**2021 (June) INRC report**

Measurements of corn root mass, root distribution, and grain yield were made in 2018-2020 in two contrasting rotation systems, a 2-year corn-soybean rotation and a 4-year corn-soybean-oat/alfalfa-alfalfa rotation that periodically received cattle manure. Plots of each rotation system were present in four replicate blocks within a 9-hectare experiment established in 2001 at the Iowa State University Marsden Farm in Boone County.

Corn root mass to a soil depth of 60 cm was measured at 3 and 105 days after planting in 2019, and at 4 and 117 days after planting in 2020. Four soil samples per plot were drawn at a location 10 cm from corn rows in 15 cm depth increments using a 32-mm-diameter soil probe. Soil from each depth increment within a plot was composited and roots were recovered using a sequence of elutriation (washing), flotation, recovery from organic debris using tweezers and a stereo microscope, drying, and weighing. No year effect on corn root mass was detected (p=0.65). In contrast, we found a significant sampling date x rotation interaction (p=0.015). Corn root mass increased 108%, from 515 to 1,073 kg ha-1, in the 2-year rotation, whereas root mass increased 49%, from 782 to 1,160 kg ha-1, in the 4-year rotation. If the initial levels of root residue decayed at an equal rate in the two rotation treatments, or if they persisted equally in the two rotations, these results would indicate that the 2-year rotation added more root mass during the growing season than did the 4-year rotation.

Maximum corn root depth was measured throughout the 2018-2020 cropping seasons in both rotation systems. Maximum root depth was determined five times in 2018, seven times in 2019, and eight times in 2020, based on four cores per plot drawn with a 19-mm-diameter soil probe. Maximum root extension was determined visually and quantified with a meter stick. Maximum root depth differed among years (p<0.0001) and rotation systems (p=0.0013), but no year x rotation system interaction occurred (p=0.66). Averaged over rotation treatments, root depth was greatest in 2019 (102.5 cm), least in 2018 (53.7 cm), and intermediate in 2020 (90.0 cm). Averaged over years, maximum root depth was 14% higher in the 4-year rotation (87.4 cm) than in the 2-year rotation (76.7 cm). These observations corroborated our hypothesis that maximum corn root depth would be greater for corn following alfalfa in the 4-year rotation than following soybean in the 2-year rotation.

Corn grain yield was determined using a 6-row combine equipped with a yield monitor and moisture meter. Sampling areas for yield were 4.6 m x 84 m. For statistical comparisons, all grain yield data were adjusted to 15.5% moisture. Corn yield was affected by a significant year x rotation interaction (p=0.0096): 6626

Taken together, data from this project indicate that compared with corn following soybean in a 2-year rotation, corn following alfalfa in a 4-year rotation had longer roots and produced yields that were as high or higher. The data also suggest that corn in the 4-year rotation invested less biomass in roots than did corn in the 2-year rotation. Possible differences between rotation systems in patterns of biomass allocation merit more attention in future research activities.

**Presentations**

Conservation Drainage Network, 2021 annual meeting, West Lafayette, IN (7 April 2021, presented on-line). Effects of cropping system diversification on crop performance, soil properties, and environmental quality.

Iowa Learning Farms Conservation Webinar, Boone, IA (10 March 2021, presented on-line, https://vimeo.com/522992315). Cropping system diversification is a path to greater sustainability.

Iowa State University Extension and Outreach, Agriculture and Natural Resources Crops Team Fall In-Service Training, Boone, IA (23 September 2020, presented on-line). Cropping system diversification is a path to greater sustainability.

Corteva Agriscience, Predictive Ag Leadership Team webinar, Johnston, IA (26 August 2020, presented on-line). Enhancing biodiversity in the U.S. Corn Belt to improve environmental quality and sustain crop production.

Northeast Iowa Resource Conservation and Development, 3rd Annual Soil Health Workshop, Monona, IA (27 February 2020). Diversified cropping systems for improved environmental quality and better soil health.

Iowa Association of Water Agencies, 2020 winter general membership meeting, Ames, IA (16 January 2020). Diversified cropping practices for water quality protection.

University of Kentucky, Department of Plant and Soil Sciences, departmental seminar, Lexington, KY (20 November 2019). Why are long-term agricultural field experiments important?

Michigan State University, Kellogg Biological Station, Long-Term Ecological Research site, All Scientist Meeting, Hickory Corners, MI (20 September 2019). Enhancing biodiversity in the Corn Belt to improve environmental quality and crop production.

Iowa Governor's Conference on Public Health, Des Moines, IA (24 April 2019). Diversification and integration: two strategies for improving sustainability.

**Additional Funding**

Hall, S.J., C.Q. Lu, S.V. Archontoulis, A. VanLoocke, M. Liebman, and M. Thompson. U.S. Department of Agriculture­­–Agriculture and Food Research Initiative. Confronting isotope-enabled models with data to quantify and predict soil carbon change in diversified cropping systems. $499,955. 2021-2024.

Ruark, M.D., M. Liebman, Y. Rui, and E. Omondi. U.S. Department of Agriculture­­–Agriculture and Food Research Initiative. Microbial contribution to building and stabilizing soil organic matter under long-term crop management practices in agroecosystems. 2020-2022. $499,744.

**GRADUATE STUDENTS**

Nichols, Virginia. Ph.D. in Agronomy (Crop Production and Physiology), Iowa State University. Entered in 2018. (Co-supervised with Dr. Sotirios Archontoulis).

**PUBLICATIONS**

Baldwin-Kordick, R., M. De, M.D. Lopez, M. Liebman, N. Lauter, J. Marino, and M.D. McDaniel. *In review*. Comprehensive impacts of diversified cropping on soil health and sustainability in the Midwestern US. **Agroecology and Sustainable Food Systems**.

Middleton, T.E., A.L. McCombs, S.R. Gailans, S. Carlson, D.L. Karlen, K.J. Moore, M. Liebman, T.C. Kaspar, M.M. Al-Kaisi, D.A. Laird, M.H. Wiedenhoeft, K. Delate, C.A. Cambardella, M.L. Thompson, E.A. Heaton, and M.D. McDaniel. *In review*. Assessing biological soil health through decomposition of inexpensive household items. **Applied Soil Ecology**.

Liebman, M., H.T.X. Nguyen, M.M. Woods, N.D. Hunt, and J.D. Hill. 2021*.* Weed seedbank diversity and sustainability indicators for simple and more diverse cropping systems. **Weed Research**, doi:10.1111/wre.12466.

Hunt, N., M. Liebman, S. Thakar, and J. Hill. 2020. Fossil energy use, climate change impacts, and air quality-related human health damages of conventional and diversified cropping systems in Iowa, USA. **Environmental Science and Technology,** doi: 10.1021/acs.est.9b06929.

Poffenbarger, H.J., D.C. Olk, C. Cambardella, J. Kersey, M. Liebman, A. Mallarino, J. Six, and M.J. Castellano. 2020. Whole-profile soil organic matter content, composition, and stability under crop rotations differing in belowground inputs. **Agriculture, Ecosystems, and Environment**, doi:10.1016/j.agee.2019.106810.

Raza, M.H., C. Harding, M. Liebman, and L.F. Leandro. 2020. Exploring the potential of high-resolution satellite imagery for the detection of soybean sudden death syndrome. **Remote Sensing** 12: 1213, doi:10.3390/rs12071213.

Hunt, N., J. Hill, and M. Liebman. 2019. Cropping system diversity effects on nutrient discharge, soil erosion, and agronomic performance. **Environmental Science and Technology** 53: 1344-1352, doi:10.1021/acs.est.8b02193.