Annual Report of the Cooperative Regional Project NC1183
January 1, 2013 - December 31, 2013

Project Title: Mycotoxins: Biosecurity, Food Safety and Biofuels Byproducts (NC129, NC1025)

Minutes of the Annual Meeting:

Meeting took place October 8, 2013 at Purdue University, W. Lafayette, IN, and using Adobe Connect.

Participants:
Burt Bluhm, University of Arkansas; Aishwarya Deliephan, Kansas State University; Rong Di, Rutgers University; Heather Hallen-Adams, University of Nebraska, Lincoln; David Jackson (Administrative Advisor), University of Nebraska; Gretchen Kuldau, Pennsylvania State University; David Ledoux, University of Missouri; John Leslie, Kansas State University; Gary Munkvold, Iowa State University; Ludmila Roze, Michigan State University; Christopher Schardl, University of Kentucky; Paul Schwarz, North Dakota State University; Xueyan Shan, Mississippi State University, J. Scott Smith, Kansas State University; Charles Woloshuk, Purdue University; Lisa Vaillancourt, University of Kentucky; Jae-Hyuk Yu, University of Wisconsin; Nancy Keller, University of Wisconsin.

Charles Woloshuk called the meeting to order at 1:00 PM (EDT). This was followed by an address from David Jackson, NC 1183 administrator. Dr. Jackson described the protocols and deadline for the committee to to prepare and submit the 2013 annual report and the project renewal (2015-2020). He highlighted the need to maintain collaborations, and when possible to write collaborative proposals.

Station Reports: The station reports were presented: Burt Bluhm (AR), Suzanne Hendrich (IA), Charles Woloshuk (IN); John Leslie and Scott Smith (KS); Christopher Schardl, Lisa Vaillancourt (KY); David LeDoux (MO), Ludmila Roze (MI), Paul Schwarz (ND), Heather Hallen-Adams, (NE), Gretchen Kuldau (PA), Jae-Hyuk Yu and Nancy Keller (WI).

Business Meeting: Charles Woloshuk called the business meeting to order at 3:00 PM (EDT). Officers for 2013 were Charles Woloshuk (Chair), Burt Bluhm (Vice Chair), and Suzanne Hendrich (Secretary). Officers for 2014 will be Burt Bluhm (Chair), Suzanne Hendrich (Vice Chair), and Lisa Vaillancourt (Secretary). Burt Bluhm will arrange the annual meeting for 2014 for May in Fayetteville, AR. The venue for the 2015 meeting will be in Iowa, organized by Suzanne Hendrich.

The committee discussed preparation of a new five-year proposal early in 2014. Objective Themes were agreed upon as follow:

1. Animal and human Issues: MO (David Ledoux) will lead. Participants: IA (Suzanne Hendrich, Wilson Rumbeiha, Steve Ensley) and NJ (Di Rong, Michael Lawton?), Others?
2. Forage endophytes: KY (Chris Scharl) will lead. Participants: OK (Carolyn Young)? Others?
3. Host resistance: MS (Xuelyan Shan) will lead. Participants: IA (Gary Munkvold), AR (Burt Bluhm), IN (Charles Woloshuk), KY, others?
4. Fungal and mycotoxin surveillance and population genetics: PA (Gretchen Kuldau) will be asked to lead. Participants: KS (John Leslie & Scott Smith), KY (Lisa Vaillencourt), IA (Gary Munkvold), IN (Charles Woloshuk), Others?
5. Fungal biology: KY (Lisa Vaillencourt) and MI (Frances Trail) will lead. Participants: WI (Nancy Keller& Jae-Hyuk Yu), AR (Burt Bluhm), IA (Gary Munkvold), IN (Charles Woloshuk), ND (Paul Schwarz), KS (John Leslie), PA (Gretchen Kuldau).

Lisa Vaillancourt, assisted by Frances Trail, will assemble the draft project proposal. Participants should submit preliminary drafts of their objectives and supporting information by January 1, 2014 to Lisa Vaillancourt.

Meeting was adjourned at 4:00 pm (EDT).

Accomplishments (2013):

Objective 1. Develop data for use in risk assessment of mycotoxins in human and animal health.

Deoxynivalenol (DON)-3-glucoside (D3G) chemical synthesis was attempted and compounds are being purified for use in cell culture (IA). Caco-2 cells, a model for human intestinal epithelial cell function, are being assessed for cytotoxicity of DON, D3G and de-epoxyDON, a major gut bacterial detoxification product of DON. Plans are to assess the ability of mouse cecal contents to form DON and de-epoxyDON from D3G, comparing conventional and altered flora mice, which may permit identification of DON detoxifying bacterial genes.

The *Fusarium/* Poultry Research Laboratory (MO) evaluated mineral and organic adsorbents to bind mycotoxins in *in vitro* and *in vivo* for poultry. The laboratory continues to produce mycotoxins in culture for in house as well as for other researchers doing animal feeding trials with mycotoxins. A number of *in vitro* and *in vivo* mycotoxin studies are planned to evaluate the efficacy of proprietary adsorbents and naturally occurring antioxidants in livestock. Of particular interest are the effects of combinations of low levels of mycotoxins on growth performance of swine and poultry, and the efficacy of adsorbents to prevent or reduce the toxic effects of combinations of mycotoxins.

Objective 2. Establish integrated strategies to manage and to reduce mycotoxin contamination in cereal grains and distillers grains.

Surveillance activities for mycotoxins continued in several of the participating states. In ND, surveys focused on determining deoxynivalenol-3 -glucoside in barley and malt. Barley samples (n=250) were analyzed for DON-3-glucoside (DON3G), and levels were found to range from non-detectable to 3.1 mg/kg. DON3G was found to increase during seed germination, which is tentatively attributed to the conjugation of DON by barley UDP-glucosyl transferase(s). In KS, a survey for mycotoxins in grain storage elevators and in the Manhattan, KS area was conducted in late September 2012, with samples analyzed in 2013. Each sample was tested for aflatoxin, fumonisin, and deoxynivalenol. All samples tested were contaminated with fumonisin, with two contaminated at very high levels – 308 & 443 ppm – and the remainder with 12-20 ppm. All samples also were contaminated with deoxynivalenol at 20-60 ppb. Three of seven samples were contaminated with low levels of aflatoxin (1 to 2.5 ppb). In 2012, much of the Corn Belt experienced severe drought conditions, and prior to corn harvest, Aspergillus ear rot was observed throughout several midwestern states. Symptomatic ears were collected from fields throughout IN (six geographic regions in the state). A total of 30 isolates of *Aspergillus flavus* were obtained and characterized. Only six isolates produced B-type aflatoxins and 13 isolates produced the mycotoxin cyclopiazonic acid. These results indicate that non-producers of aflatoxin dominated the *A. flavus* population on diseased ears. In PA, a survey was conducted of the deoxynivaneol-producing wheat head scab organism, *F. graminearum*, to determine the incidence and prevalence of the more toxigenic 3-acetyl-deoxynivalenol strains in the state. For nearly 400 cultures, the fungus was identified at the species level with molecular techniques. About ¼ of the cultures (95) were identified as *F. graminearum*. Of these, all 95 were of the 15-acetyl-deoxynivalenol chemotype except three isolates that were confirmed to be of the 3-acetyl-deoxynivalenol type. These data indicate that an incursion of the more toxigenic 3-acetyl-deoxynivalenol strains into PA is not a likely explanation for the apparent increase in overall deoxynivalenol levels in wheat and corn.

Research regarding intervention strategies was also coordinated across several states. Researchers in MO worked to develop novel strategies to reduce mycotoxin levels in animal feed. Beer fermentation residue (BFR) containing *Saccharomyces cerevisiae* cells was evaluated for ability to minimize toxic effects of aflatoxins in young broilers. Results indicated that BFR ameliorated some toxic effects in broilers caused by aflatoxins, suggesting a potential alternative for mineral adsorbents in animal feed. Additionally, binding of zearalenone by BFR demonstrates the potential of this product as an organic adsorbent for multiple mycotoxins. In KS, field trials were conducted to evaluate the effectiveness of silo bags in suppressing fungal growth, reducing mycotoxin levels, and preserving wheat quality. Key grain quality parameters such moisture content, test weight, falling number and kernel weight were unchanged during storage as were fungal colony forming units (CFUs) and the amount of mycotoxin contamination. These results indicate that silo bags can be used for temporary wheat storage. Also in KS, infrared heating was explored as a way to reduce microbial loads in wheat prior to milling. Infrared exposures of 1.0, 1.5, and 2.0 min, on average reduced fungal loads by 93, 95

and 97%, respectively, relative to tempered and untreated wheat. Wheat tempered with electrolyzed oxidizing (EO) water and infrared-treatment had a 2.2 log reduction in the fungal counts. Tempering wheat with EO water and not exposing to infrared radiation reduced the fungal count by 0.5 log. Thus, EO water has an antimicrobial effect when used alone and in combination with infrared radiation.

Several states coordinated research activities to examine the population genetics underlying geographically and taxonomically diverse mycotoxingenic fungi. Studies are in progress in KS between an inter-specific cross of *Fusarium fujikuroi* and *Fusarium proliferatum*. Over 500 progeny have been collected and pathogenicity towards apple, rice and onion are being assessed. Production of many secondary metabolites is segregating in the cross, including fumonisins, fusaproliferin, beauvericin and gibberellic acid. A rough genetic map is being constructed based on segregating AFLP markers, with a more refined genetic map expected from GBS next-generation sequencing markers. Recombination blocks could serve as indicators of genomic blocks that must remain either together or distinct for progeny to be viable and may yield new insights into speciation. Among *A. flavus* populations collected from IN, morphological characterization indicated that ten isolates produced large (L-class) sclerotia and two isolates produced small (S-class) sclerotia. The remaining isolates did not produce appreciable sclerotia. Polymerase chain reaction (PCR) analysis indicated that MAT1-1 and MAT1-2 mating types were approximately evenly distributed among the isolates, 43% and 57%, respectively, and that homothallic types were also present.

In IA, genetically modified lines of maize containing newer *Bacillus thuringensis* (BT) genes were assessed for content of fumonisins (FB) and susceptibility to insect damage (IA). A new BT gene was very effective in reducing FB contents compared with the older BT versions. Ethanol was made from corn containing up to 8 ppm FB, which did not adversely affect ethanol yield. Spiking ethanol fermentation with even higher levels of FB also did not affect ethanol production. Dried distillers grains had about 3-fold enrichment of FB in 50/57 batches. The 7 batches showing lesser increase of FB will be investigated further.

Objective 3: Define the regulation of mycotoxin biosynthesis and the molecular relationships among mycotoxigenic fungi.

A series of recent studies at WI have revealed that fungal sporulation and AF production are intimately associated via bridging activities of a new class of novel regulators called the *velvet* family proteins. In 2013, to begin to understand the functions of these *velvet* regulators, Yu's group generated individual *vosA*, *velB*, *velC*, and *vosB* deletion mutants in *A. flavus*. The deletion of *velB* causes severely impaired (number, size and morphology) of conidiation and the lack of sclerotia production. Moreover, the *velB* deletion mutant no longer produces AFB1. The deletion of *vosA* causes earlier conidiation and 2-fold more conidia at day 4. Besides, the *vosA* deletion mutant produces significantly less AFB1 comparing to wild type (WT). Importantly, the conidia derived from the *velB* and *vosA* deletion mutants appear to contain only ~30% of trehalose compared to WT spores, suggesting that both may be required for the long-term spore

viability in *A. flavus*. Although *vosB* and *vosA* share high similarity amino acid sequence (64.0%), their null mutant phenotypes are very different. The *vosB* deletion mutant doesn't show reduced spore viability, and exhibits more sclerotia formation under dark condition, while indistinguishable from WT under light condition. In addition, the *vosB* deletion mutant no longer produces AFB1. These findings have led to two key hypotheses: 1) The Velvet proteins play important roles in controlling both conidiation and AF biosynthesis in *A. flavus*; 2) The *A. flavus* specific VosB protein is a key regulator associated with sclerotia formation and AF production.

Also at WI, research has focused on identifying regulators of secondary metabolism (e.g. mycotoxin) production and/or fungal overwintering structures and to utilize such knowledge in designing rational control strategies. Interest in identifying global secondary metabolite regulators arose due to finding in the WI research group that *laeA* is a global regulatory of secondary metabolite gene clusters. This protein is conserved in fungi and regulates aflatoxin, sporulation and sclerotial production in *A. flavus*. Deletion of *laeA* reduces virulence of all fungi examined so far including the aflatoxigenic fungus *A. flavus*, *Fusarium* mycotoxin fungi, leaf pathogens and the human pathogen and agricultural pest, *A. fumigatus*. Elucidating the mechanism by which LaeA works is critical in understanding global regulation of secondary metabolism and fungal condiation in mycotoxigenic fungi.

A research collaboration was initiated between KY, IN, and AR to study the mechanisms of pathogenicity and mycotoxigenicity in *Stenocarpella maydis* (cause of Diplodia ear rot of maize), which produces the mycotoxin Diplodiotoxin. There have been very few studies of the cytology of colonization of maize tissues by *S. maydis*, and nothing is known about the molecular mechanisms of pathogenicity. At IN and AR, protocols have been developed to genetically manipulate this fungus, and a whole genome sequence assembly has been generated. Work at KY is focused on the cytology of infection by *S. maydis*. Researchers in IN and AR characterized a mutant of *Stenocarpella maydis* that secretes an unidentified green metabolite into droplets on aerial mycelia. Production of the metabolite is light induced, requiring a light-dark cycle. Strain 174 produces normal pycnidia, is pathogenic to developing corn ears, and produces the mycotoxin diplodiatoxin. Southern analysis indicated that strain 174 contains a single copy of insertion T-DNA, which was used to generate the mutation. DNA sequence at the border of the insertion site indicated that T-DNA landed 5' to a putative gene encoding a histidine kinase.

Work on FB production by black *Aspergillus* spp. (IA) showed that a good portion of these isolates produce FB2 in the laboratory, but low levels compared with *F. verticillioides* or *F. proliferatum*. Drier regions had greater levels of black *Aspergilli* in maize, which co-occurred with *A. flavus*. Further studies will be conducted on the interactions between fungal species and mycotoxigenesis.

Impact:

1. Assessments of cytotoxicity of DON, D3G and de-epoxyDON are planned to lead to determination of the role of DON and its major metabolites in inflammatory bowel

disease, which will benefit consumers, and the grain and food industries by characterizing what amounts of the mycotoxin should be of concern for this disease endpoint, informing regulatory decision making.

2. The significant increase in the levels of DON3G during malting of barley are a concern, as malt is used not only in beer, but also in other food products. This work establishes surveillance is needed to help establish integrated strategies to manage and to reduce mycotoxin contamination in cereal grains and distillers grains.

3. The study of *A. flavus* populations provided information about the toxigenic capacity of the strains causing disease in Indiana. We found that most aflatoxin-producing strains were in the most severe drought stressed areas. Also, both mating type of the fungus are present, suggesting that sexual reproduction is occurring within the Indiana populations.

4. The knowledge of the lack of 3-acetyldeoxynivalenol producing strains of *F. graminearum* suggests other explanations for the apparent increase in DON should be sought. These include changes in cultural practices, cultivar use and weather patterns. Similarly, survey's to document increases in DON in corn and wheat grain are warranted.

5. *Stenocarpella maydis* is a major fungal pathogen of Midwest corn, causing both ear and stalk rot diseases. The work provides an understanding of the molecular mechanisms that regulate development and metabolism in this fungus.

6. A better understanding of how sporulation, sclerotial production and AF biosynthesis is regulated in this important fungus will not only lead to novel prevention strategies, but will also advance our understanding of fungal pathogenesis in general and provide new insights into the development of safe and effective control strategies (e.g., new antifungal drugs/proteins, or RNAi for the *velvet* regulators and their interactions) for fungal dispersion and AF contamination with minimum effects on environmental quality and human health.

7. The presence of black Aspergillus spp. might alter FB1/FB2 ratios in maize, which could somewhat reduce mycotoxicosis risk, but the presence of these species also correlated with the presence of *A. flavus*, leading to the expectation of greater co-occurrence of FB and aflatoxins. This work shows the need for continued vigilance by grain producers and the food industry on surveillance and development of anti-mycotoxin strategies that target multiple mycotoxins, especially when grains are under drought stress.

Selected Publications and Presentations:

Publications:

Alkhayyat, F. and Yu, J.-H. 2013. Upstream Regulation of Mycotoxin Biosynthesis, *Advances in Applied Microbiology,* In Press

Amaike S, Affeldt K, Yin WB, Franke S, Anjali Choithani A, Affeldt KJ, Keller NP

(2013) The bZIP protein MeaB mediating virulence attributes in *Aspergillus flavus*. PLoS One. In press.

Bowers E, Hellmich R, Munkvold G. Vip3Aa and Cry1Ab proteins in maize reduce Fusarium ear rot and fumonisins by deterring kernel injury from multiple Lepidopteran pests. World Mycotoxin Journal. 2013;6(2):127-35. doi: 10.3920/wmj2012.1510. PubMed PMID: WOS:000318210800003

Bruns T, Munkvold G. Role of deoxynivalenol production by Fusarium graminearum in seedling infection of soybean, wheat, and maize. Phytopathology. 2013;103(6):21-. PubMed PMID: WOS:000322799500112.

Dolezal, A. L., Obrian, G. R. Dahlia, Nielsen, M., Woloshuk, C. P., Boston, R. S., Payne, G. A. 2013. Localization, morphology and transcriptional profile of *Aspergillus flavus* during seed colonization. Molecular Plant Pathology. DOI: 0.1111/mpp.12056.

Forseth RR, Amaike S, Schwenk D, Affeldt KJ, Hoffmeister D, Schroeder FC, Keller NP (2013) Homologous non-canonical NRPS gene clusters mediate redundant small-molecule biosynthesis in *Aspergillus flavus*. Angew Chem Int Ed Engl. 52:1590-4.

Prof. David M. Geiser, Dr. Takayuki Aoki, Dr. Charles W Bacon, Dr. Scott E. Baker, Dr. M.K. K. Bhattacharyya, Dr. Mary E. Brandt, Dr. Daren W. Brown, Prof. Lester W. Burgess, Dr. Sofia Noemi Chulze, Dr. Jeffery J. Coleman, Dr. James C. Correll, Dr. Sarah Covert, Prof. Pedro W. Crous, Dr. Christina A. Cuomo, G. Sybren de Hoog, Dr. Antonio Di Pietro, Dr. Wade H Elmer, Dr. Lynn Epstein, Dr. Rasmus J.N. Frandsen, Dr. Stanley Freeman, Dr. Tatiana Gagkaeva, Dr. Anthony E. Glenn, Dr. Tom Gordon, Dr. Nancy F. Gregory, Dr. Kim Hammond-Kosack, Dr. Linda Hanson, Dr. Maria del Mar Jimenez-Gasco, Dr. Seogchan Kang, Dr. Harold Corby Kistler, Dr. Gretchen A. Kuldau, Dr. John F. Leslie, Dr. Antonio Logrieco, Dr. Guozhong Lü, Dr. Erik Lysøe, Prof. Li-jun Ma, Dr. Susan McCormick, Dr. Quirico Migheli, Dr. Antonio Moretti, Dr. Françoise Munaut, Dr. Kerry O'Donnell, Prof. Ludwig H Pfenning, Prof. Randy Ploetz, Dr. Robert Proctor, Dr. Stephen A. Rehner, Dr. Vincent A.R.G. Robert, Dr. Alejandro P. Rooney, Baharuddin Salleh, Dr. Maria Mercedes Scandiani, Jonathan Scauflaire, Dylan P.G. Short, Prof. Emma Steenkamp, Dr. Haruhisa Suga, Dr. Brett Anthony Summerell, Prof. Deanna A. Sutton, Prof. Ulf Thrane, Dr. Frances Trail, Dr. Anne van Diepeningen, Dr. Hans VanEtten, Prof. Altus Viljoen, Dr. Cees Waalwijk, Dr. Todd Ward, Prof. Michael J. Wingfield, Dr. Jin-Rong Xu, Dr. X. B. Yang, Dr. Tapani Yli-Matilla, and Dr. Ning Zhang. 2013. One Fungus, One Name: Defining the genus Fusarium in a scientifically robust way that preserves longstanding use. *Phytopathology*, 103(5): 400-408.

Malcom, G. M., Kuldau, G. A., Gugino, B. K., Jimenez-Gasco, M. D. Hidden host plant associations of soilborne fungal pathogens: An ecological perspective. *Phytopathology*, 103: 538-544.

Munkvold G, Logrieco A, Susca A, Sulyok M, Krska R, Mule G, et al. Fumonisin production by black Aspergillus species in maize. Phytopathology. 2013;103(6):175-. PubMed PMID: WOS:000322799501028.

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Neeff, D. , D. Ledoux, G. Rottinghaus, A. Bermudez, A. Dakovic, R. Murarolli, and C. Oliveira. 2013. In vitro and in vivo efficacy of a hydrated sodium calcium aluminosilicate to bind and reduce aflatoxin residues in tissues of broiler chicks fed aflatoxin B_1. Poultry Science 92:131-137.

Parsons MW, Munkvold GP. Effects of planting date and environmental factors on fusarium ear rot symptoms and fumonisin B1 accumulation in maize grown in six North American locations. Plant Pathology. 2012;61(6):1130-42. doi: 10.1111/j.1365-3059.2011.02590.x. PubMed PMID: WOS:000310788500014.

Patial, V., R.K. Asrani, R.D. Patil, S. Kumar, D.R. Ledoux and G.E. Rottinghaus, 2013. Pathology of ochratoxin A-induced nephrotoxicity in Japanese Quail and its protection by seabuckthorn (*Hippophae rhamnoides* L.). (In Press; Avian Diseases).

Schardl CL, Florea S, Pan J, Nagabhyru P, Bec S, Calie PJ (2013) The epichloae: alkaloid diversity and roles in symbiosis with grasses. *Curr Opin Plant Biol* **16:** 480-488

Schardl CL, Young CA, Pan J, Florea S, Takach JE, Panaccione DG, Farman ML, Webb JS, Jaromczyk J, Charlton ND, Nagabhyru P, Chen L, Shi C, Leuchtmann A (2013) Currencies of mutualisms: sources of alkaloid genes in vertically transmitted epichloae. *Toxins* **5:** 1064-1088

Shin, K.-S., Park, H.-S., Kim, Y.-H. and Yu, J.-H. 2013. Comparative proteomic analyses reveal that FlbA down-regulates *gliT* expression and SOD activity in *Aspergillus fumigatus*. *J Proteomics* 87:40-52. doi: 10.1016/j.jprot.2013.05.009.

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Simmons HE, Dunham JP, Munkvold GP. Comparative analysis of Fusarium graminearum on two hosts using next generation sequencing. Phytopathology. 2013;103(6):134-. PubMed PMID: WOS:000322799500740

Vekiru, E., S. Fruhauf, I. Rodrigues, R. Krska, G. Schatzmayr, F. Ottner, D. R. Ledoux, G. E. Rottinghaus, and A. J. Bermudez. 2013. In Vitro binding assessment and in vivo efficacy of several adsorbents to counteract the toxic effects of aflatoxin B1. (In press; ANIFEE-12-4049).

Woloshuk, C.P. and Shim, W-B. 2013. Aflatoxins, Fumonisins, and Trichothecenes: A Convergence of Knowledge. FEMS Microbiology Reviews. 37:94-109.

Yigezu, Y.A., Alexander, C.E., Preckel, P.V., Maier, D.E., Mason, L.J., Woloshuk, C.P., Lawrence, J., and Moog, D.J. 2013. Integrated joint pest management strategies in the presence of control spillovers. European Review of Agricultural Economics. doi:10.1093/erae/jbs044.

Yin W, Amaike S, Wohlbach DJ, Gasch AP, Chiang Y-M, Wang CC, Bok JW, Rohlfs M, Keller NP (2012) An *Aspergillus nidulans* bZIP response pathway hardwired for defensive secondary metabolism operates through *aflR*. Mol Microbiol 83:1024-1034.

Meeting abstracts:

Bovo, F., L. Franco, R. Rosim, G. Rottinghaus, D. Ledoux, and C. A. Oliveira. 2013. The binding capacity of yeast-derived products for aflatoxin B_1 in buffer solution. Abstract #P1-40. European Symposium on Food Safety meeting of the International Association for Food Protection, May 15-17, Marseille, France.

Bovo, F., L. Franco, E. Kobashigawa, G. Rottinghaus, D. Ledoux, and C. A. Oliveira. 2013. Adsorption of zearalenone, ochratoxin A and deoxynivalenol by yeast-derived product in buffer solution. Abstract #P1-41. European Symposium on Food Safety meeting of the International Association for Food Protection, May 15-17, Marseille, France.

Bovo F., L. T. Franco, E. Kobashigawa, G. E. Rottinghaus, D. R. Ledoux, and C. A. F. Oliveira. 2013. Efficacy of beer fermentation residue to ameliorate performance parameters in broilers intoxicated with aflatoxin. Abstract PP VI-11, Page 202. Proceedings 19th European Symposium on Poultry Nutrition, Potsdam, Germany, August 26-29.

Bovo F., L. T. Franco, E. Kobashigawa, G. E. Rottinghaus, D. R. Ledoux, and C. A. F. Oliveira. 2013. Evaluation of serum parameters after addition of beer fermentation residue in diets of broilers intoxicated with aflatoxin. Abstract PP VI-12, Page 202. Proceedings 19th European Symposium on Poultry Nutrition, Potsdam, Germany, August 26-29.

Li, W. and Woloshuk, C. P. 2013. *Aspergillus flavus* in corn ears from Indiana under the drought conditions in 2012. Phytopathology 103(Suppl. 2):S2.80.

Romero M. P., Liu, C., Woloshuk, C. 2013. Characterization of *Stenocarpella maydis* mutants. Phytopathology 103(Suppl. 2):S2.123.