	54.3	52.9	52.5	53.1	54.5	53.6	54.1
3/31/2015	298	109.4	70.9	60.1	57.4	55.9	55.4	55.6	57.4	61.0	57.0

	6/30/2015	top	Temp at Thermocouple								bottom
Bin1	days in storage	9	8	7	6	5	4	3	2	1	average temp (2-7)
6/30/2015	0	100.4	101.3	102.4	103.3	103.3	103.1	101.5	95.9	88.0	101.6
7/2/2015	2	89.1	101.3	102.2	102.9	102.9	102.4	100.4	95.0	89.1	101.0
7/6/2015	6	90.1	100.6	101.5	102.2	101.8	100.9	98.6	93.7	88.9	99.8
7/8/2015	8	76.6	98.6	100.6	101.5	101.3	100.0	97.3	91.0	79.9	98.6
7/11/2015	11	87.1	95.4	98.2	99.7	99.5	98.1	94.6	88.3	82.8	96.4
7/13/2015	13	99.7	95.7	97.0	98.2	97.9	96.3	93.2	89.6	88.0	95.4
7/15/2015	15	91.6	97.0	96.8	97.3	96.8	95.5	93.0	91.9	91.9	95.2
7/17/2015	17	88.0	97.7	96.8	97.0	96.4	95.2	93.6	93.4	93.4	95.4
7/20/2015	20	91.6	98.6	97.5	97.3	96.6	95.7	94.8	95.4	95.9	96.2
7/22/2015	22	85.6	97.7	97.7	97.5	97.0	96.1	95.5	94.8	91.0	96.4
7/24/2015	24	89.8	97.9	97.9	97.7	97.2	96.4	95.7	94.8	93.7	96.6
7/28/2015	28	100.9	99.0	98.2	97.9	97.3	96.8	96.3	96.8	95.9	97.2
7/30/2015	30	88.7	99.1	98.4	98.1	97.7	97.0	96.8	97.2	96.3	97.5
8/3/2015	34	94.6	97.2	97.9	98.2	97.9	97.2	96.8	95.7	92.8	97.3
8/5/2015	36	79.7	96.4	97.5	97.9	97.7	97.0	96.4	95.0	91.4	96.9
8/7/2015	38	90.9	96.8	97.2	97.7	97.3	96.6	95.9	95.2	94.3	96.7
8/10/2015	41	86.9	98.6	97.3	97.2	96.8	96.3	95.9	96.8	96.4	96.7
8/12/2015	43	118.0	97.3	97.5	97.5	97.0	96.6	96.4	95.5	93.6	96.8
8/14/2015	45	83.8	96.8	97.3	97.7	97.3	96.8	96.3	95.0	92.3	96.7
8/17/2015	48	79.0	95.7	96.6	97.2	96.8	96.3	95.4	93.7	91.0	96.0
8/19/2015	50	74.3	95.2	96.1	96.8	96.4	95.9	94.8	93.2	88.2	95.5
8/21/2015	52	76.6	92.8	95.2	96.3	96.1	95.4	93.9	89.8	84.2	94.5
8/25/2015	56	69.4	89.6	92.5	94.1	93.7	92.8	90.7	86.2	80.8	91.7
8/28/2015	59	76.6	89.4	90.9	92.3	91.9	91.0	88.9	86.5	84.9	90.3
9/1/2015	63	79.2	89.1	89.6	90.7	90.3	89.4	88.0	86.9	86.2	89.2
9/3/2015	65	96.8	89.6	89.6	90.1	89.8	88.9	88.0	87.8	87.1	89.0
9/8/2015	70	89.4	91.6	90.5	90.3	89.8	89.4	89.2	90.5	91.4	90.0
9/11/2015	73	77.5	91.4	91.0	91.0	90.5	90.1	90.0	88.9	83.1	90.3
9/15/2015	77	72.5	88.0	89.8	90.5	90.1	89.6	88.3	84.9	80.4	88.9
9/18/2015	80	82.8	88.3	88.7	89.4	88.9	88.3	86.9	85.6	85.5	88.0
9/22/2015	84	74.1	86.0	87.8	88.5	88.3	87.6	86.4	83.7	80.6	87.1
9/25/2015	87	69.1	85.6	86.5	87.4	87.1	86.5	85.3	83.5	81.5	86.1
9/29/2015	91	66.6	85.1	85.8	86.5	86.4	85.6	84.7	83.1	80.4	85.4
10/2/2015	94	61.9	82.9	84.7	86.0	85.6	85.1	83.8	80.8	73.9	84.3
10/6/2015	98	59.2	78.3	82.0	84.2	84.0	83.3	81.0	76.1	70.3	81.8
10/9/2015	101	82.0	78.1	80.2	81.9	81.7	80.8	78.4	75.7	73.6	79.8
10/12/2015	104	81.1	77.7	79.0	80.6	80.2	79.3	77.5	75.7	75.2	78.7
10/16/2015	108	63.3	77.5	78.4	79.3	79.2	78.4	77.2	76.3	75.2	78.1
10/20/2015	112	64.6	75.2	77.2	78.8	78.4	77.7	76.5	74.3	72.0	77.2
10/23/2015	115	71.6	75.4	76.6	77.9	77.5	76.8	75.7	74.5	73.0	76.5
10/27/2015	119	82.0	71.4	75.0	76.8	76.6	76.1	74.5	70.7	67.1	75.0
10/30/2015	122	52.7	69.4	73.0	75.2	75.2	74.5	72.5	68.5	63.1	73.2
11/4/2015	127	77.2	67.1	69.4	71.6	71.6	70.7	68.4	65.3	65.3	69.5
11/6/2015	129	64.0	67.3	68.7	70.5	70.5	69.6	67.6	65.8	63.0	68.8
11/10/2015	133	56.7	63.9	66.9	69.1	69.1	68.4	66.6	63.3	59.9	67.2
11/13/2015	136	49.3	63.5	65.7	67.6	67.6	67.1	65.5	63.1	58.1	66.1
11/17/2015	140	64.0	62.4	64.4	66.0	66.0	65.5	64.0	61.9	61.0	64.6
11/20/2015	143	66.4	60.4	63.1	64.9	64.9	64.4	62.8	59.5	57.7	63.3
11/24/2015	147	66.2	57.0	60.8	63.1	63.3	62.6	60.4	55.3	54.1	60.9
12/1/2015	154	55.6	51.8	56.5	59.2	59.5	58.6	56.3	50.2	44.1	56.7
12/4/2015	157	38.7	49.8	53.8	56.7	56.8	55.9	53.4	48.7	44.1	54.2
12/8/2015	161	61.9	49.6	51.4	53.6	53.8	53.1	51.1	49.5	49.8	52.1
12/11/2015	164	53.8	51.1	51.3	52.7	52.7	52.3	51.1	51.3	51.8	51.9
12/15/2015	168	40.1	52.5	52.3	53.1	52.9	52.9	52.9	52.7	50.2	52.8
12/18/2015	171	49.3	48.9	51.8	53.4	53.4	53.2	52.9	49.3	44.1	52.3
12/21/2015	174	59.5	49.5	51.1	52.5	52.7	52.3	51.3	49.6	50.0	51.6
1/4/2016	188	25.3	42.3	45.5	47.8	48.2	47.5	45.7	41.9	37.8	46.1
1/8/2016	192	43.0	41.9	43.3	45.1	45.3	44.8	43.3	41.7	41.5	43.9
1/12/2016	196	27.9	39.4	41.9	43.7	43.9	43.3	42.1	39.0	36.7	42.3
1/15/2016	199	48.6	40.8	41.2	42.4	42.6	42.3	41.2	40.6	41.4	41.7
1/20/2016	204	30.0	37.9	40.3	41.9	41.9	41.5	40.8	38.3	35.6	40.8
1/22/2016	206	27.5	37.6	39.6	41.2	41.4	41.0	39.9	37.4	33.4	40.1
1/26/2016	210	30.0	39.0	38.8	40.1	40.1	39.7	38.8	39.2	38.8	39.5
1/29/2016	213	70.5	40.1	39.4	39.9	38.7	39.7	39.7	41.0	48.6	39.7
2/2/2016	217	45.3	44.6	41.9	41.2	40.8	41.2	42.3	45.7	48.2	42.2
2/5/2016	220	62.6	43.0	43.2	43.0	42.8	43.2	44.2	43.9	43.3	43.4
2/9/2016	224	48.2	44.1	44.1	44.2	44.1	44.4	44.8	44.6	44.8	44.4
2/12/2016	227	63.1	45.1	44.6	44.8	44.6	44.8	45.1	45.5	46.0	44.9
2/16/2016	231	61.3	46.9	45.5	45.5	45.3	45.5	45.9	46.9	49.5	45.8
2/22/2016	237	41.5	53.6	50.0	48.7	48.2	48.6	50.2	53.8	54.5	49.9
2/26/2016	241	55.8	50.5	51.1	51.4	51.1	51.6	52.3	50.4	45.1	51.3
3/4/2016	248	47.8	54.0	53.1	53.1	52.9	52.9	53.6	54.3	53.1	53.3
3/10/2016	254	74.5	58.1	56.3	55.8	55.4	55.6	56.7	57.9	57.7	56.3
3/15/2016	259	75.2	59.5	58.5	58.1	57.7	57.9	58.5	59.0	59.7	58.3
3/18/2016	262	57.7	59.5	59.0	58.8	58.5	58.6	59.0	58.8	56.8	58.8
3/22/2016	266	55.0	56.8	58.3	59.0	59.0	58.8	58.3	55.9	54.7	58.2
3/25/2016	269	47.3	58.6	58.1	58.6	58.5	58.3	58.1	57.7	54.3	58.2
3/28/2016	272	40.1	58.6	58.5	59.0	58.8	58.6	58.5	57.2	52.7	58.4
4/1/2016	276	73.6	61.0	59.5	59.4	59.0	59.0	59.0	59.9	59.4	59.3
4/5/2016	280	60.1	62.6	60.8	60.4	59.9	59.9	60.1	61.7	63.5	60.5
4/8/2016	283	66.6	63.5	61.9	61.3	61.0	61.2	61.9	64.0	63.1	61.9
4/12/2016	287	54.1	64.9	63.5	63.1	62.6	62.8	63.7	64.6	62.6	63.4
4/15/2016	290	57.4	65.5	64.6	64.2	63.7	63.9	64.4	64.0	62.6	64.1
4/19/2016	294	86.5	66.2	65.7	65.3	64.9	64.9	65.1	64.9	65.3	65.1
4/22/2016	297	81.3	67.1	66.2	65.8	65.5	65.3	65.3	64.9	63.5	65.5
4/26/2016	301	83.3	71.1	68.0	67.1	66.4	66.2	66.6	68.7	72.9	67.2
5/3/2016	308	53.8	67.8	69.1	69.4	68.9	68.7	68.5	65.8	61.3	68.4
5/6/2016	311	84.4	70.3	69.1	69.1	68.9	68.5	67.8	67.6	67.5	68.5
5/10/2016	315	69.4	72.3	70.7	70.0	69.4	69.1	69.3	70.3	70.7	69.8
5/13/2016	318	80.6	75.7	72.7	71.4	70.7	70.5	71.2	73.2	73.9	71.6
5/17/2016	322	58.6	73.2	73.6	73.4	72.7	72.5	72.7	71.6	68.0	72.8
5/20/2016	325	89.4	70.7	72.7	73.4	72.7	72.5	71.6	68.9	66.4	72.0
5/24/2016	329	95.5	73.9	72.5	72.5	72.0	71.6	70.9	71.6	73.6	71.9
5/27/2016	332	71.6	77.4	73.9	73.0	72.5	72.1	72.3	75.0	77.9	73.1
5/31/2016	336	110.3	80.2	77.0	75.2	74.5	74.3	75.2	77.2	79.0	75.6
6/3/2016	339	93.7	79.9	78.3	77.0	76.1	76.1	76.6	77.5	77.0	76.9
6/7/2016	343	87.3	82.4	79.9	78.6	77.9	77.7	78.1	79.3	80.2	78.6
6/10/2016	346	83.8	85.5	81.9	80.2	79.3	79.2	79.9	82.6	85.1	80.5
6/14/2016	350	86.2	87.1	84.6	82.9	81.9	81.9	82.9	85.5	86.5	83.3
6/17/2016	353	94.5	90.7	86.9	84.7	83.8	83.8	85.1	88.5	91.9	85.5
6/21/2016	357	83.8	93.2	89.8	87.8	86.7	86.9	88.2	90.7	92.5	88.4
6/24/2016	360	93.4	94.8	91.8	89.8	88.9	89.1	90.3	92.8	94.1	90.5
6/29/2016	365	90.1	94.5	93.4	92.5	91.8	91.8	92.3	92.1	90.0	92.3

	6/30/2015	top	Temp at Thermocouple							bottom	
Bin2	days in storage	9	8	7	6	5	4	3	2	1	average temp (2-7)
6/30/2015	0	124.0	98.8	102.2	102.4	102.4	102.4	102.2	99.7	93.4	101.9
7/2/2015	2	85.6	94.3	102.2	102.6	102.7	102.7	102.0	98.4	92.3	101.8
7/6/2015	6	91.0	93.0	100.9	102.2	102.4	102.4	100.9	95.7	89.2	100.8
7/8/2015	8	71.6	81.5	99.5	101.5	101.8	101.5	100.0	93.7	81.5	99.7
7/11/2015	11	95.4	87.1	94.1	98.4	100.0	100.0	97.9	90.3	82.4	96.8
7/13/2015	13	116.2	95.2	93.7	96.6	98.2	98.2	95.9	90.1	85.6	95.5
7/15/2015	15	100.4	93.2	95.2	96.1	97.2	97.0	94.5	90.7	88.7	95.1
7/17/2015	17	84.2	92.1	96.8	96.4	96.8	96.1	93.9	90.9	88.5	95.2
7/20/2015	20	99.5	94.3	98.1	97.3	97.0	96.1	94.1	91.6	89.8	95.7
7/22/2015	22	91.8	88.0	98.6	97.9	97.2	96.1	94.3	91.4	86.5	95.9
7/24/2015	24	99.5	92.1	97.5	97.7	97.3	96.3	94.6	91.4	88.7	95.8
7/28/2015	28	111.9	97.7	98.6	97.9	97.3	96.3	94.6	92.3	90.0	96.2
7/30/2015	30	86.5	92.5	98.8	98.2	97.3	96.4	94.8	92.7	90.7	96.4
8/3/2015	34	106.5	92.3	97.3	97.9	97.5	96.6	95.2	92.3	88.0	96.1
8/5/2015	36	74.3	84.4	96.3	97.3	97.2	96.4	95.0	91.8	87.4	95.7
8/7/2015	38	101.3	91.9	95.5	96.4	96.6	96.1	94.6	91.9	90.1	95.2
8/10/2015	41	81.1	91.9	97.9	96.8	96.4	95.7	94.3	92.8	91.9	95.7
8/12/2015	43	137.1	103.6	97.7	97.3	96.8	95.9	94.6	92.3	88.9	95.8
8/14/2015	45	84.2	86.9	96.8	97.3	96.8	96.1	94.8	92.1	88.7	95.7
8/17/2015	48	74.3	84.2	95.4	96.4	96.4	95.9	94.6	91.6	88.0	95.1
8/19/2015	50	66.7	81.0	95.0	96.1	96.1	95.5	94.3	91.2	86.0	94.7
8/21/2015	52	72.9	80.1	92.7	95.2	95.5	95.2	93.7	88.9	81.7	93.5
8/25/2015	56	73.0	73.4	88.2	91.6	93.0	93.0	91.6	86.0	79.0	90.6
8/28/2015	59	73.4	80.1	87.4	89.8	91.2	91.2	89.4	85.3	81.7	89.1
9/1/2015	63	82.6	82.0	87.8	88.9	89.8	89.6	87.8	85.1	83.1	88.2
9/3/2015	65	108.1	90.1	88.9	89.1	89.4	88.9	87.4	85.3	83.8	88.2
9/8/2015	70	91.9	90.5	91.6	90.5	90.0	89.2	88.0	87.3	87.6	89.4
9/11/2015	73	76.5	80.6	91.9	91.4	90.7	89.8	88.7	86.5	81.5	89.8
9/15/2015	77	71.1	76.5	88.2	90.5	90.5	90.1	88.7	84.2	78.8	88.7
9/18/2015	80	85.1	83.7	87.3	88.9	89.6	89.1	87.4	84.4	82.6	87.8
9/22/2015	84	74.5	76.5	85.6	88.0	88.7	88.2	86.5	82.8	78.6	86.6
9/25/2015	87	67.6	73.2	84.9	86.7	87.4	87.3	85.6	82.6	79.7	85.8
9/29/2015	91	63.7	71.2	84.9	86.2	86.5	86.2	84.7	81.9	78.8	85.1
10/2/2015	94	64.6	65.3	83.8	86.0	86.4	86.0	84.4	80.4	72.7	84.5
10/6/2015	98	56.3	61.9	78.1	82.9	84.4	84.4	82.8	77.0	69.1	81.6
10/9/2015	101	90.1	78.1	76.5	79.9	81.7	82.0	80.2	75.7	71.2	79.3
10/12/2015	104	89.2	76.8	76.5	79.0	80.2	80.4	78.6	75.2	73.6	78.3
10/16/2015	108	59.2	67.6	77.2	79.0	79.9	79.3	77.9	75.4	73.4	78.1
10/20/2015	112	63.5	66.4	75.2	78.4	79.3	79.0	77.5	74.1	70.3	77.3
10/23/2015	115	73.0	70.7	75.2	77.2	78.3	78.1	76.8	74.1	70.9	76.6
10/27/2015	119	94.3	75.0	71.6	75.7	77.0	77.0	75.7	71.6	65.3	74.8
10/30/2015	122	51.1	54.7	69.4	73.9	75.4	75.7	74.3	69.6	63.0	73.1
11/4/2015	127	84.0	71.8	65.7	69.8	71.8	72.3	70.7	66.2	63.7	69.4
11/6/2015	129	72.5	61.5	66.4	69.1	70.9	71.2	69.4	66.4	63.5	68.9
11/10/2015	133	63.7	56.8	64.4	68.4	69.8	69.8	68.4	64.4	59.9	67.5
11/13/2015	136	61.0	49.5	64.4	67.3	68.5	68.5	67.1	64.2	59.5	66.7
11/17/2015	140	63.1	63.6	62.6	66.2	67.5	67.6	66.2	62.8	60.1	65.5
11/20/2015	143	74.3	62.2	61.2	64.8	66.2	66.4	64.9	61.0	56.3	64.1
11/24/2015	147	75.2	60.4	57.2	62.6	64.2	64.4	63.0	58.1	52.9	61.6
12/1/2015	154	67.3	50.2	51.8	57.9	60.1	60.8	59.2	52.7	44.6	57.1
12/4/2015	157	46.0	38.5	49.1	54.7	57.2	57.9	56.3	50.9	45.5	54.4
12/8/2015	161	72.0	56.8	49.6	52.9	54.7	54.9	53.2	50.4	49.1	52.6
12/11/2015	164	61.2	52.0	51.8	53.1	54.1	54.1	52.7	51.4	52.0	52.9
12/15/2015	168	37.6	43.3	54.1	54.7	54.7	54.1	53.4	52.9	51.1	54.0
12/18/2015	171	58.5	47.8	51.6	54.9	55.0	54.7	54.1	51.4	44.8	53.6
12/21/2015	174	69.8	56.1	49.6	52.9	54.1	54.1	53.4	51.1	50.4	52.5
1/4/2016	188	24.3	27.5	42.1	46.9	48.7	49.5	48.2	43.7	39.2	46.5
1/8/2016	192	43.5	41.9	41.5	44.8	46.6	46.9	45.1	42.6	41.5	44.6
1/12/2016	196	26.2	30.0	39.7	43.3	45.0	45.3	44.1	40.3	35.8	43.0
1/16/2016	200	56.5	45.3	40.8	42.8	43.7	43.9	42.8	41.0	42.4	42.5
1/20/2016	204	28.8	31.3	39.4	43.0	43.7	43.7	42.8	39.6	35.4	42.0
1/22/2016	206	27.5	29.3	38.1	41.5	42.8	43.0	42.1	38.8	34.9	41.1
1/26/2016	210	33.6	31.5	38.5	39.7	41.0	41.4	40.3	39.4	40.5	40.1
1/29/2016	213	82.0	62.8	40.3	40.5	40.8	40.8	40.1	40.6	45.5	40.5
2/2/2016	217	48.2	46.4	46.4	43.9	42.8	41.9	41.7	44.4	48.7	43.5
2/5/2016	220	72.5	54.1	46.0	46.2	45.0	44.2	44.2	43.9	42.3	44.9
2/9/2016	224	48.4	47.3	46.2	46.9	46.4	45.7	45.5	44.8	43.7	45.9
2/12/2016	227	71.4	55.0	46.4	46.9	46.8	46.4	46.0	45.5	45.1	46.3
2/16/2016	231	68.0	56.3	47.8	47.8	47.5	47.1	46.6	46.4	48.2	47.2
2/22/2016	237	42.6	44.6	55.8	52.3	50.7	49.6	49.5	52.5	55.4	51.7
2/26/2016	241	66.7	50.2	53.2	54.5	53.2	52.7	52.7	51.3	46.9	52.9
3/4/2016	248	54.3	46.4	55.9	55.9	55.0	54.5	54.1	54.3	54.5	55.0
3/10/2016	254	82.4	66.4	59.5	58.5	57.4	56.7	56.5	57.4	57.4	57.7
3/15/2016	259	82.9	69.1	59.9	59.5	58.8	58.3	58.3	58.3	59.5	58.9
3/18/2016	262	59.7	56.3	60.4	60.4	59.5	59.2	59.0	58.5	57.4	59.5
3/22/2016	266	57.2	54.5	57.0	59.5	59.9	59.5	59.2	56.5	55.0	58.6
3/25/2016	269	59.2	48.4	59.4	59.4	59.5	59.4	58.6	58.3	56.3	59.1
3/28/2016	272	44.4	42.4	59.7	60.1	59.9	59.5	59.0	57.6	53.6	59.3
4/1/2016	276	78.6	68.5	61.7	60.6	60.3	59.9	59.2	59.4	58.6	60.2
4/5/2016	280	63.7	60.8	62.8	61.7	61.2	60.6	60.1	60.3	62.8	61.1
4/8/2016	283	74.1	63.1	65.3	63.5	62.4	61.7	61.3	62.6	63.5	62.8
4/12/2016	287	61.9	56.1	66.2	64.9	64.0	63.1	63.0	63.5	62.2	64.1
4/15/2016	290	59.5	59.5	65.8	65.5	64.8	64.0	63.9	63.1	61.9	64.5
4/19/2016	294	91.4	79.9	66.9	66.4	65.7	65.1	64.6	63.7	62.1	65.4
4/22/2016	297	94.3	74.7	67.1	66.4	65.8	65.5	64.9	63.7	62.2	65.6
4/26/2016	301	88.5	79.5	70.7	68.0	66.9	66.2	65.5	66.2	70.2	67.3
5/3/2016	308	61.9	55.4	68.5	70.0	69.3	68.5	68.0	65.3	61.0	68.3
5/6/2016	311	94.5	79.0	69.4	69.3	68.9	68.5	67.5	65.8	65.5	68.2
5/10/2016	315	80.8	70.2	72.9	71.2	70.0	68.9	68.0	68.0	69.3	69.8
5/13/2016	318	91.4	78.4	76.3	73.0	71.2	70.2	69.3	70.0	71.2	71.7
5/17/2016	322	56.3	61.3	74.3	74.5	73.0	72.0	71.2	69.4	66.4	72.4
5/20/2016	325	97.3	82.0	70.3	72.9	72.7	72.1	71.2	68.0	63.7	71.2
5/24/2016	329	109.4	88.2	72.5	71.6	71.6	71.2	70.3	69.1	70.2	71.1
5/27/2016	332	70.5	73.4	76.1	73.0	72.1	71.6	70.5	71.2	74.3	72.4
5/31/2016	336	117.5	99.5	80.2	76.3	74.5	73.4	72.7	73.0	74.3	75.0
6/3/2016	339	105.1	88.2	80.2	78.1	76.1	75.0	74.3	74.1	73.8	76.3
6/7/2016	343	97.3	85.1	81.7	79.3	77.7	76.6	75.9	75.4	76.3	77.8
6/10/2016	346	86.2	83.8	85.1	81.5	79.3	78.1	77.2	77.5	80.2	79.8
6/14/2016	350	89.8	86.7	87.4	84.4	81.7	80.6	79.7	80.2	81.3	82.3
6/17/2016	353	101.1	93.9	89.8	85.8	83.5	82.2	81.5	82.6	86.2	84.2
6/21/2016	357	86.0	86.0	92.7	88.9	86.5	84.9	84.2	84.7	86.5	87.0
6/24/2016	360	95.5	92.1	94.8	91.2	88.7	87.1	86.4	86.7	88.3	89.2
6/29/2016	365	94.3	89.6	94.1	92.8	91.0	89.8	88.9	87.4	85.3	90.7

	6/30/2015	top	Temp at Thermocouple							bottom	
Bin3	days in storage	9	8	7	6	5	4	3	2	1	average temp (2-7)
6/30/2015	0	100.4	87.3	103.1	103.1	103.3	102.9	101.3	95.7	128.5	101.6
7/2/2015	2	100.0	88.5	102.7	102.9	103.1	102.4	100.4	95.0	86.5	101.1
7/5/2015	5	99.1	86.9	101.8	102.2	102.4	101.3	98.6	93.2	90.5	99.9
7/8/2015	8	94.3	77.0	100.4	101.3	101.5	100.2	97.0	89.8	69.8	98.4
7/11/2015	11	93.0	82.4	98.2	99.7	99.9	98.4	94.6	87.8	95.9	96.4
7/13/2015	13	94.6	86.9	97.0	98.1	98.2	96.8	93.6	89.2	114.8	95.5
7/15/2015	15	96.1	90.5	96.8	97.0	97.2	95.7	93.2	90.7	101.8	95.1
7/17/2015	17	96.4	89.8	97.0	96.6	96.6	95.2	93.2	91.4	83.3	95.0
7/20/2015	20	97.5	91.9	97.7	96.8	96.6	95.5	94.1	92.5	101.3	95.5
7/22/2015	22	95.2	88.2	97.7	97.2	96.8	95.7	94.3	91.9	92.8	95.6
7/24/2015	24	96.6	91.6	97.9	97.3	97.0	95.9	94.5	92.3	102.7	95.8
7/28/2015	28	97.9	91.9	98.2	97.3	97.0	96.1	94.8	93.6	110.7	96.2
7/30/2015	30	97.7	93.9	98.6	97.7	97.2	96.3	95.2	94.3	85.1	96.6
8/3/2015	34	95.2	90.1	97.9	97.9	97.3	96.4	95.2	92.8	109.0	96.3
8/5/2015	36	93.7	89.2	97.3	97.5	97.3	96.4	95.0	92.3	74.5	96.0
8/7/2015	38	95.5	93.4	97.2	97.0	97.0	96.1	94.6	92.8	102.2	95.8
8/10/2015	41	97.3	94.3	97.5	96.8	96.4	95.7	94.8	94.3	79.2	95.9
8/12/2015	43	97.0	91.6	97.5	97.0	96.8	95.9	95.0	93.2	125.4	95.9
8/14/2015	45	94.3	90.9	97.2	97.0	96.8	96.1	95.0	92.8	81.7	95.8
8/17/2015	48	93.2	89.6	96.4	96.8	96.8	95.9	94.5	92.1	73.8	95.4
8/19/2015	50	92.3	84.7	95.9	96.3	96.1	95.4	93.7	91.0	64.6	94.7
8/21/2015	52	89.6	82.0	94.8	95.7	95.9	94.8	92.8	87.8	72.0	93.6
8/25/2015	56	85.3	80.6	91.4	93.0	93.4	92.3	89.8	84.9	75.9	90.8
8/28/2015	59	87.1	83.7	90.1	91.4	91.6	90.7	88.5	85.3	72.7	89.6
9/1/2015	63	86.9	85.5	89.2	89.8	90.1	89.1	87.4	85.6	84.0	88.5
9/3/2015	65	88.3	85.8	89.2	89.4	89.6	88.7	87.4	86.2	107.2	88.4
9/8/2015	70	90.9	90.5	90.3	89.6	89.6	88.9	88.3	88.7	89.8	89.2
9/11/2015	73	87.4	80.8	90.3	90.0	89.8	89.2	88.3	86.0	74.8	88.9
9/15/2015	77	84.9	79.0	89.4	90.0	90.0	89.2	87.4	83.5	71.6	88.3
9/18/2015	80	86.9	84.7	88.7	88.9	89.1	88.2	86.5	84.7	85.5	87.7
9/22/2015	84	83.5	79.3	87.4	88.0	88.2	87.3	85.6	82.0	76.1	86.4
9/25/2015	87	82.8	81.3	86.5	87.1	87.3	86.4	84.7	82.6	69.4	85.8
9/29/2015	91	81.5	80.4	85.6	86.2	86.2	85.5	84.0	81.9	65.3	84.9
10/2/2015	94	77.9	71.1	84.4	85.5	85.6	84.7	82.9	78.8	66.2	83.7
10/6/2015	98	73.4	69.3	81.5	83.7	84.0	82.9	80.4	74.8	55.6	81.2
10/9/2015	101	76.8	71.6	79.7	81.1	81.7	80.6	78.3	74.7	82.0	79.4
10/12/2015	104	75.7	75.4	78.6	79.9	80.2	79.2	77.2	75.0	86.9	78.4
10/16/2015	108	74.5	74.3	77.9	78.8	79.0	78.1	76.8	75.4	57.9	77.7
10/20/2015	112	72.1	70.3	76.5	77.9	78.3	77.4	75.9	73.2	64.6	76.5
10/23/2015	115	73.0	71.4	76.1	77.0	77.4	76.6	75.4	73.4	72.7	76.0
10/27/2015	119	69.4	66.2	74.3	76.1	76.6	75.7	73.9	69.8	93.0	74.4
10/30/2015	122	64.6	62.2	72.1	74.7	75.0	74.5	72.1	67.8	50.2	72.7
11/4/2015	127	66.7	66.0	68.9	70.9	71.8	70.7	68.5	65.3	79.0	69.4
11/6/2015	129	64.0	62.6	68.0	69.8	70.5	69.6	68.0	65.7	69.8	68.6
11/10/2015	133	60.4	59.4	66.2	68.2	69.1	68.2	66.4	63.1	59.4	66.9
11/13/2015	136	57.6	58.3	64.6	67.1	67.8	67.1	65.5	63.0	61.9	65.9
11/17/2015	140	61.9	60.1	64.0	65.5	66.2	65.5	64.0	61.7	61.5	64.5
11/20/2015	143	58.8	58.1	62.6	64.4	65.3	64.6	62.8	59.5	71.6	63.2
11/24/2015	147	55.4	53.8	59.9	62.6	63.5	62.8	60.6	56.3	72.3	61.0
12/1/2015	154	48.4	42.8	55.6	58.6	59.7	58.8	55.9	49.6	68.9	56.4
12/4/2015	157	45.1	44.2	52.9	56.1	57.2	56.3	53.6	48.7	47.7	54.1
12/8/2015	161	49.3	50.0	51.1	52.9	54.0	53.2	51.6	49.6	73.0	52.1
12/11/2015	164	49.6	52.3	50.9	52.0	52.9	52.3	51.4	51.4	60.3	51.8
12/15/2015	168	49.8	49.8	52.3	52.5	52.9	52.7	52.7	52.3	38.5	52.6
12/18/2015	171	46.4	43.7	51.4	52.9	53.6	53.2	52.3	49.3	52.3	52.1
12/21/2015	174	49.6	50.4	50.9	52.0	52.9	52.5	51.8	50.4	66.2	51.8
1/4/2016	188	37.6	37.6	44.8	47.3	48.4	47.7	45.7	41.7	23.4	45.9
1/8/2016	192	41.4	41.0	43.0	44.6	45.5	44.8	43.5	41.7	42.4	43.9
1/12/2016	196	36.7	36.3	41.5	43.2	44.1	43.5	42.1	38.7	25.5	42.2
1/16/2016	200	40.1	42.1	41.0	42.1	42.8	42.4	41.5	41.0	59.5	41.8
1/20/2016	204	35.6	34.0	39.7	41.2	41.9	41.5	40.5	37.6	27.9	40.4
1/22/2016	206	34.9	32.5	39.2	40.6	41.4	41.0	39.7	37.0	29.1	39.8
1/26/2016	210	36.5	39.4	38.8	39.4	40.1	39.7	39.2	39.4	37.4	39.4
1/29/2016	213	43.7	51.1	39.7	39.4	39.7	39.6	39.9	41.5	78.6	40.0
2/2/2016	217	44.8	47.8	42.3	40.8	40.8	41.0	42.1	45.5	52.3	42.1
2/5/2016	220	42.8	43.5	43.3	42.6	42.8	42.8	43.5	43.3	69.8	43.1
2/9/2016	224	44.1	44.4	44.2	43.9	44.1	44.1	44.4	44.2	47.7	44.2
2/12/2016	227	45.1	45.5	44.8	44.4	44.8	44.6	44.8	45.1	63.7	44.8
2/16/2016	231	47.7	49.1	45.9	45.3	45.5	45.5	45.7	46.6	68.5	45.8
2/22/2016	237	50.7	54.5	50.2	48.2	47.8	48.2	49.6	53.2	44.4	49.5
2/26/2016	241	46.6	44.6	51.1	51.1	51.1	51.1	51.4	49.6	71.1	50.9
3/4/2016	248	50.4	53.6	53.2	52.9	53.1	53.1	53.4	54.3	60.4	53.3
3/10/2016	254	58.1	57.2	56.7	55.4	55.4	55.4	56.3	57.4	77.2	56.1
3/15/2016	259	60.4	60.6	58.6	57.7	57.6	57.6	58.1	58.8	85.6	58.1
3/18/2016	262	57.7	56.5	59.2	58.5	58.5	58.3	58.6	58.6	57.4	58.6
3/22/2016	266	55.4	55.6	58.1	58.6	59.0	58.6	58.1	55.8	58.6	58.0
3/25/2016	269	53.6	54.7	58.1	58.3	58.5	58.1	57.9	57.7	61.9	58.1
3/28/2016	272	53.2	51.1	58.3	58.6	58.6	58.5	57.9	56.3	50.9	58.0
4/1/2016	276	61.0	58.6	59.9	59.0	59.0	58.8	58.8	59.5	75.2	59.2
4/5/2016	280	61.7	64.0	61.0	60.1	59.9	59.7	60.1	61.3	65.3	60.4
4/8/2016	283	61.2	63.7	62.2	61.2	61.0	60.8	61.5	63.5	75.0	61.7
4/12/2016	287	61.7	61.7	64.0	62.8	62.6	62.6	63.0	63.7	65.5	63.1
4/15/2016	290	63.5	62.4	64.6	63.9	63.7	63.5	63.5	63.1	59.9	63.7
4/19/2016	294	68.0	64.0	65.8	64.9	64.8	64.6	64.4	63.9	84.2	64.7
4/22/2016	297	66.0	63.3	66.4	65.5	65.5	64.9	64.6	63.7	100.8	65.1
4/26/2016	301	72.1	74.3	68.5	66.6	66.2	65.8	66.2	68.2	86.7	66.9
5/3/2016	308	62.8	61.2	68.9	69.1	68.7	68.2	67.5	64.6	65.5	67.8
5/6/2016	311	69.1	67.8	69.3	68.9	68.7	68.0	67.3	66.6	91.4	68.1
5/10/2016	315	70.0	71.6	70.7	69.6	69.3	68.7	68.5	69.4	87.4	69.4
5/13/2016	318	73.6	73.9	73.0	71.1	70.5	70.0	70.3	71.8	95.9	71.1
5/17/2016	322	70.3	66.7	73.6	72.7	72.5	71.8	71.4	69.8	55.2	72.0
5/20/2016	325	70.2	65.5	72.3	72.7	72.5	72.0	70.7	67.5	92.3	71.3
5/24/2016	329	74.3	73.9	72.7	72.0	71.8	71.1	70.3	70.3	108.9	71.4
5/27/2016	332	77.0	79.2	74.5	72.5	72.1	71.6	71.6	73.6	69.8	72.7
5/31/2016	336	82.2	78.1	77.5	74.7	74.3	73.6	73.9	75.2	110.3	74.9
6/3/2016	339	78.3	76.6	78.3	76.3	75.4	75.2	75.4	75.6	103.1	76.0
6/7/2016	343	80.4	80.1	79.9	78.1	77.4	77.0	77.0	77.7	96.3	77.9
6/10/2016	346	84.2	83.5	82.0	79.7	78.8	78.3	78.4	80.2	85.1	79.6
6/14/2016	350	85.6	84.9	84.7	82.0	81.1	80.8	81.1	82.6	92.7	82.1
6/17/2016	353	90.1	90.5	87.1	84.2	83.3	82.8	83.5	85.6	101.7	84.4
6/21/2016	357	91.6	90.0	90.0	87.1	86.0	85.6	86.0	87.3	86.2	87.0
6/24/2016	360	93.0	91.6	91.9	89.2	88.2	87.6	88.0	89.2	92.3	89.0
6/29/2016	365	91.6	87.6	93.2	91.6	90.9	90.3	89.8	88.7	96.1	90.8

	6/30/2015	top	Temp at Thermocouple							bottom	
Bin4	days in storage	9	8	7	6	5	4	3	2	1	average temp (2-7)
6/30/2015	0	121.3	100.0	105.1	105.6	105.4	102.7	94.8	94.1	91.6	101.3
7/2/2015	2	85.3	99.1	104.9	105.8	105.4	102.6	96.6	92.5	89.8	101.3
7/5/2015	5	91.0	97.0	103.6	105.1	104.5	102.2	97.5	91.6	87.8	100.8
7/8/2015	8	71.4	88.3	102.2	104.0	103.3	101.3	96.6	88.0	80.6	99.2
7/11/2015	11	94.6	89.6	98.4	102.0	101.8	99.9	94.6	85.8	80.2	97.1
7/13/2015	13	113.7	93.4	96.8	99.7	99.9	98.1	93.2	86.9	83.5	95.8
7/15/2015	15	100.0	95.0	96.4	98.4	98.6	96.8	92.5	88.5	86.5	95.2
7/17/2015	17	84.2	95.2	97.0	97.7	97.7	96.1	92.5	89.2	87.4	95.0
7/20/2015	20	99.5	96.4	97.7	97.7	97.3	95.9	93.2	90.5	88.9	95.4
7/22/2015	22	90.7	91.6	98.2	97.9	97.3	96.1	93.6	89.2	85.3	95.4
7/24/2015	24	99.1	94.5	97.7	97.9	97.3	96.3	93.6	89.6	86.9	95.4
7/28/2015	28	110.7	97.0	98.2	97.9	97.3	96.3	93.7	91.0	88.9	95.7
7/30/2015	30	86.5	95.7	98.4	98.1	97.3	96.4	94.3	91.6	89.6	96.0
8/3/2015	34	104.0	92.5	97.7	98.1	97.5	96.6	94.3	90.3	86.9	95.8
8/5/2015	36	74.7	89.6	97.0	97.9	97.3	96.4	94.1	89.8	86.0	95.4
8/7/2015	38	100.0	93.7	96.3	97.3	97.0	96.1	93.7	90.5	88.3	95.2
8/10/2015	41	81.3	95.9	97.2	96.8	96.6	95.7	93.7	92.3	91.0	95.4
8/12/2015	43	136.4	96.4	97.3	97.0	96.6	95.9	93.9	90.7	88.3	95.2
8/14/2015	45	84.2	90.9	96.8	97.2	96.8	95.9	94.1	90.5	87.6	95.2
8/17/2015	48	74.5	89.2	95.9	96.8	96.6	95.7	93.6	89.8	86.9	94.7
8/19/2015	50	67.1	86.2	94.6	96.3	96.4	95.4	93.2	89.1	84.9	94.2
8/21/2015	52	73.0	84.4	93.9	95.9	95.9	95.0	92.3	85.8	81.0	93.1
8/25/2015	56	73.8	78.8	90.1	93.2	93.4	92.8	89.6	83.8	78.4	90.5
8/28/2015	59	73.8	83.8	88.7	91.4	91.8	91.0	88.2	84.2	81.3	89.2
9/1/2015	63	82.4	84.6	87.8	89.6	90.0	89.2	86.9	84.4	82.4	88.0
9/3/2015	65	107.2	87.6	88.2	89.1	89.4	88.7	86.9	85.1	83.5	87.9
9/8/2015	70	90.7	91.0	89.8	89.4	89.2	88.7	87.4	87.4	87.1	88.7
9/11/2015	73	77.0	83.8	88.7	88.3	88.0	87.4	86.5	85.6	82.4	87.4
9/15/2015	77	71.8	81.1	88.7	90.0	89.6	88.9	86.9	82.8	78.8	87.8
9/18/2015	80	85.1	85.1	87.4	88.9	88.9	88.0	86.0	83.7	82.0	87.2
9/22/2015	84	74.8	79.9	86.2	88.0	88.0	87.3	85.3	81.1	77.9	86.0
9/25/2015	87	68.4	79.0	85.3	86.9	87.1	86.2	84.4	81.3	79.0	85.2
9/29/2015	91	63.7	77.5	84.7	85.8	86.0	85.5	83.5	80.8	78.4	84.4
10/2/2015	94	64.6	71.6	83.8	85.3	85.3	84.7	82.9	77.9	72.7	83.3
10/6/2015	98	56.3	67.3	79.9	83.5	83.8	83.3	80.6	73.9	68.9	80.8
10/9/2015	101	89.4	75.2	77.5	80.8	81.7	81.0	78.3	73.9	71.2	78.9
10/12/2015	104	87.4	74.8	76.8	79.2	79.9	79.3	77.0	74.1	72.5	77.7
10/16/2015	108	59.5	72.5	76.5	78.1	78.4	78.1	76.3	74.7	73.6	77.0
10/20/2015	112	64.0	69.4	75.4	77.4	77.7	77.4	75.7	72.7	70.2	76.1
10/23/2015	115	72.5	71.4	74.8	76.5	77.0	76.6	75.2	72.7	70.7	75.5
10/27/2015	119	90.0	67.8	72.9	75.7	76.1	75.7	73.9	68.9	65.3	73.9
10/30/2015	122	51.1	59.2	70.7	73.9	74.8	74.5	72.3	67.1	62.8	72.2
11/4/2015	127	82.8	66.4	66.7	70.3	71.6	71.1	68.5	64.4	62.8	68.8
11/6/2015	129	70.7	61.3	66.4	68.9	70.0	69.4	67.6	64.8	62.4	67.9
11/10/2015	133	63.5	57.6	64.9	68.0	68.7	68.4	66.4	62.6	59.7	66.5
11/13/2015	136	59.4	52.5	64.2	66.6	67.3	67.1	65.5	62.2	59.0	65.5
11/17/2015	140	62.8	61.3	62.2	64.9	65.8	65.7	64.0	61.2	59.7	64.0
11/20/2015	143	73.6	57.4	61.7	64.0	64.9	64.6	63.0	59.0	56.3	62.9
11/24/2015	147	73.0	54.3	58.5	62.2	63.1	63.0	60.8	55.9	52.9	60.6
12/1/2015	154	62.1	44.8	54.1	58.5	59.7	59.4	56.8	49.6	44.2	56.4
12/4/2015	157	45.7	40.6	51.3	55.9	57.4	57.0	54.1	48.6	45.0	54.1
12/8/2015	161	68.9	50.0	49.6	52.7	54.0	53.6	51.4	49.3	48.6	51.8
12/11/2015	164	61.0	49.8	50.2	51.6	52.7	52.3	51.1	51.1	51.3	51.5
12/15/2015	168	37.9	47.5	52.3	52.0	52.3	52.3	52.0	52.0	50.5	52.2
12/18/2015	171	56.5	43.9	51.4	52.9	52.9	53.1	52.3	48.7	44.6	51.9
12/21/2015	174	68.2	50.5	49.6	52.0	52.5	52.5	51.3	49.6	48.7	51.3
1/4/2016	188	25.0	32.7	43.5	47.3	48.4	48.2	46.0	41.9	38.7	45.9
1/8/2016	192	43.3	41.0	41.5	44.2	45.5	45.3	43.5	41.7	41.0	43.6
1/12/2016	196	26.1	33.6	40.5	43.0	43.9	43.9	42.3	39.0	37.0	42.1
1/16/2016	200	55.0	41.2	40.1	41.9	42.8	42.6	41.2	41.0	41.2	41.6
1/20/2016	204	28.8	33.4	39.2	41.4	41.9	41.9	41.0	38.3	35.8	40.6
1/22/2016	206	27.7	32.4	38.5	40.6	41.4	41.4	40.3	37.6	34.9	40.0
1/26/2016	210	32.2	34.2	38.1	39.4	40.1	40.1	39.2	39.2	39.0	39.4
1/29/2016	213	80.8	48.6	38.8	39.2	39.7	39.7	39.2	41.4	43.7	39.7
2/2/2016	217	47.5	46.4	42.6	40.1	40.1	40.3	41.2	45.5	48.0	41.6
2/5/2016	220	68.7	44.1	43.9	42.8	42.1	42.3	43.0	43.3	42.6	42.9
2/9/2016	224	48.4	44.6	44.6	44.1	43.7	43.7	44.1	44.2	43.5	44.1
2/12/2016	227	67.3	46.6	44.8	44.6	44.4	44.4	44.6	45.5	45.3	44.7
2/16/2016	231	66.2	50.2	45.9	45.1	45.1	45.1	45.3	46.9	48.0	45.6
2/22/2016	237	43.3	49.6	51.8	48.2	47.5	47.5	48.7	53.2	54.5	49.5
2/26/2016	241	63.3	44.8	52.2	51.4	50.5	50.5	51.1	49.8	46.6	50.9
3/4/2016	248	55.6	48.4	53.8	52.9	52.3	52.3	52.7	53.8	53.4	53.0
3/10/2016	254	82.0	59.5	57.0	55.2	54.7	54.7	55.4	56.7	56.5	55.6
3/15/2016	259	81.0	61.9	58.3	57.4	56.8	56.8	57.0	57.9	57.7	57.4
3/18/2016	262	59.5	56.5	59.2	58.3	57.9	57.7	57.7	57.7	56.5	58.1
3/22/2016	266	56.7	54.1	57.2	58.6	58.6	58.5	57.6	55.0	53.8	57.6
3/25/2016	269	57.7	50.2	58.1	58.1	58.1	58.1	57.4	56.8	54.7	57.8
3/28/2016	272	43.3	48.4	58.5	58.3	58.3	58.1	57.7	55.8	52.9	57.8
4/1/2016	276	77.0	61.9	59.9	58.8	58.6	58.5	58.1	58.6	57.9	58.8
4/5/2016	280	63.9	61.7	60.8	59.9	59.5	59.4	59.2	60.8	61.7	59.9
4/8/2016	283	73.0	60.1	62.8	61.0	60.4	60.1	60.4	62.6	62.1	61.2
4/12/2016	287	60.8	59.2	64.4	62.8	62.1	61.9	62.1	62.8	61.2	62.7
4/15/2016	290	59.2	62.2	64.6	63.9	63.1	63.0	63.0	62.4	61.0	63.3
4/19/2016	294	91.2	69.4	65.8	64.9	64.4	64.0	63.7	63.0	61.7	64.3
4/22/2016	297	91.2	66.0	66.2	65.5	64.9	64.6	64.0	63.1	61.3	64.7
4/26/2016	301	88.0	74.3	68.2	66.4	65.8	65.5	64.9	67.1	68.2	66.3
5/3/2016	308	61.3	58.3	68.9	69.1	68.4	68.0	67.1	63.7	60.1	67.5
5/6/2016	311	93.7	69.4	68.5	68.7	68.4	68.0	66.7	65.8	64.6	67.7
5/10/2016	315	80.1	68.9	70.9	69.3	68.7	68.2	67.6	68.2	67.6	68.8
5/13/2016	318	88.7	73.4	73.4	70.7	70.0	69.4	69.1	70.7	70.3	70.6
5/17/2016	322	56.3	67.1	73.6	72.9	71.8	71.4	70.7	68.5	65.5	71.5
5/20/2016	325	96.1	69.8	71.6	72.9	72.3	71.8	70.3	66.4	62.8	70.9
5/24/2016	329	108.7	75.7	71.8	71.6	71.6	71.1	69.8	69.4	69.1	70.9
5/27/2016	332	70.7	76.3	73.9	71.8	71.6	71.2	70.5	72.7	73.2	72.0
5/31/2016	336	115.7	84.6	77.7	74.5	73.6	73.0	73.0	74.3	73.9	74.4
6/3/2016	339	103.5	77.0	77.9	75.4	74.3	74.3	73.9	74.5	73.0	75.1
6/7/2016	343	95.0	79.9	79.7	77.9	76.8	76.3	75.7	76.5	75.7	77.2
6/10/2016	346	86.7	84.4	82.0	79.3	78.1	77.5	77.2	79.3	79.3	78.9
6/14/2016	350	88.5	85.5	85.1	82.0	80.6	80.2	80.1	81.5	80.8	81.6
6/17/2016	353	100.4	91.4	87.1	84.2	82.6	82.0	82.0	84.4	85.1	83.7
6/21/2016	357	85.6	90.7	90.1	87.1	85.5	84.9	84.7	86.2	86.2	86.4
6/24/2016	360	95.9	92.3	92.3	89.2	87.4	86.7	86.7	88.0	87.6	88.4
6/29/2016	365	91.2	88.7	93.0	91.8	90.5	89.8	89.1	87.3	85.1	90.3

	6/30/2015	top	Temp at Thermocouple						bottom	
Bin5	days in storage	9	8	7	6	5	4	3	2	1	average temp (2-7)
6/30/2015	0	106.2	103.3	106.9	107.8	108.1	108.7	108.1	101.8	90.5	106.9
7/2/2015	2	88.7	102.6	106.3	107.2	107.8	108.0	106.2	99.9	90.9	105.9
7/5/2015	5	90.1	101.3	104.9	106.0	106.5	105.6	102.7	96.3	88.7	103.7
7/8/2015	8	74.8	96.8	103.5	105.3	105.4	104.0	100.6	93.2	81.0	102.0
7/11/2015	11	88.7	95.0	100.6	102.7	103.1	101.3	97.5	90.0	81.7	99.2
7/13/2015	13	104.0	96.4	99.1	100.9	100.9	99.1	95.5	89.6	84.4	97.5
7/15/2015	15	94.1	97.3	98.8	99.9	99.7	97.9	94.8	90.5	87.1	96.9
7/17/2015	17	86.4	97.9	98.8	99.1	99.0	97.2	94.5	91.0	87.8	96.6
7/20/2015	20	93.6	98.6	99.5	99.1	98.6	97.0	95.0	92.1	89.1	96.9
7/22/2015	22	86.4	95.9	99.1	99.1	98.6	97.0	95.0	91.6	86.0	96.7
7/24/2015	24	92.3	97.3	99.3	99.1	98.6	97.0	95.2	91.6	87.6	96.8
7/28/2015	28	104.9	99.1	99.5	99.1	98.4	97.0	95.2	92.5	89.2	97.0
7/30/2015	30	87.8	98.0	99.5	99.0	98.0	97.0	95.5	93.0	89.0	97.0
8/3/2015	34	98.6	96.1	98.8	99.0	98.4	97.0	95.2	91.9	87.4	96.7
8/5/2015	36	77.2	94.3	98.2	98.6	97.9	96.8	95.0	91.6	86.7	96.4
8/7/2015	38	93.4	96.1	97.9	98.2	97.7	96.4	94.6	91.6	88.9	96.1
8/10/2015	41	84.4	98.1	98.2	97.7	97.2	95.9	94.5	92.7	90.9	96.0
8/12/2015	43	127.6	97.9	98.2	97.9	97.3	96.1	94.6	92.1	88.5	96.0
8/14/2015	45	83.3	94.8	97.7	97.9	97.3	96.1	94.6	91.8	87.8	95.9
8/17/2015	48	77.0	93.7	97.2	97.3	97.0	95.7	94.1	91.0	87.1	95.4
8/19/2015	50	70.9	92.5	96.4	96.8	96.4	95.2	93.4	90.1	84.9	94.7
8/21/2015	52	75.0	90.1	95.2	96.3	95.9	94.6	92.5	87.8	81.5	93.7
8/25/2015	56	69.8	86.0	92.7	94.3	94.1	92.8	90.1	85.1	78.8	91.5
8/28/2015	59	75.2	88.0	91.2	92.3	92.3	90.9	88.3	84.7	81.5	90.0
9/1/2015	63	79.9	87.8	90.1	90.7	90.7	89.2	87.3	84.7	82.6	88.8
9/3/2015	65	100.9	89.1	90.1	90.1	90.0	88.7	87.1	85.1	83.3	88.5
9/8/2015	70	89.8	91.6	91.2	90.5	89.8	88.9	87.8	87.1	86.9	89.2
9/11/2015	73	76.5	89.2	91.6	91.0	90.5	89.4	88.5	86.2	81.5	89.5
9/15/2015	77	72.1	85.8	90.1	90.7	90.3	89.1	87.4	83.5	78.8	88.5
9/18/2015	80	83.3	87.6	89.4	89.6	89.2	88.0	86.2	83.8	82.2	87.7
9/22/2015	84	74.3	84.2	88.0	88.7	88.3	87.3	85.5	82.4	78.4	86.7
9/25/2015	87	68.0	83.3	87.1	87.8	87.4	86.2	84.7	82.0	79.0	85.9
9/29/2015	91	63.9	82.4	86.4	86.9	86.5	85.5	83.8	81.3	78.1	85.1
10/2/2015	94	61.9	78.4	85.1	86.2	86.0	84.7	83.1	79.3	72.5	84.1
10/6/2015	98	57.2	73.9	82.0	84.2	84.4	82.9	80.8	75.6	69.3	81.7
10/9/2015	101	85.1	77.7	80.4	82.0	82.0	80.8	78.4	74.8	71.8	79.7
10/12/2015	104	83.3	76.6	79.3	80.6	80.6	79.3	77.2	74.5	72.7	78.6
10/16/2015	108	60.8	75.4	78.6	79.5	79.3	78.1	76.6	74.5	72.9	77.8
10/20/2015	112	63.1	72.7	77.2	78.4	78.4	77.2	75.4	73.0	70.2	76.6
10/23/2015	115	72.1	73.8	76.6	77.9	77.7	76.6	75.2	73.0	70.7	76.2
10/27/2015	119	86.5	70.7	74.8	76.8	77.0	75.9	74.1	70.3	65.8	74.8
10/30/2015	122	51.4	64.9	72.7	75.2	75.4	74.3	72.3	68.2	62.8	73.0
11/4/2015	127	81.0	67.6	69.4	71.6	72.1	70.9	68.5	65.3	63.7	69.6
11/6/2015	129	65.3	64.6	68.7	70.7	70.9	69.8	67.8	65.1	61.9	68.8
11/10/2015	133	59.0	60.8	66.7	69.1	69.4	68.4	66.4	63.1	59.5	67.2
11/13/2015	136	50.5	57.7	65.5	67.6	68.2	67.3	65.5	62.6	58.3	66.1
11/17/2015	140	63.7	62.6	64.4	66.2	66.6	65.5	63.9	61.5	59.9	64.7
11/20/2015	143	70.3	59.7	63.1	64.9	65.5	64.6	63.0	59.9	57.0	63.5
11/24/2015	147	70.0	56.3	60.4	63.1	63.7	62.8	60.8	56.7	53.8	61.3
12/1/2015	154	60.1	49.3	56.1	59.2	60.1	59.0	56.5	51.3	45.1	57.0
12/4/2015	157	40.1	45.5	53.2	56.5	57.4	56.5	54.0	49.5	45.1	54.5
12/8/2015	161	66.0	50.0	51.4	53.6	54.1	53.2	51.6	49.5	49.1	52.2
12/11/2015	164	59.0	50.2	51.4	52.5	53.1	52.3	51.3	50.5	51.1	51.9
12/15/2015	168	37.9	50.0	52.5	52.9	53.1	52.7	52.3	51.8	50.2	52.6
12/18/2015	171	52.3	46.8	51.6	53.1	53.4	53.1	52.3	49.6	45.0	52.2
12/21/2015	174	63.3	50.2	50.9	52.3	52.7	52.3	51.4	49.6	49.3	51.5
1/4/2016	188	23.0	37.6	44.8	47.5	48.4	47.8	46.0	42.4	38.8	46.2
1/8/2016	192	43.3	41.5	43.2	44.8	45.5	45.0	43.7	41.9	41.4	44.0
1/12/2016	196	25.3	36.9	41.5	43.5	44.2	43.7	42.4	39.7	37.4	42.5
1/16/2016	200	50.5	40.6	41.2	42.4	43.0	42.4	41.5	40.6	41.4	41.9
1/20/2016	204	29.1	35.8	39.9	41.5	42.1	41.5	40.8	38.7	36.1	40.8
1/22/2016	206	27.0	35.1	39.2	41.0	41.5	41.2	40.1	37.8	34.7	40.1
1/26/2016	210	28.8	36.3	38.8	39.7	40.3	39.7	39.2	38.8	38.8	39.4
1/29/2016	213	75.7	44.4	39.9	39.7	39.9	39.6	39.6	40.6	45.7	39.9
2/2/2016	217	45.3	44.8	42.4	41.0	40.8	40.6	41.5	44.1	47.1	41.7
2/5/2016	220	66.4	43.3	43.2	42.8	42.8	42.6	43.3	43.3	42.6	43.0
2/9/2016	224	48.7	44.2	44.2	43.9	43.9	43.9	44.1	44.1	43.9	44.0
2/12/2016	227	65.5	45.7	44.4	44.4	44.2	44.4	44.6	44.6	45.1	44.4
2/16/2016	231	62.8	47.7	45.7	45.1	45.0	45.1	45.3	46.0	48.0	45.4
2/22/2016	237	41.5	50.5	50.2	48.2	47.8	47.8	48.9	51.8	53.2	49.1
2/26/2016	241	59.5	46.9	50.7	50.9	50.7	50.9	51.3	50.0	45.9	50.8
3/4/2016	248	48.6	50.2	52.7	52.5	52.3	52.3	52.7	52.9	52.5	52.6
3/10/2016	254	77.9	58.1	56.5	55.2	55.0	54.9	55.4	56.3	56.5	55.6
3/15/2016	259	77.5	60.6	58.6	57.4	57.2	57.2	57.4	57.7	57.9	57.6
3/18/2016	262	58.8	57.7	59.0	58.3	58.1	58.1	58.1	57.7	55.9	58.2
3/22/2016	266	55.2	55.6	57.9	58.5	58.6	58.3	57.7	55.6	53.8	57.8
3/25/2016	269	51.4	53.6	57.7	58.1	58.1	57.7	57.2	56.5	54.1	57.6
3/28/2016	272	40.3	53.4	58.1	58.5	58.5	58.1	57.6	56.1	52.3	57.8
4/1/2016	276	76.6	61.3	59.7	59.0	58.8	58.3	58.1	58.1	57.6	58.7
4/5/2016	280	61.7	61.7	61.0	59.9	59.7	59.2	59.2	59.5	61.0	59.8
4/8/2016	283	69.6	61.3	62.1	61.0	60.6	60.4	60.8	61.5	61.3	61.1
4/12/2016	287	56.5	61.5	63.5	62.8	62.2	61.9	62.2	62.4	60.8	62.5
4/15/2016	290	57.6	63.5	64.6	63.7	63.3	63.1	63.1	62.4	60.8	63.4
4/19/2016	294	91.2	68.4	65.8	64.9	64.6	64.2	64.0	63.5	62.2	64.5
4/22/2016	297	85.3	66.2	66.2	65.5	65.1	64.8	64.4	63.5	61.5	64.9
4/26/2016	301	85.5	72.1	68.5	66.7	66.0	65.7	65.5	66.4	68.4	66.5
5/3/2016	308	56.1	63.0	68.5	68.9	68.5	68.0	67.5	64.8	59.9	67.7
5/6/2016	311	89.8	69.4	69.1	68.9	68.5	67.8	67.1	65.5	64.2	67.8
5/10/2016	315	73.9	70.2	70.7	69.6	69.1	68.4	68.0	67.8	67.3	68.9
5/13/2016	318	84.4	73.9	73.0	71.2	70.3	69.8	69.8	70.0	69.8	70.7
5/17/2016	322	57.4	70.5	73.6	72.9	72.1	71.6	71.2	69.4	65.5	71.8
5/20/2016	325	94.1	70.7	72.1	72.7	72.5	71.8	70.7	67.5	63.5	71.2
5/24/2016	329	102.6	74.5	72.7	72.1	71.8	70.9	70.2	69.4	69.4	71.2
5/27/2016	332	70.9	77.2	74.5	72.7	72.1	71.4	71.2	71.8	73.0	72.3
5/31/2016	336	116.4	82.8	77.7	75.2	74.1	73.6	73.6	74.1	73.9	74.7
6/3/2016	339	98.6	79.0	78.8	76.8	75.7	75.2	75.0	74.8	73.0	76.1
6/7/2016	343	90.0	81.0	80.1	78.4	77.4	76.8	76.6	76.1	75.4	77.6
6/10/2016	346	85.3	84.7	82.2	79.9	78.8	78.1	77.9	78.4	79.0	79.2
6/14/2016	350	88.0	86.0	84.7	82.6	81.3	80.6	80.8	81.1	80.8	81.9
6/17/2016	353	97.3	90.7	87.4	84.4	83.3	82.6	82.9	83.8	84.9	84.1
6/21/2016	357	83.8	91.9	90.1	87.4	86.0	85.3	85.6	86.0	86.0	86.7
6/24/2016	360	95.5	93.6	92.1	89.6	88.3	87.4	87.8	88.0	87.4	88.9
6/29/2016	365	89.6	91.6	93.4	91.9	91.0	90.1	89.8	88.2	84.6	90.7

	6/30/2015	top			Temp at Thermocouple					bottom	
Bin6	days in storage	9	8	7	6	5	4	3	2	1	average temp (2-7)
6/30/2015	0	125.2	102.2	106.7	106.5	105.6	104.0	104.9	104.9	97.3	105.4
7/2/2015	2	86.5	100.0	106.0	106.7	106.0	104.9	104.4	101.5	94.1	104.9
7/5/2015	5	94.1	97.9	104.2	105.4	105.6	104.5	102.0	96.8	89.8	103.1
7/8/2015	8	71.2	85.6	102.2	104.5	104.9	103.8	100.6	94.5	81.9	101.8
7/11/2015	11	99.5	88.9	96.8	100.9	102.4	101.3	97.3	90.1	81.5	98.1
7/13/2015	13	120.4	94.5	95.9	98.8	100.2	99.1	95.2	89.6	84.4	96.5
7/15/2015	15	106.0	96.3	96.8	98.1	99.1	97.7	94.3	90.1	87.4	96.0
7/17/2015	17	84.7	96.3	98.2	98.2	98.6	97.0	93.7	90.7	88.3	96.1
7/20/2015	20	105.1	97.9	99.3	98.8	98.6	96.8	94.1	91.8	90.0	96.6
7/22/2015	22	93.7	91.9	100.0	99.5	98.6	97.0	94.5	91.6	86.2	96.9
7/24/2015	24	105.4	95.4	98.8	99.1	98.6	97.0	94.3	91.0	87.8	96.5
7/28/2015	28	117.1	98.8	99.7	99.1	98.4	97.0	94.5	92.3	90.0	96.8
7/30/2015	30	87.1	96.4	100.0	99.5	98.6	97.2	94.8	92.7	90.3	97.1
8/3/2015	34	108.0	93.2	98.6	99.1	98.6	97.3	95.0	92.1	88.0	96.8
8/5/2015	36	74.1	88.9	97.7	98.4	98.2	97.0	94.8	91.6	87.1	96.3
8/7/2015	38	106.2	94.6	96.6	97.3	97.5	96.4	94.3	91.4	89.2	95.6
8/10/2015	41	80.6	96.4	98.8	97.7	97.3	96.1	94.1	92.5	91.8	96.1
8/12/2015	43	141.8	99.1	98.8	98.4	97.7	96.4	94.5	92.3	89.1	96.4
8/14/2015	45	85.1	91.2	97.9	98.2	97.7	96.4	94.6	91.9	88.2	96.1
8/17/2015	48	74.3	89.6	96.4	97.3	97.2	96.1	94.1	91.0	87.8	95.4
8/19/2015	50	65.8	84.6	94.3	96.8	96.8	95.9	93.7	90.9	85.8	94.7
8/21/2015	52	72.7	84.0	93.7	95.9	96.1	95.4	93.0	88.3	81.1	93.7
8/25/2015	56	80.4	78.1	89.2	92.3	93.7	93.2	90.5	85.5	78.8	90.7
8/28/2015	59	73.2	83.5	88.3	90.1	91.6	91.0	88.5	84.9	81.5	89.1
9/1/2015	63	86.9	85.5	88.5	89.4	90.1	89.4	87.4	84.7	82.8	88.3
9/3/2015	65	114.1	90.1	89.8	89.6	90.0	89.1	87.1	85.3	83.8	88.5
9/8/2015	70	91.9	92.8	92.3	91.4	90.7	89.6	88.2	87.4	87.6	89.9
9/11/2015	73	77.5	82.9	90.9	90.7	91.6	90.5	88.9	87.1	81.5	90.0
9/15/2015	77	75.0	80.6	89.4	90.9	91.0	90.5	88.3	84.2	78.6	89.1
9/18/2015	80	88.9	86.0	88.3	89.4	90.0	89.2	87.1	84.4	82.2	88.1
9/22/2015	84	78.4	79.7	86.9	88.5	89.1	88.3	86.2	82.6	77.9	86.9
9/25/2015	87	72.1	78.6	86.0	87.1	87.8	87.1	85.1	82.0	79.3	85.9
9/29/2015	91	66.2	77.4	86.0	86.7	86.9	86.2	84.2	81.7	78.8	85.3
10/2/2015	94	70.5	70.5	84.7	86.5	86.5	85.8	83.8	80.6	72.9	84.7
10/6/2015	98	55.9	65.8	79.7	83.3	84.4	84.2	81.5	76.5	69.1	81.6
10/9/2015	101	90.9	76.3	77.2	80.1	81.9	81.5	79.0	75.4	71.8	79.2
10/12/2015	104	91.0	76.3	77.2	79.0	80.4	79.9	77.5	74.8	72.9	78.1
10/16/2015	108	59.0	72.7	78.1	79.0	79.7	79.0	77.0	75.4	73.6	78.0
10/20/2015	112	64.9	69.3	76.3	78.6	79.0	78.4	76.6	73.9	70.3	77.1
10/23/2015	115	72.5	71.4	75.9	77.4	78.1	77.5	75.9	73.9	70.7	76.5
10/27/2015	119	92.5	70.9	72.9	75.7	76.6	76.5	74.7	71.1	65.3	74.6
10/30/2015	122	50.9	58.1	70.7	73.9	75.4	74.8	73.0	69.1	62.6	72.8
11/4/2015	127	84.7	68.7	66.2	69.6	71.6	71.4	69.1	65.3	63.0	68.9
11/6/2015	129	77.2	62.2	66.6	68.7	70.3	70.3	68.2	66.0	62.4	68.4
11/10/2015	133	68.9	58.1	65.1	68.0	69.1	68.9	67.1	64.0	59.2	67.0
11/13/2015	136	68.0	52.7	65.1	67.1	68.2	68.0	66.2	63.9	58.1	66.4
11/17/2015	140	62.8	62.6	62.8	65.7	66.9	66.7	64.9	62.2	59.5	64.9
11/20/2015	143	74.5	59.2	61.9	64.6	65.8	65.5	63.7	60.3	60.3	63.6
11/24/2015	147	76.8	57.0	58.1	62.1	63.7	63.5	61.7	57.7	52.9	61.1
12/1/2015	154	68.2	46.0	52.3	57.2	59.5	59.7	57.7	52.7	43.9	56.5
12/4/2015	157	52.0	40.3	49.6	54.3	56.8	57.0	54.9	50.2	44.6	53.8
12/8/2015	161	72.7	52.7	50.0	52.5	54.3	54.1	52.0	49.8	48.4	52.1
12/11/2015	164	64.6	51.4	51.8	52.7	53.8	53.2	51.8	51.1	50.9	52.4
12/15/2015	168	37.4	46.6	54.0	54.0	54.1	53.6	52.9	52.7	49.8	53.6
12/18/2015	171	58.3	45.7	52.3	54.1	54.5	54.1	53.2	50.7	43.9	53.2
12/21/2015	174	71.6	53.4	49.8	52.3	53.6	53.6	52.2	50.0	48.4	51.9
1/4/2016	188	24.8	31.5	42.8	46.4	48.4	48.6	46.8	43.2	38.7	46.0
1/8/2016	192	43.7	41.5	41.9	44.2	46.0	46.0	44.2	42.3	41.0	44.1
1/12/2016	196	24.3	32.7	40.3	43.0	44.6	44.4	43.0	40.3	37.2	42.6
1/16/2016	200	59.9	43.9	41.0	42.1	43.3	43.3	42.1	41.0	41.2	42.1
1/20/2016	204	28.4	32.9	39.9	42.3	43.3	43.0	41.9	39.6	36.0	41.7
1/22/2016	206	28.9	31.6	38.7	41.2	42.4	42.4	41.2	38.8	35.2	40.8
1/26/2016	210	33.4	33.8	38.5	39.4	40.6	40.6	39.7	39.2	38.5	39.7
1/29/2016	213	82.6	54.7	40.3	40.1	40.6	40.3	39.7	40.3	43.9	40.2
2/2/2016	217	49.8	47.3	45.7	43.0	42.1	41.5	41.9	44.6	47.8	43.1
2/5/2016	220	74.8	48.4	46.4	45.5	44.6	43.9	43.9	44.1	42.4	44.7
2/9/2016	224	49.1	46.6	46.6	46.4	45.9	45.5	45.1	44.8	43.2	45.7
2/12/2016	227	72.9	50.5	46.6	46.4	46.4	46.0	45.5	45.5	45.0	46.1
2/16/2016	231	70.7	53.6	47.8	47.3	47.1	46.6	46.2	46.4	48.0	46.9
2/22/2016	237	46.6	49.6	55.4	51.8	50.2	49.5	50.0	53.1	54.9	51.7
2/26/2016	241	69.4	46.9	53.8	53.8	52.9	52.5	52.5	51.8	46.6	52.9
3/4/2016	248	63.3	48.9	56.1	55.4	54.7	54.1	53.8	54.1	53.6	54.7
3/10/2016	254	86.2	61.7	59.5	58.1	57.2	56.5	56.5	57.4	57.2	57.5
3/15/2016	259	85.6	65.3	59.5	59.0	58.5	58.1	58.1	58.1	58.3	58.6
3/18/2016	262	60.1	56.5	60.6	59.9	59.4	59.0	58.6	58.5	56.8	59.3
3/22/2016	266	58.1	55.0	57.9	59.5	59.5	59.4	58.5	56.3	54.1	58.5
3/25/2016	269	68.0	51.1	60.1	59.5	59.5	59.0	58.3	57.7	54.7	59.0
3/28/2016	272	51.8	48.0	60.6	60.1	59.9	59.4	58.5	57.4	53.4	59.3
4/1/2016	276	80.6	65.3	62.2	60.8	60.4	59.9	59.0	59.2	58.1	60.3
4/5/2016	280	67.8	63.0	63.3	61.9	61.3	60.8	59.9	60.3	61.9	61.3
4/8/2016	283	76.1	61.9	66.2	64.0	62.8	61.9	61.5	62.6	61.9	63.2
4/12/2016	287	67.6	59.0	66.7	65.5	64.4	63.7	63.1	63.5	61.3	64.5
4/15/2016	290	61.7	62.6	66.6	66.2	65.3	64.6	63.9	62.8	60.8	64.9
4/19/2016	294	93.7	71.8	66.7	66.4	66.0	65.5	64.6	63.7	61.9	65.5
4/22/2016	297	99.1	68.9	66.9	66.4	66.2	65.7	64.6	63.7	61.5	65.6
4/26/2016	301	91.8	76.6	70.7	68.4	67.3	66.4	65.5	66.0	68.5	67.4
5/3/2016	308	67.6	57.4	69.4	70.2	69.4	68.7	67.6	65.1	60.3	68.4
5/6/2016	311	100.8	73.4	70.0	69.6	69.4	68.5	67.1	65.5	64.0	68.4
5/10/2016	315	87.8	70.0	73.4	71.6	70.3	69.1	68.0	67.8	68.0	70.0
5/13/2016	318	95.4	75.2	76.3	73.4	71.6	70.3	69.4	70.2	70.7	71.9
5/17/2016	322	55.6	65.1	74.8	74.7	73.4	72.3	71.1	69.4	65.5	72.6
5/20/2016	325	100.0	72.7	71.2	73.0	72.9	72.3	70.7	67.6	62.8	71.3
5/24/2016	329	116.8	78.8	72.1	71.6	71.8	71.1	69.8	69.1	69.1	70.9
5/27/2016	332	70.3	76.3	75.2	72.7	72.0	71.2	70.3	71.2	72.9	72.1
5/31/2016	336	122.4	88.9	79.9	76.3	74.5	73.2	72.7	73.4	73.4	75.0
6/3/2016	339	109.2	79.9	79.9	77.9	75.9	75.0	74.3	74.3	72.9	76.2
6/7/2016	343	100.4	81.7	81.5	79.2	77.5	76.6	75.7	75.4	75.2	77.7
6/10/2016	346	89.1	85.3	84.7	81.5	79.3	78.1	77.0	77.5	79.2	79.7
6/14/2016	350	90.7	86.2	87.6	84.6	82.0	80.6	79.9	80.6	81.1	82.6
6/17/2016	353	105.1	92.8	89.4	86.0	83.7	82.4	81.7	82.8	85.3	84.3
6/21/2016	357	87.8	90.3	92.5	89.2	86.5	85.3	84.4	85.1	86.0	87.2
6/24/2016	360	99.0	92.8	94.8	91.4	88.7	87.4	86.5	87.1	87.8	89.3
6/29/2016	365	94.6	88.5	94.1	93.0	91.0	90.1	88.9	87.4	84.6	90.8

Sample	Date	Bin	Liner	Days in storage	% FFA
060614B1	6/6/2014	1	1	0	0.219
061314B1	6/13/2014	1	1	7	0.239
062014B1	6/20/2014	1	1	14	0.266
062714B1	6/27/2014	1	1	21	0.338
070414B1	7/4/2014	1	1	28	0.376
071114B1	7/11/2014	1	1	35	0.398
071914B1	7/19/2014	1	1	43	0.446
072514B1	7/25/2014	1	1	49	0.365
080114B1	8/1/2014	1	1	56	0.384
081514B1	8/15/2014	1	1	70	0.444
082914B1	8/29/2014	1	1	84	0.510
091214B1	9/12/2014	1	1	98	0.638
092614B1	9/26/2014	1	1	112	0.739
103114B1	10/31/2014	1	1	147	0.787
120314B1	12/3/2014	1	1	180	0.863
010515B1	1/5/2015	1	1	213	0.697
013015B1	1/30/2015	1	1	238	0.743
030315B1	3/3/2015	1	1	270	0.748
033115B1	3/31/2015	1	1	298	0.968
060614B2	6/6/2014	2	1	0	0.265
061314B2	6/13/2014	2	1	7	0.232
062014B2	6/20/2014	2	1	14	0.257
062714B2	6/27/2014	2	1	21	0.315
070414B2	7/4/2014	2	1	28	0.372
071114B2	7/11/2014	2	1	35	0.365
071914B2	7/19/2014	2	1	43	0.443
072514B2	7/25/2014	2	1	49	0.414
080114B2	8/1/2014	2	1	56	0.505
081514B2	8/15/2014	2	1	70	0.483
082914B2	8/29/2014	2	1	84	0.540
091214B2	9/12/2014	2	1	98	0.664
092614B2	9/26/2014	2	1	112	0.785
103114B2	10/31/2014	2	1	147	0.648
120314B2	12/3/2014	2	1	180	0.712
010515B2	1/5/2015	2	1	213	0.803
013015B2	1/30/2015	2	1	238	0.754
030315B2	3/3/2015	2	1	270	0.689
033115B2	3/31/2015	2	1	298	0.812
060614B3	6/6/2014	3	2	0	0.249
061314B3	6/13/2014	3	2	7	0.219
062014B3	6/20/2014	3	2	14	0.289
062714B3	6/27/2014	3	2	21	0.309
070414B3	7/4/2014	3	2	28	0.298
071114B3	7/11/2014	3	2	35	0.297
071914B3	7/19/2014	3	2	43	0.414
072514B3	7/25/2014	3	2	49	0.363
080114B3	8/1/2014	3	2	56	0.428
081514B3	8/15/2014	3	2	70	0.495
082914B3	8/29/2014	3	2	84	0.508
091214B3	9/12/2014	3	2	98	0.581
092614B3	9/26/2014	3	2	112	0.652
103114B3	10/31/2014	3	2	147	0.601
120314B3	12/3/2014	3	2	180	0.641
010515B3	1/5/2015	3	2	213	0.658
013015B3	1/30/2015	3	2	238	0.626
030315B3	3/3/2015	3	2	270	0.532
033115B3	3/31/2015	3	2	298	0.637

Sample	Date	Bin	Liner	Days in storage	% FFA
060614B4	6/6/2014	4	2	0	0.259
061314B4	6/13/2014	4	2	7	0.292
062014B4	6/20/2014	4	2	14	0.331
062714B4	6/27/2014	4	2	21	0.320
070414B4	7/4/2014	4	2	28	0.360
071114B4	7/11/2014	4	2	35	0.384
071914B4	7/19/2014	4	2	43	0.497
072514B4	7/25/2014	4	2	49	0.464
080114B4	8/1/2014	4	2	56	0.558
081514B4	8/15/2014	4	2	70	0.531
082914B4	8/29/2014	4	2	84	0.702
091214B4	9/12/2014	4	2	98	0.656
092614B4	9/26/2014	4	2	112	0.778
103114B4	10/31/2014	4	2	147	0.794
120314B4	12/3/2014	4	2	180	0.819
010515B4	1/5/2015	4	2	213	0.799
013015B4	1/30/2015	4	2	238	0.821
030315B4	3/3/2015	4	2	270	0.842
033115B4	3/31/2015	4	2	298	0.979
060614B5	6/6/2014	5	1	0	0.327
061314B5	6/13/2014	5	1	7	0.255
062014B5	6/20/2014	5	1	14	0.287
062714B5	6/27/2014	5	1	21	0.367
070414B5	7/4/2014	5	1	28	0.355
071114B5	7/11/2014	5	1	35	0.399
071914B5	7/19/2014	5	1	43	0.497
072514B5	7/25/2014	5	1	49	0.512
080114B5	8/1/2014	5	1	56	0.579
081514B5	8/15/2014	5	1	70	0.444
082914B5	8/29/2014	5	1	84	0.548
091214B5	9/12/2014	5	1	98	0.656
092614B5	9/26/2014	5	1	112	0.809
103114B5	10/31/2014	5	1	147	0.821
120314B5	12/3/2014	5	1	180	0.815
010515B5	1/5/2015	5	1	213	0.801
013015B5	1/30/2015	5	1	238	0.774
030315B5	3/3/2015	5	1	270	0.615
033115B5	3/31/2015	5	1	298	0.866
060614B6	6/6/2014	6	2	0	0.183
061314B6	6/13/2014	6	2	7	0.206
062014B6	6/20/2014	6	2	14	0.228
062714B6	6/27/2014	6	2	21	0.296
070414B6	7/4/2014	6	2	28	0.308
071114B6	7/11/2014	6	2	35	0.309
071914B6	7/19/2014	6	2	43	0.412
072514B6	7/25/2014	6	2	49	0.416
080114B6	8/1/2014	6	2	56	0.472
081514B6	8/15/2014	6	2	70	0.439
082914B6	8/29/2014	6	2	84	0.550
091214B6	9/12/2014	6	2	98	0.672
092614B6	9/26/2014	6	2	112	0.698
103114B6	10/31/2014	6	2	147	0.692
120314B6	12/3/2014	6	2	180	0.867
010515B6	1/5/2015	6	2	213	0.815
013015B6	1/30/2015	6	2	238	0.794
030315B6	3/3/2015	6	2	270	0.798
033115B6	3/31/2015	6	2	298	0.888

Sample	Date	Bin	Liner	Days in storage	% FFA
063015B1	6/30/2015	1	2	0	0.195
072815B1	7/28/2015	1	2	28	0.154
082515B1	8/25/2015	1	2	56	0.22
092215B1	9/22/2015	1	2	84	0.138
102015B1	10/20/2015	1	2	112	0.207
112415B1	11/24/2015	1	2	147	0.215
122115B1	12/21/2015	1	2	174	0.196
012616B1	1/26/2016	1	2	210	0.230
022516B1	2/25/2016	1	2	240	0.208
032816B1	3/28/2016	1	2	272	0.231
042816B1	4/28/2016	1	2	303	0.213
060116B1	6/1/2016	1	2	337	0.205
062916B1	6/29/2016	1	2	365	0.277
063015B2	6/30/2015	2	1	0	0.179
072815B2	7/28/2015	2	1	28	0.138
082515B2	8/25/2015	2	1	56	0.179
092215B2	9/22/2015	2	1	84	0.122
102015B2	10/20/2015	2	1	112	0.22
112415B2	11/24/2015	2	1	147	0.22
122115B2	12/21/2015	2	1	174	0.155
012616B2	1/26/2016	2	1	210	0.223
022516B2	2/25/2016	2	1	240	0.221
032816B2	3/28/2016	2	1	272	0.256
042816B2	4/28/2016	2	1	303	0.239
060116B2	6/1/2016	2	1	337	0.247
062916B2	6/29/2016	2	1	365	0.294
063015B3	6/30/2015	3	2	0	0.163
072815B3	7/28/2015	3	2	28	0.155
082515B3	8/25/2015	3	2	56	0.204
092215B3	9/22/2015	3	2	84	0.139
102015B3	10/20/2015	3	2	112	0.187
112415B3	11/24/2015	3	2	147	0.22
122115B3	12/21/2015	3	2	174	0.22
012616B3	1/26/2016	3	2	210	0.205
022516B3	2/25/2016	3	2	240	0.257
032816B3	3/28/2016	3	2	272	0.214
042816B3	4/28/2016	3	2	303	0.262
060116B3	6/1/2016	3	2	337	0.221
062916B3	6/29/2016	3	2	365	0.277
063015B4	6/30/2015	4	1	0	0.187
072815B4	7/28/2015	4	1	28	0.163
082515B4	8/25/2015	4	1	56	0.212
092215B4	9/22/2015	4	1	84	0.171
102015B4	10/20/2015	4	1	112	0.196
112415B4	11/24/2015	4	1	147	0.217

Sample	Date	Bin	Liner	Days in storage	% FFA
122115B4	12/21/2015	4	1	174	0.187
012616B4	1/26/2016	4	1	210	0.218
022516B4	2/25/2016	4	1	240	0.213
032816B4	3/28/2016	4	1	272	0.231
042816B4	4/28/2016	4	1	303	0.286
060116B4	6/1/2016	4	1	337	0.221
062916B4	6/29/2016	4	1	365	0.284
063015B5	6/30/2015	5	2	0	0.162
072815B5	7/28/2015	5	2	28	0.147
082515B5	8/25/2015	5	2	56	0.204
092215B5	9/22/2015	5	2	84	0.139
102015B5	10/20/2015	5	2	112	0.179
112415B5	11/24/2015	5	2	147	0.204
122115B5	12/21/2015	5	2	174	0.203
012616B5	1/26/2016	5	2	210	0.197
022516B5	2/25/2016	5	2	240	0.269
032816B5	3/28/2016	5	2	272	0.278
042816B5	4/28/2016	5	2	303	0.272
060116B5	6/1/2016	5	2	337	0.267
062916B5	6/29/2016	5	2	365	0.319
063015B6	6/30/2015	6	1	0	0.154
072815B6	7/28/2015	6	1	28	0.171
082515B6	8/25/2015	6	1	56	0.195
092215B6	9/22/2015	6	1	84	0.187
102015B6	10/20/2015	6	1	112	0.187
112415B6	11/24/2015	6	1	147	0.215
122115B6	12/21/2015	6	1	174	0.22
012616B6	1/26/2016	6	1	210	0.221
022516B6	2/25/2016	6	1	240	0.230
032816B6	3/28/2016	6	1	272	0.238
042816B6	4/28/2016	6	1	303	0.280
060116B6	6/1/2016	6	1	337	0.262
062916B6	6/29/2016	6	1	365	0.312
063015C	6/30/2015	C		0	0.198
082515C	8/25/2015	C		56	0.212
092215C	9/22/2015	C		84	0.138
102015C	10/20/2015	C		112	0.203
112415C	11/24/2015	C		147	0.204
122115C	12/21/2015	C		174	0.187
012616C	1/26/2016	C		210	0.175
022516C	2/25/2016	C		240	0.192
032816C	3/28/2016	C		272	0.200
042816C	4/28/2016	C		303	0.242
060116C	6/1/2016	C		337	0.131
062916C	6/29/2016	C		365	0.191

Location	Date	Days in storage	Germination
Bin 1	6/3/2014	0	0.94
Bin 1	8/8/2014	66	0.44
Bin 1	8/22/2014	80	0.16
Bin 1	9/5/2014	94	0.02
Bin 2	6/3/2014	0	0.94
Bin 2	8/8/2014	66	0.66
Bin 2	8/22/2014	80	0.38
Bin 2	9/5/2014	94	0.04
Bin 3	6/3/2014	0	0.94
Bin 3	8/8/2014	66	0.66
Bin 3	8/22/2014	80	0.56
Bin 3	9/5/2014	94	0.34
Bin 4	6/3/2014	0	0.94
Bin 4	8/8/2014	66	0.1
Bin 4	8/22/2014	80	0.02
Bin 4	9/5/2014	94	0
Bin 5	6/3/2014	0	0.94
Bin 5	8/8/2014	66	0.32
Bin 5	8/22/2014	80	0.14
Bin 5	9/5/2014	94	0.08
Bin 6	6/3/2014	0	0.94
Bin 6	8/8/2014	66	0.2
Bin 6	8/22/2014	80	0
Bin 6	9/5/2014	94	0
Post hoc germinations for year 1			

Sample	Location	Date	Day in storage	Germinations	Germination %
063015B1	Bin 1	6/30/2015	0	46	92%
071415B1	Bin 1	7/14/2015	14	46	92%
072815B1	Bin 1	7/28/2015	28	44	88%
081115B1	Bin 1	8/11/2015	42	43	86%
082515B1	Bin 1	8/25/2015	56	45	90%
092215B1	Bin 1	9/22/2015	84	47	94%
102015B1	Bin 1	10/20/2015	112	47	94%
112415B1	Bin 1	11/24/2015	147	45	90%
122115B1	Bin 1	12/21/2015	174	48	96%
012616B1	Bin 1	1/26/2016	210	47	94%
022516B1	Bin 1	2/25/2016	240	47	94%
032816B1	Bin 1	3/28/2016	272	47	94%
042816B1	Bin 1	4/28/2016	303	49	98%
060116B1	Bin 1	6/1/2016	337	44	88%
062916B1	Bin 1	6/29/2016	365	41	82%
063015B2	Bin 2	6/30/2015	0	41	82%
071415B2	Bin 2	7/14/2015	14	44	88%
072815B2	Bin 2	7/28/2015	28	42	84%
081115B2	Bin 2	8/11/2015	42	44	88%
082515B2	Bin 2	8/25/2015	56	43	86%
092215B2	Bin 2	9/22/2015	84	46	92%
102015B2	Bin 2	10/20/2015	112	43	86%
112415B2	Bin 2	11/24/2015	147	44	88%
122115B2	Bin 2	12/21/2015	174	45	90%
012616B2	Bin 2	1/26/2016	210	40	80%
022516B2	Bin 2	2/25/2016	240	43	86%
032816B2	Bin 2	3/28/2016	272	45	90%
042816B2	Bin 2	4/28/2016	303	48	96%
060116B2	Bin 2	6/1/2016	337	42	84%
062916B2	Bin 2	6/29/2016	365	42.5	85%
063015B3	Bin 3	6/30/2015	0	40	80%
071415B3	Bin 3	7/14/2015	14	37	74%
072815B3	Bin 3	7/28/2015	28	48	96%
081115B3	Bin 3	8/11/2015	42	45	90%
082515B3	Bin 3	8/25/2015	56	48	96%
092215B3	Bin 3	9/22/2015	84	45	90%
102015B3	Bin 3	10/20/2015	112	47	94%
112415B3	Bin 3	11/24/2015	147	45	90%
122115B3	Bin 3	12/21/2015	174	42	84%
012616B3	Bin 3	1/26/2016	210	47	94%
022516B3	Bin 3	2/25/2016	240	49	98%
032816B3	Bin 3	3/28/2016	272	50	100%
042816B3	Bin 3	4/28/2016	303	49	98%
060116B3	Bin 3	6/1/2016	337	46	92%
062916B3	Bin 3	6/29/2016	365	45	90%
063015B4	Bin 4	6/30/2015	0	47	94%
071415B4	Bin 4	7/14/2015	14	41	82%
072815B4	Bin 4	7/28/2015	28	43	86%
081115B4	Bin 4	8/11/2015	42	42	84%
082515B4	Bin 4	8/25/2015	56	45	90%
092215B4	Bin 4	9/22/2015	84	44	88%
102015B4	Bin 4	10/20/2015	112	47	94%

Sample	Location	Date	Day in storage	Germinations	Germination %
112415B4	Bin 4	11/24/2015	147	39	78%
122115B4	Bin 4	12/21/2015	174	43	86%
012616B4	Bin 4	1/26/2016	210	44	88%
022516B4	Bin 4	2/25/2016	240	45	90%
032816B4	Bin 4	3/28/2016	272	47	94%
042816B4	Bin 4	4/28/2016	303	44	88%
060116B4	Bin 4	6/1/2016	337	46	92%
062916B4	Bin 4	6/29/2016	365	42.5	85%
063015B5	Bin 5	6/30/2015	0	46	92%
071415B5	Bin 5	7/14/2015	14	44	88%
072815B5	Bin 5	7/28/2015	28	44	88%
081115B5	Bin 5	8/11/2015	42	43	86%
082515B5	Bin 5	8/25/2015	56	45	90%
092215B5	Bin 5	9/22/2015	84	42	84%
102015B5	Bin 5	10/20/2015	112	48	96%
112415B5	Bin 5	11/24/2015	147	45	90%
122115B5	Bin 5	12/21/2015	174	42	84%
012616B5	Bin 5	1/26/2016	210	43	86%
022516B5	Bin 5	2/25/2016	240	45	90%
032816B5	Bin 5	3/28/2016	272	46	92%
042816B5	Bin 5	4/28/2016	303	49	98%
060116B5	Bin 5	6/1/2016	337	42	84%
062916B5	Bin 5	6/29/2016	365	36	72%
063015B6	Bin 6	6/30/2015	0	42	84%
071415B6	Bin 6	7/14/2015	14	35	70%
072815B6	Bin 6	7/28/2015	28	45	90%
081115B6	Bin 6	8/11/2015	42	44	88%
082515B6	Bin 6	8/25/2015	56	44	88%
092215B6	Bin 6	9/22/2015	84	42	84%
102015B6	Bin 6	10/20/2015	112	49	98%
112415B6	Bin 6	11/24/2015	147	40	80%
122115B6	Bin 6	12/21/2015	174	41	82%
012616B6	Bin 6	1/26/2016	210	42	84%
022516B6	Bin 6	2/25/2016	240	46	92%
032816B6	Bin 6	3/28/2016	272	47	94%
042816B6	Bin 6	4/28/2016	303	45	90%
060116B6	Bin 6	6/1/2016	337	33	66%
062916B6	Bin 6	6/29/2016	365	36	72%
063015C	Control	6/30/2015	0	50	100%
071415C	Control	7/14/2015	14	49	98%
072815C	Control	7/28/2015	28	48	96%
081115C	Control	8/11/2015	42	50	100%
082515C	Control	8/25/2015	56	50	100%
092215C	Control	9/22/2015	84	48	96%
102015C	Control	10/20/2015	112	49	98%
112415C	Control	11/24/2015	147	50	100%
122115C	Control	12/21/2015	174	49	98%
012616C	Control	1/26/2016	210	50	100%
022516C	Control	2/25/2016	240	49	98%
032816C	Control	3/28/2016	272	49	98%
042816C	Control	4/28/2016	303	50	100%
060116C	Control	6/1/2016	337	49	98%
062916C	Control	6/29/2016	365	49.5	99%

```
DM 'log;clear;output;clear;';
DATA one;
INPUT bin liner date temp;
* First six months in storage;
* Lined=1, Unlined=2;
* Date = days in storage;
DATALINES;
1   1   0   95.3
Omitted in output
;
DATA two;
INPUT bin liner date temp;
* Last four months in storage;
* Lined=1, Unlined=2;
* Date = days in storage;
DATALINES;
1   1   186 51.0
Omitted in output
;

PROC ANOVA DATA=one;
CLASS liner bin;
MODEL temp=liner bin;
TITLE 'First six months';
RUN;

PROC ANOVA DATA=two;
CLASS liner bin;
MODEL temp=liner bin;
TITLE 'Last four months';
RUN;
QUIT;
```

First six months

The ANOVA Procedure

Class Level Information		
Class	**Levels**	**Values**
liner	2	1 2
bin	6	1 2 3 4 5 6

Number of Observations Read	366
Number of Observations Used	366

First six months

The ANOVA Procedure

Dependent Variable: temp

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	2820.15443	470.02574	3.45	0.0025
Error	359	48845.03071	136.05858		
Corrected Total	365	51665.18514			

R-Square	Coeff Var	Root MSE	temp Mean
0.054585	13.09949	11.66442	89.04481

Source	DF	Anova SS	Mean Square	F Value	Pr > F
liner	1	1157.214863	1157.214863	8.51	0.0038
bin	5	1662.939563	332.587913	2.44	0.0339

Last four months

The ANOVA Procedure

Class Level Information		
Class	**Levels**	**Values**
liner	2	1 2
bin	6	1 2 3 4 5 6

Number of Observations Read	174
Number of Observations Used	174

Last four months

The ANOVA Procedure

Dependent Variable: temp

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	106.706207	17.784368	0.57	0.7564
Error	167	5240.680690	31.381321		
Corrected Total	173	5347.386897			

R-Square	Coeff Var	Root MSE	temp Mean
0.019955	12.18170	5.601903	45.98621

Source	DF	Anova SS	Mean Square	F Value	Pr > F
liner	1	41.71862069	41.71862069	1.33	0.2506
bin	5	64.98758621	12.99751724	0.41	0.8385

```
DM 'log;clear;output;clear;';
DATA one;
INPUT bin liner date ffa;
* Lined=1, Unlined=2;
* Date = days in storage;
DATALINES;
1   1   0   0.219
Omitted in output
;
*PROC PRINT DATA=one;

PROC ANOVA DATA=one;
CLASS liner bin;
MODEL ffa=liner bin;
RUN;

PROC MIXED DATA=one;
CLASS liner bin;
MODEL ffa= /HTYPE=1 solution;
REPEATED/TYPE=sp(pow)(date) SUBJECT=bin(liner);
RUN;

PROC MIXED DATA=one;
CLASS liner bin;
MODEL ffa=date date*date/HTYPE=1 solution;
REPEATED/TYPE=sp(pow)(date) SUBJECT=bin(liner);
RUN;

PROC SORT; BY liner date;
PROC MEANS mean; BY liner date; VAR ffa;
OUTPUT OUT=new MEAN= mffa;
PROC PLOT;
PLOT mffa*date=liner;
RUN;
QUIT;
```

The ANOVA Procedure

Class Level Information		
Class	**Levels**	**Values**
liner	2	1 2
bin	6	1 2 3 4 5 6

Number of Observations Read	114
Number of Observations Used	114

The ANOVA Procedure

Dependent Variable: ffa

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	0.17890802	0.02981800	0.67	0.6778
Error	107	4.79573792	0.04481998		
Corrected Total	113	4.97464594			

R-Square	Coeff Var	Root MSE	ffa Mean
0.035964	39.57860	0.211707	0.534904

Source	DF	Anova SS	Mean Square	F Value	Pr > F
liner	1	0.00753797	0.00753797	0.17	0.6826
bin	5	0.17137004	0.03427401	0.76	0.5772

The Mixed Procedure

Model Information	
Data Set	WORK.ONE
Dependent Variable	ffa
Covariance Structure	Spatial Power
Subject Effect	bin(liner)
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Class Level Information		
Class	**Levels**	**Values**
liner	2	1 2
bin	6	1 2 3 4 5 6

Dimensions	
Covariance Parameters	2
Columns in X	1
Columns in Z	0
Subjects	6
Max Obs per Subject	19

Number of Observations	
Number of Observations Read	114
Number of Observations Used	114
Number of Observations Not Used	0

Iteration History			
Iteration	**Evaluations**	**-2 Res Log Like**	**Criterion**
0	1	-27.48649197	
1	2	-148.47844148	8059.6689340
2	1	-200.70323326	14924.879645
3	1	-232.01818181	0.21212560
4	1	-244.90878617	0.02324680
5	1	-248.24685815	0.00038859
6	1	-248.32665484	0.00000701
7	1	-248.32827337	0.00000000

Convergence criteria met.

Covariance Parameter Estimates		

Cov Parm	Subject	Estimate
SP(POW)	bin(liner)	0.9973
Residual		0.08273

Fit Statistics	
-2 Res Log Likelihood	-248.3
AIC (Smaller is Better)	-244.3
AICC (Smaller is Better)	-244.2
BIC (Smaller is Better)	-244.7

Null Model Likelihood Ratio Test		
DF	Chi-Square	Pr > ChiSq
1	220.84	<.0001

Solution for Fixed Effects					
Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	0.5798	0.09929	5	5.84	0.0021

The Mixed Procedure

Model Information	
Data Set	WORK.ONE
Dependent Variable	ffa
Covariance Structure	Spatial Power
Subject Effect	bin(liner)
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Class Level Information		
Class	**Levels**	**Values**
liner	2	1 2
bin	6	1 2 3 4 5 6

Dimensions	
Covariance Parameters	2
Columns in X	3
Columns in Z	0
Subjects	6
Max Obs per Subject	19

Number of Observations	
Number of Observations Read	114
Number of Observations Used	114
Number of Observations Not Used	0

Iteration History			
Iteration	**Evaluations**	**-2 Res Log Like**	**Criterion**
0	1	-214.62214141	
1	2	-251.39556675	0.44352828
2	1	-259.82681926	0.00043224
3	1	-259.92109653	0.00000297
4	1	-259.92178954	0.00000000

Convergence criteria met.

Covariance Parameter Estimates		
Cov Parm	**Subject**	**Estimate**
SP(POW)	bin(liner)	0.9772
Residual		0.008990

Fit Statistics	
-2 Res Log Likelihood	-259.9
AIC (Smaller is Better)	-255.9
AICC (Smaller is Better)	-255.8
BIC (Smaller is Better)	-256.3

Null Model Likelihood Ratio Test		
DF	Chi-Square	Pr > ChiSq
1	45.30	<.0001

Solution for Fixed Effects					
Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	0.2570	0.03662	5	7.02	0.0009
date	0.004201	0.000543	106	7.74	<.0001
date*date	-7.85E-6	1.732E-6	106	-4.53	<.0001

Type 1 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
date	1	106	138.15	<.0001
date*date	1	106	20.55	<.0001

The MEANS Procedure

liner=1 date=0

Analysis Variable : ffa
Mean
0.2703333

liner=1 date=7

Analysis Variable : ffa
Mean
0.2420000

liner=1 date=14

Analysis Variable : ffa
Mean
0.2700000

liner=1 date=21

Analysis Variable : ffa
Mean
0.3400000

liner=1 date=28

Analysis Variable : ffa
Mean
0.3676667

liner=1 date=35

Analysis Variable : ffa
Mean
0.3873333

liner=1 date=43

Analysis Variable : ffa
Mean
0.4620000

liner=1 date=49

Analysis Variable : ffa
Mean
0.4303333

liner=1 date=56

Analysis Variable : ffa
Mean
0.4893333

liner=1 date=70

Analysis Variable : ffa
Mean
0.4570000

liner=1 date=84

Analysis Variable : ffa
Mean
0.5326667

liner=1 date=98

Analysis Variable : ffa
Mean
0.6526667

liner=1 date=112

Analysis Variable : ffa
Mean
0.7776667

liner=1 date=147

Analysis Variable : ffa
Mean
0.7520000

liner=1 date=180

Analysis Variable : ffa
Mean

0.7966667

liner=1 date=213

Analysis Variable : ffa
Mean
0.7670000

liner=1 date=238

Analysis Variable : ffa
Mean
0.7570000

liner=1 date=270

Analysis Variable : ffa
Mean
0.6840000

liner=1 date=298

Analysis Variable : ffa
Mean
0.8820000

liner=2 date=0

Analysis Variable : ffa
Mean
0.2303333

liner=2 date=7

Analysis Variable : ffa
Mean
0.2390000

liner=2 date=14

Analysis Variable : ffa
Mean
0.2826667

liner=2 date=21

Analysis Variable : ffa
Mean
0.3083333

liner=2 date=28

Analysis Variable : ffa
Mean
0.3220000

liner=2 date=35

Analysis Variable : ffa
Mean
0.3300000

liner=2 date=43

Analysis Variable : ffa
Mean
0.4410000

liner=2 date=49

Analysis Variable : ffa
Mean
0.4143333

liner=2 date=56

Analysis Variable : ffa
Mean
0.4860000

liner=2 date=70

Analysis Variable : ffa
Mean
0.4883333

liner=2 date=84

Analysis Variable : ffa
Mean

0.5866667

liner=2 date=98

Analysis Variable : ffa
Mean
0.6363333

liner=2 date=112

Analysis Variable : ffa
Mean
0.7093333

liner=2 date=147

Analysis Variable : ffa
Mean
0.6956667

liner=2 date=180

Analysis Variable : ffa
Mean
0.7756667

liner=2 date=213

Analysis Variable : ffa
Mean
0.7573333

liner=2 date=238

Analysis Variable : ffa
Mean
0.7470000

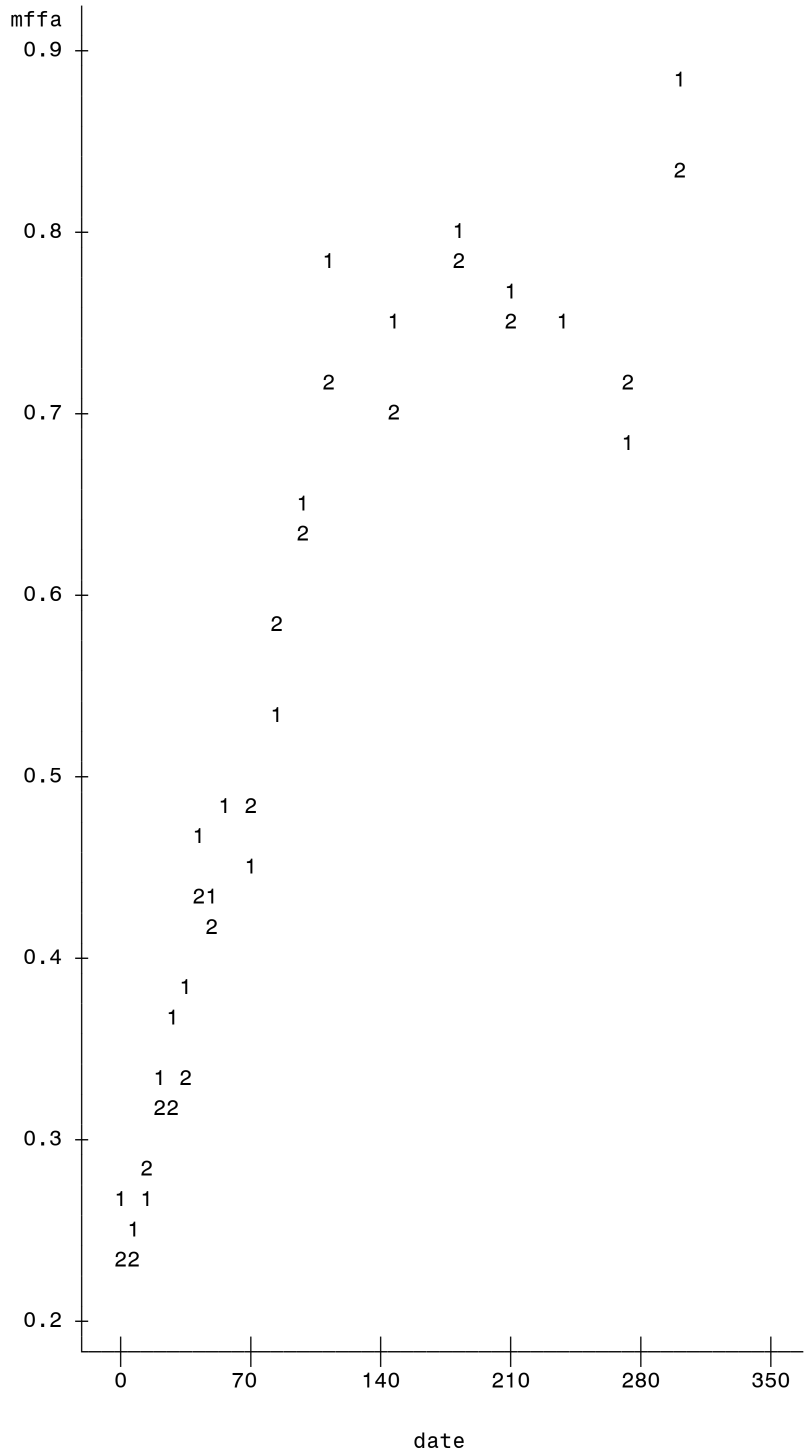
liner=2 date=270

Analysis Variable : ffa
Mean
0.7240000

liner=2 date=298

Analysis Variable : ffa
Mean
0.8346667

Plot of mffa*date. Symbol is value of liner.



NOTE: 2 obs hidden.

```
DM 'log;clear;output;clear;';
title;
DATA one;
INPUT bin liner date ffa;
* Lined=1, Unlined=2;
* Date = days in storage;
DATALINES;
1   2   0   0.195
Omitted in output
;
*PROC PRINT DATA=one;

PROC ANOVA DATA=one;
CLASS liner bin;
MODEL ffa=liner bin;
RUN;

PROC MIXED DATA=one;
CLASS liner bin;
MODEL ffa= /HTYPE=1 solution;
REPEATED/TYPE=sp(pow)(date) SUBJECT=bin(liner);
RUN;

PROC MIXED DATA=one;
CLASS liner bin;
MODEL ffa=date/HTYPE=1 solution;
REPEATED/TYPE=sp(pow)(date) SUBJECT=bin(liner);
RUN;

PROC SORT; BY liner date;
PROC MEANS mean; BY liner date; VAR ffa;
OUTPUT OUT=new MEAN= mffa;
PROC PLOT;
PLOT mffa*date=liner;
RUN;
QUIT;
```

The ANOVA Procedure

Class Level Information		
Class	Levels	Values
liner	2	1 2
bin	6	1 2 3 4 5 6

Number of Observations Read	78
Number of Observations Used	78

The ANOVA Procedure

Dependent Variable: ffa

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	0.00244031	0.00040672	0.20	0.9753
Error	71	0.14345641	0.00202051		
Corrected Total	77	0.14589672			

R-Square	Coeff Var	Root MSE	ffa Mean
0.016726	21.11605	0.044950	0.212872

Source	DF	Anova SS	Mean Square	F Value	Pr > F
liner	1	0.00012313	0.00012313	0.06	0.8057
bin	5	0.00231718	0.00046344	0.23	0.9485

The Mixed Procedure

Model Information	
Data Set	WORK.ONE
Dependent Variable	ffa
Covariance Structure	Spatial Power
Subject Effect	bin(liner)
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Class Level Information

Class	Levels	Values
liner	2	1 2
bin	6	1 2 3 4 5 6

Dimensions	
Covariance Parameters	2
Columns in X	1
Columns in Z	0
Subjects	6
Max Obs per Subject	13

Number of Observations	
Number of Observations Read	78
Number of Observations Used	78
Number of Observations Not Used	0

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	-259.81371110	
1	2	-272.27712401	238.96431281
2	1	-280.17621820	0.00428116
3	1	-280.68956223	0.00079309
4	1	-280.86945667	0.00001212
5	1	-280.87204520	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Subject	Estimate
SP(POW)	bin(liner)	0.9810
Residual		0.002082

Fit Statistics	
-2 Res Log Likelihood	-280.9
AIC (Smaller is Better)	-276.9
AICC (Smaller is Better)	-276.7
BIC (Smaller is Better)	-277.3

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
1	21.06	<.0001

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	0.2170	0.008886	5	24.42	<.0001

The Mixed Procedure

Model Information	
Data Set	WORK.ONE
Dependent Variable	ffa
Covariance Structure	Spatial Power
Subject Effect	bin(liner)
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Class Level Information		
Class	Levels	Values
liner	2	1 2
bin	6	1 2 3 4 5 6

Dimensions	
Covariance Parameters	2
Columns in X	2
Columns in Z	0
Subjects	6
Max Obs per Subject	13

Number of Observations	
Number of Observations Read	78
Number of Observations Used	78
Number of Observations Not Used	0

Iteration History			
Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	-324.72654623	
1	2	-323.97556525	0.00164055
2	1	-324.45656790	0.00059916
3	1	-324.63180774	0.00021142
4	1	-324.69358443	0.00007367
5	1	-324.71510551	0.00002558
6	1	-324.72257683	0.00000887
7	1	-324.72516878	0.00000308
8	1	-324.72606809	0.00000107
9	1	-324.72638021	0.00000037
10	1	-324.72648857	0.00000013
11	1	-324.72652620	0.00000004
12	1	-324.72653927	0.00000002
13	1	-324.72654381	0.00000001

Convergence criteria met.

Covariance Parameter Estimates		
Cov Parm	Subject	Estimate
SP(POW)	bin(liner)	0.5522
Residual		0.000642

Fit Statistics	
-2 Res Log Likelihood	-324.7
AIC (Smaller is Better)	-320.7
AICC (Smaller is Better)	-320.6
BIC (Smaller is Better)	-321.1

Null Model Likelihood Ratio Test		
DF	Chi-Square	Pr > ChiSq
1	0.00	1.0000

Solution for Fixed Effects					
Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	0.1581	0.005302	5	29.82	<.0001
date	0.000306	0.000025	71	12.29	<.0001

Type 1 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
date	1	71	151.08	<.0001

The MEANS Procedure

liner=1 date=0

Analysis Variable : ffa
Mean
0.1733333

liner=1 date=28

Analysis Variable : ffa
Mean
0.1573333

liner=1 date=56

Analysis Variable : ffa
Mean
0.1953333

liner=1 date=84

Analysis Variable : ffa
Mean
0.1600000

liner=1 date=112

Analysis Variable : ffa
Mean
0.2010000

liner=1 date=147

Analysis Variable : ffa
Mean
0.2173333

liner=1 date=174

Analysis Variable : ffa
Mean
0.1873333

liner=1 date=210

Analysis Variable : ffa
Mean
0.2206667

liner=1 date=240

Analysis Variable : ffa
Mean
0.2213333

liner=1 date=272

Analysis Variable : ffa
Mean

0.2416667

liner=1 date=303

Analysis Variable : ffa
Mean
0.2683333

liner=1 date=337

Analysis Variable : ffa
Mean
0.2433333

liner=1 date=365

Analysis Variable : ffa
Mean
0.2966667

liner=2 date=0

Analysis Variable : ffa
Mean
0.1733333

liner=2 date=28

Analysis Variable : ffa
Mean
0.1520000

liner=2 date=56

Analysis Variable : ffa
Mean
0.2093333

liner=2 date=84

Analysis Variable : ffa
Mean
0.1386667

liner=2 date=112

Analysis Variable : ffa
Mean
0.1910000

liner=2 date=147

Analysis Variable : ffa
Mean
0.2130000

liner=2 date=174

Analysis Variable : ffa
Mean

0.2063333

liner=2 date=210

Analysis Variable : ffa
Mean
0.2106667

liner=2 date=240

Analysis Variable : ffa
Mean
0.2446667

liner=2 date=272

Analysis Variable : ffa
Mean
0.2410000

liner=2 date=303

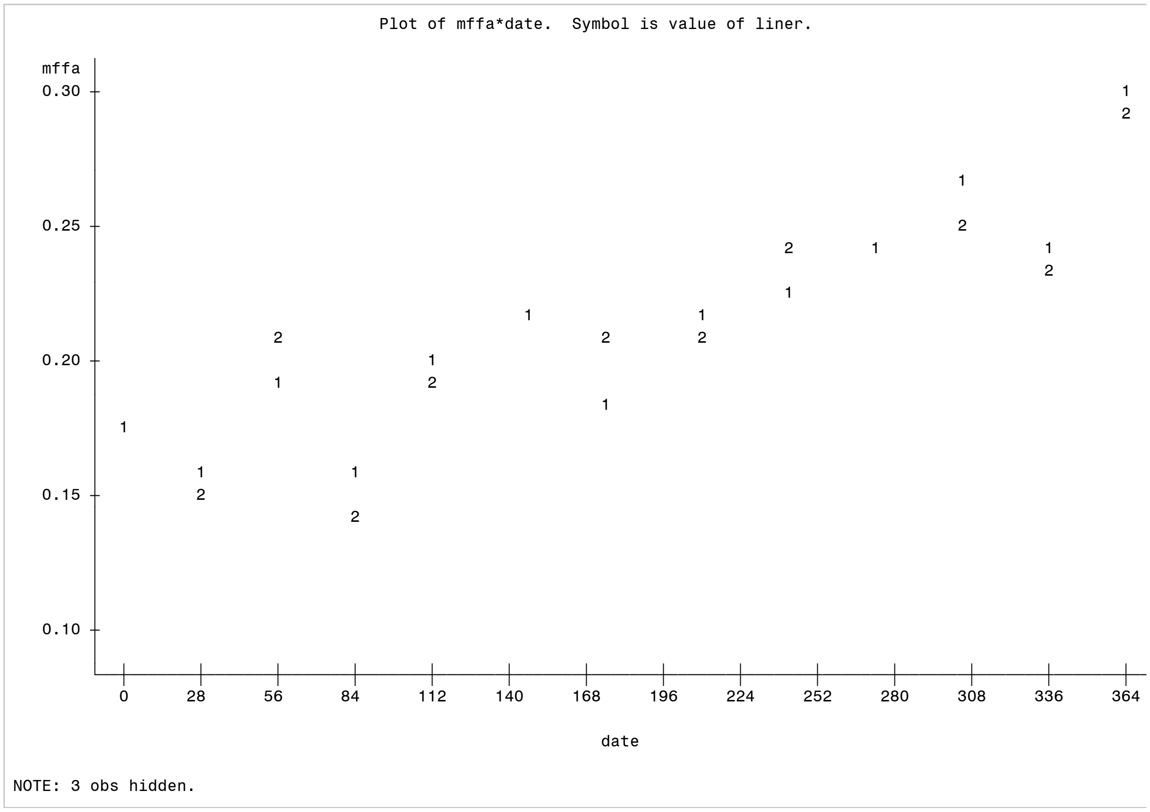
Analysis Variable : ffa
Mean
0.2490000

liner=2 date=337

Analysis Variable : ffa
Mean
0.2310000

liner=2 date=365

Analysis Variable : ffa
Mean
0.2910000

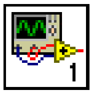


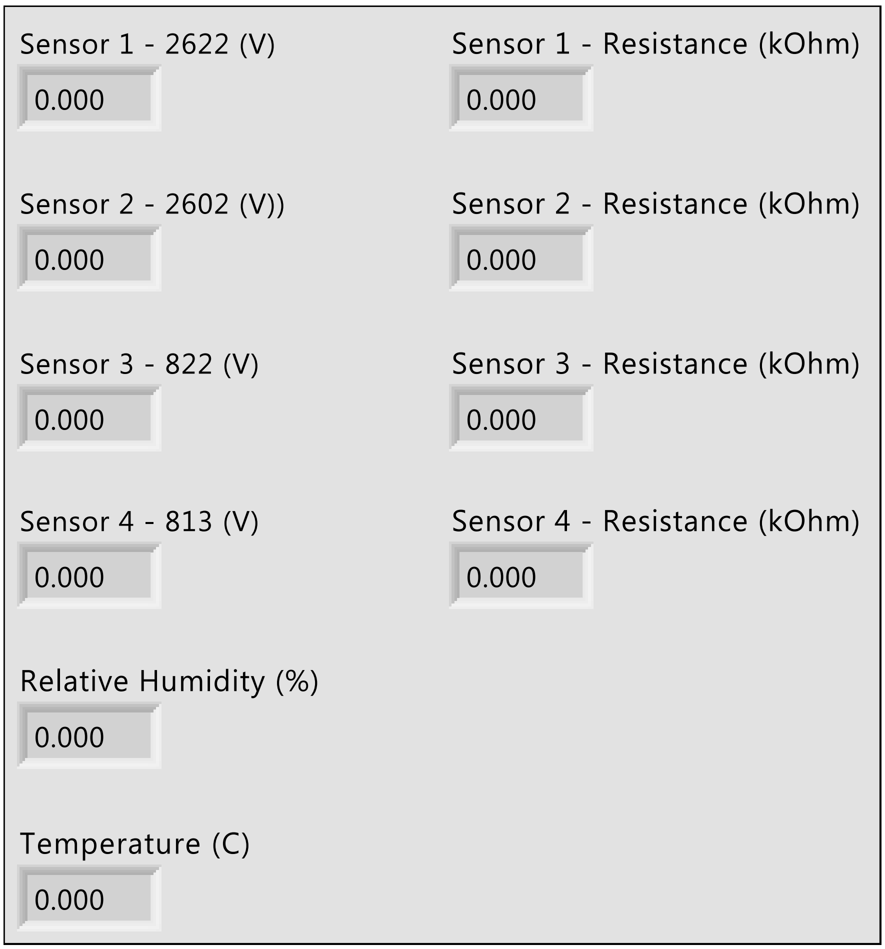
Plot of mffa*date. Symbol is value of liner.
mffa
0.30
0.25
0.20
0.15
0.10
0
28
56
84
112
140
168
196
224
252
280
308
336
364
date
NOTE: 3 obs hidden.

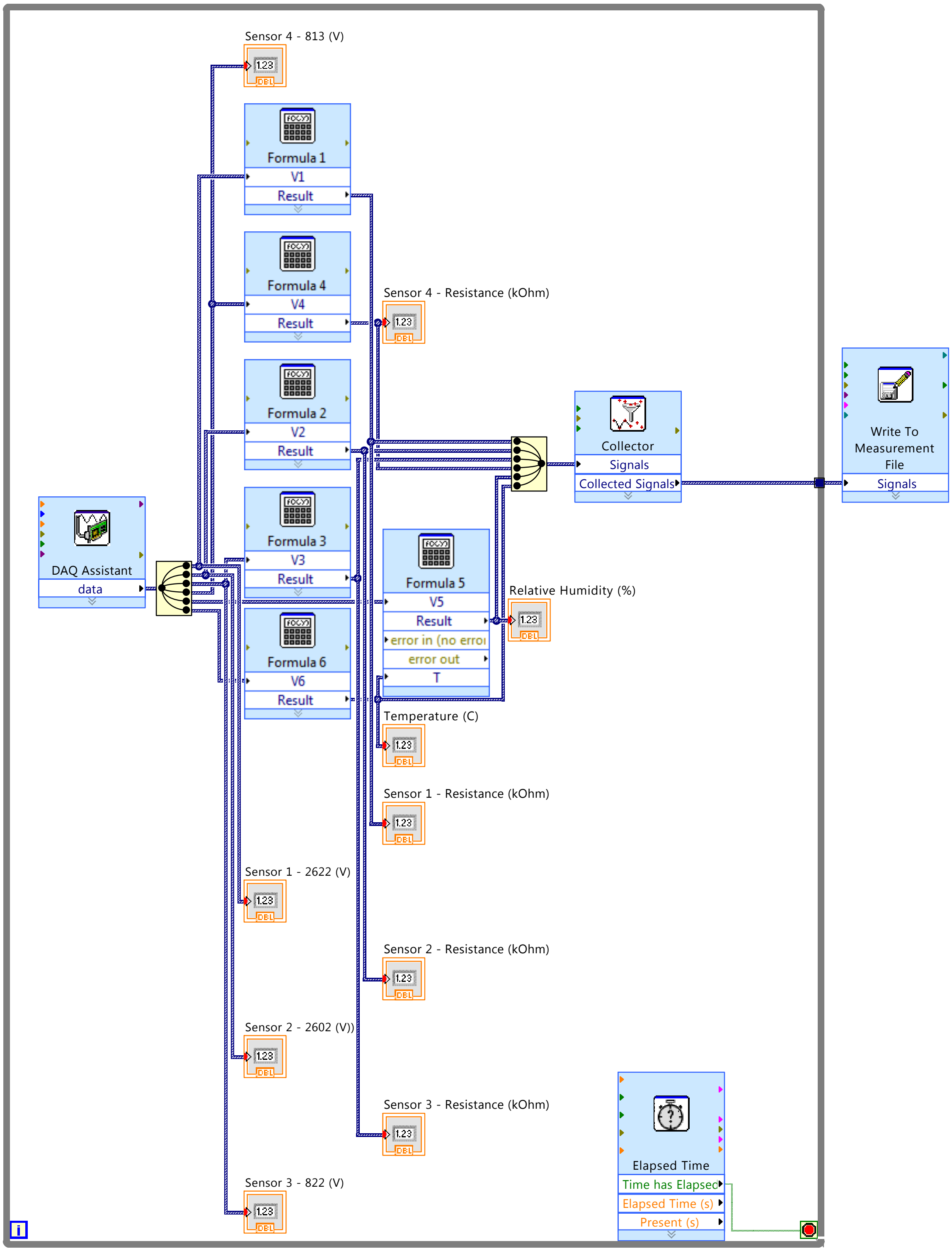
APPENDIX 2

DEVELOPMENT OF A LOW-COST ELECTRONIC NOSE FOR THE DETECTION OF MOLD IN STORED WINTER CANOLA SEED

Canola sniffer - 4-3-17 update.vi







Sensor 4 - 813 (V)
Formula 1
V1
Result
Formula 4
V4
Result
Sensor 4 - Resistance (kOhm)
Formula 2
V2
Result
Collector
Signals
Collected Signals
Write To Measurement File
Signals
DAQ Assistant
data
Formula 3
V3
Result
Formula 5
V5
Result
error in (no error
error out
T
Relative Humidity (%)
Formula 6
V6
Result
Temperature (C)
Sensor 1 - Resistance (kOhm)
Sensor 1 - 2622 (V)
Sensor 2 - Resistance (kOhm)
Sensor 2 - 2602 (V))
Sensor 3 - Resistance (kOhm)
Elapsed Time
Time has Elapsed
Elapsed Time (s)
Present (s)
Sensor 3 - 822 (V)

Contents

- Testdataimport_maxten_Rs_Ro
- Read data
- Calculations for sensor 1
- Calculations for sensor 2
- Calculations for sensor 3
- Calculations for sensor 4
- Normalize sensor response using air reference

Testdataimport_maxten_Rs_Ro

Read sensor data from Labview output, collect the max 10 sensor responses and the temp and RH associated with each of these, calculate the air reference value associated with this temp and RH, normalize the mean sensor response for the max sensor response with the air reference (Rs/Ro).

```
sensor_mean=zeros(10,4);
```

Read data

```
for j=1:10;
```

```
datfile=['C:\Kevin Moore\MATLAB\WorkingFolder\canola 16mc 5-1-17\' num2str(j) '.lvm'];
fid=fopen(datfile,'rt');
data=textscan(fid,'%f %f %f %f %f %f %f %f %f %f %f %f','Headerlines',23,'Delimiter',',','CollectOutput',1);
sensordata=cell2mat(data);
[sensordata_sorted sorted_index]=sort(sensordata);
```

Calculations for sensor 1

```
    sensordata_sorted(:,10)=sensordata(sorted_index(:,2),10);
    sensordata_sorted(:,12)=sensordata(sorted_index(:,2),12);
    maxresponse(j,1) = mean(sensordata_sorted(1:10,2));
    airRH(j,1) = mean(sensordata_sorted(1:10,10));
    temp(j,1) = mean(sensordata_sorted(1:10,12));
    if airRH(j,1)<=36;
        airzero(j,1) = -2.41404*airRH(j,1)+ 101.90376;
    elseif airRH(j,1)>=39;
        airzero(j,1) = -7.39771*airRH(j,1)+ 315.70355;
    else
        airzero(j,1) = (-2.41404*airRH(j,1)+ 101.90376) + (((temp(j,1)-36)/3)*((-1.1813*airRH(j,1))+ 37.35606));
    end
```

Calculations for sensor 2

```
    sensordata_sorted(:,10)=sensordata(sorted_index(:,4),10);
    sensordata_sorted(:,12)=sensordata(sorted_index(:,4),12);
    maxresponse(j,2) = mean(sensordata_sorted(1:10,4));
    airRH(j,2) = mean(sensordata_sorted(1:10,10));
    temp(j,2) = mean(sensordata_sorted(1:10,12));
    if airRH(j,2)<=36;
        airzero(j,2) = 4.07655*airRH(j,2)+ 16.83763;
    elseif airRH(j,2)>=39;
        airzero(j,2) = 8.60778*airRH(j,2)- 115.74911;
    else
        airzero(j,2) = (4.07655*airRH(j,2)+ 16.83763) + (((temp(j,2)-36)/3)*((4.53123*airRH(j,2))- 132.58674));
    end
```

Calculations for sensor 3

```
    sensordata_sorted(:,10)=sensordata(sorted_index(:,6),10);
    sensordata_sorted(:,12)=sensordata(sorted_index(:,6),12);
    maxresponse(j,3) = mean(sensordata_sorted(1:10,6));
    airRH(j,3) = mean(sensordata_sorted(1:10,10));
    temp(j,3) = mean(sensordata_sorted(1:10,12));
    if airRH(j,3)<=36;
        airzero(j,3) = -5.33501*airRH(j,3)+ 238.16059;
    elseif airRH(j,3)>=39;
        airzero(j,3) = -7.39771*airRH(j,3)+ 315.70355;
    else
```

```
        airzero(j,3) = (-5.33501*airRH(j,3)+ 238.16059) + (((temp(j,3)-36)/3)*((-2.0627*airRH(j,3))+ 77.54296));
    end
```

Calculations for sensor 4

```
    sensordata_sorted(:,10)=sensordata(sorted_index(:,8),10);
    sensordata_sorted(:,12)=sensordata(sorted_index(:,8),12);
    maxresponse(j,4) = mean(sensordata_sorted(1:10,8));
    airRH(j,4) = mean(sensordata_sorted(1:10,10));
    temp(j,4) = mean(sensordata_sorted(1:10,12));
    if airRH(j,4)<=36;
        airzero(j,4) = -7.30549*airRH(j,4)+ 337.63933;
    elseif airRH(j,4)>=39;
        airzero(j,4) = -9.14383*airRH(j,4)+ 388.50821;
    else
        airzero(j,4) = (-7.30549*airRH(j,4)+ 337.63933) + (((temp(j,4)-36)/3)*((-1.83834*airRH(j,4))+ 50.86888));
    end
```

Normalize sensor response using air reference

```
sensor_mean(j,1) = maxresponse(j,1)/airzero(j,1);
sensor_mean(j,2) = maxresponse(j,2)/airzero(j,2);
sensor_mean(j,3) = maxresponse(j,3)/airzero(j,3);
sensor_mean(j,4) = maxresponse(j,4)/airzero(j,4);


fclose(fid);
```

```
end;
dlmwrite('C:\Kevin Moore\MATLAB\WorkingFolder\canola_16MC.csv',sensor_mean);
```

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Lot	Inoculation	Time	S1	S2	S3	S4
2016	10x7	6dpi	0.66512	0.11758	0.54407	0.76602
2016	10x7	6dpi	0.72365	0.11859	0.6009	0.79311
2016	10x7	6dpi	0.83716	0.15564	0.72077	0.8912
2016	10x7	6dpi	0.84915	0.16394	0.74112	0.92486
2016	10x7	6dpi	0.76377	0.14561	0.64514	0.84497
2016	10x6	6dpi	0.81108	0.16401	0.67273	0.86808
2016	10x6	6dpi	0.65931	0.11694	0.54105	0.77147
2016	10x6	6dpi	0.76543	0.1263	0.5944	0.84463
2016	10x6	6dpi	0.86643	0.18214	0.75649	0.93015
2016	10x6	6dpi	0.66273	0.12777	0.5541	0.7924
2016	10x5	6dpi	0.77691	0.1406	0.63408	0.80851
2016	10x5	6dpi	0.94347	0.24495	0.80429	0.90129
2016	10x5	6dpi	0.76667	0.14112	0.64308	0.87124
2016	10x5	6dpi	0.79821	0.15173	0.67915	0.83761
2016	10x5	6dpi	0.77343	0.14539	0.63206	0.87525
2016	10x0	6dpi	0.68107	0.11905	0.55381	0.77502
2016	10x0	6dpi	0.81066	0.14364	0.65918	0.87383
2016	10x0	6dpi	0.90667	0.19706	0.74678	0.95276
2016	10x0	6dpi	0.76637	0.14246	0.63424	0.84726
2016	10x0	6dpi	0.74625	0.13277	0.61097	0.77857
2016	NT	6dpi	1.2732	0.38516	1.235	1.0431
2016	NT	6dpi	1.1774	0.39001	1.084	0.94308
2016	NT	6dpi	1.019	0.28906	0.98461	0.91983
2016	NT	6dpi	1.2899	0.35742	1.1764	0.99173
2016	NT	6dpi	1.2337	0.32902	1.1604	0.99544
2015	10x7	6dpi	1.0108	0.21459	0.88939	0.94233
2015	10x7	6dpi	0.92146	0.17045	0.78877	0.9338
2015	10x7	6dpi	0.87081	0.18016	0.73231	0.87908
2015	10x7	6dpi	0.98938	0.20109	0.84189	0.94417
2015	10x7	6dpi	0.81699	0.14605	0.68218	0.85651
2015	10x6	6dpi	0.78371	0.13069	0.62038	0.80345
2015	10x6	6dpi	0.89027	0.17788	0.76909	0.89144
2015	10x6	6dpi	0.88592	0.19151	0.78135	0.97143
2015	10x6	6dpi	0.92312	0.18529	0.77615	0.90318
2015	10x6	6dpi	0.85494	0.17207	0.68985	0.88926
2015	10x5	6dpi	0.93649	0.18912	0.84159	0.93677
2015	10x5	6dpi	0.84466	0.16546	0.7114	0.82964
2015	10x5	6dpi	0.86249	0.17289	0.71695	0.89372
2015	10x5	6dpi	0.98027	0.24041	0.89211	0.95438
2015	10x5	6dpi	0.83258	0.14368	0.65066	0.87685
2015	10x0	6dpi	0.99794	0.19722	0.87781	0.93818
2015	10x0	6dpi	0.87014	0.15994	0.73158	0.90936
2015	10x0	6dpi	0.74031	0.12339	0.59339	0.79575
2015	10x0	6dpi	0.68188	0.1008	0.51026	0.7534
2015	10x0	6dpi	0.78878	0.15241	0.66522	0.82277
2015	NT	6dpi	1.0748	0.31562	0.94807	0.89059
2015	NT	6dpi	1.1936	0.33187	1.0573	0.99851
2015	NT	6dpi	1.085	0.27387	0.96773	0.9306
2015	NT	6dpi	1.0309	0.26899	0.91791	0.89344
2015	NT	6dpi	1.1189	0.30715	1.0284	0.96561

Lot	Inoculation	Time	S1	S2	S3	S4
2016	10x7	12dpi	0.75266	0.11579	0.62464	0.84857
2016	10x7	12dpi	0.70785	0.10922	0.58	0.95152
2016	10x7	12dpi	0.65073	0.087697	0.50395	0.80524
2016	10x7	12dpi	0.59666	0.082373	0.46096	0.75714
2016	10x7	12dpi	0.6118	0.086574	0.48491	0.77774
2016	10x6	12dpi	0.72922	0.1248	0.60756	0.95406
2016	10x6	12dpi	0.63359	0.089603	0.52025	0.90325
2016	10x6	12dpi	0.72894	0.10745	0.58925	0.96064
2016	10x6	12dpi	0.5813	0.089349	0.44456	0.76597
2016	10x6	12dpi	0.54245	0.077522	0.41076	0.74327
2016	10x5	12dpi	0.60882	0.089849	0.47709	0.75603
2016	10x5	12dpi	0.66269	0.091669	0.52443	0.88903
2016	10x5	12dpi	0.60241	0.087497	0.47835	0.77262
2016	10x5	12dpi	0.5371	0.07795	0.42378	0.73681
2016	10x5	12dpi	0.59275	0.090022	0.46267	0.75204
2016	10x0	12dpi	0.53975	0.07179	0.40538	0.72831
2016	10x0	12dpi	0.64067	0.087008	0.49313	0.88748
2016	10x0	12dpi	0.63299	0.099189	0.52356	0.76973
2016	10x0	12dpi	0.6346	0.091013	0.49776	0.78792
2016	10x0	12dpi	0.59821	0.075487	0.44595	0.78307
2016	NT	12dpi	1.036	0.24547	1.031	0.92474
2016	NT	12dpi	1.2171	0.40551	1.1772	1.1404
2016	NT	12dpi	1.1829	0.29031	1.1659	1.1523
2016	NT	12dpi	1.1002	0.3625	1.0647	0.94951
2016	NT	12dpi	1.0918	0.32684	1.0842	0.96246
2015	10x7	12dpi	1.0178	0.20497	0.98689	1.0649
2015	10x7	12dpi	0.72712	0.10265	0.58728	0.82396
2015	10x7	12dpi	0.75635	0.11864	0.62875	0.95949
2015	10x7	12dpi	0.66901	0.10191	0.53153	0.76806
2015	10x7	12dpi	0.61892	0.096837	0.49284	0.7709
2015	10x6	12dpi	0.7503	0.10945	0.60454	0.83265
2015	10x6	12dpi	0.63504	0.10034	0.5237	0.76549
2015	10x6	12dpi	0.7963	0.12194	0.65552	1.0015
2015	10x6	12dpi	0.677	0.087098	0.51827	0.85898
2015	10x6	12dpi	0.77028	0.12493	0.64588	0.98884
2015	10x5	12dpi	0.71034	0.10509	0.56866	0.80621
2015	10x5	12dpi	0.69242	0.092541	0.53733	0.86284
2015	10x5	12dpi	0.81091	0.12966	0.7112	0.98656
2015	10x5	12dpi	0.63002	0.088972	0.4869	0.8035
2015	10x5	12dpi	0.68931	0.098544	0.52345	0.86404
2015	10x0	12dpi	0.70754	0.095856	0.55596	0.89048
2015	10x0	12dpi	0.66624	0.088898	0.51935	0.88621
2015	10x0	12dpi	0.66082	0.11208	0.53679	0.80304
2015	10x0	12dpi	0.57797	0.070876	0.41081	0.77313
2015	10x0	12dpi	0.76658	0.10969	0.63395	0.97649
2015	NT	12dpi	1.0749	0.26573	1.0165	1.0524
2015	NT	12dpi	1.1485	0.24589	1.0767	0.97834
2015	NT	12dpi	0.97363	0.25138	0.94199	0.91501
2015	NT	12dpi	1.2387	0.32015	1.1987	1.1508
2015	NT	12dpi	1.1594	0.28339	1.1673	1.1406
2016	10x7	18dpi	0.5925	0.10036	0.45001	0.68487

Lot	Inoculation	Time	S1	S2	S3	S4
2016	10x7	18dpi	0.67164	0.10532	0.50504	0.74141
2016	10x7	18dpi	0.58308	0.085633	0.43996	0.69179
2016	10x7	18dpi	0.61159	0.099642	0.47842	0.7076
2016	10x7	18dpi	0.59512	0.088403	0.44689	0.68295
2016	10x6	18dpi	0.63977	0.10609	0.50186	0.77364
2016	10x6	18dpi	0.596	0.098905	0.46945	0.78665
2016	10x6	18dpi	0.61194	0.089842	0.44962	0.71011
2016	10x6	18dpi	0.54397	0.071642	0.3884	0.64831
2016	10x6	18dpi	0.56207	0.086027	0.42935	0.7601
2016	10x5	18dpi	0.63673	0.10415	0.49086	0.84082
2016	10x5	18dpi	0.57843	0.071662	0.39759	0.66442
2016	10x5	18dpi	0.58032	0.094946	0.46361	0.78668
2016	10x5	18dpi	0.52787	0.069173	0.37272	0.62391
2016	10x5	18dpi	0.54384	0.073151	0.3764	0.63207
2016	10x0	18dpi	0.54244	0.075071	0.38801	0.76337
2016	10x0	18dpi	0.52998	0.072761	0.39399	0.6548
2016	10x0	18dpi	0.5486	0.080265	0.42204	0.69722
2016	10x0	18dpi	0.60004	0.095574	0.46889	0.79586
2016	10x0	18dpi	0.61594	0.090119	0.47434	0.71182
2016	NT	18dpi	1.1154	0.39056	1.1409	0.91261
2016	NT	18dpi	1.0574	0.38124	1.1266	0.91455
2016	NT	18dpi	1.0999	0.40142	1.1377	0.90909
2016	NT	18dpi	1.0963	0.38273	1.1428	0.91246
2016	NT	18dpi	1.1748	0.38457	1.1928	0.88715
2015	10x7	18dpi	1.1027	0.2512	1.1073	0.88768
2015	10x7	18dpi	0.63275	0.1065	0.50031	0.80007
2015	10x7	18dpi	0.59332	0.092496	0.43683	0.7074
2015	10x7	18dpi	0.63902	0.10938	0.49812	0.73714
2015	10x7	18dpi	0.6668	0.095791	0.49916	0.76827
2015	10x6	18dpi	0.65189	0.11465	0.51099	0.78378
2015	10x6	18dpi	0.66999	0.12255	0.53983	0.83778
2015	10x6	18dpi	0.66125	0.12458	0.54859	0.79745
2015	10x6	18dpi	0.65418	0.11742	0.53727	0.79796
2015	10x6	18dpi	0.69595	0.12621	0.53553	0.75509
2015	10x5	18dpi	0.68624	0.11218	0.53917	0.74304
2015	10x5	18dpi	0.60933	0.099726	0.47237	0.8131
2015	10x5	18dpi	0.64235	0.10541	0.49847	0.73844
2015	10x5	18dpi	0.65128	0.11509	0.51828	0.85028
2015	10x5	18dpi	0.61302	0.080555	0.43432	0.68663
2015	10x0	18dpi	0.63426	0.1119	0.50605	0.82251
2015	10x0	18dpi	0.57375	0.080185	0.43441	0.73702
2015	10x0	18dpi	0.59861	0.09102	0.45079	0.69459
2015	10x0	18dpi	0.49691	0.065278	0.3495	0.65982
2015	10x0	18dpi	0.6193	0.086807	0.44568	0.68642
2015	NT	18dpi	1.0107	0.34523	0.98873	0.8531
2015	NT	18dpi	1.1376	0.40279	1.1531	0.90089
2015	NT	18dpi	1.0465	0.32916	1.0675	0.96667
2015	NT	18dpi	1.0974	0.3323	1.0919	0.89494
2015	NT	18dpi	1.084	0.36214	1.0644	0.89461

```
DATA enose;
INPUT year$ inoc$ dpi$ class$ s1 s2 s3 s4;
DATALINES;
2016	10x7	6dpi	mold	0.66512	0.11758	0.54407	0.76602
2016	10x7	6dpi	mold	0.72365	0.11859	0.6009	0.79311
2016	10x7	6dpi	mold	0.83716	0.15564	0.72077	0.8912
2016	10x7	6dpi	mold	0.84915	0.16394	0.74112	0.92486
2016	10x7	6dpi	mold	0.76377	0.14561	0.64514	0.84497
2016	10x6	6dpi	mold	0.81108	0.16401	0.67273	0.86808
2016	10x6	6dpi	mold	0.65931	0.11694	0.54105	0.77147
2016	10x6	6dpi	mold	0.76543	0.1263	0.5944	0.84463
2016	10x6	6dpi	mold	0.86643	0.18214	0.75649	0.93015
2016	10x6	6dpi	mold	0.66273	0.12777	0.5541	0.7924
2016	10x5	6dpi	mold	0.77691	0.1406	0.63408	0.80851
2016	10x5	6dpi	mold	0.94347	0.24495	0.80429	0.90129
2016	10x5	6dpi	mold	0.76667	0.14112	0.64308	0.87124
2016	10x5	6dpi	mold	0.79821	0.15173	0.67915	0.83761
2016	10x5	6dpi	mold	0.77343	0.14539	0.63206	0.87525
2016	10x0	6dpi	mold	0.68107	0.11905	0.55381	0.77502
2016	10x0	6dpi	mold	0.81066	0.14364	0.65918	0.87383
2016	10x0	6dpi	mold	0.90667	0.19706	0.74678	0.95276
2016	10x0	6dpi	mold	0.76637	0.14246	0.63424	0.84726
2016	10x0	6dpi	mold	0.74625	0.13277	0.61097	0.77857
2016	NT	6dpi	NT	1.2732	0.38516	1.235	1.0431
2016	NT	6dpi	NT	1.1774	0.39001	1.084	0.94308
2016	NT	6dpi	NT	1.019	0.28906	0.98461	0.91983
2016	NT	6dpi	NT	1.2899	0.35742	1.1764	0.99173
2016	NT	6dpi	NT	1.2337	0.32902	1.1604	0.99544
2015	10x7	6dpi	mold	1.0108	0.21459	0.88939	0.94233
2015	10x7	6dpi	mold	0.92146	0.17045	0.78877	0.9338
2015	10x7	6dpi	mold	0.87081	0.18016	0.73231	0.87908
2015	10x7	6dpi	mold	0.98938	0.20109	0.84189	0.94417
2015	10x7	6dpi	mold	0.81699	0.14605	0.68218	0.85651
2015	10x6	6dpi	mold	0.78371	0.13069	0.62038	0.80345
2015	10x6	6dpi	mold	0.89027	0.17788	0.76909	0.89144
2015	10x6	6dpi	mold	0.88592	0.19151	0.78135	0.97143
2015	10x6	6dpi	mold	0.92312	0.18529	0.77615	0.90318
2015	10x6	6dpi	mold	0.85494	0.17207	0.68985	0.88926
2015	10x5	6dpi	mold	0.93649	0.18912	0.84159	0.93677
2015	10x5	6dpi	mold	0.84466	0.16546	0.7114	0.82964
2015	10x5	6dpi	mold	0.86249	0.17289	0.71695	0.89372
2015	10x5	6dpi	mold	0.98027	0.24041	0.89211	0.95438
2015	10x5	6dpi	mold	0.83258	0.14368	0.65066	0.87685
2015	10x0	6dpi	mold	0.99794	0.19722	0.87781	0.93818
2015	10x0	6dpi	mold	0.87014	0.15994	0.73158	0.90936
2015	10x0	6dpi	mold	0.74031	0.12339	0.59339	0.79575
2015	10x0	6dpi	mold	0.68188	0.1008	0.51026	0.7534
2015	10x0	6dpi	mold	0.78878	0.15241	0.66522	0.82277
2015	NT	6dpi	NT	1.0748	0.31562	0.94807	0.89059
2015	NT	6dpi	NT	1.1936	0.33187	1.0573	0.99851
2015	NT	6dpi	NT	1.085	0.27387	0.96773	0.9306
2015	NT	6dpi	NT	1.0309	0.26899	0.91791	0.89344
2015	NT	6dpi	NT	1.1189	0.30715	1.0284	0.96561
2016	10x7	12dpi	mold	0.75266	0.11579	0.62464	0.84857
2016	10x7	12dpi	mold	0.70785	0.10922	0.58	0.95152
```

2016	10x7	12dpi	mold	0.65073	0.087697	0.50395	0.80524
2016	10x7	12dpi	mold	0.59666	0.082373	0.46096	0.75714
2016	10x7	12dpi	mold	0.6118	0.086574	0.48491	0.77774
2016	10x6	12dpi	mold	0.72922	0.1248	0.60756	0.95406
2016	10x6	12dpi	mold	0.63359	0.089603	0.52025	0.90325
2016	10x6	12dpi	mold	0.72894	0.10745	0.58925	0.96064
2016	10x6	12dpi	mold	0.5813	0.089349	0.44456	0.76597
2016	10x6	12dpi	mold	0.54245	0.077522	0.41076	0.74327
2016	10x5	12dpi	mold	0.60882	0.089849	0.47709	0.75603
2016	10x5	12dpi	mold	0.66269	0.091669	0.52443	0.88903
2016	10x5	12dpi	mold	0.60241	0.087497	0.47835	0.77262
2016	10x5	12dpi	mold	0.5371	0.07795	0.42378	0.73681
2016	10x5	12dpi	mold	0.59275	0.090022	0.46267	0.75204
2016	10x0	12dpi	mold	0.53975	0.07179	0.40538	0.72831
2016	10x0	12dpi	mold	0.64067	0.087008	0.49313	0.88748
2016	10x0	12dpi	mold	0.63299	0.099189	0.52356	0.76973
2016	10x0	12dpi	mold	0.6346	0.091013	0.49776	0.78792
2016	10x0	12dpi	mold	0.59821	0.075487	0.44595	0.78307
2016	NT	12dpi	NT	1.036	0.24547	1.031	0.92474
2016	NT	12dpi	NT	1.2171	0.40551	1.1772	1.1404
2016	NT	12dpi	NT	1.1829	0.29031	1.1659	1.1523
2016	NT	12dpi	NT	1.1002	0.3625	1.0647	0.94951
2016	NT	12dpi	NT	1.0918	0.32684	1.0842	0.96246
2015	10x7	12dpi	mold	1.0178	0.20497	0.98689	1.0649
2015	10x7	12dpi	mold	0.72712	0.10265	0.58728	0.82396
2015	10x7	12dpi	mold	0.75635	0.11864	0.62875	0.95949
2015	10x7	12dpi	mold	0.66901	0.10191	0.53153	0.76806
2015	10x7	12dpi	mold	0.61892	0.096837	0.49284	0.7709
2015	10x6	12dpi	mold	0.7503	0.10945	0.60454	0.83265
2015	10x6	12dpi	mold	0.63504	0.10034	0.5237	0.76549
2015	10x6	12dpi	mold	0.7963	0.12194	0.65552	1.0015
2015	10x6	12dpi	mold	0.677	0.087098	0.51827	0.85898
2015	10x6	12dpi	mold	0.77028	0.12493	0.64588	0.98884
2015	10x5	12dpi	mold	0.71034	0.10509	0.56866	0.80621
2015	10x5	12dpi	mold	0.69242	0.092541	0.53733	0.86284
2015	10x5	12dpi	mold	0.81091	0.12966	0.7112	0.98656
2015	10x5	12dpi	mold	0.63002	0.088972	0.4869	0.8035
2015	10x5	12dpi	mold	0.68931	0.098544	0.52345	0.86404
2015	10x0	12dpi	mold	0.70754	0.095856	0.55596	0.89048
2015	10x0	12dpi	mold	0.66624	0.088898	0.51935	0.88621
2015	10x0	12dpi	mold	0.66082	0.11208	0.53679	0.80304
2015	10x0	12dpi	mold	0.57797	0.070876	0.41081	0.77313
2015	10x0	12dpi	mold	0.76658	0.10969	0.63395	0.97649
2015	NT	12dpi	NT	1.0749	0.26573	1.0165	1.0524
2015	NT	12dpi	NT	1.1485	0.24589	1.0767	0.97834
2015	NT	12dpi	NT	0.97363	0.25138	0.94199	0.91501
2015	NT	12dpi	NT	1.2387	0.32015	1.1987	1.1508
2015	NT	12dpi	NT	1.1594	0.28339	1.1673	1.1406
2016	10x7	18dpi	mold	0.5925	0.10036	0.45001	0.68487
2016	10x7	18dpi	mold	0.67164	0.10532	0.50504	0.74141
2016	10x7	18dpi	mold	0.58308	0.085633	0.43996	0.69179
2016	10x7	18dpi	mold	0.61159	0.099642	0.47842	0.7076
2016	10x7	18dpi	mold	0.59512	0.088403	0.44689	0.68295
2016	10x6	18dpi	mold	0.63977	0.10609	0.50186	0.77364
2016	10x6	18dpi	mold	0.596	0.098905	0.46945	0.78665

```
2016    10x6    18dpi   mold    0.61194 0.089842    0.44962 0.71011
2016    10x6    18dpi   mold    0.54397 0.071642    0.3884  0.64831
2016    10x6    18dpi   mold    0.56207 0.086027    0.42935 0.7601
2016    10x5    18dpi   mold    0.63673 0.10415     0.49086 0.84082
2016    10x5    18dpi   mold    0.57843 0.071662    0.39759 0.66442
2016    10x5    18dpi   mold    0.58032 0.094946    0.46361 0.78668
2016    10x5    18dpi   mold    0.52787 0.069173    0.37272 0.62391
2016    10x5    18dpi   mold    0.54384 0.073151    0.3764  0.63207
2016    10x0    18dpi   mold    0.54244 0.075071    0.38801 0.76337
2016    10x0    18dpi   mold    0.52998 0.072761    0.39399 0.6548
2016    10x0    18dpi   mold    0.5486  0.080265    0.42204 0.69722
2016    10x0    18dpi   mold    0.60004 0.095574    0.46889 0.79586
2016    10x0    18dpi   mold    0.61594 0.090119    0.47434 0.71182
2016    NT      18dpi   NT      1.1154  0.39056     1.1409  0.91261
2016    NT      18dpi   NT      1.0574  0.38124     1.1266  0.91455
2016    NT      18dpi   NT      1.0999  0.40142     1.1377  0.90909
2016    NT      18dpi   NT      1.0963  0.38273     1.1428  0.91246
2016    NT      18dpi   NT      1.1748  0.38457     1.1928  0.88715
2015    10x7    18dpi   mold    1.1027  0.2512      1.1073  0.88768
2015    10x7    18dpi   mold    0.63275 0.1065      0.50031 0.80007
2015    10x7    18dpi   mold    0.59332 0.092496    0.43683 0.7074
2015    10x7    18dpi   mold    0.63902 0.10938     0.49812 0.73714
2015    10x7    18dpi   mold    0.6668  0.095791    0.49916 0.76827
2015    10x6    18dpi   mold    0.65189 0.11465     0.51099 0.78378
2015    10x6    18dpi   mold    0.66999 0.12255     0.53983 0.83778
2015    10x6    18dpi   mold    0.66125 0.12458     0.54859 0.79745
2015    10x6    18dpi   mold    0.65418 0.11742     0.53727 0.79796
2015    10x6    18dpi   mold    0.69595 0.12621     0.53553 0.75509
2015    10x5    18dpi   mold    0.68624 0.11218     0.53917 0.74304
2015    10x5    18dpi   mold    0.60933 0.099726    0.47237 0.8131
2015    10x5    18dpi   mold    0.64235 0.10541     0.49847 0.73844
2015    10x5    18dpi   mold    0.65128 0.11509     0.51828 0.85028
2015    10x5    18dpi   mold    0.61302 0.080555    0.43432 0.68663
2015    10x0    18dpi   mold    0.63426 0.1119      0.50605 0.82251
2015    10x0    18dpi   mold    0.57375 0.080185    0.43441 0.73702
2015    10x0    18dpi   mold    0.59861 0.09102     0.45079 0.69459
2015    10x0    18dpi   mold    0.49691 0.065278    0.3495  0.65982
2015    10x0    18dpi   mold    0.6193  0.086807    0.44568 0.68642
2015    NT      18dpi   NT      1.0107  0.34523     0.98873 0.8531
2015    NT      18dpi   NT      1.1376  0.40279     1.1531  0.90089
2015    NT      18dpi   NT      1.0465  0.32916     1.0675  0.96667
2015    NT      18dpi   NT      1.0974  0.3323      1.0919  0.89494
2015    NT      18dpi   NT      1.084   0.36214     1.0644  0.89461
;

TITLE ' ';
*PROC PRINT DATA=enose;
RUN;

*Test normality assumption;
PROC GLM DATA=enose;
CLASS class;
MODEL s1 s2 s3 s4 = class/NOUNI;
MANOVA H=class;
OUTPUT OUT=RESIDS(KEEP=R1 R2 R3 R4) R=R1 R2 R3 R4;
```

```
TITLE 'Test Normality';
RUN;
PROC PRINCOMP DATA=Resids PLOT(NCOMP=2) =SCORE;
VAR R1 R2 R3 R4;
RUN;

* Evaluate separation of classes;
TITLE 'Plot of Linear Discriminants';
PROC CANDISC DATA=enose ncan=3 out=outcan;
ods exclude tstruc bstruc pstruc tcoef pcoef;
CLASS class;
var s1 s2 s3 s4;
run;
%plotit(data=outcan, plotvars=Can2 Can1, symvar=class, symlen=4, symsize=0.4, labelva
run;


*Test equal covariance assumption;
PROC DISCRIM DATA=enose POOL=TEST;
CLASS class;
TITLE 'Test Equal Covariance';
RUN;

*Discriminate analysis;
PROC DISCRIM DATA=enose CROSSVALIDATE CROSSLIST;
CLASS class;
TITLE 'Linear Discriminate Analysis';
RUN;

PROC DISCRIM DATA=enose POOL=NO CROSSVALIDATE CROSSLIST;
CLASS class;
PRIORS 'mold'=.5 'NT'=.5 ;
TITLE 'Quadratic Discriminate Analysis';
RUN;

PROC DISCRIM DATA=enose METHOD=NPAR K=3 POOL=YES CROSSVALIDATE CROSSLIST;
CLASS class;
TITLE 'Nearest Neighbor Method';
RUN;

*Test to determine if all sensors are required for classification;
PROC STEPDISC DATA=enose METHOD=FORWARD;
CLASS class;
TITLE 'Forward Stepwise Selection';
RUN;
```

Test Normality

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
class	2	NT mold

Number of Observations Read	150
Number of Observations Used	150

Test Normality

The GLM Procedure
Multivariate Analysis of Variance

Characteristic Roots and Vectors of: E Inverse * H, where H = Type III SSCP Matrix for class E = Error SSCP Matrix					
		Characteristic Vector V'EV=1			
Characteristic Root	Percent	s1	s2	s3	s4
4.36538135	100.00	-0.64004099	2.03917434	0.53859027	-0.12478195
0.00000000	0.00	-0.59804311	2.07153461	-0.82108493	1.56165657
0.00000000	0.00	-2.44217349	-2.09155901	2.82755097	0.00000000
0.00000000	0.00	-1.20117846	2.34706830	0.00000000	0.00000000

MANOVA Test Criteria and Exact F Statistics for the Hypothesis of No Overall class Effect H = Type III SSCP Matrix for class E = Error SSCP Matrix S=1 M=1 N=71.5					
Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.18638004	158.25	4	145	<.0001
Pillai's Trace	0.81361996	158.25	4	145	<.0001
Hotelling-Lawley Trace	4.36538135	158.25	4	145	<.0001
Roy's Greatest Root	4.36538135	158.25	4	145	<.0001

Test Normality

The PRINCOMP Procedure

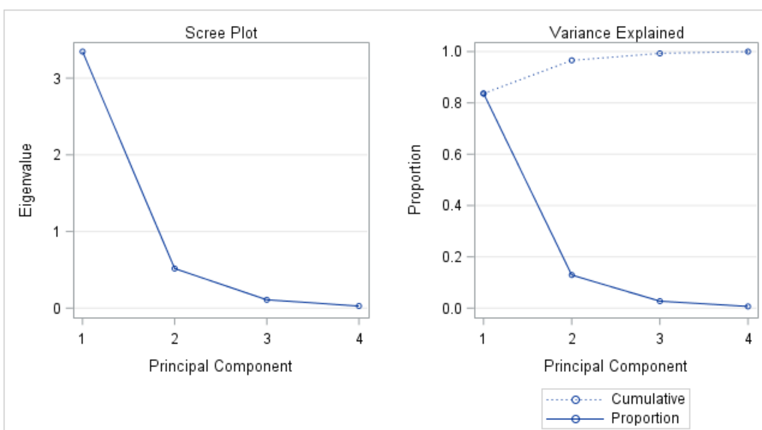
Observations	150
Variables	4

Simple Statistics				
	R1	**R2**	**R3**	**R4**
Mean	0.0000000000	0.0000000000	0.0000000000	0.0000000000
StD	0.1187040697	0.0425471558	0.1293369990	0.0893016080

Correlation Matrix				
	R1	**R2**	**R3**	**R4**
R1	1.0000	0.8284	0.9691	0.7550
R2	0.8284	1.0000	0.8641	0.4927
R3	0.9691	0.8641	1.0000	0.7446
R4	0.7550	0.4927	0.7446	1.0000

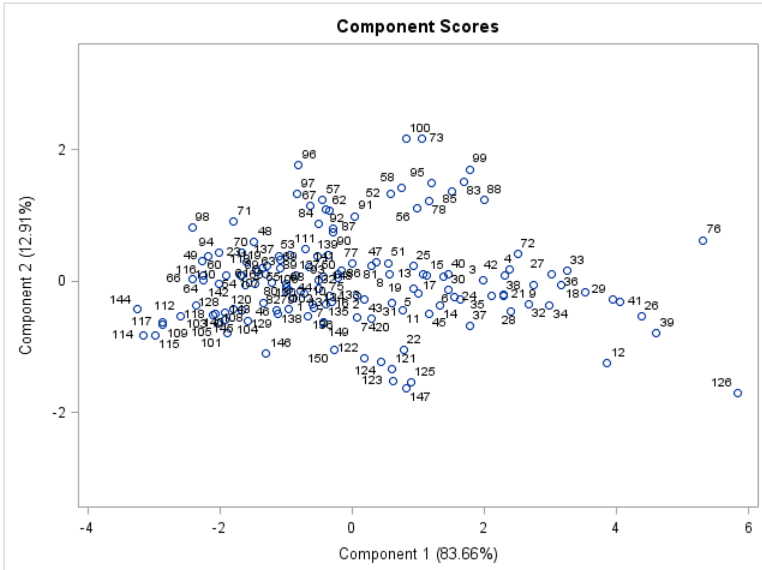
Eigenvalues of the Correlation Matrix				
	Eigenvalue	**Difference**	**Proportion**	**Cumulative**
1	3.34656768	2.83028880	0.8366	0.8366
2	0.51627887	0.40692326	0.1291	0.9657
3	0.10935561	0.08155777	0.0273	0.9931
4	0.02779784		0.0069	1.0000

Eigenvectors				
	Prin1	**Prin2**	**Prin3**	**Prin4**
R1	0.533794	-.027056	-.566884	0.626878
R2	0.479419	-.603034	0.624152	0.130161
R3	0.537571	-.088278	-.338178	-.767372
R4	0.442989	0.792354	0.417986	0.034972



Test Normality

The PRINCOMP Procedure



Plot of Linear Discriminants

The CANDISC Procedure

Total Sample Size	150	**DF Total**	149
Variables	4	**DF Within Classes**	148
Classes	2	**DF Between Classes**	1

Number of Observations Read	150
Number of Observations Used	150

Class Level Information

class	Variable Name	Frequency	Weight	Proportion
NT	NT	30	30.0000	0.200000
mold	mold	120	120.0000	0.800000

Plot of Linear Discriminants

The CANDISC Procedure

Multivariate Statistics and Exact F Statistics					
S=1 M=1 N=71.5					
Statistic	**Value**	**F Value**	**Num DF**	**Den DF**	**Pr > F**
Wilks' Lambda	0.18638004	158.25	4	145	<.0001
Pillai's Trace	0.81361996	158.25	4	145	<.0001
Hotelling-Lawley Trace	4.36538135	158.25	4	145	<.0001
Roy's Greatest Root	4.36538135	158.25	4	145	<.0001

Plot of Linear Discriminants

The CANDISC Procedure

	Canonical Correlation	Adjusted Canonical Correlation	Approximate Standard Error	Squared Canonical Correlation	Eigenvalues of Inv(E)*H = CanRsq/(1-CanRsq)				Test of H0: The canonical correlations in th	
					Eigenvalue	Difference	Proportion	Cumulative	Likelihood Ratio	Approximate F Value
1	0.902009	0.900493	0.015269	0.813620	4.3654		1.0000	1.0000	0.18638004	158.25

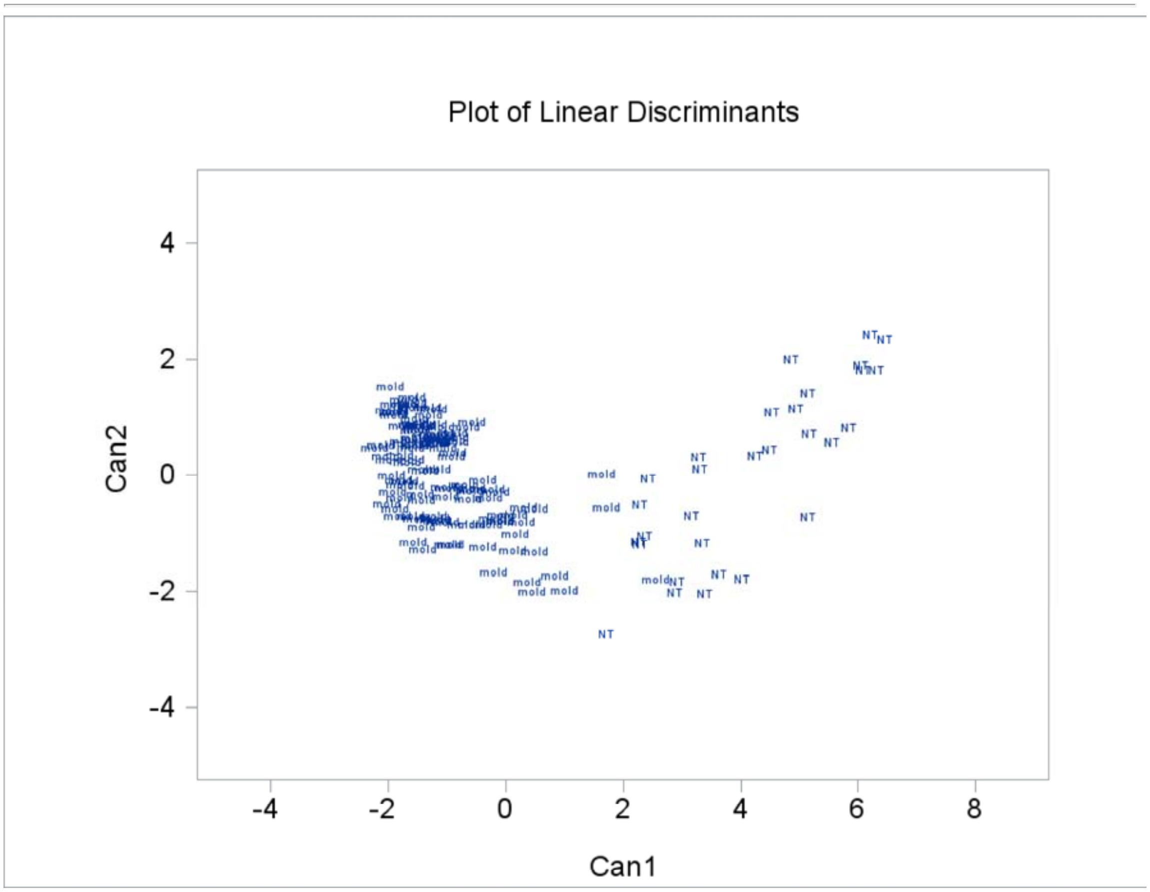
Note: The F statistic is exact.

Plot of Linear Discriminants

The CANDISC Procedure

Raw Canonical Coefficients			
Variable	Can1	Can2	Can3
s1	-7.78643473	-15.62407251	-20.41565325
s2	24.80762649	26.90999618	10.32304147
s3	6.55223342	1.61830025	7.35969086
s4	-1.51803790	-0.44297020	16.76685058

Class Means on Canonical Variables			
class	Can1	Can2	Can3
NT	4.150747528	-0.000000000	-0.000000000
mold	-1.037686882	0.000000000	0.000000000



Plot of Linear Discriminants
Can2
Can1

Test Equal Covariance

The DISCRIM Procedure

Total Sample Size	150	**DF Total**	149
Variables	4	**DF Within Classes**	148
Classes	2	**DF Between Classes**	1

Number of Observations Read	150
Number of Observations Used	150

Class Level Information					
class	**Variable Name**	**Frequency**	**Weight**	**Proportion**	**Prior Probability**
NT	NT	30	30.0000	0.200000	0.500000
mold	mold	120	120.0000	0.800000	0.500000

Within Covariance Matrix Information		
class	**Covariance Matrix Rank**	**Natural Log of the Determinant of the Covariance Matrix**
NT	4	-23.15587
mold	4	-26.51497
Pooled	4	-24.72085

Test Equal Covariance

The DISCRIM Procedure
Test of Homogeneity of Within Covariance Matrices

Chi-Square	DF	Pr > ChiSq
159.409538	10	<.0001

Since the Chi-Square value is significant at the 0.1 level, the within covariance matrices will be used in the discriminant function.
Reference: Morrison, D.F. (1976) Multivariate Statistical Methods p252.

Test Equal Covariance

The DISCRIM Procedure

Generalized Squared Distance to class		
From class	NT	mold
NT	-23.15587	32.41463
mold	17.65085	-26.51497

Test Equal Covariance

The DISCRIM Procedure
Classification Summary for Calibration Data: WORK.ENOSE
Resubstitution Summary using Quadratic Discriminant Function

Number of Observations and Percent Classified into class			
From class	NT	mold	Total
NT	30 100.00	0 0.00	30 100.00
mold	4 3.33	116 96.67	120 100.00
Total	34 22.67	116 77.33	150 100.00
Priors	0.5	0.5	

Error Count Estimates for class			
	NT	mold	Total
Rate	0.0000	0.0333	0.0167
Priors	0.5000	0.5000	

Linear Discriminate Analysis

The DISCRIM Procedure

Total Sample Size	150	**DF Total**	149
Variables	4	**DF Within Classes**	148
Classes	2	**DF Between Classes**	1

Number of Observations Read	150
Number of Observations Used	150

Class Level Information					
class	**Variable Name**	**Frequency**	**Weight**	**Proportion**	**Prior Probability**
NT	NT	30	30.0000	0.200000	0.500000
mold	mold	120	120.0000	0.800000	0.500000

Pooled Covariance Matrix Information	
Covariance Matrix Rank	**Natural Log of the Determinant of the Covariance Matrix**
4	-24.72085

Linear Discriminate Analysis

The DISCRIM Procedure

Generalized Squared Distance to class		
From class	NT	mold
NT	0	26.91985
mold	26.91985	0

Linear Discriminant Function for class		
Variable	NT	mold
Constant	-76.51453	-63.23154
s1	135.19174	175.59115
s2	236.65806	107.94532
s3	-194.30425	-228.30009
s4	138.66101	146.53725

Linear Discriminate Analysis

The DISCRIM Procedure
Classification Summary for Calibration Data: WORK.ENOSE
Resubstitution Summary using Linear Discriminant Function

Number of Observations and Percent Classified into class			
From class	NT	mold	Total
NT	30 100.00	0 0.00	30 100.00
mold	3 2.50	117 97.50	120 100.00
Total	33 22.00	117 78.00	150 100.00
Priors	0.5	0.5	

Error Count Estimates for class			
	NT	mold	Total
Rate	0.0000	0.0250	0.0125
Priors	0.5000	0.5000	

Linear Discriminate Analysis

The DISCRIM Procedure
Classification Results for Calibration Data: WORK.ENOSE
Cross-validation Results using Linear Discriminant Function

Posterior Probability of Membership in class					
Obs	From class	Classified into class		NT	mold
1	mold	mold		0.0000	1.0000
2	mold	mold		0.0000	1.0000
3	mold	mold		0.0001	0.9999
4	mold	mold		0.0002	0.9998
5	mold	mold		0.0000	1.0000
6	mold	mold		0.0001	0.9999
7	mold	mold		0.0000	1.0000
8	mold	mold		0.0000	1.0000
9	mold	mold		0.0016	0.9984
10	mold	mold		0.0000	1.0000
11	mold	mold		0.0000	1.0000
12	mold	NT	*	0.7411	0.2589
13	mold	mold		0.0000	1.0000
14	mold	mold		0.0001	0.9999
15	mold	mold		0.0000	1.0000
16	mold	mold		0.0000	1.0000
17	mold	mold		0.0000	1.0000
18	mold	mold		0.0017	0.9983
19	mold	mold		0.0000	1.0000
20	mold	mold		0.0000	1.0000
21	NT	NT		1.0000	0.0000
22	NT	NT		1.0000	0.0000
23	NT	NT		0.9999	0.0001
24	NT	NT		1.0000	0.0000
25	NT	NT		1.0000	0.0000
26	mold	mold		0.0313	0.9687
27	mold	mold		0.0001	0.9999
28	mold	mold		0.0007	0.9993
29	mold	mold		0.0027	0.9973
30	mold	mold		0.0000	1.0000
31	mold	mold		0.0000	1.0000
32	mold	mold		0.0008	0.9992
33	mold	mold		0.0044	0.9956
34	mold	mold		0.0007	0.9993
35	mold	mold		0.0001	0.9999
36	mold	mold		0.0044	0.9956
37	mold	mold		0.0002	0.9998
38	mold	mold		0.0002	0.9998
39	mold	NT	*	0.7383	0.2617
40	mold	mold		0.0000	1.0000
41	mold	mold		0.0042	0.9958
42	mold	mold		0.0000	1.0000
43	mold	mold		0.0000	1.0000
44	mold	mold		0.0000	1.0000
45	mold	mold		0.0001	0.9999
46	NT	NT		0.9998	0.0002
47	NT	NT		0.9998	0.0002

48	NT	NT		0.9610	0.0390
49	NT	NT		0.9706	0.0294
50	NT	NT		0.9997	0.0003
51	mold	mold		0.0000	1.0000
52	mold	mold		0.0000	1.0000
53	mold	mold		0.0000	1.0000
54	mold	mold		0.0000	1.0000
55	mold	mold		0.0000	1.0000
56	mold	mold		0.0000	1.0000
57	mold	mold		0.0000	1.0000
58	mold	mold		0.0000	1.0000
59	mold	mold		0.0000	1.0000
60	mold	mold		0.0000	1.0000
61	mold	mold		0.0000	1.0000
62	mold	mold		0.0000	1.0000
63	mold	mold		0.0000	1.0000
64	mold	mold		0.0000	1.0000
65	mold	mold		0.0000	1.0000
66	mold	mold		0.0000	1.0000
67	mold	mold		0.0000	1.0000
68	mold	mold		0.0000	1.0000
69	mold	mold		0.0000	1.0000
70	mold	mold		0.0000	1.0000
71	NT	NT		0.9405	0.0595
72	NT	NT		1.0000	0.0000
73	NT	NT		0.9975	0.0025
74	NT	NT		1.0000	0.0000
75	NT	NT		1.0000	0.0000
76	mold	mold		0.1528	0.8472
77	mold	mold		0.0000	1.0000
78	mold	mold		0.0000	1.0000
79	mold	mold		0.0000	1.0000
80	mold	mold		0.0000	1.0000
81	mold	mold		0.0000	1.0000
82	mold	mold		0.0000	1.0000
83	mold	mold		0.0000	1.0000
84	mold	mold		0.0000	1.0000
85	mold	mold		0.0000	1.0000
86	mold	mold		0.0000	1.0000
87	mold	mold		0.0000	1.0000
88	mold	mold		0.0000	1.0000
89	mold	mold		0.0000	1.0000
90	mold	mold		0.0000	1.0000
91	mold	mold		0.0000	1.0000
92	mold	mold		0.0000	1.0000
93	mold	mold		0.0000	1.0000
94	mold	mold		0.0000	1.0000
95	mold	mold		0.0000	1.0000
96	NT	NT		0.9675	0.0325
97	NT	mold	*	0.2261	0.7739
98	NT	NT		0.9862	0.0138
99	NT	NT		0.9999	0.0001
100	NT	NT		0.9972	0.0028
101	mold	mold		0.0000	1.0000
102	mold	mold		0.0000	1.0000
103					

	mold	**mold**		0.0000	1.0000
104	**mold**	**mold**		0.0000	1.0000
105	**mold**	**mold**		0.0000	1.0000
106	**mold**	**mold**		0.0000	1.0000
107	**mold**	**mold**		0.0000	1.0000
108	**mold**	**mold**		0.0000	1.0000
109	**mold**	**mold**		0.0000	1.0000
110	**mold**	**mold**		0.0000	1.0000
111	**mold**	**mold**		0.0000	1.0000
112	**mold**	**mold**		0.0000	1.0000
113	**mold**	**mold**		0.0000	1.0000
114	**mold**	**mold**		0.0000	1.0000
115	**mold**	**mold**		0.0000	1.0000
116	**mold**	**mold**		0.0000	1.0000
117	**mold**	**mold**		0.0000	1.0000
118	**mold**	**mold**		0.0000	1.0000
119	**mold**	**mold**		0.0000	1.0000
120	**mold**	**mold**		0.0000	1.0000
121	**NT**	**NT**		1.0000	0.0000
122	**NT**	**NT**		1.0000	0.0000
123	**NT**	**NT**		1.0000	0.0000
124	**NT**	**NT**		1.0000	0.0000
125	**NT**	**NT**		1.0000	0.0000
126	**mold**	**NT**	*	1.0000	0.0000
127	**mold**	**mold**		0.0000	1.0000
128	**mold**	**mold**		0.0000	1.0000
129	**mold**	**mold**		0.0000	1.0000
130	**mold**	**mold**		0.0000	1.0000
131	**mold**	**mold**		0.0000	1.0000
132	**mold**	**mold**		0.0000	1.0000
133	**mold**	**mold**		0.0000	1.0000
134	**mold**	**mold**		0.0000	1.0000
135	**mold**	**mold**		0.0000	1.0000
136	**mold**	**mold**		0.0000	1.0000
137	**mold**	**mold**		0.0000	1.0000
138	**mold**	**mold**		0.0000	1.0000
139	**mold**	**mold**		0.0000	1.0000
140	**mold**	**mold**		0.0000	1.0000
141	**mold**	**mold**		0.0000	1.0000
142	**mold**	**mold**		0.0000	1.0000
143	**mold**	**mold**		0.0000	1.0000
144	**mold**	**mold**		0.0000	1.0000
145	**mold**	**mold**		0.0000	1.0000
146	**NT**	**NT**		1.0000	0.0000
147	**NT**	**NT**		1.0000	0.0000
148	**NT**	**NT**		1.0000	0.0000
149	**NT**	**NT**		1.0000	0.0000
150	**NT**	**NT**		1.0000	0.0000

*** Misclassified observation**

Linear Discriminate Analysis

The DISCRIM Procedure
Classification Summary for Calibration Data: WORK.ENOSE
Cross-validation Summary using Linear Discriminant Function

Number of Observations and Percent Classified into class			
From class	NT	mold	Total
NT	29 96.67	1 3.33	30 100.00
mold	3 2.50	117 97.50	120 100.00
Total	32 21.33	118 78.67	150 100.00
Priors	0.5	0.5	

Error Count Estimates for class			
	NT	mold	Total
Rate	0.0333	0.0250	0.0292
Priors	0.5000	0.5000	

Quadratic Discriminate Analysis

The DISCRIM Procedure

Total Sample Size	150	**DF Total**	149
Variables	4	**DF Within Classes**	148
Classes	2	**DF Between Classes**	1

Number of Observations Read	150
Number of Observations Used	150

Class Level Information					
class	**Variable Name**	**Frequency**	**Weight**	**Proportion**	**Prior Probability**
NT	NT	30	30.0000	0.200000	0.500000
mold	mold	120	120.0000	0.800000	0.500000

Within Covariance Matrix Information		
class	**Covariance Matrix Rank**	**Natural Log of the Determinant of the Covariance Matrix**
NT	4	-23.15587
mold	4	-26.51497

Quadratic Discriminate Analysis

The DISCRIM Procedure

Generalized Squared Distance to class		
From class	NT	mold
NT	-21.76958	33.80092
mold	19.03714	-25.12867

Quadratic Discriminate Analysis

The DISCRIM Procedure
Classification Summary for Calibration Data: WORK.ENOSE
Resubstitution Summary using Quadratic Discriminant Function

Number of Observations and Percent Classified into class			
From class	**NT**	**mold**	**Total**
NT	30 100.00	0 0.00	30 100.00
mold	4 3.33	116 96.67	120 100.00
Total	34 22.67	116 77.33	150 100.00
Priors	0.5	0.5	

Error Count Estimates for class			
	NT	**mold**	**Total**
Rate	0.0000	0.0333	0.0167
Priors	0.5000	0.5000	

Quadratic Discriminate Analysis

The DISCRIM Procedure
Classification Results for Calibration Data: WORK.ENOSE
Cross-validation Results using Quadratic Discriminant Function

Posterior Probability of Membership in class					
Obs	From class	Classified into class		NT	mold
1	mold	mold		0.0000	1.0000
2	mold	mold		0.0000	1.0000
3	mold	mold		0.0000	1.0000
4	mold	mold		0.0000	1.0000
5	mold	mold		0.0000	1.0000
6	mold	mold		0.0000	1.0000
7	mold	mold		0.0000	1.0000
8	mold	mold		0.0000	1.0000
9	mold	mold		0.0001	0.9999
10	mold	mold		0.0000	1.0000
11	mold	mold		0.0000	1.0000
12	mold	NT	*	1.0000	0.0000
13	mold	mold		0.0000	1.0000
14	mold	mold		0.0000	1.0000
15	mold	mold		0.0000	1.0000
16	mold	mold		0.0000	1.0000
17	mold	mold		0.0000	1.0000
18	mold	mold		0.0031	0.9969
19	mold	mold		0.0000	1.0000
20	mold	mold		0.0000	1.0000
21	NT	NT		1.0000	0.0000
22	NT	NT		1.0000	0.0000
23	NT	NT		1.0000	0.0000
24	NT	NT		1.0000	0.0000
25	NT	NT		1.0000	0.0000
26	mold	mold		0.1589	0.8411
27	mold	mold		0.0011	0.9989
28	mold	mold		0.0001	0.9999
29	mold	mold		0.0543	0.9457
30	mold	mold		0.0000	1.0000
31	mold	mold		0.0000	1.0000
32	mold	mold		0.0003	0.9997
33	mold	mold		0.0003	0.9997
34	mold	mold		0.0015	0.9985
35	mold	mold		0.0000	1.0000
36	mold	mold		0.0102	0.9898
37	mold	mold		0.0000	1.0000
38	mold	mold		0.0000	1.0000
39	mold	NT	*	0.9537	0.0463
40	mold	mold		0.0000	1.0000
41	mold	mold		0.1269	0.8731
42	mold	mold		0.0000	1.0000
43	mold	mold		0.0000	1.0000
44	mold	mold		0.0000	1.0000
45	mold	mold		0.0000	1.0000
46	NT	NT		1.0000	0.0000
47	NT	NT		1.0000	0.0000

48	**NT**	**NT**		0.9992	0.0008
49	**NT**	**NT**		0.9997	0.0003
50	**NT**	**NT**		1.0000	0.0000
51	**mold**	**mold**		0.0000	1.0000
52	**mold**	**mold**		0.0000	1.0000
53	**mold**	**mold**		0.0000	1.0000
54	**mold**	**mold**		0.0000	1.0000
55	**mold**	**mold**		0.0000	1.0000
56	**mold**	**mold**		0.0000	1.0000
57	**mold**	**mold**		0.0000	1.0000
58	**mold**	**mold**		0.0000	1.0000
59	**mold**	**mold**		0.0000	1.0000
60	**mold**	**mold**		0.0000	1.0000
61	**mold**	**mold**		0.0000	1.0000
62	**mold**	**mold**		0.0000	1.0000
63	**mold**	**mold**		0.0000	1.0000
64	**mold**	**mold**		0.0000	1.0000
65	**mold**	**mold**		0.0000	1.0000
66	**mold**	**mold**		0.0000	1.0000
67	**mold**	**mold**		0.0000	1.0000
68	**mold**	**mold**		0.0000	1.0000
69	**mold**	**mold**		0.0000	1.0000
70	**mold**	**mold**		0.0000	1.0000
71	**NT**	**NT**		1.0000	0.0000
72	**NT**	**NT**		1.0000	0.0000
73	**NT**	**NT**		0.9999	0.0001
74	**NT**	**NT**		1.0000	0.0000
75	**NT**	**NT**		1.0000	0.0000
76	**mold**	**NT**	*	0.9996	0.0004
77	**mold**	**mold**		0.0000	1.0000
78	**mold**	**mold**		0.0000	1.0000
79	**mold**	**mold**		0.0000	1.0000
80	**mold**	**mold**		0.0000	1.0000
81	**mold**	**mold**		0.0000	1.0000
82	**mold**	**mold**		0.0000	1.0000
83	**mold**	**mold**		0.0000	1.0000
84	**mold**	**mold**		0.0000	1.0000
85	**mold**	**mold**		0.0000	1.0000
86	**mold**	**mold**		0.0000	1.0000
87	**mold**	**mold**		0.0000	1.0000
88	**mold**	**mold**		0.0000	1.0000
89	**mold**	**mold**		0.0000	1.0000
90	**mold**	**mold**		0.0000	1.0000
91	**mold**	**mold**		0.0000	1.0000
92	**mold**	**mold**		0.0000	1.0000
93	**mold**	**mold**		0.0000	1.0000
94	**mold**	**mold**		0.0000	1.0000
95	**mold**	**mold**		0.0000	1.0000
96	**NT**	**NT**		0.9969	0.0031
97	**NT**	**NT**		0.9873	0.0127
98	**NT**	**NT**		0.9999	0.0001
99	**NT**	**NT**		1.0000	0.0000
100	**NT**	**NT**		1.0000	0.0000
101	**mold**	**mold**		0.0000	1.0000
102	**mold**	**mold**		0.0000	1.0000
103					

	mold	**mold**		0.0000	1.0000
104	**mold**	**mold**		0.0000	1.0000
105	**mold**	**mold**		0.0000	1.0000
106	**mold**	**mold**		0.0000	1.0000
107	**mold**	**mold**		0.0000	1.0000
108	**mold**	**mold**		0.0000	1.0000
109	**mold**	**mold**		0.0000	1.0000
110	**mold**	**mold**		0.0000	1.0000
111	**mold**	**mold**		0.0000	1.0000
112	**mold**	**mold**		0.0000	1.0000
113	**mold**	**mold**		0.0000	1.0000
114	**mold**	**mold**		0.0000	1.0000
115	**mold**	**mold**		0.0000	1.0000
116	**mold**	**mold**		0.0000	1.0000
117	**mold**	**mold**		0.0000	1.0000
118	**mold**	**mold**		0.0000	1.0000
119	**mold**	**mold**		0.0000	1.0000
120	**mold**	**mold**		0.0000	1.0000
121	**NT**	**NT**		1.0000	0.0000
122	**NT**	**NT**		1.0000	0.0000
123	**NT**	**NT**		1.0000	0.0000
124	**NT**	**NT**		1.0000	0.0000
125	**NT**	**NT**		1.0000	0.0000
126	**mold**	**NT**	*	1.0000	0.0000
127	**mold**	**mold**		0.0000	1.0000
128	**mold**	**mold**		0.0000	1.0000
129	**mold**	**mold**		0.0000	1.0000
130	**mold**	**mold**		0.0000	1.0000
131	**mold**	**mold**		0.0000	1.0000
132	**mold**	**mold**		0.0000	1.0000
133	**mold**	**mold**		0.0000	1.0000
134	**mold**	**mold**		0.0000	1.0000
135	**mold**	**mold**		0.0000	1.0000
136	**mold**	**mold**		0.0000	1.0000
137	**mold**	**mold**		0.0000	1.0000
138	**mold**	**mold**		0.0000	1.0000
139	**mold**	**mold**		0.0000	1.0000
140	**mold**	**mold**		0.0000	1.0000
141	**mold**	**mold**		0.0000	1.0000
142	**mold**	**mold**		0.0000	1.0000
143	**mold**	**mold**		0.0000	1.0000
144	**mold**	**mold**		0.0000	1.0000
145	**mold**	**mold**		0.0000	1.0000
146	**NT**	**NT**		1.0000	0.0000
147	**NT**	**NT**		1.0000	0.0000
148	**NT**	**NT**		1.0000	0.0000
149	**NT**	**NT**		1.0000	0.0000
150	**NT**	**NT**		1.0000	0.0000

*** Misclassified observation**

Quadratic Discriminate Analysis

The DISCRIM Procedure
Classification Summary for Calibration Data: WORK.ENOSE
Cross-validation Summary using Quadratic Discriminant Function

Number of Observations and Percent Classified into class			
From class	NT	mold	Total
NT	30 100.00	0 0.00	30 100.00
mold	4 3.33	116 96.67	120 100.00
Total	34 22.67	116 77.33	150 100.00
Priors	0.5	0.5	

Error Count Estimates for class			
	NT	mold	Total
Rate	0.0000	0.0333	0.0167
Priors	0.5000	0.5000	

Nearest Neighbor Method

The DISCRIM Procedure

Total Sample Size	150	**DF Total**	149
Variables	4	**DF Within Classes**	148
Classes	2	**DF Between Classes**	1

Number of Observations Read	150
Number of Observations Used	150

Class Level Information					
class	**Variable Name**	**Frequency**	**Weight**	**Proportion**	**Prior Probability**
NT	NT	30	30.0000	0.200000	0.500000
mold	mold	120	120.0000	0.800000	0.500000

Nearest Neighbor Method

The DISCRIM Procedure
Classification Summary for Calibration Data: WORK.ENOSE
Resubstitution Summary using 3 Nearest Neighbors

Number of Observations and Percent Classified into class			
From class	NT	mold	Total
NT	30 100.00	0 0.00	30 100.00
mold	4 3.33	116 96.67	120 100.00
Total	34 22.67	116 77.33	150 100.00
Priors	0.5	0.5	

Error Count Estimates for class			
	NT	mold	Total
Rate	0.0000	0.0333	0.0167
Priors	0.5000	0.5000	

Nearest Neighbor Method

The DISCRIM Procedure
Classification Results for Calibration Data: WORK.ENOSE
Cross-validation Results using 3 Nearest Neighbors

Posterior Probability of Membership in class					
Obs	**From class**	**Classified into class**		**NT**	**mold**
1	mold	mold		0.0000	1.0000
2	mold	mold		0.0000	1.0000
3	mold	mold		0.0000	1.0000
4	mold	mold		0.0000	1.0000
5	mold	mold		0.0000	1.0000
6	mold	mold		0.0000	1.0000
7	mold	mold		0.0000	1.0000
8	mold	mold		0.0000	1.0000
9	mold	mold		0.0000	1.0000
10	mold	mold		0.0000	1.0000
11	mold	mold		0.0000	1.0000
12	mold	NT	*	0.8881	0.1119
13	mold	mold		0.0000	1.0000
14	mold	mold		0.0000	1.0000
15	mold	mold		0.0000	1.0000
16	mold	mold		0.0000	1.0000
17	mold	mold		0.0000	1.0000
18	mold	mold		0.0000	1.0000
19	mold	mold		0.0000	1.0000
20	mold	mold		0.0000	1.0000
21	NT	NT		1.0000	0.0000
22	NT	NT		1.0000	0.0000
23	NT	NT		1.0000	0.0000
24	NT	NT		1.0000	0.0000
25	NT	NT		1.0000	0.0000
26	mold	mold		0.0000	1.0000
27	mold	mold		0.0000	1.0000
28	mold	mold		0.0000	1.0000
29	mold	mold		0.0000	1.0000
30	mold	mold		0.0000	1.0000
31	mold	mold		0.0000	1.0000
32	mold	mold		0.0000	1.0000
33	mold	mold		0.0000	1.0000
34	mold	mold		0.0000	1.0000
35	mold	mold		0.0000	1.0000
36	mold	mold		0.0000	1.0000
37	mold	mold		0.0000	1.0000
38	mold	mold		0.0000	1.0000
39	mold	NT	*	0.6648	0.3352
40	mold	mold		0.0000	1.0000
41	mold	mold		0.0000	1.0000
42	mold	mold		0.0000	1.0000
43	mold	mold		0.0000	1.0000
44	mold	mold		0.0000	1.0000
45	mold	mold		0.0000	1.0000
46	NT	NT		1.0000	0.0000
47	NT	NT		1.0000	0.0000

48	NT	NT		1.0000	0.0000
49	NT	NT		0.8922	0.1078
50	NT	NT		1.0000	0.0000
51	mold	mold		0.0000	1.0000
52	mold	mold		0.0000	1.0000
53	mold	mold		0.0000	1.0000
54	mold	mold		0.0000	1.0000
55	mold	mold		0.0000	1.0000
56	mold	mold		0.0000	1.0000
57	mold	mold		0.0000	1.0000
58	mold	mold		0.0000	1.0000
59	mold	mold		0.0000	1.0000
60	mold	mold		0.0000	1.0000
61	mold	mold		0.0000	1.0000
62	mold	mold		0.0000	1.0000
63	mold	mold		0.0000	1.0000
64	mold	mold		0.0000	1.0000
65	mold	mold		0.0000	1.0000
66	mold	mold		0.0000	1.0000
67	mold	mold		0.0000	1.0000
68	mold	mold		0.0000	1.0000
69	mold	mold		0.0000	1.0000
70	mold	mold		0.0000	1.0000
71	NT	NT		0.8922	0.1078
72	NT	NT		1.0000	0.0000
73	NT	NT		1.0000	0.0000
74	NT	NT		1.0000	0.0000
75	NT	NT		1.0000	0.0000
76	mold	NT	*	0.8881	0.1119
77	mold	mold		0.0000	1.0000
78	mold	mold		0.0000	1.0000
79	mold	mold		0.0000	1.0000
80	mold	mold		0.0000	1.0000
81	mold	mold		0.0000	1.0000
82	mold	mold		0.0000	1.0000
83	mold	mold		0.0000	1.0000
84	mold	mold		0.0000	1.0000
85	mold	mold		0.0000	1.0000
86	mold	mold		0.0000	1.0000
87	mold	mold		0.0000	1.0000
88	mold	mold		0.0000	1.0000
89	mold	mold		0.0000	1.0000
90	mold	mold		0.0000	1.0000
91	mold	mold		0.0000	1.0000
92	mold	mold		0.0000	1.0000
93	mold	mold		0.0000	1.0000
94	mold	mold		0.0000	1.0000
95	mold	mold		0.0000	1.0000
96	NT	NT		0.8922	0.1078
97	NT	NT		0.6742	0.3258
98	NT	NT		1.0000	0.0000
99	NT	NT		1.0000	0.0000
100	NT	NT		0.8922	0.1078
101	mold	mold		0.0000	1.0000
102	mold	mold		0.0000	1.0000
103					

	mold	mold		0.0000	1.0000
104	mold	mold		0.0000	1.0000
105	mold	mold		0.0000	1.0000
106	mold	mold		0.0000	1.0000
107	mold	mold		0.0000	1.0000
108	mold	mold		0.0000	1.0000
109	mold	mold		0.0000	1.0000
110	mold	mold		0.0000	1.0000
111	mold	mold		0.0000	1.0000
112	mold	mold		0.0000	1.0000
113	mold	mold		0.0000	1.0000
114	mold	mold		0.0000	1.0000
115	mold	mold		0.0000	1.0000
116	mold	mold		0.0000	1.0000
117	mold	mold		0.0000	1.0000
118	mold	mold		0.0000	1.0000
119	mold	mold		0.0000	1.0000
120	mold	mold		0.0000	1.0000
121	NT	NT		1.0000	0.0000
122	NT	NT		1.0000	0.0000
123	NT	NT		1.0000	0.0000
124	NT	NT		1.0000	0.0000
125	NT	NT		1.0000	0.0000
126	mold	NT	*	1.0000	0.0000
127	mold	mold		0.0000	1.0000
128	mold	mold		0.0000	1.0000
129	mold	mold		0.0000	1.0000
130	mold	mold		0.0000	1.0000
131	mold	mold		0.0000	1.0000
132	mold	mold		0.0000	1.0000
133	mold	mold		0.0000	1.0000
134	mold	mold		0.0000	1.0000
135	mold	mold		0.0000	1.0000
136	mold	mold		0.0000	1.0000
137	mold	mold		0.0000	1.0000
138	mold	mold		0.0000	1.0000
139	mold	mold		0.0000	1.0000
140	mold	mold		0.0000	1.0000
141	mold	mold		0.0000	1.0000
142	mold	mold		0.0000	1.0000
143	mold	mold		0.0000	1.0000
144	mold	mold		0.0000	1.0000
145	mold	mold		0.0000	1.0000
146	NT	NT		1.0000	0.0000
147	NT	NT		1.0000	0.0000
148	NT	NT		1.0000	0.0000
149	NT	NT		1.0000	0.0000
150	NT	NT		1.0000	0.0000

*** Misclassified observation**

Nearest Neighbor Method

The DISCRIM Procedure
Classification Summary for Calibration Data: WORK.ENOSE
Cross-validation Summary using 3 Nearest Neighbors

Number of Observations and Percent Classified into class			
From class	NT	mold	Total
NT	30 100.00	0 0.00	30 100.00
mold	4 3.33	116 96.67	120 100.00
Total	34 22.67	116 77.33	150 100.00
Priors	0.5	0.5	

Error Count Estimates for class			
	NT	mold	Total
Rate	0.0000	0.0333	0.0167
Priors	0.5000	0.5000	

Forward Stepwise Selection

The STEPDISC Procedure

The Method for Selecting Variables is FORWARD			
Total Sample Size	150	**Variable(s) in the Analysis**	4
Class Levels	2	**Variable(s) Will Be Included**	0
		Significance Level to Enter	0.15

Number of Observations Read	150
Number of Observations Used	150

Class Level Information				
class	**Variable Name**	**Frequency**	**Weight**	**Proportion**
NT	NT	30	30.0000	0.200000
mold	mold	120	120.0000	0.800000

Forward Stepwise Selection

The STEPDISC Procedure
Forward Selection: Step 1

Statistics for Entry, DF = 1, 148				
Variable	R-Square	F Value	Pr > F	Tolerance
s1	0.6630	291.16	<.0001	1.0000
s2	0.8004	593.58	<.0001	1.0000
s3	0.7189	378.48	<.0001	1.0000
s4	0.3073	65.65	<.0001	1.0000

Variable s2 will be entered.

Variable(s) That Have Been Entered
s2

Multivariate Statistics					
Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.199573	593.58	1	148	<.0001
Pillai's Trace	0.800427	593.58	1	148	<.0001
Average Squared Canonical Correlation	0.800427				

Forward Stepwise Selection

The STEPDISC Procedure
Forward Selection: Step 2

Statistics for Entry, DF = 1, 147				
Variable	Partial R-Square	F Value	Pr > F	Tolerance
s1	0.0402	6.15	0.0143	0.1101
s3	0.0134	2.00	0.1596	0.0722
s4	0.0264	3.98	0.0478	0.5388

Variable s1 will be entered.

Variable(s) That Have Been Entered	
s1	s2

Multivariate Statistics					
Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.191558	310.20	2	147	<.0001
Pillai's Trace	0.808442	310.20	2	147	<.0001
Average Squared Canonical Correlation	0.808442				

Forward Stepwise Selection

The STEPDISC Procedure
Forward Selection: Step 3

Statistics for Entry, DF = 1, 146				
Variable	Partial R-Square	F Value	Pr > F	Tolerance
s3	0.0220	3.28	0.0721	0.0140
s4	0.0007	0.10	0.7483	0.0530

Variable s3 will be entered.

Variable(s) That Have Been Entered		
s1	s2	s3

Multivariate Statistics					
Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.187347	211.10	3	146	<.0001
Pillai's Trace	0.812653	211.10	3	146	<.0001
Average Squared Canonical Correlation	0.812653				

Forward Stepwise Selection

The STEPDISC Procedure
Forward Selection: Step 4

Statistics for Entry, DF = 1, 145				
Variable	Partial R-Square	F Value	Pr > F	Tolerance
s4	0.0052	0.75	0.3872	0.0129

No variables can be entered.

No further steps are possible.

Forward Stepwise Selection

The STEPDISC Procedure

Forward Selection Summary										
Step	Number In	Entered	Partial R-Square	F Value	Pr > F	Wilks' Lambda	Pr < Lambda	Average Squared Canonical Correlation	Pr > ASCC
1	1	s2	0.8004	593.58	<.0001	0.19957319	<.0001	0.80042681	<.0001
2	2	s1	0.0402	6.15	0.0143	0.19155822	<.0001	0.80844178	<.0001
3	3	s3	0.0220	3.28	0.0721	0.18734707	<.0001	0.81265293	<.0001

APPENDIX 3

GRAIN ENTRAPMENT PRESSURE ON THE TORSO: CAN YOU BREATHE WHILE BURIED IN GRAIN?

```
dm 'log;clear;output;clear;';
DATA one;
INPUT id$ rep grain$ mp depth d;
* depth is in inches with 0=top of shoulders;
* data is based on full sensor area;
DATALINES;
62614tos1      1   Wheat      0.261   0    0
62614tos2      2   Wheat      0.272   0    0
62614tos3      3   Wheat      0.312   0    0
62614toh1      1   Wheat      0.416   11   11
62614toh2      2   Wheat      0.377   11   11
62614toh3      3   Wheat      0.408   11   11
62614toh+1-1   1   Wheat      0.453   23   23
62614toh+1-2   2   Wheat      0.472   23   23
62614toh+1-3   3   Wheat      0.463   23   23
62614toh+2-1   1   Wheat      0.545   35   35
62614toh+2-2   2   Wheat      0.551   35   35
62614toh+2-3   3   Wheat      0.517   35   35
82014tos1      1   Canola     0.23    0    0
82014tos2      2   Canola     0.221   0    0
82014tos3      3   Canola     0.252   0    0
82114toh1      1   Canola     0.349   11   11
82114toh2      2   Canola     0.311   11   11
82114toh3      3   Canola     0.332   11   11
82114toh+1-1   1   Canola     0.371   23   23
82114toh+1-2   2   Canola     0.346   23   23
82114toh+1-3   3   Canola     0.376   23   23
82214toh+2-1   1   Canola     0.373   35   35
82214toh+2-2   2   Canola     0.353   35   35
82214toh+2-3   3   Canola     0.386   35   35
102114tos1     1   Soybeans   0.38    0    0
102114tos2     2   Soybeans   0.388   0    0
102114tos3     3   Soybeans   0.369   0    0
102114toh1     1   Soybeans   0.45    11   11
102114toh2     2   Soybeans   0.447   11   11
102114toh3     3   Soybeans   0.424   11   11
102114toh+1-1  1   Soybeans   0.513   23   23
102114toh+1-2  2   Soybeans   0.544   23   23
102114toh+1-3  3   Soybeans   0.497   23   23
102214toh+2-1  1   Soybeans   0.582   35   35
102214toh+2-2  2   Soybeans   0.563   35   35
102214toh+2-3  3   Soybeans   0.559   35   35
8415tos1       1   Corn       0.357   0    0
8415tos2       2   Corn       0.46    0    0
8415tos3       3   Corn       0.42    0    0
8415toh1       1   Corn       0.42    11   11
8415toh2       2   Corn       0.413   11   11
8415toh3       3   Corn       0.421   11   11
8515toh+1-1    1   Corn       0.546   23   23
8515toh+1-2    2   Corn       0.541   23   23
8515toh+1-3    3   Corn       0.521   23   23
8515toh+2-1    1   Corn       0.546   35   35
8515toh+2-2    2   Corn       0.604   35   35
8515toh+2-3    3   Corn       0.567   35   35
;
```

```
*PROC PRINT DATA=one;

PROC GLM;
CLASS depth grain rep;
MODEL mp=grain depth grain*depth grain*depth*rep;
TEST H=grain depth grain*depth E=grain*depth*rep;
lsmeans grain*depth/slice = (depth grain) diff E=grain*depth*rep;
RUN;

PROC SORT; BY grain;
PROC GLM; BY grain; CLASS rep;
MODEL mp= d d*d/ss1 solution;
RUN;

QUIT;
```

The SAS System

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
depth	4	0 11 23 35
grain	4	Canola Corn Soybeans Wheat
rep	3	1 2 3

Number of Observations Read	48
Number of Observations Used	48

The SAS System

The GLM Procedure

Dependent Variable: mp

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	47	0.47334898	0.01007125	.	.
Error	0	0.00000000	.		
Corrected Total	47	0.47334898			

R-Square	Coeff Var	Root MSE	mp Mean
1.000000	.	.	0.426646

Source	DF	Type I SS	Mean Square	F Value	Pr > F
grain	3	0.19444673	0.06481558	.	.
depth	3	0.24044273	0.08014758	.	.
depth*grain	9	0.02349219	0.00261024	.	.
depth*grain*rep	32	0.01496733	0.00046773	.	.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
grain	3	0.19444673	0.06481558	.	.
depth	3	0.24044273	0.08014758	.	.
depth*grain	9	0.02349219	0.00261024	.	.
depth*grain*rep	32	0.01496733	0.00046773	.	.

Tests of Hypotheses Using the Type III MS for depth*grain*rep as an Error Term					
Source	DF	Type III SS	Mean Square	F Value	Pr > F
grain	3	0.19444673	0.06481558	138.58	<.0001
depth	3	0.24044273	0.08014758	171.35	<.0001
depth*grain	9	0.02349219	0.00261024	5.58	0.0001

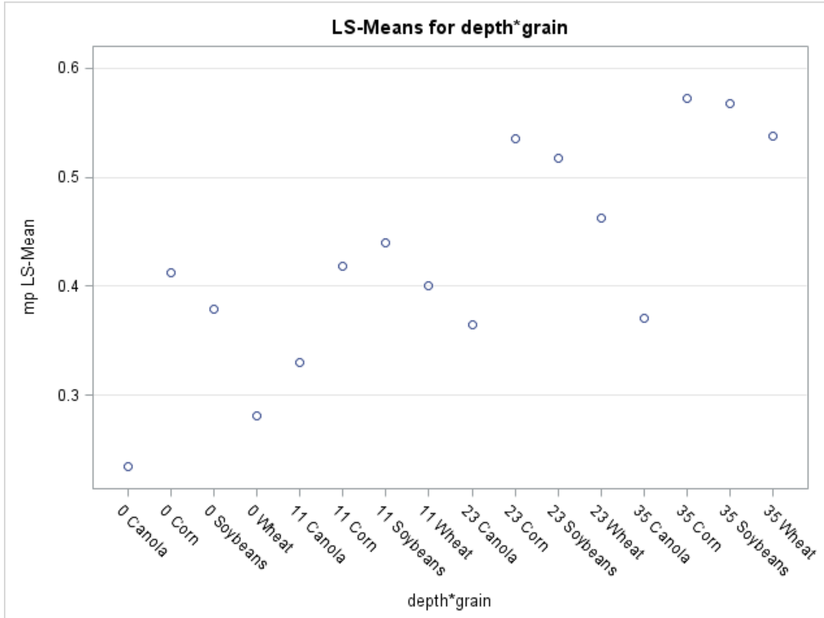
The SAS System

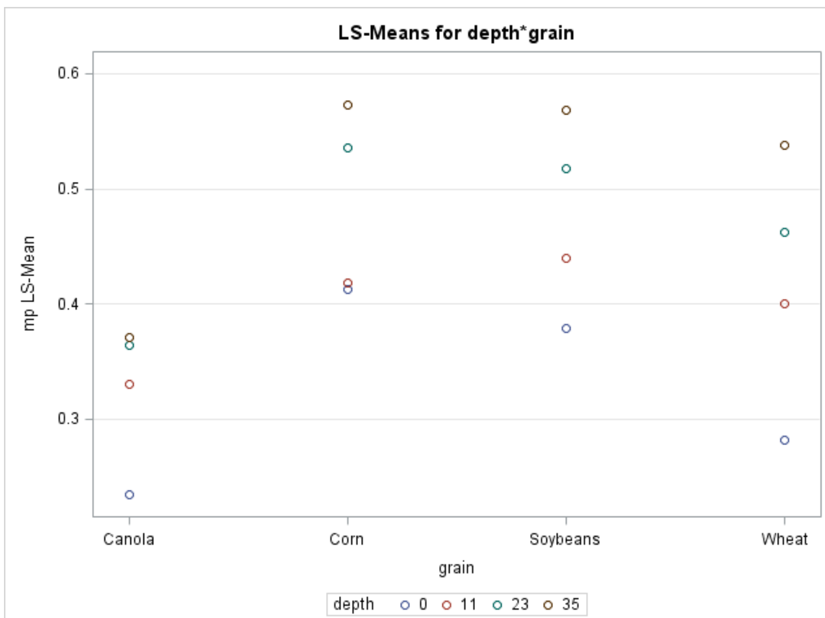
The GLM Procedure
Least Squares Means
Standard Errors and Probabilities Calculated Using the Type III MS for depth*grain*rep as an Error Term

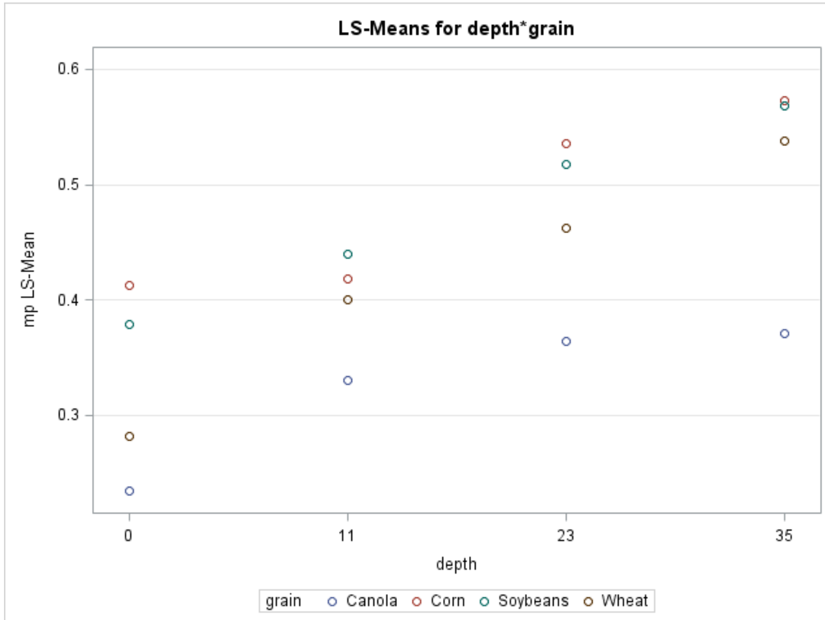
depth	grain	mp LSMEAN	LSMEAN Number
0	Canola	0.23433333	1
0	Corn	0.41233333	2
0	Soybeans	0.37900000	3
0	Wheat	0.28166667	4
11	Canola	0.33066667	5
11	Corn	0.41800000	6
11	Soybeans	0.44033333	7
11	Wheat	0.40033333	8
23	Canola	0.36433333	9
23	Corn	0.53600000	10
23	Soybeans	0.51800000	11
23	Wheat	0.46266667	12
35	Canola	0.37066667	13
35	Corn	0.57233333	14
35	Soybeans	0.56800000	15
35	Wheat	0.53766667	16

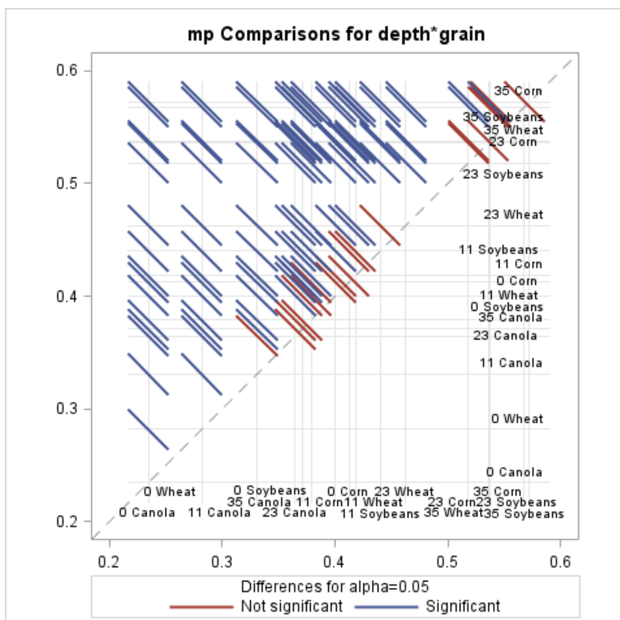
Least Squares Means for effect depth*grain
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: mp

i/j	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1		<.0001	<.0001	0.0115	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
2	<.0001		0.0682	<.0001	<.0001	0.7504	0.1227	0.5017	0.0105	<.0001	<.0001	0.0076	0.0246	<.0001	<.0001	<.0001
3	<.0001	0.0682		<.0001	0.0100	0.0345	0.0015	0.2359	0.4124	<.0001	<.0001	<.0001	0.6402	<.0001	<.0001	<.0001
4	0.0115	<.0001	<.0001		0.0091	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
5	<.0001	<.0001	0.0100	0.0091		<.0001	<.0001	0.0004	0.0656	<.0001	<.0001	<.0001	0.0304	<.0001	<.0001	<.0001
6	<.0001	0.7504	0.0345	<.0001	<.0001		0.2151	0.3246	0.0047	<.0001	<.0001	0.0165	0.0115	<.0001	<.0001	<.0001
7	<.0001	0.1227	0.0015	<.0001	<.0001	0.2151		0.0304	0.0001	<.0001	0.0001	0.2151	0.0004	<.0001	<.0001	<.0001
8	<.0001	0.5017	0.2359	<.0001	0.0004	0.3246	0.0304		0.0498	<.0001	<.0001	0.0013	0.1027	<.0001	<.0001	<.0001
9	<.0001	0.0105	0.4124	<.0001	0.0656	0.0047	0.0001	0.0498		<.0001	<.0001	<.0001	0.7222	<.0001	<.0001	<.0001
10	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		0.3157	0.0002	<.0001	0.0479	0.0794	0.9254
11	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0001	<.0001	<.0001	0.3157		0.0037	<.0001	0.0043	0.0079	0.2737
12	<.0001	0.0076	<.0001	<.0001	<.0001	0.0165	0.2151	0.0013	<.0001	0.0002	0.0037		<.0001	<.0001	<.0001	0.0002
13	<.0001	0.0246	0.6402	<.0001	0.0304	0.0115	0.0004	0.1027	0.7222	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001
14	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0479	0.0043	<.0001	<.0001		0.8077	0.0584
15	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0794	0.0079	<.0001	<.0001	0.8077		0.0955
16	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.9254	0.2737	0.0002	<.0001	0.0584	0.0955	


LS-Means for depth*grain
mp LS-Mean
0.6
0.5
0.4
0.3
0 Canola
0 Corn
0 Soybeans
0 Wheat
11 Canola
11 Corn
11 Soybeans
11 Wheat
23 Canola
23 Corn
23 Soybeans
23 Wheat
35 Canola
35 Corn
35 Soybeans
35 Wheat
depth*grain


LS-Means for depth*grain
mp LS-Mean
0.6
0.5
0.4
0.3
Canola
Corn
Soybeans
Wheat
grain
depth 0 11 23 35


LS-Means for depth*grain
mp LS-Mean
depth
grain Canola Corn Soybeans Wheat


mp Comparisons for depth*grain
Differences for alpha=0.05
Not significant
Significant

The SAS System

The GLM Procedure
Least Squares Means

depth*grain Effect Sliced by depth for mp					
depth	DF	Sum of Squares	Mean Square	F Value	Pr > F
0	3	0.061884	0.020628	44.10	<.0001
11	3	0.020189	0.006730	14.39	<.0001
23	3	0.053637	0.017879	38.23	<.0001
35	3	0.082230	0.027410	58.60	<.0001

The SAS System

The GLM Procedure
Least Squares Means

depth*grain Effect Sliced by grain for mp					
grain	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Canola	3	0.035655	0.011885	25.41	<.0001
Corn	3	0.059991	0.019997	42.75	<.0001
Soybeans	3	0.062726	0.020909	44.70	<.0001
Wheat	3	0.105562	0.035187	75.23	<.0001

Note: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

The SAS System

The GLM Procedure

grain=Canola

Class Level Information		
Class	**Levels**	**Values**
rep	3	1 2 3

Number of Observations Read	12
Number of Observations Used	12

The SAS System

The GLM Procedure

Dependent Variable: mp

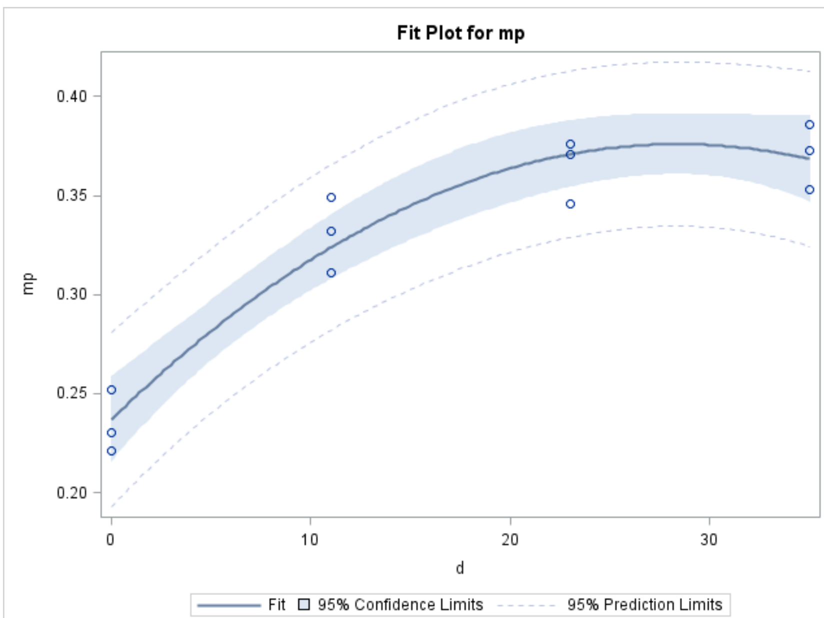
grain=Canola

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	0.03534714	0.01767357	60.92	<.0001
Error	9	0.00261086	0.00029010		
Corrected Total	11	0.03795800			

R-Square	Coeff Var	Root MSE	mp Mean
0.931217	5.240677	0.017032	0.325000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
d	1	0.02883214	0.02883214	99.39	<.0001
d*d	1	0.00651500	0.00651500	22.46	0.0011

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	0.2368111534	0.00953518	24.84	<.0001
d	0.0098004003	0.00133161	7.36	<.0001
d*d	-.0001725185	0.00003640	-4.74	0.0011



The SAS System

The GLM Procedure

grain=Corn

Class Level Information		
Class	**Levels**	**Values**
rep	3	1 2 3

Number of Observations Read	12
Number of Observations Used	12

The SAS System

The GLM Procedure

Dependent Variable: mp

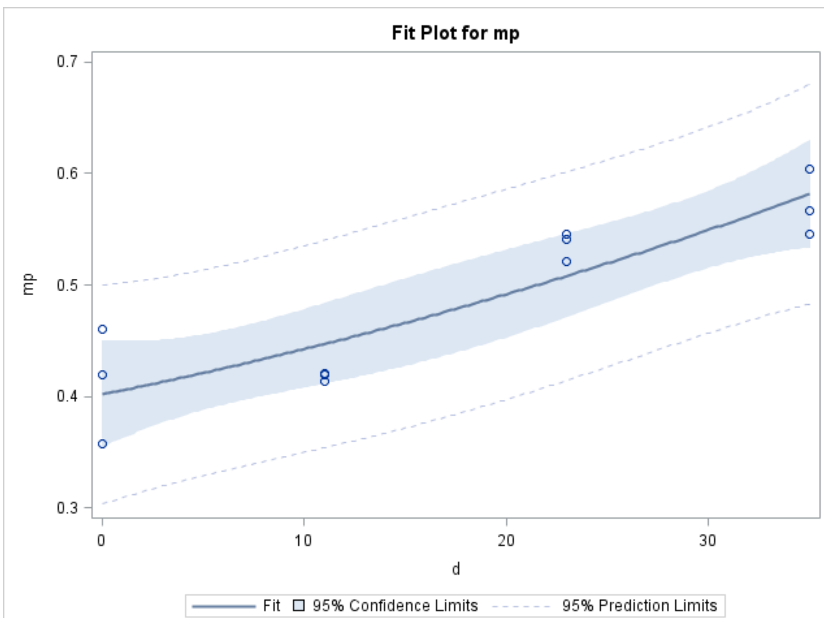
grain=Corn

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	0.05454806	0.02727403	18.96	0.0006
Error	9	0.01294861	0.00143873		
Corrected Total	11	0.06749667			

R-Square	Coeff Var	Root MSE	mp Mean
0.808159	7.826131	0.037931	0.484667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
d	1	0.05415076	0.05415076	37.64	0.0002
d*d	1	0.00039730	0.00039730	0.28	0.6119

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	0.4019200838	0.02123480	18.93	<.0001
d	0.0036392265	0.00296550	1.23	0.2509
d*d	0.0000426025	0.00008107	0.53	0.6119



The SAS System

The GLM Procedure

grain=Soybeans

Class Level Information		
Class	**Levels**	**Values**
rep	3	1 2 3

Number of Observations Read	12
Number of Observations Used	12

The SAS System

The GLM Procedure

Dependent Variable: mp

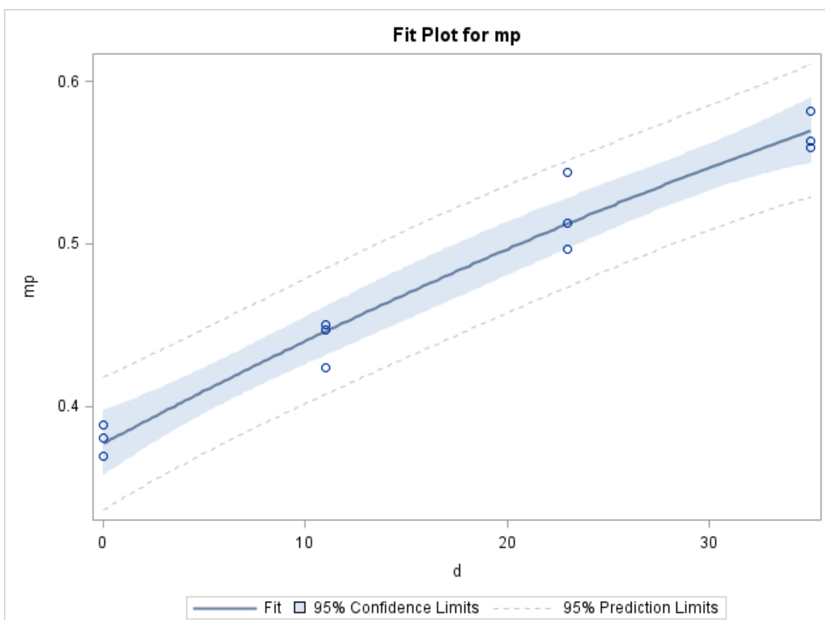
grain=Soybeans

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	0.06251672	0.03125836	125.59	<.0001
Error	9	0.00223995	0.00024888		
Corrected Total	11	0.06475667			

R-Square	Coeff Var	Root MSE	mp Mean
0.965410	3.311973	0.015776	0.476333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
d	1	0.06229103	0.06229103	250.28	<.0001
d*d	1	0.00022569	0.00022569	0.91	0.3658

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	0.3769581606	0.00883193	42.68	<.0001
d	0.0066334239	0.00123340	5.38	0.0004
d*d	-.0000321096	0.00003372	-0.95	0.3658



The SAS System

The GLM Procedure

grain=Wheat

Class Level Information		
Class	**Levels**	**Values**
rep	3	1 2 3

Number of Observations Read	12
Number of Observations Used	12

The SAS System

The GLM Procedure

Dependent Variable: mp

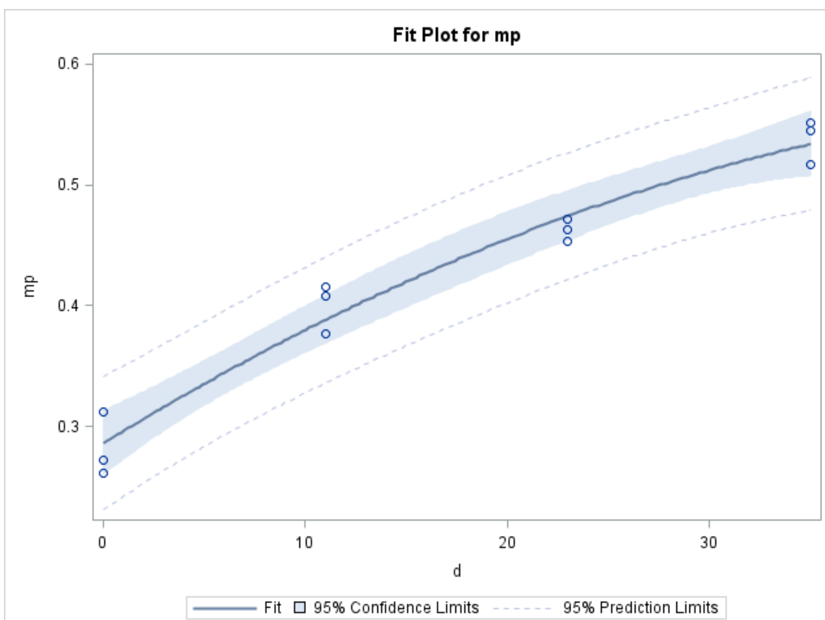
grain=Wheat

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	0.10461582	0.05230791	115.52	<.0001
Error	9	0.00407509	0.00045279		
Corrected Total	11	0.10869092			

R-Square	Coeff Var	Root MSE	mp Mean
0.962508	5.059359	0.021279	0.420583

Source	DF	Type I SS	Mean Square	F Value	Pr > F
d	1	0.10276213	0.10276213	226.95	<.0001
d*d	1	0.00185369	0.00185369	4.09	0.0737

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	0.2860087659	0.01191257	24.01	<.0001
d	0.0103020551	0.00166362	6.19	0.0002
d*d	-.0000920232	0.00004548	-2.02	0.0737



```
dm 'log;clear;output;clear;';
DATA one;
INPUT id$ rep grain$ mp depth d;
* depth is in inches with 0=top of shoulders;
* data is based on full sensor area;
* front and back contact pressure data combined;
DATALINES;
62614tos1       1   Wheat   0.261   0   0
62614tos2       2   Wheat   0.272   0   0
62614tos3       3   Wheat   0.312   0   0
62614toh1       1   Wheat   0.416   11  11
62614toh2       2   Wheat   0.377   11  11
62614toh3       3   Wheat   0.408   11  11
62614toh+1-1    1   Wheat   0.453   23  23
62614toh+1-2    2   Wheat   0.472   23  23
62614toh+1-3    3   Wheat   0.463   23  23
62614toh+2-1    1   Wheat   0.545   35  35
62614toh+2-2    2   Wheat   0.551   35  35
62614toh+2-3    3   Wheat   0.517   35  35
82014tos1       1   Canola  0.23    0   0
82014tos2       2   Canola  0.221   0   0
82014tos3       3   Canola  0.252   0   0
82114toh1       1   Canola  0.349   11  11
82114toh2       2   Canola  0.311   11  11
82114toh3       3   Canola  0.332   11  11
82114toh+1-1    1   Canola  0.371   23  23
82114toh+1-2    2   Canola  0.346   23  23
82114toh+1-3    3   Canola  0.376   23  23
82214toh+2-1    1   Canola  0.373   35  35
82214toh+2-2    2   Canola  0.353   35  35
82214toh+2-3    3   Canola  0.386   35  35
102114tos1      1   Corn/Soybeans   0.38    0   0
102114tos2      2   Corn/Soybeans   0.388   0   0
102114tos3      3   Corn/Soybeans   0.369   0   0
8415tos1        1   Corn/Soybeans   0.357   0   0
8415tos2        2   Corn/Soybeans   0.46    0   0
8415tos3        3   Corn/Soybeans   0.42    0   0
102114toh1      1   Corn/Soybeans   0.45    11  11
102114toh2      2   Corn/Soybeans   0.447   11  11
102114toh3      3   Corn/Soybeans   0.424   11  11
8415toh1        1   Corn/Soybeans   0.42    11  11
8415toh2        2   Corn/Soybeans   0.413   11  11
8415toh3        3   Corn/Soybeans   0.421   11  11
102114toh+1-1   1   Corn/Soybeans   0.513   23  23
102114toh+1-2   2   Corn/Soybeans   0.544   23  23
102114toh+1-3   3   Corn/Soybeans   0.497   23  23
8515toh+1-1     1   Corn/Soybeans   0.546   23  23
8515toh+1-2     2   Corn/Soybeans   0.541   23  23
8515toh+1-3     3   Corn/Soybeans   0.521   23  23
102214toh+2-1   1   Corn/Soybeans   0.582   35  35
102214toh+2-2   2   Corn/Soybeans   0.563   35  35
102214toh+2-3   3   Corn/Soybeans   0.559   35  35
8515toh+2-1     1   Corn/Soybeans   0.546   35  35
8515toh+2-2     2   Corn/Soybeans   0.604   35  35
8515toh+2-3     3   Corn/Soybeans   0.567   35  35
```

```
;
*PROC PRINT DATA=one;

PROC GLM;
CLASS depth grain rep;
MODEL mp=grain depth grain*depth grain*depth*rep;
TEST H=grain depth grain*depth E=grain*depth*rep;
lsmeans grain*depth/slice = (depth grain) diff E=grain*depth*rep;
RUN;

PROC SORT; BY grain;
PROC GLM; BY grain; CLASS rep;
MODEL mp= d d*d/ss1 solution;
RUN;

QUIT;
```

The SAS System

The GLM Procedure

Class Level Information		
Class	**Levels**	**Values**
depth	4	0 11 23 35
grain	3	Canola Corn/Soy Wheat
rep	3	1 2 3

Number of Observations Read	48
Number of Observations Used	48

The SAS System

The GLM Procedure

Dependent Variable: mp

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	35	0.46580198	0.01330863	21.16	<.0001
Error	12	0.00754700	0.00062892		
Corrected Total	47	0.47334898			

R-Square	Coeff Var	Root MSE	mp Mean
0.984056	5.877993	0.025078	0.426646

Source	DF	Type I SS	Mean Square	F Value	Pr > F
grain	2	0.19403006	0.09701503	154.26	<.0001
depth	3	0.24044273	0.08014758	127.44	<.0001
depth*grain	6	0.02097985	0.00349664	5.56	0.0058
depth*grain*rep	24	0.01034933	0.00043122	0.69	0.7921

Source	DF	Type III SS	Mean Square	F Value	Pr > F
grain	2	0.19403006	0.09701503	154.26	<.0001
depth	3	0.21993563	0.07331188	116.57	<.0001
depth*grain	6	0.02097985	0.00349664	5.56	0.0058
depth*grain*rep	24	0.01034933	0.00043122	0.69	0.7921

Tests of Hypotheses Using the Type III MS for depth*grain*rep as an Error Term					
Source	DF	Type III SS	Mean Square	F Value	Pr > F
grain	2	0.19403006	0.09701503	224.98	<.0001
depth	3	0.21993563	0.07331188	170.01	<.0001
depth*grain	6	0.02097985	0.00349664	8.11	<.0001

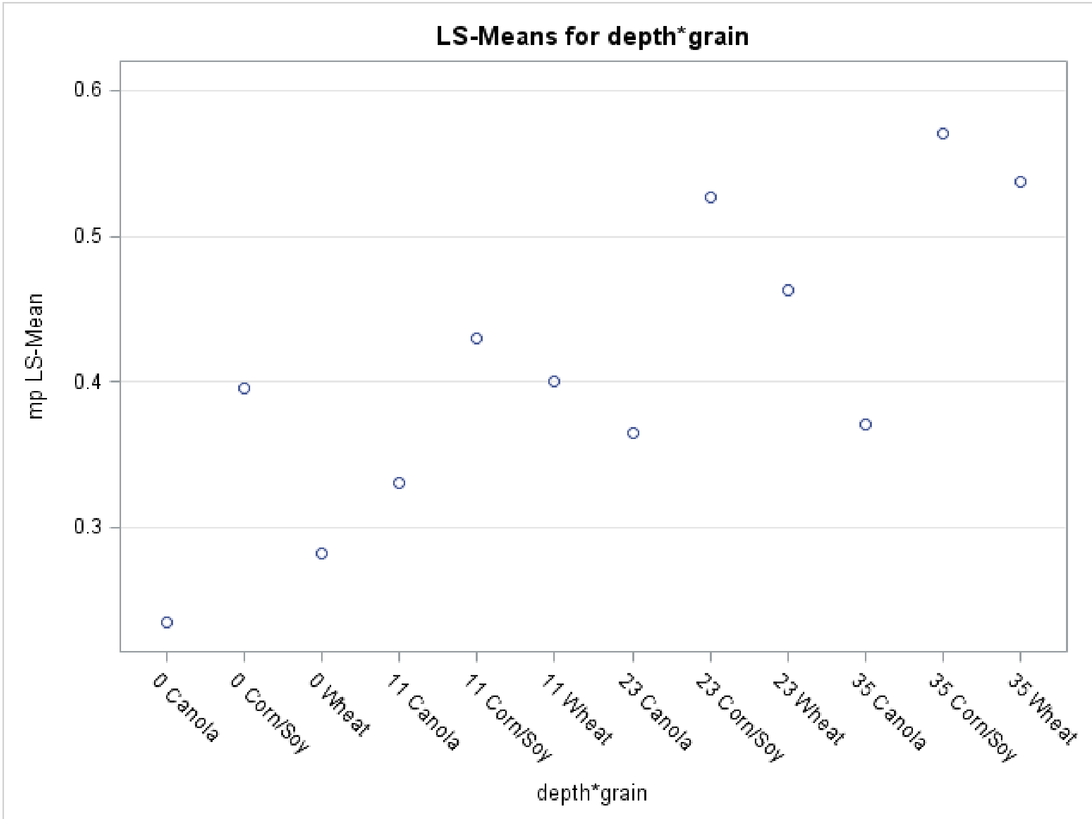
The SAS System

The GLM Procedure
Least Squares Means
Standard Errors and Probabilities Calculated Using the Type III MS for depth*grain*rep as an Error Term

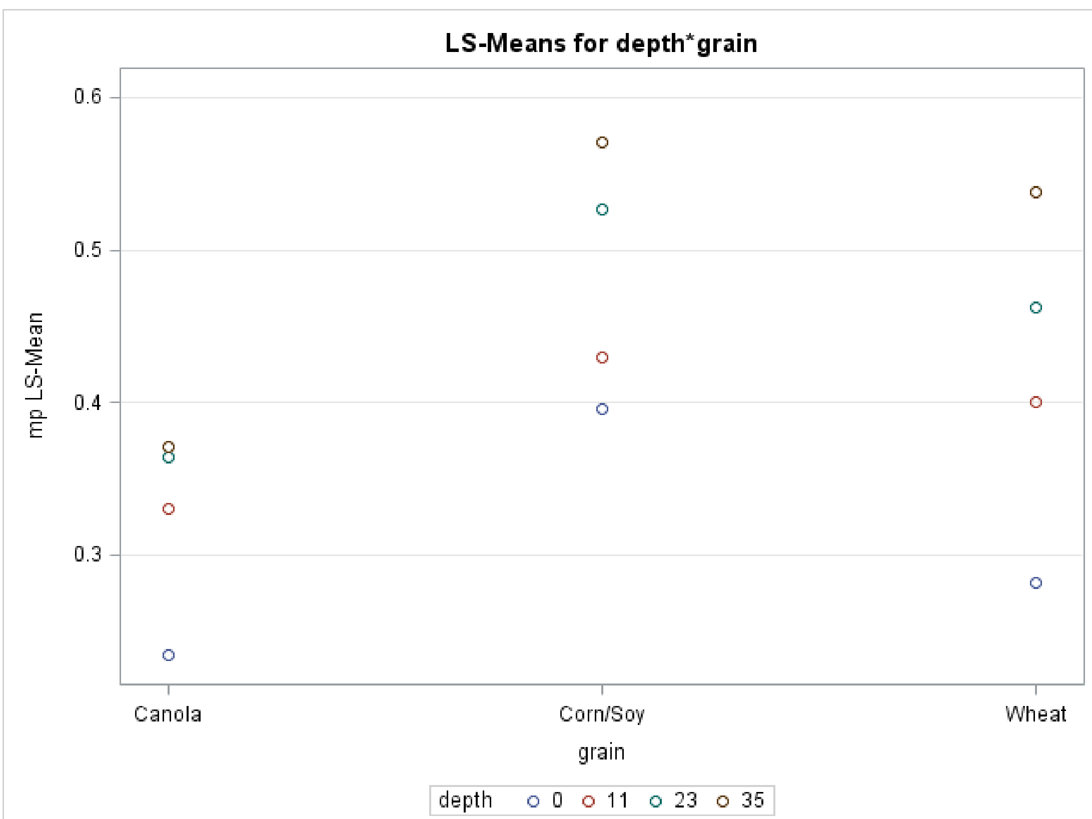
depth	grain	mp LSMEAN	LSMEAN Number
0	Canola	0.23433333	1
0	Corn/Soy	0.39566667	2
0	Wheat	0.28166667	3
11	Canola	0.33066667	4
11	Corn/Soy	0.42916667	5
11	Wheat	0.40033333	6
23	Canola	0.36433333	7
23	Corn/Soy	0.52700000	8
23	Wheat	0.46266667	9
35	Canola	0.37066667	10
35	Corn/Soy	0.57016667	11
35	Wheat	0.53766667	12

Least Squares Means for effect depth*grain
Pr > |t| for H0: LSMean(i)=LSMean(j)
Dependent Variable: mp

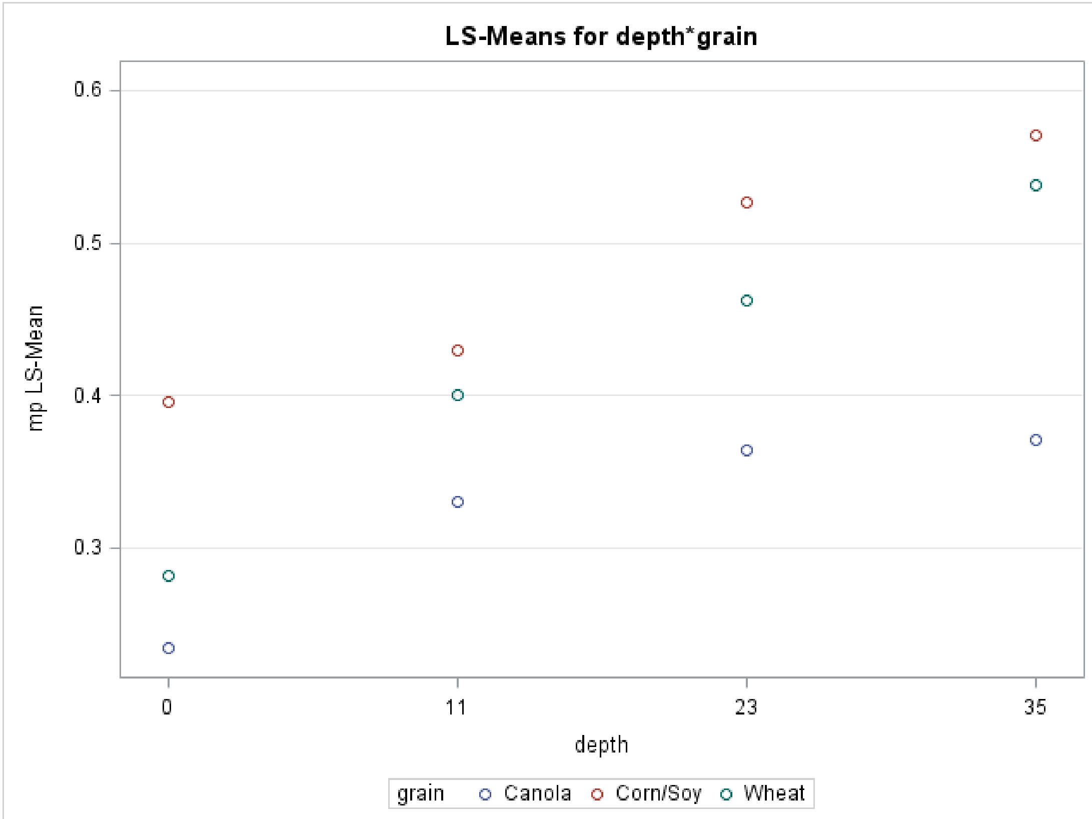
i/j	1	2	3	4	5	6	7	8	9	10	11	12
1		<.0001	0.0101	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
2	<.0001		<.0001	0.0002	0.0101	0.7534	0.0433	<.0001	0.0001	0.1016	<.0001	<.0001
3	0.0101	<.0001		0.0080	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
4	<.0001	0.0002	0.0080		<.0001	0.0004	0.0586	<.0001	<.0001	0.0268	<.0001	<.0001
5	<.0001	0.0101	<.0001	<.0001		0.0613	0.0002	<.0001	0.0317	0.0005	<.0001	<.0001
6	<.0001	0.7534	<.0001	0.0004	0.0613		0.0442	<.0001	0.0012	0.0929	<.0001	<.0001
7	<.0001	0.0433	<.0001	0.0586	0.0002	0.0442		<.0001	<.0001	0.7120	<.0001	<.0001
8	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		0.0002	<.0001	0.0014	0.4746
9	<.0001	0.0001	<.0001	<.0001	0.0317	0.0012	<.0001	0.0002		<.0001	<.0001	0.0002
10	<.0001	0.1016	<.0001	0.0268	0.0005	0.0929	0.7120	<.0001	<.0001		<.0001	<.0001
11	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0014	<.0001	<.0001		0.0366
12	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.4746	0.0002	<.0001	0.0366	

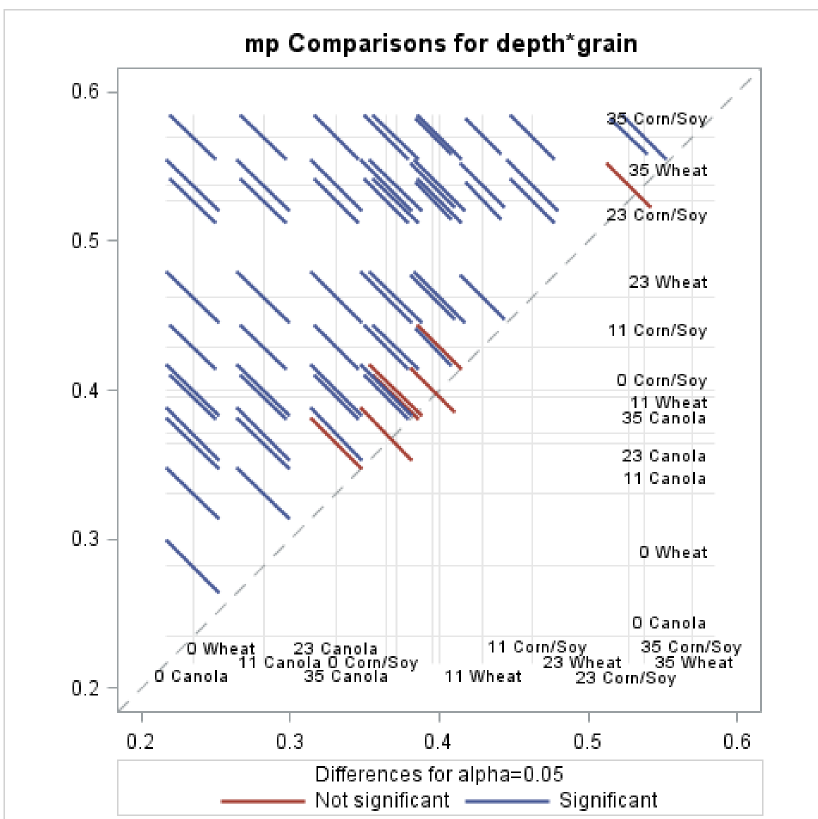


LS-Means for depth*grain
0.6
0.5
0.4
0.3
mp LS-Mean
0 Canola
0 Corn/Soy
0 Wheat
11 Canola
11 Corn/Soy
11 Wheat
23 Canola
23 Corn/Soy
23 Wheat
35 Canola
35 Corn/Soy
35 Wheat
depth*grain



LS-Means for depth*grain
0.6
0.5
0.4
0.3
mp LS-Mean
Canola
Corn/Soy
Wheat
grain
depth 0 11 23 35


LS-Means for depth*grain
mp LS-Mean
0.6
0.5
0.4
0.3
0
11
23
35
depth
grain Canola Corn/Soy Wheat


mp Comparisons for depth*grain
35 Corn/Soy
35 Wheat
23 Corn/Soy
23 Wheat
11 Corn/Soy
0 Corn/Soy
11 Wheat
35 Canola
23 Canola
11 Canola
0 Wheat
0 Canola
0.6
0.5
0.4
0.3
0.2
Differences for alpha=0.05
Not significant
Significant

The SAS System

The GLM Procedure
Least Squares Means

depth*grain Effect Sliced by depth for mp					
depth	DF	Sum of Squares	Mean Square	F Value	Pr > F
0	2	0.060217	0.030109	69.82	<.0001
11	2	0.019441	0.009720	22.54	<.0001
23	2	0.053151	0.026575	61.63	<.0001
35	2	0.082201	0.041101	95.31	<.0001

The SAS System

The GLM Procedure
Least Squares Means

depth*grain Effect Sliced by grain for mp					
grain	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Canola	3	0.035655	0.011885	27.56	<.0001
Corn/Soy	3	0.120205	0.040068	92.92	<.0001
Wheat	3	0.105562	0.035187	81.60	<.0001

Note: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

The SAS System

The GLM Procedure

grain=Canola

Class Level Information		
Class	**Levels**	**Values**
rep	3	1 2 3

Number of Observations Read	12
Number of Observations Used	12

The SAS System

The GLM Procedure

Dependent Variable: mp

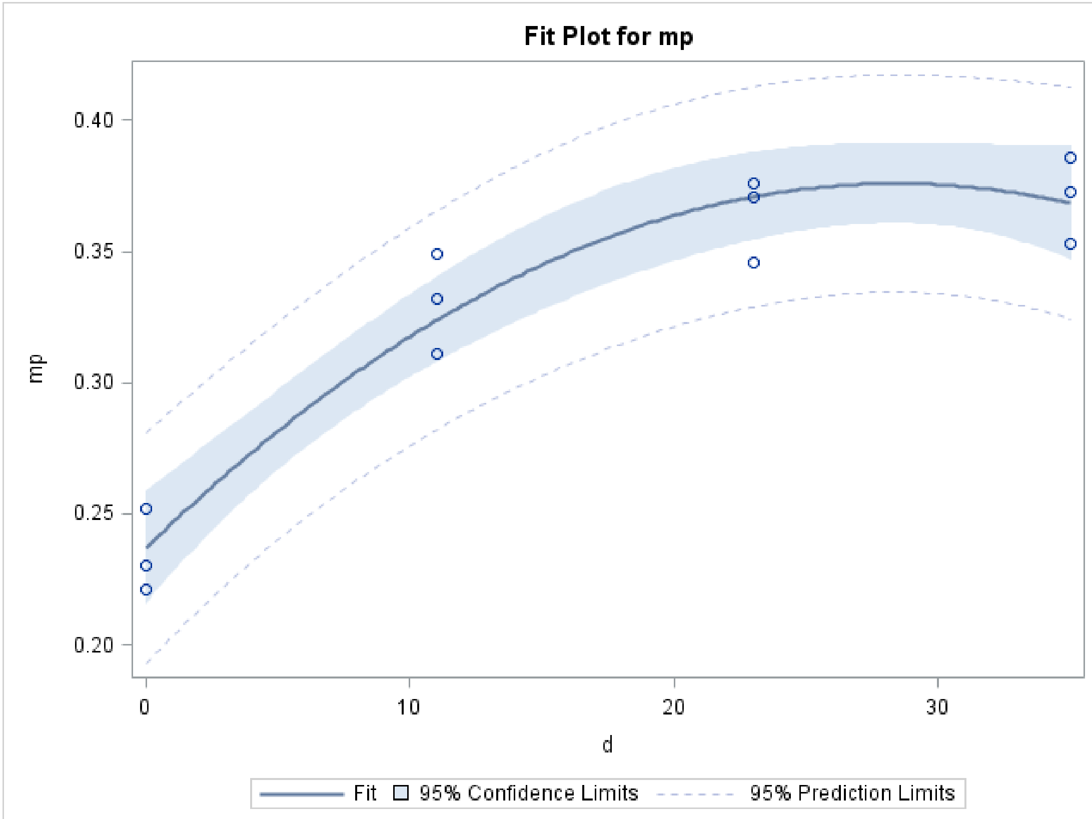
grain=Canola

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	0.03534714	0.01767357	60.92	<.0001
Error	9	0.00261086	0.00029010		
Corrected Total	11	0.03795800			

R-Square	Coeff Var	Root MSE	mp Mean
0.931217	5.240677	0.017032	0.325000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
d	1	0.02883214	0.02883214	99.39	<.0001
d*d	1	0.00651500	0.00651500	22.46	0.0011

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	0.2368111534	0.00953518	24.84	<.0001
d	0.0098004003	0.00133161	7.36	<.0001
d*d	-.0001725185	0.00003640	-4.74	0.0011


Fit Plot for mp
0.40
0.35
0.30
0.25
0.20
mp
0
10
20
30
d
Fit
95% Confidence Limits
95% Prediction Limits

The SAS System

The GLM Procedure

grain=Corn/Soy

Class Level Information		
Class	**Levels**	**Values**
rep	3	1 2 3

Number of Observations Read	24
Number of Observations Used	24

The SAS System

The GLM Procedure

Dependent Variable: mp

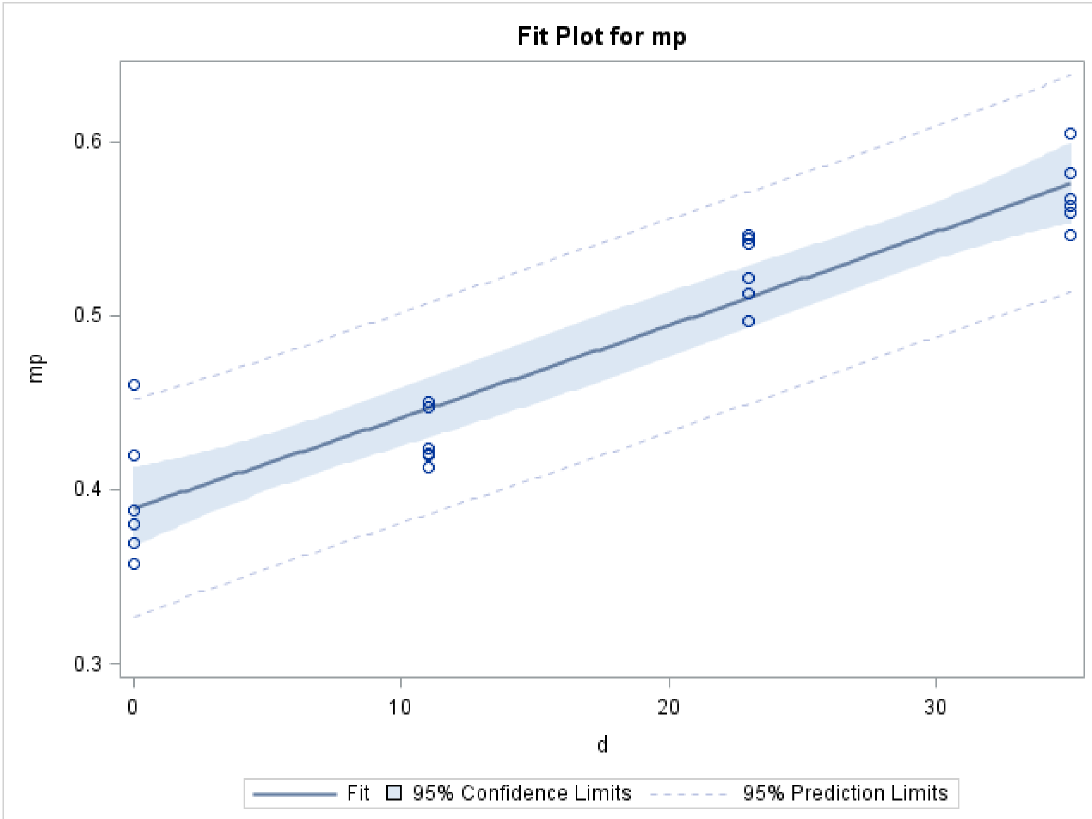
grain=Corn/Soy

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	0.11631140	0.05815570	74.66	<.0001
Error	21	0.01635860	0.00077898		
Corrected Total	23	0.13267000			

R-Square	Coeff Var	Root MSE	mp Mean
0.876697	5.808581	0.027910	0.480500

Source	DF	Type I SS	Mean Square	F Value	Pr > F
d	1	0.11629935	0.11629935	149.30	<.0001
d*d	1	0.00001205	0.00001205	0.02	0.9022

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	0.3894391222	0.01104858	35.25	<.0001
d	0.0051363252	0.00154297	3.33	0.0032
d*d	0.0000052464	0.00004218	0.12	0.9022



Fit Plot for mp
mp
0.3
0.4
0.5
0.6
0
10
20
30
d
Fit
95% Confidence Limits
95% Prediction Limits

The SAS System

The GLM Procedure

grain=Wheat

Class Level Information		
Class	**Levels**	**Values**
rep	3	1 2 3

Number of Observations Read	12
Number of Observations Used	12

The SAS System

The GLM Procedure

Dependent Variable: mp

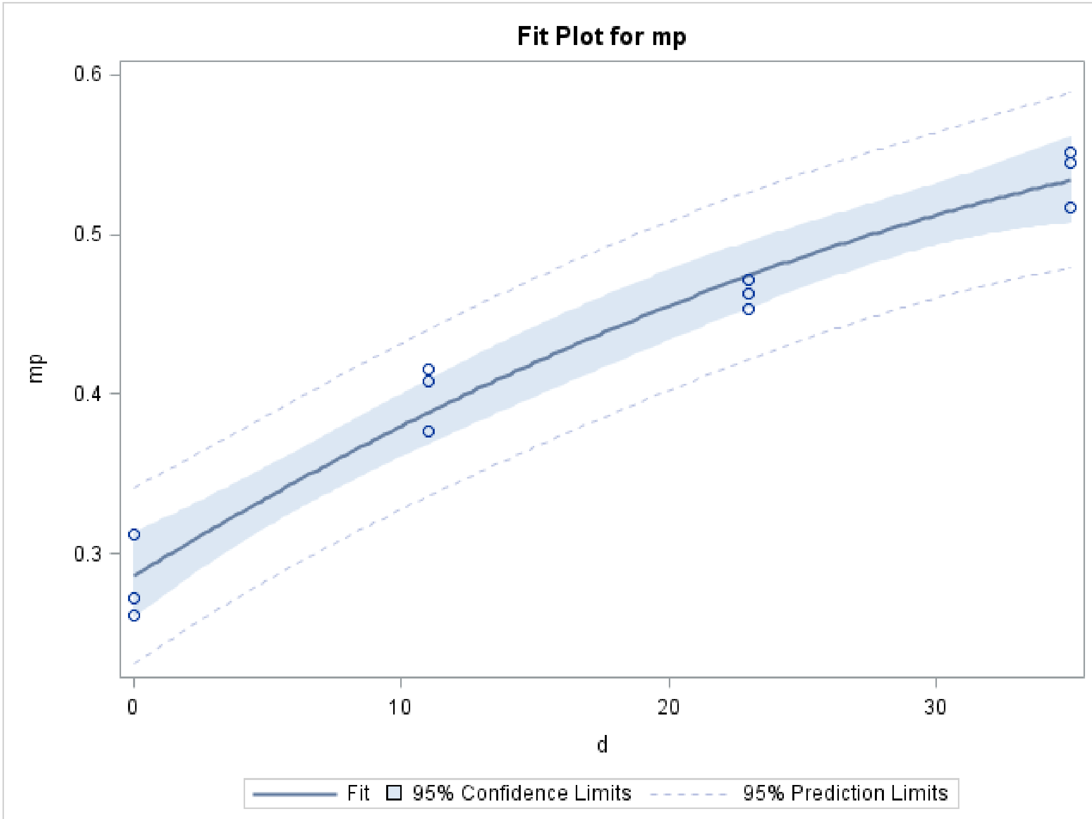
grain=Wheat

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	0.10461582	0.05230791	115.52	<.0001
Error	9	0.00407509	0.00045279		
Corrected Total	11	0.10869092			

R-Square	Coeff Var	Root MSE	mp Mean
0.962508	5.059359	0.021279	0.420583

Source	DF	Type I SS	Mean Square	F Value	Pr > F
d	1	0.10276213	0.10276213	226.95	<.0001
d*d	1	0.00185369	0.00185369	4.09	0.0737

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	0.2860087659	0.01191257	24.01	<.0001
d	0.0103020551	0.00166362	6.19	0.0002
d*d	-.0000920232	0.00004548	-2.02	0.0737



Fit Plot for mp
0.6
0.5
0.4
0.3
mp
0
10
20
30
d
Fit
95% Confidence Limits
95% Prediction Limits

VITA

Kevin Gerald Moore

Candidate for the Degree of

Doctor of Philosophy

Thesis: STORAGE AND ELECTRONIC MOLD ODOR DETECTION OF WINTER CANOLA SEED WITH SAFETY IMPLICATIONS FOR QUALITY LOSS

Major Field: Biosystems Engineering

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Biosystems at Oklahoma State University, Stillwater, Oklahoma in July, 2017.

Completed the requirements for the Master of Business Administration at Oklahoma State University, Stillwater, OK in 2001.

Completed the requirements for the Bachelor of Science in Chemical Engineering at Oklahoma State University, Stillwater, Oklahoma in 1995.

Experience:

Research Engineer, Biosystems and Agricultural Engineering, Oklahoma State University, Stillwater, OK. December 2012 – Present

Director, Student Academic Services, College of Engineering, Architecture, and Technology, Oklahoma State University, Stillwater, OK. August 2006 – November 2012

Manager, Proposal Services, College of Engineering, Architecture, and Technology, Oklahoma State University, Stillwater, OK. November 2003 – July 2006

Design and Sales Engineer, Sulzer Chemtech, Tulsa, OK. July 1998 – November 2003

Technical Marketing Analyst, Nutter Engineering (acquired by Sulzer Chemtech), Tulsa, OK. January 1996 – June 1998