NC-213

(The U.S. Quality Grains Research Consortium)

2018 ANNUAL PROGRESS REPORTS

Published: February 2019

MARKETING AND DELIVERY OF QUALITY GRAINS AND BIOPROCESS COPRODUCTS

2018 Officers

Chair ..... Anton Bekkerman, Montana State University

Vice Chair ..... Griffiths Atungulu, The University of Arkansas

Secretary ..... Paul Armstrong, Research Agricultural Engineer, USDA-ARS-CGAHR-SPIERU

Past Chair ..... Sam McNeill, University of Kentucky

Industry Advisory Committee Chair ..... Chuck Hill, AgriGold Hybrids

The Andersons, Inc. ..... Christopher Reed

CSREES/USDA Representative ..... Hongda Chen, National Program Leader, Bioprocessing Engineering/Nanotechnology, USDA-National Institute of Food and Agriculture

Administrative Advisor/Coordinator ..... David A. Benfield, The Ohio State University

Administrative Support and Report Production ..... Bill Koshar, The Ohio State University

Participating Stations	Representatives
University of Arkansas	Griffiths G. Atungulu*
University of Idaho	Dojin Ryu*
University of Illinois	Vijay Singh* Grace Danao, Peter Goldsmith, Kent Rausch, Matthew Stasiewicz, Mike Tumbleson
Purdue University	Klein Ileleji * Kinglsy Ambrose, Linda Mason
Iowa State University	Gretchen A Mosher* Carl Bern, Erin Bowers, Shweta Chopra, Charles Hurburgh, Jr., Dirk Maier, Kurt Rosentrater
Kansas State University	Carlos Campabadal* Subramanyam Bhadriraju, Tom Phillips
University of Kentucky	Michael Montross* Sam McNeill

Mississippi State University ..... Haibo Yao*

Montana State University ..... David K. Weaver*
Anton Bekkerman

University of Nebraska ..... Devin Rose*

North Dakota State University ..... Senay Semsek*
Clifford Hall, Kenneth Hellevang, Frank Manthey

The Ohio State University ..... Pierce Paul*

Oklahoma State University ..... Brian D. Adam*
Patricia Rayas-Duarte, Carol Jones

Texas AgriLife Research ..... Tim J. Herrman*
Kyung M. Lee, Janie Moore, Wei Li

University of Wisconsin ..... Sundaram Gunasekaran*

USDA, ARS, CGAHR, Manhattan, Kansas ..... Mark Casada*
Paul Armstrong, Frank Arthur, Scott Bean, Dan Brabec, Jim Campbell, Thomas J. Herald

*Official Voting Representative. (Material on Participating Stations obtained from office of NCRA - NIMSS Appendix E as of February 6, 2019.)

The Industry Advisory Committee

The NC-213 Industry Advisory Committee consists of at least five NC-213 stakeholder members recruited by and voted on by the NC-213 Executive Committee to serve a two-year term each. This committee serves in an advisory role to NC-213, its Executive Committee and its membership. In addition, the committee serves as a reviewer pool for The Andersons Grant Review Committee, acts as a liaison between NC-213 researchers and the industry, actively encourages existing industry stakeholders and recruits new industry stakeholders to participate in NC-213 and provides active feedback regarding research agenda and results. Current members are listed below:

AgriGold Hybrids ..... Chuck Hill (Chair 2012 – Present) – 2010-Present

The **Andersons**, Inc. ..... Christopher Reed – 2016-Present

Cargill ..... Nick Friant – July 2007-Present

FOSS. ..... Steve Nenonen – 2012 Present

Foss Analytical AB ..... Jan-Ake Persson – 2006-Present

Former committee members:

The **Andersons**, Inc. ..... Joe Needham, 2006-2016

Consolidated Grain and Barge ..... James Stitzlein, Chair – 1997-2012

Illinois Crop Improvement ..... John McKinney

Pioneer ..... Morrie Bryant – 2012-2017

The **Quaker** Oats Company/PepsiCo ..... A. Bruce Roskens

Contents[1]

NC-213 Objective 1

To characterize quality and safety attributes of cereals, oilseeds, and their processed products, and to develop related measurement systems.

NC-213 Objective 2

To develop efficient operating and management systems that maintain quality, capture value, and preserve food safety in the farm-to-user supply chain.

NC-213 Objective 3

To be a multi-institutional framework for the creation of measureable impacts generated by improvements in the supply chain that maintain quality, increase value, and protect food safety/security.

---

[1] Please note that some reports have more than one contributing institution and author. In the Contents, only the principal investigator, along with their institution, is listed. Please refer to the individual report for a complete list.

NC-213 (The U.S. Quality Grains Research Consortium)

Objective 1

To characterize quality and safety attributes of cereals, oilseeds, and their processed products, and to develop related measurement systems.

Title

Analysis of Soybean Meal Protein Content Using NIR Hyperspectral Imaging.

By

Dantes, Princess Tiffany G., Graduate Research Assistant, Agricultural Engineering, Iowa State University
Hurburgh, C.R., Professor, Agricultural Engineering

Outputs

Near-infrared (NIR) hyperspectral imaging (HSI) was used to develop a calibration model to predict protein content of soybean meal and to show the distribution of protein content in a soybean meal sample. Total of 189 soybean meal samples with 10 regions of interest per sample were analyzed using a Corning reflectance NIR HSI system in the 850 to 1700 nm wavelength range. Mean spectra, which were preprocessed using standard normal variate, and reference % protein content measurements (using combustion method) were the input data in the partial least squares (PLS) regression for model calibration. The final model achieved root mean square error (RMSE), R2 and standard error (SE) of 0.699, 0.835 and 0.699, respectively. The model was then used to predict and visualize protein content distribution in a sample. The performance of the model for soybean meal protein content is relatively low as compared to NIR models for whole grains, but it is comparable with other NIR models for soybean meal on bulk samples.

Outcomes/Impacts

Visualization of component distribution is not possible with normal single-point of illumination NIR. The value of the hyperspectral method is to increase the spatial resolution of the test to the point that subcomponents, such as amino acids, that are at low concentration in bulk, but at high concentration at the pixel level, can be measured. Amino acid estimation will be the next activity in this project.

Funding Sources

Corning Advanced Optics, Iowa Grain Quality Initiative.

Publications

Sekhon J. K., K. A. Rosentrater, S. Jung, and T. Wang. 2018. Effect of co-products of enzyme-assisted aqueous extraction of soybeans, enzymes, and surfactant on oil recovery from integrated corn-soy fermentation. *Industrial Crops and Products* 121: 441-451.

Suleiman, R. and **K. A. Rosentrater**. 2018. Techno-economic analysis (TEA) of extruded aquafeeds. *Journal of Food Research* 7(5): 57-68.

Contact

Princess Tiffany G. Dantes, 3224 NSRIC, 1029 N University Blvd, ISU, Ames, IA 50011-3611
pgdantes@iastate.edu
515-294-3137

Title

Multispectral Imaging Methodology to Measure Fungal Growth and aflatoxin in Maize.

By

Yao, Haibo, Geosystems Research Institute/Mississippi Agricultural & Forestry Experiment Station, Mississippi State University

Output

Sorting of contaminated maize kernels is an approach to reduce aflatoxin levels in maize samples. The current research aims to evaluate an approach of repeated screening and sorting of maize samples to decrease the aflatoxin levels in contaminated grain with a multispectral fluorescence-based aflatoxin detection method. The multispectral fluorescence-based method uses two narrow bandwidth fluorescence bands for the detection. This method was developed based on a fluorescence shift phenomenon observed in the blue-green spectral region for maize kernels with a high aflatoxin content. A dual-camera imaging system was developed for rapid detection of contaminated corn. This multispectral system includes two scientific grade 14-bit Pixelfly cameras and two narrow-band filters. Corn samples were collected from field experiments and industrial sources. Research has also been carried out in using near infrared spectroscopy (400 – 2,500 nm) and shortwave near infrared (SWIR) hyperspectral imaging (1,000 – 2,500 nm) for aflatoxin contamination detection in maize kernels.

Outcomes/Impacts

The focus is on the development of rapid, non-destructive technologies for fungal infection and aflatoxin detection in grains. Aflatoxin is a naturally occurring toxin, found in grain crops and products. It is regarded as one of the most important food safety problems in the world. Maize contaminated with toxigenic strains of A. flavus can result in great losses to the agricultural industry and pose threats to public health. The research effort aims at providing a rapid, non-destructive method for screening maize at elevators or grain collection points, identifying and diverting contaminated grain into alternative uses, thereby protecting the food supply and increasing producer profitability. Results from the current study enhanced the potential of using fluorescence multispectral imaging for the detection of fungal infected and aflatoxin contaminated maize.

Publications.

Yao, H., Y. Huang, L. Tang, L. Tian, D. Bhatnagar, and T. E. Cleveland. 2018. Using Hyperspectral Data in Precision Farming Applications, Chapter 1 of Vol. IV, Advance Applications in Agricultural Crops and Natural Vegetation, in book Hyperspectral Remote Sensing of Vegetation, Second Edition. Editor-in-Chief, Prasad S. Thenkabail. CRC Press.

Tao, F., Yao, H., Hruska, Z., Burger, W., Rajasekaran, K., Bhatnagar, D. 2018. Recent development of optical methods in rapid and non-destructive detection of aflatoxin and fungal contamination in agricultural products. Trends in Analytical Chemistry, DOI: 10.1016/j.trac.2017.12.017. v100, 65-81.

Tao, F., Yao, H., Zhu, F., Hruska, Z., Liu, Y., Rajasekaran, K, and Bhatnagar, D. 2018. Feasibility of using visible/near-infrared (Vis/NIR) spectroscopy to detect aflatoxigenic fungus and aflatoxin contamination on corn kernels. ASABE Paper No. 1801006. St. Joseph, MI.: ASABE.

Han, D., Yao, H., Hruska, Z., Kincaid, R., Ramezanpour, C., Rajasekaran, K., & Bhatnagar, D. 2018. Development of high speed dual-camera system for batch screening of aflatoxin contamination of corn using

multispectral fluorescence imaging. Proceedings of SPIE, “Sensing for Agriculture and Food Quality and Safety X”, 10665-17. April 18, 2018.

Tao, F., Yao, H., Hruska, Z., Kincaid, R., Liu, Y., Rajasekaran, K., & Bhatnagar, D. 2018. Rapid and non-destructive detection of aflatoxin contamination of peanut kernels using visible/near-infrared (Vis/NIR) spectroscopy. Proceedings of SPIE, “Sensing for Agriculture and Food Quality and Safety X”, 10665-18. April 18, 2018.

Funding Sources

USDA/Mississippi State University Cooperative Agreement

Mississippi State University Agricultural and Forestry Experiment Station Special Research Initiative

Title

Improving Safety and Quality of Wheat Flour.

By

Rose, D., University of Nebraska-Lincoln
Bianchini-Huebner A.
Stratton, J.
Baenziger, P.S.
Regassa, T.
Waters, B.

Outputs

The broad objectives of the NC-213 Multistate Project are: 1) to measure, model, and assess factors which influence quality and safety attributes in the post-harvest usage, drying, handling, and distribution of cereal grains and oilseeds; 2) to improve management and operational systems to increase efficiency, retain quality, enhance value, and preserve food safety in the farm-to-user supply chain; and 3) to work with multi-institutional colleagues to improve the cereal grain and oilseed supply chain by creating measurable impacts that preserve quality, increase value, and maintain food safety/food security. Our group's contribution to this project was on objective 1. No contributions to objectives 2 and 3 were made during the reporting year.

This final reporting year, a project was completed in collaboration with a milling company on compositional and functional changes in whole wheat flour after germination. The phytic acid, thiamine, and dough strength of whole grain flour from germinated wheat decreased, whereas lysine, asparagine, GABA, lipase, esterase, and lipoxygenase activities increased compared with flour from ungerminated wheat. Mixing time was not affected by germination time. A small but significant effect of drying temperature was observed for asparagine, GABA, dough strength, and lipase and esterase activities. Drying temperature did not show any differences when the grains were germinated for up to 48 h. Whole grain flour from germinated wheat was added to ungerminated whole wheat flour at 2, 5, and 10 % (flour basis). Doughs and breads made from these composite flours had improved mixing properties, loaf volume, and firmness, except at the highest proportions and from longer germination times.

Outcomes/Impacts

We are currently working with milling companies on production of functional whole wheat flours with enhanced nutritional value through germination.

Although no progress was made on our saline organic acid tempering and our steam-treatment processes for improving wheat microbial safety, we have continued to work with industry on implementation of these processes in commercial practice.

Publications

Poudel R, Rose DJ. 2018. Changes in enzymatic activities and functionality of whole wheat flour due to steaming of wheat kernels. Food Chemistry 263:315-320.

Title

Flaxseed and Food Safety.

By

Hall, Clifford, North Dakota State University, Fargo

Accomplishments

Flaxseed is an oilseed that has documented health benefits. People consume flaxseed for a number of reasons, but improving cardiovascular health is one of the primary reasons. The anti-inflammatory, cholesterol-lowering and glycemic modulating activities are observed benefits of flaxseed consumption. The high levels of omega-3 fatty acid, dietary fiber, anti-carcinogenic lignans and proteins are thought to be the reason for the health benefits of flaxseed. The current research involves the determination of oil and omega-3 fatty acids in flaxseed in samples provided by breeders.

The research provides flaxseed data for breeder to select the best production management practices for optimal flaxseed oil and omega-3 fatty acid contents. The value of flaxseed production to flaxseed growers is over $70 million. Enhancing the already nutrient dense flaxseed will support the growth of this niche market where flaxseed is sold.

The total oil and fatty acid profiles were completed on flaxseed samples provided by the flaxseed breeders. Over a hundred samples of flaxseed were provided. The samples were blind coded with three digit codes to us. The samples were dried to determine moisture and then extracted using a Soxhlet apparatus. After oil recovery, a sample of oil was prepared for fatty acid determination. A gas chromatograph was used to determine the fatty acids.

The moisture content (%), total hexane extractable oil (%) and fatty acid profile (% of oil) were determined using common laboratory methods. The linolenic acid (i.e. omega-3) contents were also calculated on a 100 g basis. All data was pooled, and mean, minimum, and maximum values determined.

The flaxseed moisture contents ranged from 4.6 to 7.1% with a mean value of 6.8%. The oil contents ranged from 36.1 to 43.8% on a dry weight basis (d.w.b.). The mean oil content 40.4% d.w.b. The mean palmitic, stearic, oleic, linoleic and linolenic contents in the oil fraction were 5.4, 4.0, 19.5, 14.3 and 57.1%, respectively. The linolenic acid is the most important fatty acid in flaxseed that is responsible for the anti-inflammatory activity. The linolenic acid ranged from 52.8 to 62.6% in the extracted oil. Conversion to a milled flaxseed basis, linolenic ranged from 20.1 to 25.6 g/ 100 g flaxseed with a mean value of 23.1 g/ 100 g flaxseed. A serving size of flaxseed is approximately 13 g; thus, a serving of flaxseed would provide approximately 3 g of linolenic acid.

Outcomes/Impacts

The outcome of this study relates to the applied knowledge gained regarding the oil content and composition in flaxseed. The data collected can provide breeders with information they can use to select flaxseed varieties with high linolenic acid contents.

The research results were presented at the Flax Institute of America and to a Nigerian trade team sponsored by the Cochran program.

Our Researchers will continue the analysis of flaxseed oil and fatty acid composition for breeder.

Publications

Year Published: 2018

Full Citation: Shah, M., Eklund, B., Lima, LGC., Bergholz, T. and Hall, C. 2018. Microbial and Chemical Shelf-Life of Vacuum Steam-Pasteurized Whole Flaxseed and Milled Flaxseed. J. Food Sci. 83(2):300-308. doi: 10.1007/s11947-017-2052-7

Full Citation: Hall III, C., Bergholz, T., and Shah, M. Shelf-life of Pasteurized Flaxseed. Flax Institute of America. April 2018. Fargo, ND.

Title

Characterizing Mill Flow of Durum Genotypes.

By

Manthey, F.A., North Dakota State University, Fargo
Liu, Y.
Elias, E.M.

Outputs

We have observed that movement of ground material during milling of durum into semolina varied with genotype. It is well documented that high test weight and kernel weight and large kernel size favors high semolina yield. Available information regarding durum grain traits that relate to the movement of material in a roller mill is limited. Changes in movement of material during milling can cause the mill to become unbalanced resulting in too much or too little material moving in the pneumatic lines or passing over the sieves in sifters and purifiers which can be detrimental to semolina quality. Previous research identified durum genotypes that varied in their milling quality, particularly in their semolina yield. This research was conducted to determine the relationship between milling yield and movement of ground material in the mill during the milling process. Experiment used grain from nine durum genotypes grown near Casselton, ND. Grain was milled on a Buhler MLU 202 that was configured with two Miag purifiers. Each purifier had two sections. Grain quality and mill flow were determined.

Outcomes/Impacts

Genotypes differed in test weight, kernel weight, kernel virtuousness, kernel hardness and kernel protein content. Movement of ground material through the mill varied with genotype. Total semolina yield was strongly correlated with the amount of semolina removed by the first purifier section. The amount of material sent to the first purifier is determined by passing the release material over a series of sieves. The 'overs' go to purifier section two and the 'throughs' go to purifier section one. Elevated release from the first break rolls can overwhelm the sieves and result in enhanced flow of material to the second purifier and reduced flow to the first purifier. Release from the first break rolls was lower with grain having high than low protein content. Total semolina extraction was positively correlated, and total flour extraction was negatively correlated with kernel vitreousness and kernel hardness. Both kernel vitreousness and kernel hardness were positively correlated with kernel protein content. These results indicate that grain protein content had an important role in determining milling characteristics of durum wheat genotypes.

Title

Wet Milling Affects Deoxynivalenol Concentration in Wheat Starch and Gluten.

By

Simsek, S., North Dakota State University, Fargo
Manthey, F.
Magallanes-López, A.

Outputs

Fusarium head blight (FHB) is a disease common in cereal grains which is caused by the infection of fungi from the Fusarium sp. Deoxynivalenol (DON) is a trichothecene mycotoxin produced by Fusarium graminearum and F. culmorum, which infects grain causing decreased grain yields, as well as food safety concerns. DON accumulation in bran and endosperm can vary with time of infection. Early infection generally results in high DON levels in endosperm, while late infection results in high DON levels in bran and outer layer of endosperm.

The presence of mycotoxins, such as DON, in grains not only carries health concerns, it also has a negative economic impact for producers. At grain elevators a discount is applied depending on the severity of the FHB outbreak during the growing season. Postharvest price discounts can go from rejected product, low grade reclassification to price discounts. For example, in 2014 wheat prices were $6/bu, so a discount of $1 represented 17% of the total price, a loss of $40/acre or $99/ha.

Taking advantage of the water solubility of DON, an alternative use for low priced grain is possible. In the ingredients market, starch and vital wheat gluten prices are around $500 and $900 per ton, respectively. Understanding the effect of wet milling process on the fate of DON may help identify strategies that could result in desirable wheat wet milled fractions free from contaminants for industry.

Wheat wet milling begins with semolina/flour obtained by dry milling. Dry milling separates grain based on physical characteristics of bran, germ and endosperm. Wet milling separates grain into fractions based on chemistry, protein, starch, lipid, and fiber (bran). Protein, starch, lipid and fiber can be used in food and industrial systems.

Our objective was to:
--Determine if DON can be removed from starch and protein fractions using wet milling process.

We hypothesized that:
--DON could be removed from contaminated grain during wet milling
--DON would not be detected in starch or gluten fractions after wet milling

Three durum wheat samples from the 2016 annual crop survey, and three hard red spring (HRS) wheat experimental lines provided by the Hard Spring Wheat Breeding program of North Dakota State University.

Wheat was milled into semolina/farina using a Quadramat Jr. Mill (C.W. Brabender Instruments). Three milling fractions were collected: bran, shorts, and semolina/farina. Wet milling was done using a Glutomatic 2200 gluten washer (Perten Instruments, Sweden).

The starch and water-soluble material were separated by centrifugation (2500 x g for 15 min). The gluten fraction and crude starch were weighed, dried overnight in an oven at 45°C, then ground using a mortar and pestle. Soluble fraction was obtained by freeze-drying the wash water.

DON content of the samples and fractions was determined according to the method of TAcke and Casper (1996). Samples were shaken with acetonitrile:water (84:16) for one hour. After the samples settled, the extract was passed through a clean-up column, dried and derivitized. The derivatized sample was analyzed using gas xhromatography with electron capture detection (GC-ECD) (Tacke and Casper 1996).

ANOVA was conducted with SAS v 9.4 and means were separated by Fisher's Protected LSD at the 5% level.

Outcomes/Impacts

The Durum and HRWS samples had high levels on DON in the whole wheat flour, which after the dry milling process were redistributed along the semolina, farina, shorts and bran. The bran the fraction had the highest mycotoxin concentration, which is typical for the dry milling process.
The recovery of the functional fractions were slightly different for durum and HRS wheat. The starch recovery for durum wheat ranged from 72.6 to 76.7% and the starch recovery for HRS wheat ranged from 72.6 to 77.6%. The protein recovery for the durum and HRS wheat samples ranged from 11.3-13.6% and 16.2 and 19.1%, respectively.

Table 1 Recovery of wet milling fractions and average DON levels

	Starch fraction		Gluten fraction		Water solubles	
Semolina/ Farina	Starch recovery (%)	DON (µg g-1)	Protein recovery (%)	DON (µg g-1)	Water soluble recovery (%)	DON (µg g-1)
Durum Wheat						
Sample 1	76.6 ab	ND	13.6 a	ND	7.4 a	104.3 a
Sample 2	76.7 ab	ND	11.3 b	ND	7.3 a	55.7 b
Sample 3	72.6 b	ND	11.8 b	ND	5.8 c	46.3 c
HRS Wheat						
Sample 1	77.6 a	ND	16.2 b	ND	6.0 a	48.0 a
Sample 2	72.6 a	ND	16.5 b	ND	5.4 ab	49.3 a
Sample 3	74.8 a	ND	19.1 a	ND	5.8 ab	32.9 b

*Means with the same letter within columns are not significantly different ($P < 0.05$). ND: Below the limit of quantification (<0.2 µg g-1). DON = Deoxynivalenol, HRSW = Hard red spring wheat.

As expected, after wet milling, the concentration of the mycotoxin in the starch and gluten was below the limit of quantification. The majority of DON is now concentrated in the water-soluble fraction. The first hypotheses is confirmed since the DON is successfully removed for fractions intended for human consumption.

DON levels were also evaluated in bran that had been washed with water. In the durum and HRS wheat bran, DON levels were high before wet milling, after wet milling DON was lower, but detectable. The DON in the bran before washing ranged from 6.1 to 15.5 µg g-1. Then after washing with water the DON contents of the bran samples ranged from 1.6 to 0.2 µg g-1. It may be possible to wash or wet mill some bran samples to remove enough DON so that the level would fall under the FDA advisory levels for human or animal consumption.

In conclusion, this research has proved that DON can actually be removed up to undetectable levels from starch and gluten fractions during the wet milling. Overall, a discounted product, like DON contaminated grain, can have a potential use by applying wet milling processes, obtaining not only the free-mycotoxin products, but highly valuable in the market. Further research is needed to determine the functional properties of the starch and gluten fractions after wet milling. Also, it would be beneficial to determine if the wet milling procedures remove other mycotoxins and masked or bound mycotoxins in the same manner as DON.

References

Tacke, B.K., and Casper, H.H. 1996. Determination of Deoxynivalenol in wheat, barley and malt by column cleanup and gas chromatography with electron capture detection. J. AOAC Int. 79:472-475.

Publications.

Magallanes López, A. M. (2018). Fate of deoxynivalenol during wet milling (Order No. 10974700). Available from Dissertations & Theses @ North Dakota State University. (2133955805). Retrieved from https://ezproxy.lib.ndsu.nodak.edu/login?url=https://search.proquest.com/docview/2133955805?accountid=6766

Title

Detection and Reduction of Contaminants in Grain and Feed.

By

Herrman, T.J., Texas A&M AgriLife Research
Lee, K.M.
Li, W.
Moore, J.M.

Outputs

Raman spectroscopy for detection of antimicrobials and pesticides. Surface-enhanced Raman spectroscopy (SERS) was used to explore the feasibility of the spectroscopic technique as a simple and low-cost analytical tool for rapid detection and characterization of antimicrobial and pesticide residues in feed samples. For this study, silver nanosphere and gold nanoparticles were prepared and evaluated by testing OTSC regulatory samples as well as spiked samples with monensin, decoquinate, lasalocid sodium, chlortetracycline, oxytetracycline, chlorpyrifos, and aldicarb. The test results showed a distinctive difference in spectra intensity and profile among samples with different levels of antimicrobials and pesticides. Chemometric models developed for classification of the samples yielded a high correct classification rate, up to 100% while the models for quantification achieved an excellent prediction ability, $R2 > 0.95$. The study results imply that SERS method should be capable of identifying and quantifying the level of selective antimicrobials and pesticides depending on particle size, concentration, and affinity between nanoparticles and the target molecules.

Reduction of aflatoxin in cottonseed and cottonseed meal. Research includes investigation into cleaning/separating and treatment with atmospheric cold plasma. This research looked into the dimensions, sphericity, surface area, 1000 seed mass, projected area, color, density and volume of clean versus moldy fuzzy cottonseed. Results will give insight into which parameters can be used to identify contaminated cottonseed and prepare it for the next step of this work, treatment with atmospheric cold plasma.

Outcomes/Impacts

SERS technique, as demonstrated and proved in previous studies, would be highly efficient and promising analytical platform for rapid detection, characterization, and quantification of antimicrobials and pesticides in diverse feed and food products. If it's further improved by increasing efficiency of system components and accuracy of algorithms, SERS technique could offer a very powerful tool for rapid and reliable determination of antimicrobials, pesticides, and other contaminants, providing higher value of feed and food products by enhancing their quality and safety.

Publications

Yarbrough, D. 2018. Raman Spectroscopy: How to keep our animals and us healthy. Explorations. 10, 35–38.

Funding Source(s)

Office of the Texas State Chemist

Title

Impacting Quality through Preservation, Enhancement, and Measurement of Grain and Plant Traits.

By

Armstrong, Paul R., CGAHR, USDA-ARS, Manhattan KS

Outputs

Research resulted in publications on the following topics, 1) single-kernel near infrared analysis on detecting black-tip and insect damage in wheat and a phenotyping instrument for small grains (Pubs. 1,2 &3), 2) post-harvest evaluation of maize storage in Ghana (Pubs. 4,5 &6), 3) agronomical studies on nitrogen usage and response of soybeans (Pubs. 7 & 8)

Outcomes/Impacts

Objective 1 To characterize quality attributes and develop systems to measure quality of cereals, oilseeds, and bioprocess coproducts.

1) Single seed analysis provided information on near infrared spectroscopy to determine damage in wheat seed and a practical phenotyping method for small grains breeders to evaluate compositional as well as morphological traits.

Objective 2 To develop methods to maintain quality, capture value, and preserve food safety at key points in the harvest to end-product value chain.

2) Post harvest loss (PHL) studies in Ghana have provided much needed information on insect damage, moisture levels and mycotoxin levels in maize. This information is being used to create new strategies to minimize PHL by introducing suitable dryers, changing harvest practices and insect monitoring and fumigation.

3) Studies on soybean response and use of nitrogen will provide a fundamental knowledge and can lead to better production practices.

Publications

Wu, T., Armstrong, P.R., Maghirang, E.B. 2018. Vis- and NIR-based instruments for detection of black-tip damaged wheat kernels: A comparative study. Transactions of the ASABE. 61(2):461-467. https://doi.org/10.13031/trans.12432. Log No. 341744

Determining damage levels in wheat caused by Sunn pest (Eurygaster integriceps) using visible and Near-Infrared spectroscopy. ARMSTRONG, PAUL R., MAGHIRANG, ELIZABETH, OZULU, MEHMET. Journal of Cereal Science, Accepted

Clohessy, J. W., Pauli, D., Kreher, K. M., Buckler V, E. S., Armstrong, P. R., Wu, T., Hoekenga, O. A., Jannink, J.-L., Sorrells, M. E., and Gore, M. A. 2018. A low-cost automated system for high-throughput phenotyping of single oat seeds. *The Plant Phenome Journal* In Press doi: 10.2135/tppj2018.07.0005

Manu, N., Osekre, E.A., Opit, G.P., Campbell, J.F., Arthur, F.H., Mbata, G., Armstrong, P.R., Danso, J.K. 2018. Population dynamics of stored maize insect pests in warehouses in two districts of Ghana. Journal of Stored Products Research. 76:102-110. https://doi.org/10.1016/j.jspr.2018.01.001. Log No. 344434

Danso, J.K., Osekre, E.A., Manu, N., Opit, G.P., Armstrong, P.R., Arthur, F.H., Campbell, J.F., Mbata, G., McNeil, S.G. 2018. Post-harvest insect infestation and mycotoxin levels in maize markets in the Middle Belt of Ghana. Journal of Stored Products Research. 77:9-15. https://doi.org/10.1016/j.jspr.2018.02.004. Log No. 348331

Moisture content, insect pest infestation and mycotoxin levels of maize in markets in the northern region of Ghana. (2019). N.Manu, G.P.Opit E.A.Osekre F.H.Arthur G.Mbata P.Armstrong J.K.Danso S.G.McNeill J.F.Campbell 2019. https://doi.org/10.1016/j.jspr.2018.10.007

Tamagno, Santiago & Sadras, Victor & W. Haegele, Jason & R. Armstrong, Paul & Ciampitti, Ignacio. (2018). Interplay between nitrogen fertilizer and biological nitrogen fixation in soybean: implications on seed yield and biomass allocation. Scientific Reports. 8. 10.1038/s41598-018-35672-1.

Ortez, O & Salvagiotti, Fernando & M. Enrico, J & Prasad, P. V. Vara & Armstrong, P & Ciampitti, Ignacio. (2018). Exploring Nitrogen Limitation for Historical and Modern Soybean Genotypes. Agronomy Journal. 110. 10.2134/agronj2018.04.0271.

NC-213 (The U.S. Quality Grains Research Consortium)

Objective 2

To develop efficient operating and management systems that maintain quality, capture value, and preserve food safety in the farm-to-user supply chain.

Title

Processing and Post-harvest Systems Engineering to Maintain Grain Quality and Prevent Mycotoxin Contamination.

By

Atungulu, G.G., Division of Agriculture, University of Arkansas

Outputs

Studying kinetics of grain quality degradation, mold growth, and mycotoxin development during on-farm, in-bin drying, storage and aeration.

Determination of accurate mathematical models, their validation and optimization for use in actual grain drying, storage and aeration processes.

Development of novel techniques to enhance drying rates while maintaining grain quality

Development of methods for detection, decontamination, and detoxification of harmful-grain molds and mycotoxins.

Outcome/Impacts

A computer simulation platform capable of predicting natural air in-bin drying of rice, corn and soybean has been built; models used in the simulations have been validated using field experiments. Sensors using mathematical equations generated have been developed and are applied in managing grain moisture content by nearly 100 growers in Arkansas and elsewhere.

Some 15 million bushels of rice stored in on-farm bins in Arkansas, Louisiana, and Mississippi use recommendations generated for rice harvest moisture content and management strategies to eliminate discoloration during in-bin grain drying and storage.

Recommended rice chilling technology and protocol has been adopted by at least 3 rice growers in Arkansas (for the first time) with significant improvement of milling yield, 55/70 to 65/70.

Accomplished development of innovative one-pass rice drying technology: Preliminary results, although just for one rice type (medium-grain), one rice cultivar and at one level of harvest moisture content, demonstrated the potential to use 915 MHz microwave energy (~600 kJ/kg-grain) coupled with “holding” the grain at warm temperatures to significantly lower the rice moisture contents (to 14-16%) and maintain head rice yields > 65%.

Demonstrated potential for selective infrared heating to inactivate mycotoxigenic molds responsible for aflatoxin contamination of corn.

Training of next generation grain processing and post-harvest engineers: Advised as thesis/dissertation director 5 Ph.D., 1 M.S., and 1 undergraduate honors students; currently on 7 M.S., and 3 Ph.D. graduate student committees.

Publications

Legend: *: Indicates corresponding author. Underscore: Indicates student advisee.

Refereed Journal Papers

Bruce RM, Atungulu GG*. 2018. Assessment of pasting characteristics of size fractionated industrial parboiled and non-parboiled broken rice. Cereal Chemistry, 95(6), 889–899. DOI: 10.1002/cche.10107

Luthra K, Sadaka S*, Atungulu GG. 2018. Exploration of Rough Rice Head Yield Subjected To Drying and Retention Durations in A Fluidized Bed System. American Society of Biological and agricultural Engineers, Applied Engineering in Agriculture. 34(5):877-885. https://doi.org/10.13031/aea.12925.

Shafiekhani S, Atungulu GG*. 2018. Impacts of storage temperature and rice moisture content on color characteristics of rice from fields with different disease management practices. Journal of Stored Product Research. 78 (1), 89-97. https://doi.org/10.1016/j.jspr.2018.07.001.

Sadaka S*, Atungulu GG. 2018. Drying of Rough Rice Using Heated Husk for Heat Transfer and Moisture Adsorption. Applied Engineering in Agriculture. 34(3). 605-615. https://doi.org/10.13031/aea.12739

Sadaka S*, Atungulu GG. (2018). Grain Sorghum Drying Kinetics under Isothermal Conditions Using Thermogravimetric Analyzer. BioResources, 13(1), 1534-1547.

Atungulu GG*, Olatunde GA. 2018. Assessment of New In-Bin Drying and Storage Technology for Soybean Seed. Drying Technology. 36(4), 383-399. http://dx.doi.org/10.1080/07373937.2017.1335751.

Atungulu GG*, Olatunde GA, Sadaka S. 2018. Impact of Rewetting and Drying of Rough Rice on Prediction of Moisture Content Profiles during On-Farm In-Bin Drying and Storage. Drying Technology. 36(4) 468-476. http://dx.doi.org/10.1080/07373937.2017.1345933.

Atungulu GG*, Olatunde G, Wilson S. 2018. Engineering Methods to Reduce Aflatoxin Contamination of Corn in On-Farm Bin Drying and Storage Systems. Drying Technology. 36(8): 932-951 https://doi.org/10.1080/07373937.2017.1365726

Olatunde G. Atungulu GG*. 2018. Milling behavior and microstructure of rice dried using microwave set at 915 MHz frequency. Journal of Cereal Science, 80 (2018)167-173 doi: 10.1016/j.jcs.2018.02.008.

Smith D, Atungulu GG*, Sadaka S, Rogers S. 2018. Implications of Microwave Drying Using 915 MHz Frequency on Rice Physicochemical Properties. Cereal Chemistry, 95(2), 221-225 (https://doi.org/10.1002/cche.10012).

Smith D, Atungulu GG*. 2018. Impact of Drying Deep Beds of Rice with Microwave Set At 915 MHz Frequency on Rice Microbial Community Responses. Cereal Chemistry, 2018(95), 130-140 (https://doi.org/10.1002/cche.10018).

Xu F*, Zhang J, Wang Z, Yao Y, Atungulu GG, Ju X, Wang L. 2018. Absorption and Metabolism of Peptide WDHHAPQLR Derived from Rapeseed Protein and Inhibition of HUVECs Apoptosis under Oxidative Stress. Journal of Agricultural and Food Chemistry. 2018, 66, 5178−5189 DOI: 10.1021/acs.jafc.8b01620.

Book Chapters

Atungulu GG*, Kolb RE, Karcher J, Mohammadi-Shad Z. Postharvest Technology- Rice Storage and cooling conservation. Rice Chemistry and Technology, 4th Edition, (ed. Jinson Bao). Elsevier Publication, 525 B Street, San Diego CA 92101. Published by Elsevier Inc. in cooperation with AACC International. (pg. 517-555). https://doi.org/10.1016/B978-0-12-811508-4.00016-2.

Atungulu GG*, and Sadaka S. Postharvest Technology- Rice Drying. Rice Chemistry and Technology, 4th Edition, (ed. Jinson Bao). Elsevier Publication, 525 B Street, San Diego CA 92101. Published by Elsevier Inc. in cooperation with AACC International. (Pg. 473-515). https://doi.org/10.1016/B978-0-12-811508-4.00015-0.

Atungulu GG*, Olatunde G, Sadaka S. Rice Aeration: Fundamental and principles. In: Advances in Science and Engineering of Rice. (Eds. Zhongli Pan & Gabreil Ragab Khir). Destech Publications, 439 North Duke St., Lancaster, Pennsylvania 17602. (pg. 143-168).

Atungulu GG*, Olatunde G, Sadaka S. Rice Safety. In: Advances in Science and Engineering of Rice. (Eds. Zhongli Pan & Gabreil Ragab Khir). Destech Publications, 439 North Duke St., Lancaster, Pennsylvania 17602. (pg. 169-190).

Atungulu GG*.2018. Infrared Food Processing Technology: Fundamentals and Case Studies of Recent Advances in Grain Processing. In: Alternatives to Conventional Food Processing: 2nd Edition Edited by Andrew Proctor. Green Chemistry Series No. 53. The Royal Society of Chemistry; Thomas Graham House, Science Park, Milton Road Cambridge CB4 0WF, UK. Pg. 397-417.

Atungulu GG*, Mohammadi Shad Z. Reference on Mycotoxins Occurrence, prevalence and Risk Assessment in Food Systems. In Handbook of Research on Technologies and Systems for Food Preservation. (Eds. Pedro Dinis Gaspar and Pedro Dinho da Silva.) IGI Global Book Publishers (In Press): https://www.igi-global.com/publish/call-for-papers/call-details/3192.

Atungulu GG*, Shafiekhani S. Reference on Rice Quality and Safety. In Handbook of Research on Technologies and Systems for Food Preservation. (Eds. Pedro Dinis Gaspar and Pedro Dinho da Silva). IGI Global Book Publishers (In Press): https://www.igi-global.com/publish/call-for-papers/call-details/3192.

Atungulu GG*, Shafiekhani S. Rice Drying Systems. In. Storage of Grains and Their Products 5th Edition (Eds. Rosentrater, Kurt A). Elsevier Publishers (In Press).

Title

Risk Assessment for the Food Safety Concerns of Mycotoxins in the Pacific Northwest under Climate Variability.

By

Ryu, D., University of Idaho

Outputs

A two-year soil survey quantifying the amount of Fusarium culmorum, a potentially toxigenic fungus capable of causing Fusarium head Blight (FHB) has been completed by sampling from agricultural fields across the Inland Pacific Northwest (INW). A total of 20,765 soil Fusaria have been collected from 9 fields across a precipitation gradient and 2,293 have been putatively identified as F. culmorum using morphological criteria. Species confirmation of the collected isolates using PCR-based methods is in progress.

The difference in isolation frequency of F. culmorum based on sampled field, quadrat, and sampling iteration has been analyzed using Bayesian inference with a varying intercepts approach. This allows for the quantification of uncertainty in isolation frequency of F. culmorum based on the different experimental clusters within the soil survey. Isolation frequency varied the most be the field being sampled from, followed by the sampling quadrat and sampling iteration. Isolation frequency of F. culmorum was lower in the higher regions of sampled fields. Differences in annual climate summaries for each field, such as precipitation and growing-degree days, were investigated by testing both linear and polynomial equations with either single or multiple annual climate variables. Annual climate summaries are too coarse of a resolution, and the remaining variability due to differences in sampling quadrat and iteration make the predictions too variable for use by growers. In addition, isolation frequency alone is insufficient in characterizing the magnitude of F. culmorum present in an agricultural field. The results are currently in review with the journal Phytopathology.

The soil dilution factor used during plating allowed for a population density estimate as propagules per gram soil (PPG). This additional information enhances the isolation frequency data and allows for the quantification of the population density. Since differences in isolation frequency varied the most be sample field, the population densities from all sampled quadrats within a field during a sampling iteration were pooled together. An exponential distribution was used to model the population density which properly captures the variability in sampling quadrats which is not possible when only using isolation frequency.

A predictive model for PPG values based on local climate has been developed. The model utilizes past precipitation and potential evapotranspiration data to compute an atmospheric water balance. The atmospheric water balance was calculated using either the prior 35 years or prior 90 days reference to the sampling date to create a historical term and a seasonal term. F. culmorum was isolated more frequently from cool and wet climate regimes which is captured by the historical atmospheric water balance term. F. culmorum was also isolated more frequently during the winter and spring compared to the summer and fall which is captured by the seasonal atmospheric water balance term. This approach also accounts for the issues with multicollinearity of weather variables which was demonstrated when evaluating model equations with isolation frequency data. The model demonstrated good predictive accuracy and was used along with 10 global climate models for two different climate change scenarios. RCP 4.5 is a low climate change scenario that assumes greenhouse gas emissions stabilize by mid-century and fall afterwards. RCP 8.5 is a high climate change scenario that assumes greenhouse gas emissions continue through the end of the 21st century. Population densities of F. culmorum are forecasted to remain constant across all 9 sampled fields for both climate change scenarios. The balancing effect of hotter and drier summers with warmer and wetter winters suggests that this potentially toxigenic plant pathogen will remain in the INW under the tested climate change scenarios.

Evaluation of the toxigenic potential of collected F. culmorum isolates is in progress. Both PCR-based and culture methods will be utilized to determine the type and magnitude of trichothecene mycotoxins produced by a large population of F. culmorum isolates. Data collected will be used for risk assessment in conjunction with the forecasted population densities in agricultural soil. Determination of mycotoxin concentration in both grains and extracts from fungal cultures is currently being assessed using an HPLC method with UV detection.

Outcomes/Impacts

Formed a network of wheat producers across the Inland Pacific Northwest to collect soil samples for quantification of potentially toxigenic Fusarium spp.

Monitored the population density of F. culmorum across a precipitation gradient over 2 years and collected potentially toxigenic isolates for further study

Evaluated differences in the variability of F. culmorum isolation frequency to show that the greatest differences were across fields as opposed to within fields

Evaluated the limitations of annual climate variables with isolate frequency data to develop a novel approach to quantify F. culmorum population densities

Related the population density of F. culmorum to site-specific climate variables to create a predictive model based on precipitation and potential evapotranspiration

Applied an ensemble of global climate models to forecast future changes in F. culmorum population density in the Inland Pacific Northwest under climate change

Publications

Utility of a multilevel modelling approach to investigate differences in isolation frequency of Fusarium culmorum in agricultural soil across the Inland Pacific Northwest. Phytopathology (in review).

Title

Reflectance Spectroscopy to Identify Mycotoxins in Single Corn Kernels for Rapid Testing and Remediation Sorting.

By

Stasiewicz, M. J., University of Illinois at Urbana-Champaign.

Outputs

Skewed distribution of mycotoxin contamination in corn complicates bulk-testing for mycotoxin detection because very few kernels often contain most of the toxin. This skewed nature also presents an opportunity to both detect hotspots of contamination and enable remediation though high-throughput sorting. Foundational work in our lab, outside this project, started with adapting a relatively simple multi-spectral optical sorter to remove mycotoxins from corn in developing world contexts. We found that using light reflected from 9 LEDs spanning the visible and NIR range we can achieve about 80% sensitivity and specificity to identify Kenyan corn kernels with aflatoxin >10 ppb or fumonisin >1 ppm. Sorting market corn achieved a mean reduction of 83% for both mycotoxins, while rejecting 0-25% of the samples

Work in our lab on this this project has gathered high-throughput, higher-resolution reflectance and fluorescence spectra from ultraviolet to NIR. For this, we used a calibration set of 384 kernels from artificially inoculated and uninoculated control cobs sourced from NC-213 collaborator Haibo Yao of Mississippi State University. We developed random forests models to classify kernels with aflatoxin ≥20 ppb. Results show cross-validation sensitivity of 86% to reject and 97% specificity to accept kernels at a 20 ppb threshold.

We are also conducting a study of aflatoxin and fumonisin distribution in single corn kernels, using as source material commercial corn from Texas, specifically from NC-213 collaborator Tim Herrman. We stratified 250 g subsamples according to bulk aflatoxin (AF) and fumonisin (FM) level. We have tested 528 kernels, from samples at 9 different bulk levels, and found skewed distributions. 99% of the kernels had AF <20 ppb and 92% of the kernels had FM <1 ppm. The remaining kernels were highly contaminated, with up to 105 ppb AF or up to 100 ppm FM. Ongoing work in testing additional kernels and working on developing improved classification algorithms that can accommodate the highly-skewed nature of this calibration data.

Outcomes/Impacts

One scientific outcome of this work is the publication of a paper in Food Control describing the single-kernel classification algorithm for artificially contaminated corn. In addition, we have extended this work to naturally contaminated corn from Texas, gathering initial data on the skewed distribution of aflatoxins and fumonisins.

A major administrative outcome of this project has been that junior faculty member Stasiewicz has been able to develop working relationships with NC-213 members Haibo Yao, Tim Herrman and Paul Armstrong. The first two faculty have provided Stasiewicz with source material for research work, which has resulted in one peer-reviewed publication and graduate student presentations on this work. Finally, Stasiewicz has led a USDA NIFA proposal and an Anderson's Team proposal with Yao, Herrman, and Armstrong as Co-PI or Collaborating PIs; these proposals would likely not have been developed without interactions facilitated by the NC-312 annual meeting.

Publications

Cheng, X., A. Vella, and M. J. Stasiewicz. 2018. Classification of aflatoxin contaminated single corn kernels by ultraviolet to near infrared spectroscopy. Food Cont. (in press, accepted Nov. 2018). https://doi.org/10.1016/j.foodcont.2018.11.037.

Funding Sources and Amounts

This mycotoxin study was supported by a departmental Lo Fellowship and USDA Cooperative State Research, Education, and Extension Service Hatch Project ILLU-698-903.
Awarded Grant(s) and Contract(s)

M.J. Stasiewicz. Simulating large-number bulk-product sampling to improve food safety sampling plans. ILSI North America Food Microbiology Committee. $109,949. 2018-2020.

Title

Role of Worker Decision-making in Effective Food Safety Modernization Act Implementation.

By

Bowers, Erin, Associate Scientist, Agricultural & Biosystems Engineering, Iowa State University
Mosher, Gretchen, Associate Professor, Agricultural & Biosystems Engineering

Outputs

Several food safety decision-making scenarios have been developed for use with personnel who have completed the Preventive Controls Qualified Individual training for animal foods. The primary goal of the project is to better understand the decision-making process of those make decisions about food safety in the grain and feed handling environment.

Outcomes/Impacts

A better understanding of the decision-making process has potential to improve training and professional development of employees. Long term, the goal is to increase the number of grain feed industry employees who can make appropriate food safety decisions relating grain and feed product handling.

Publications

Disturbance to control insects in stored grain – Mike Sserunjogi, Tom Brumm, Dirk Maier, and Carl Bern (2018)
Wireless sensors for quality monitoring and management of stored grain inventories – Roger Aby and Dirk Maier (2018)

Testing plastic films for air tightness of hermetic storage bags – Cristine Ignacio, Sam Cook, Carl Bern, and Dirk Maier (2018)

Application of blockchain technology in agri-food supply chain – Priyanka Gupta and Shweta Chopra (2018)

Summary of traceability practices and standards in the USA and world bulk commodity markets – Richa Sharma, Charles Hurburgh, Shweta Chopra, and Gretchen Mosher (2017)

Modeling traceability in the bulk material supply chain – Richa Sharma, Charles Hurburgh, Shweta Chopra, and Gretchen Mosher (2018)

Suleiman, R., C. J. Bern, T. J. Brumm, and K. A. Rosentrater. 2018. Impact of moisture content and maize weevils and maize quality during hermetic and non-hermetic storage. Journal of Stored Products Research 78: 1-10.

Ramaswamy, S.K. and G.A. Mosher. 2018. Using workers' compensation claims data to characterize occupational injuries in the biofuels industry. Safety Science, 103(March), 352-360.

Funding Source(s)

The Andersons Research Grant Program – Regular Competition 2017

Title

Methods and Guidelines for Enabling Traceability in the Bulk Product Supply Chain.

By

Chopra, Shweta, Assistant Professor, Agricultural & Biosystems Engineering, Iowa State University
Hurburgh, Charles, Professor, Agricultural & Biosystems Engineering
Mosher, Gretchen, Associate Professor, Agricultural & Biosystems Engineering
Sharma, Richa, Graduate research assistant, Agricultural & Biosystems Engineering

Outputs

A step-wise methodological traceability framework was designed to address traceability objectives for each supply chain participant. The guideline template for bulk grain and products uses a step-wise methodology to promote best practices for achieving wholesome traceability. Legal and quality standards such as FSMA and ISO 22000:2018 present traceability and related terminology in different ways; this protocol presents a common terminology, validation procedures, and a unified approach to application of traceability in the grain supply chain, in support of any sanctioned standard.

Outcomes/Impacts

A methodological traceability template provides a starting point for regulatory and business based traceability in the bulk grain supply chain. Complexities associated with interlinked operations across supply chain participants have been one obstacle to effective traceability for bulk materials in the past.

Funding Source(s)

National Institute of Standards and Technology (NIST)

Title

Identification and Testing of Physical Parameters to Quantify the Behavior of Grain Flow for Traceability Purposes.

By

Hurburgh, Charles, Professor, Agricultural & Biosystems Engineering, Iowa State University
Mosher, Gretchen, Associate Professor, Agricultural & Biosystems Engineering
Tenboer, Heather, Graduate research assistant, Agricultural & Biosystems Engineering

Outputs

To accommodate the blended and comingled nature of bulk materials, a mathematical characterization and model the flow of grain and bulk materials at points across the grain and grain product supply chains allows researchers to predict how inputs will distribute in the blended load. A measurement of how much uncertainty is acceptable in the characterization and how the uncertainty levels could be impacted by traceability is currently under investigation.

Outcomes/Impacts

The impact of this research will allow researchers and in-field practitioners to develop protocols for measurement, define parameters, and create a mathematical model of how blended and comingled grain flow, which in turn allows a mathematical prediction with higher precision and accuracy than has been previously possible.
Funding source: National Institute of Standards and Technology (NIST)

Funding Source(s)

National Institute of Standards and Technology (NIST)

Title

Evaluation of Pre-harvest and Harvest losses during Corn Harvest.

By

Montross, M.D., University of Kentucky, Department of Biosystems and Agricultural Engineering
McNeill, S.G.
Sama, M.P.
Dvorak, J.S.

Mark, T.B., University of Kentucky, Department of Agricultural Economics
Martin, B.

Turner, A.P., Clemson University, Agricultural Sciences Department

Outputs

Harvest losses need to be properly managed to reduce waste and maximize profits, and producers must balance potentially increasing losses with energy savings from allowing grain to field dry. Harvest losses are a combination of pre-harvest loss and machine loss. Pre-harvest losses occur due to dropped ears, pests feeding on the grain, or other 'invisible' losses. Machine losses occur at all stages of combing. Gathering losses are a combination of ears the corn head fails to pick up and kernels that are butt shelled. Threshing or cylinder losses occur when grain is not fully separated from the cob. Separation losses occur when the grain is not fully separated and is carried out the back of the combine with the MOG.

To measure machine losses, a normally operating combine was quickly stopped and allowed to clean out before backing up 5-10 m. Header kernel loss was evaluated by collecting kernels on the ground in front of the combine where the corn had been harvested but the combine had yet to pass. The process was repeated in an area behind the combine to evaluate total kernel loss. Partially shelled cobs were kept separate and counted as cylinder losses. The area for both of these measurements was 2.5 m2, across the full width of the corn head. Total ear loss was measured by collecting whole and partial ears in an area 30 m2 behind the combine. Pre-harvest losses were evaluated by collecting downed ears in a 30 m2 area directly in front of where the combine stopped for machine loss measurement. Yield was estimated in the same area by counting ears in a 10 m section of 3 rows. Every 10th ear was hand shelled, dried, and weighed to determine the average yield per ear. Additionally, yield was estimated from the mass of grain harvested by the combine and the row length. All collected material was oven dried before weighing, and calculations were adjusted back to a moisture of 15%.

Outcomes/Impacts

This study presents a single year evaluation of corn harvest losses in Kentucky. To evaluate typical harvest losses, losses were measured for four cooperating producers' combines operating under normal conditions and total losses were found to be between 0.8% to 2.4% of total yield (86 to 222 dry kg ha-1). On average, the combine head accounted for 66% of the measured losses, and the total losses were highly variable, with coefficients of variation ranging from 21.7% to 77.2%. Additionally, yield and harvest losses were monitored in a single field at four points over the course of the 2017 harvest season to assess loss changes with respect to time and moisture. Measurement points were selected to cover a wide range of grain moisture (33.9, 26.4, 19.8, and 14.6% w.b.) contents representing high moisture corn, the upper limit for drying, normal drying, and corn field dried to nominally 15%. There was no significant difference in the potential yield at any moisture level, and the observed yield and losses displayed little

variation for moisture levels from 33.9% to 19.8%, with total losses less than 1% (82 to 130 dry kg ha-1). Large amounts of lodging occurred when the grain was allowed to field dry to 14.6%, which resulted in a 18.9% reduction in yield, and measured harvest losses in excess of 9%. Allowing the grain to field dry generally improved test weight and reduced mechanical damage, however, there was a trend of increased mold and other damage in prolonged field drying.

Yield and harvest losses over time in a single field was collected again in 2018. The data has not been fully analyzed. However, there is a significant difference from 2017 due to wind damage that caused sever lodging.

The tradeoff between field losses during field dry down and artificial drying of higher moisture corn is difficult. Proper adjustment of a combine could reduce harvest losses by 1.5%. Drying costs are often $0.05 per bushel per point of moisture. At a 10 point moisture removal this would equal approximately 12% of the value of the corn, assuming $4.00/bu. However, yield reduction and harvest losses rapidly increased to 27% if the corn was allowed to field dry.

Title

Understanding and Capturing Economic Value within Changing Grain Marketing Landscapes.

By

Anton Bekkerman, Montana State University
David Weaver

Outputs

Numerous research projects have been developed and either published, under review, or in progress that directly relate to the Objective 2. The publication "Modeling Joint Dependence of Invasive Pests: The Case of the Wheat Stem Sawfly" assessed the economic impacts and optimal farm technologies and strategies for managing one of the most-costly pests for northern Great Plains wheat producers. The wheat stem sawfly (WSS) creates significant issues in both wheat yields and quality characteristics and developing more informed strategies for agricultural producers to deal with the pest can significantly reduce the quality reduction and variation in the final product. Working across the economics and entomology disciplines, we use a unique farm-level dataset to estimate the expected losses associated with WSS and then evaluate two popular WSS management strategies.

The publication “Farming System and Wheat Cultivar Affect Infestation of, and Parasitism on *Cephus cinctus* in the Northern Great Plains” addresses potential enhancements in biological control of wheat stem sawflies under organic cropping scenarios. As in the paper described above, WSS negatively impacts quality of wheat, as well as yield. Wheat stems where WSS larvae have been killed by parasitoids yields better and this is known to manifest in greater seed number and seed weight, as well as fewer infertile spikelets. Organic cultivation of wheat in the drylands of Montana is challenged because of water availability and reduced yield is compensated by premiums paid for organic sourced wheat. Further limiting the negative interaction between WSS and quality should be of added benefit for organic wheat production.

The paper "Vulnerability of dryland agricultural regimes to economic and climatic change" was also an interdisciplinary effort across ecology, rural sociology, and agricultural economics. The research focused on large-scale agricultural systems that are central to food production in North America but could be threatened by vulnerability to economic and climatic stressors during the 21st century. We assess the vulnerability of large-scale agricultural systems to variation in multiple stressors and investigate alternative adaptation strategies under novel conditions, focusing on dryland farms in Montana's northern Great Plains (NGP), which represent large-scale semiarid agricultural systems that are likely to be affected by climate change.

The project also collected elevator-level and farmer-level survey information regarding grain quality evaluation and variety selection. The elevator-level survey provides the current state of Montana elevators' decisions about how to assess wheat quality and damage characteristics for the grain delivered by Montana producers. The farmer-level survey collected information about farmers' choices regarding the wheat and barley varieties that they chose to plant. As new varieties are introduced into the market each year, the survey provides important information on the state of the grain industry in Montana.

Lastly, the numerous blog posts and recorded podcasts directly address applied, measurable issues related to wheat markets in a timely and relevant fashion. This year, topics focused on international trade issues, recovery from drought, and wheat quality valuation and volatility. For example, the posts "How Far Does Montana Grain Travel from the Farm" and "When Does Marketing Grain to Canada Pay?" provided information and web-based tools that helped grain producers better understand the market opportunities and costs of marketing their grain. The post "How

Are Pulse Crops Affecting the Economics of Northern Great Plains Agricultural and What's Next?" discussed the impacts of increases in the pulse acreage in the northern Great Plains and provided information about research that found the impacts on wheat quality that was grown in rotation with pulses. Another post, "How the JD.com Deal Could Boost the US Pulse and Barley Sectors" offered insights about the potential increases in domestic demand for high-quality grains that could be used as feed for animals that are intended to be shipped into specialty markets.

Outcomes/Impacts

The work on the wheat stem sawfly resulted in a number of empirical insights. First, we were able to estimate—across numerous years and numerous locations—the production impacts of the WSS on wheat productivity. Additionally, the implementation of these findings into simulated management strategies led to the finding that management approaches minimizing long-run infestation levels are preferred to those that seek to maximize yield potential in exchange for higher risk of intertemporal infestation. This is an important data-driven result that overcomes previously held beliefs and "intuitions" about optimal WSS management methods. In addition, insights into potential benefits of increased biological control in organic wheat systems also confers potential further gains in profitability of this management scenario.

The research on producers' behaviors in response to market and climate uncertainty also yielded several interesting outcomes. Through a combination of qualitative and quantitative assessment measures, we find that although farmers perceived few alternative agronomic options for adapting to drought, strategies for adapting to high input prices were more plentiful. We also find that during periods of intense stress--high price variability and limited soil moisture--farmers are least likely to adopt new technologies and farm management techniques. These results are critical for understanding how producers' evaluate management choices and the hurdles that may exist in incenting farmers to adopt higher-quality but more perceived-to-be risky crop varieties.

The elevator quality assessment survey information provided important insights about differences and similarities that Montana elevators have with facilities in other states in assessing grain and the economic value they place on different post-harvest qualities. Farmer-level survey results offer important information for understanding the likely grain quality that will be supplied by Montana producers during the 2018/19 marketing year (and likely for the next 2-3 marketing years). This information is particularly useful to domestic and foreign buyers of Montana grain, who make purchasing decisions based on their knowledge about the grain quality characteristics that are likely to be procured from Montana elevators.

During the reporting period, the www.AgEconMT.com project and website, on which blog posts and podcasts are posted, received over 16,400 visitors. Many of these visitors are consumed information related to wheat quality and marketing issues. The project has also had a significant impact in social media, with over 150,000 individuals having seen blog posts and podcasts distributed via the Twitter platform.

Publications

Bekkerman, A., and D. K. Weaver. 2018."Modeling Joint Dependence of Invasive Pests: The Case of the Wheat Stem Sawfly." *Journal of Agricultural and Resource Economics*. 42(2):172-194

Lawrence, P. G., B. D. Maxwell, L. J. Rew, C. Ellis, and A. Bekkerman. 2018. Vulnerability of dryland agricultural regimes to economic and climatic change. *Ecology and Society.* 23(1):34. https://doi.org/10.5751/ES-09983-230134

Adhikari, S., T. Seipel, F. D. Menalled, and D. K. Weaver. 2018. Farming system and wheat cultivar affect infestation of and parasitism on *Cephus cinctus* in the Northern Great Plains. *Pest Management Science.* 74(11):2480-2487

Title

Impacting Quality through Preservation, Enhancement, and Measurement of Grain and Plant Traits.

By

Armstrong, Paul R., CGAHR, USDA-ARS, Manhattan KS

Outputs

Research resulted in publications on the following topics, 1) single-kernel near infrared analysis on detecting black-tip and insect damage in wheat and a phenotyping instrument for small grains (Pubs. 1,2 &3), 2) post-harvest evaluation of maize storage in Ghana (Pubs. 4,5 &6), 3) agronomical studies on nitrogen usage and response of soybeans (Pubs. 7 & 8).

Outcomes/Impacts

Objective 1 To characterize quality attributes and develop systems to measure quality of cereals, oilseeds, and bioprocess coproducts.

1) Single seed analysis provided information on near infrared spectroscopy to determine damage in wheat seed and a practical phenotyping method for small grains breeders to evaluate compositional as well as morphological traits.

Objective 2 To develop methods to maintain quality, capture value, and preserve food safety at key points in the harvest to end product value chain.

2) Post harvest loss (PHL) studies in Ghana have provided much needed information on insect damage, moisture levels and mycotoxin levels in maize. This information is being used to create new strategies to minimize PHL by introducing suitable dryers, changing harvest practices and insect monitoring and fumigation.

3) Studies on soybean response and use of nitrogen will provide a fundamental knowledge and can lead to better production practices.

Publications

Wu, T., Armstrong, P.R., Maghirang, E.B. 2018. Vis- and NIR-based instruments for detection of black-tip damaged wheat kernels: A comparative study. Transactions of the ASABE. 61(2):461-467. https://doi.org/10.13031/trans.12432. Log No. 341744

Determining damage levels in wheat caused by Sunn pest (Eurygaster integriceps) using visible and Near-Infrared spectroscopy. ARMSTRONG, PAUL R., MAGHIRANG, ELIZABETH, OZULU, MEHMET. Journal of Cereal Science, Accepted

Clohessy, J. W., Pauli, D., Kreher, K. M., Buckler V, E. S., Armstrong, P. R., Wu, T., Hoekenga, O. A., Jannink, J.-L., Sorrells, M. E., and Gore, M. A. 2018. A low-cost automated system for high-throughput phenotyping of single oat seeds. *The Plant Phenome Journal* In Press doi: 10.2135/tppj2018.07.0005

Manu, N., Osekre, E.A., Opit, G.P., Campbell, J.F., Arthur, F.H., Mbata, G., Armstrong, P.R., Danso, J.K. 2018. Population dynamics of stored maize insect pests in warehouses in two districts of Ghana. Journal of Stored Products Research. 76:102-110. https://doi.org/10.1016/j.jspr.2018.01.001. Log No. 344434

Danso, J.K., Osekre, E.A., Manu, N., Opit, G.P., Armstrong, P.R., Arthur, F.H., Campbell, J.F., Mbata, G., McNeil, S.G. 2018. Post-harvest insect infestation and mycotoxin levels in maize markets in the Middle Belt of Ghana. Journal of Stored Products Research. 77:9-15. https://doi.org/10.1016/j.jspr.2018.02.004. Log No. 348331

Moisture content, insect pest infestation and mycotoxin levels of maize in markets in the northern region of Ghana. (2019). N.Manu, G.P.Opit E.A.Osekre F.H.Arthur G.Mbata P.Armstrong J.K.Danso S.G.McNeill J.F.Campbell 2019. https://doi.org/10.1016/j.jspr.2018.10.007

Tamagno, Santiago & Sadras, Victor & W. Haegele, Jason & R. Armstrong, Paul & Ciampitti, Ignacio. (2018). Interplay between nitrogen fertilizer and biological nitrogen fixation in soybean: implications on seed yield and biomass allocation. Scientific Reports. 8. 10.1038/s41598-018-35672-1.

Ortez, O & Salvagiotti, Fernando & M. Enrico, J & Prasad, P. V. Vara & Armstrong, P & Ciampitti, Ignacio. (2018). Exploring Nitrogen Limitation for Historical and Modern Soybean Genotypes. Agronomy Journal. 110. 10.2134/agronj2018.04.0271.

NC-213 (The U.S. Quality Grains Research Consortium)

Objective 3

To be a multi-institutional framework for the creation of measureable impacts generated by improvements in the supply chain that maintain quality, increase value, and protect food safety/security.

Title

Strategies for Selective Handling of Soybeans to Maximize Soybean Processing Value.

By

Hurburgh, C. R., Professor, Agricultural & Biosystems Engineering, Iowa State University
Barr, Bennett, Graduate Research Assistant, Agricultural & Biosystems Engineering

Outputs

An Iowa grain firm with soybean processing capacity assessed the protein and oil from the 2018 crop as received at locations providing soybeans to the processing plant. Three high-volume locations used NIR units to test each incoming load. Other locations (36) were asked to provide 2 composite samples per harvest day to one of the testing locations. The overall goals were to determine if there were large enough protein and oil variations to selectively segregate soybeans either load by load or by location to be shipped to the processing plant. The total of protein and oil (SUM) was highly correlated with processing value as estimated by our new SPROC processing model. One percentage point of SUM is worth about 15 cents per bushel to the expeller processing plant. This was a low protein, high oil year; the gain in oil did not fully offset the theoretical value of the loss in protein. However, it is easier or the processing plant to capture value for more oil than for more protein. The overall averages for all samples were 32.7% protein and 20.1% oil.

Outcomes/Impacts

The company will expand the testing and develop an action plan for capitalizing on locational differences. Testing of samples at the processing plant will be used to verify measurements taken at elevator observations, over the year, since the origin of soybeans delivered to the plant is always known.

Significant improvements in processing margins appear possible by managing the logistics of soybean shipments from receiving locations to the processing plant versus other market locations.

Funding Source(s)

United Soybean Board, elevator collaborator, Iowa Grain Quality Initiative

Title

Segregation Strategies for non-GM corn: Improving Effectiveness Through an Analytical Modeling Approach.

By

Mosher, Gretchen A., Associate Professor, Agricultural & Biosystems Engineering, Iowa State University
Dolphin, Chad J., Graduate Research Assistant, Agricultural & Biosystems Engineering

Ambrose, R.P. Kingsly, Associate Professor, Agricultural & Biological Engineering, Purdue University
Salish, Karthik, Graduate Research Assistant, Agricultural & Biological Engineering

Outputs

Two major outputs were generated from this project to improve the segregation of non-GM during grain handling. First, a decision-making tool was developed and tested through a Java-based software program. The program was designed to predict potential GM adventitious presence in non-GM corn loads, using various parameters. A second output was the development of a probabilistic model and Monte Carlo simulation to predict the likelihood of non-GM loads meeting selected tolerance levels for adventitious presence, given the normal parameters of handling non-GM corn from field to elevator.

Outcomes/Impacts

Adventitious presence is the presence of genetically modified product in a load that is intended for markets that desire non-genetically modified grain. Tolerance levels for adventitious presence range from less than 1 percent to 5 percent. When adventitious presence is found at levels above the tolerance level, the non-GM grain load can no longer be sold at its premium price and must be sold at commodity prices, adding risk for non-GM producers. This project provides tools for prediction and decision-making about feasible tolerance levels by providing data to support the long-standing question about the feasibility of existing tolerance levels. In the short term, the data will assist policy makers as they set GM policy and tolerance levels for international markets. In the long term, the data and tools generated by the project will lower the risk level for non-GM growers, breeders, and handlers.

Funding Source(s)

The Andersons Research Grant Program – Team Competition 2016