MOSES CONFERENCE 2022, La Crosse, WI

SARE PROJECT LNC17-389

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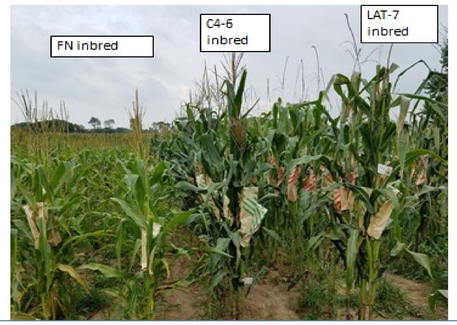
Testing N Efficient, High Methionine Corn Hybrids with Organic Farmers

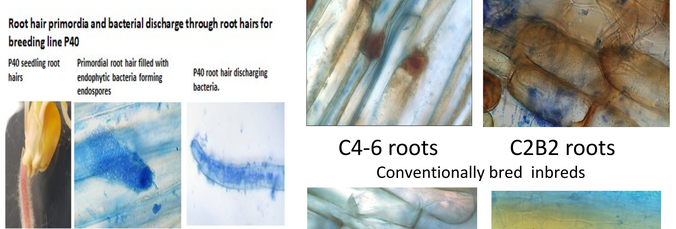
Background

Endophytes: Corn, North America's most productive and most grown cereal, has pollution problems due to N fertilizers and lack of nutritional density in its grain. We tested new hybrids which possess microbial partnerships that enhance nutrient availability in the rhizosphere and provide the plant with oxidized microbial biomass through rhizophagy cycles. Such cycles entail the excretion of mineral depleted bacteria from root hairs and the reabsorption of mineral enriched bacteria by young growing roots. Hybrids with the Mandaamin inbred C4-6 as a parent express these traits and also appear to fix N_2.



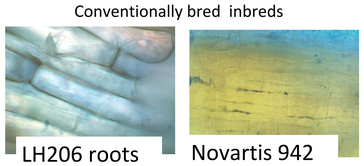
Phenotype of N efficient/N2 fixing inbreds. Results in 2019 with corn inbreds following after a winter rye disk down crop. FN is a typical inbred. The pedigree of LAT-7 is 1/4th Mixeno.

Mandaamin Inbreds



C4-6 roots C2B2 roots

Conventionally bred inbreds

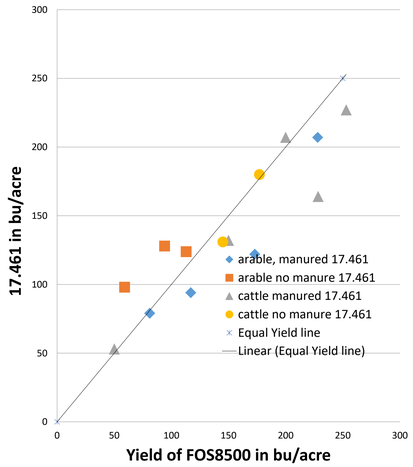


LH206 roots Novartis 942

Methods and Results

Working with Rhizophagy: The hybrids were studied in the context of different farming systems and soil fertility conditions. Studies with microscopy, field trials on different farms, and mineral and natural isotope analyses showed that 1) the plants exercise rhizophagic cycles with seed associated bacteria, leading to nitrogen efficiency in field trials, high levels of $\delta^{15}N$ in tissues, and grain with high protein and mineral contents; 2) these partnerships result in comparable yields to manured commercial hybrids where no manure is added to the Mandaamin hybrids.

Yields of 17.461 and FOS8500



Level	no sites	% of FOS check		bu/acre	
system effect					
arable	14	106	a	120	a
cattle	14	97	a	162	a
hybrid effect					
17.461	14	102	a	139	a
FOS8500	14	100	a	144	a
manure effect					
none	10	**108**	a	130	a
manured	18	**94**	b	152	a
system x hybrid interaction					
arable, 17.461	7	**111**	**a**	121	a
arable,FOS8500	7	**100**	**b**	119	a
cattle,17.461	7	**94**	**b**	156	a
cattle,FOS8500	7	**100**	**b**	169	a
manure x hybrid interaction					
none,17.461	5	**117**	a	136	a
none,FOS8500	5	**100**	b	125	a
manured,17.461	9	88	b	141	a
manured,FOS8500	9	100	b	163	a
manure x hybrid x system interaction					
none,17.461,arable	3	**137**	a	117	a
none,FOS8500,arable	3	**100**	b	89	a
none,17.461,cattle	2	96	b	156	a
none,FOS8500,cattle	2	100	b	161	a
manured,17.461,arable	4	85	b	126	a
manured,FOS8500,arable	4	100	b	150	a
manured,17.461,cattle	5	92	b	157	a
manured,FOS8500,cattle	5	100	b	176	a

The C4-6 based Mandaamin hybrids also respond negatively to fresh manure but positively to high organic N and to high soil protein levels resulting from cattle manure. The negative effect of fresh manure applications on the C4-6 based hybrids extends to yield and mineral uptake and this problem is worse on soils with low organic matter content probably because the manure interferes with the rhizophagy cycles (see chart).

Nitrogen efficiency and fixation: Natural isotope abundance studies of the Mandaamin hybrids indicated enhanced N_2 fixation. This paralleled increased mobilization of nutrients from soil into grain. The balance of fixation and acquisition from soil microbial biomass/organic matter depended on hybrid, farm history, soil quality, and year of trials. The highest estimates for fixation level of N_2 into grain (48%) and acquisition of N from microbial biomass/easily available organic matter (58%) was estimated for the C2B2.C46 hybrid when grown under organic arable systems in 2019. However, the other Mandaamin hybrids (17.461 and 17.2B24) tested appeared to fix or extract more N from biomass or the air when they were grown under the organic or conventional cattle systems.

Nutritional Density: Tests with the OREI funded CASH project (University of Illinois) on 32 organic sites over 2 years in WI, IL, IN, showed that two Mandaamin hybrids (17.461 and 17.2B24) had similar (11% less) yields to the commercial hybrids. But they had 10 and 18% more protein, 32% more oil, 44 and 63% more zeaxanthin, 48 to 150% more β-cryptoxanthin, 38 to 65% more β-carotene, 10 and 15% more lysine, 33 and 42% more methionine, and 10 and 16% more cysteine in their grain than did the checks.
These differences (except yield) were all statistically significant at the 95% security level. The Mandaamin hybrids also had 23 to 25% higher methionine contents in their protein than did the checks. All this is especially important for important for improving organic poultry and human health. Studies with formulation of diets together with a poultry scientist suggest that the nutritional value of the Mandaamin hybrids should offset a slightly lower yield in terms of price of the corn and value/acre by reducing the need for organic soymeal.
Further mineral analysis In the OREI project revealed that the Mandaamin hybrids had 17 to 24% more iron, 22 to 32% more manganese, 13 to 54% more copper, and 11 to 12 more zinc in their grain than did the checks. Analysis in the SARE project confirmed results with amino acids and showed the Mandaamin hybrids average mineral content across many minerals, and their uptake ranged 12-24% higher than the check. The highest value in almost every case was for the 17.461 hybrid.

USDA

This project is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2017-38640-26916 through the North Central Region Sustainable Agriculture Research and Education program under sub-award number LNC17-389. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture or SARE. USDA is an equal opportunity employer and service provider.

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Mandaamin Institute

Foundation Organic Seeds, LLC O.C.I.A. Member

Acknowledgements: This research was made possible by the cooperation and assistance of numerous people, institutions, and farms. This includes the help of many organic and biodynamic farmers who participated in the thinking behind the project and the work with it on their farms. The Corn and Soil Health project, centered at the University of Illinois, with OREI funds accomplished basic soil analyses, worked up data on soils and farms, and helped in formulating experimental designs for the farm trials. USDA-ARS, Morris, Minnesota did tissue analysis of corn for minerals and helped prepare samples for isotope analysis. Foundation Organic Seed contributed seed and advice to the project. Rutgers University contributed rhizophagy research on maize seedlings, advice on interpreting our results, and continuous inspiration based on their research findings. University of Wisconsin Extension and Pepin County Conservation helped organize farmers and events and meetings around the issue of N_2 fixing corn and helped carry out on farm research in the NW part of Wisconsin. Wood Ends Soil Testing Lab and Cornell University assisted with extra soil quality tests. At the Mandaamin Institute, co-workers got the field research done. Any errors in interpretation of results are due to the author and not to any of the people mentioned above. Finally we would like to acknowledge funding from USDA-NIFA-OREI, SARE and the Ceres Trust, without which this work could not have been accomplished.

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