

Breeding corn for positive soil microbial interactions.

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Can we increase the reliability of protein and methionine content of our corn hybrids with associative bacteria?

- **Sugar Cane Production in Brazil with endophytes.**
- Inoculation of corn with bacteria increased yields but did not alleviate N stress on unfertilized plots (UW Madison Riggs, et al., 2001).
- Nitrogen fixation in commercial corn hybrids in Uruguay between 0 and 33% of the total N accumulated (Montañez et al, 2009).
- A community of bacteria was identified that could fix N inside the plant.
- Cultivars of maize vary in their ability to foster N fixation by these organisms (García de Salamone et al., 1996; Montañez et al, 2009).
- Cultivars with activated defense systems against pathogens do not allow colonization (Miche et al. 2006).
- Fusarium is an endophyte in corn and it defends its niche with fusaric acid (Bacon et al., 2004).

Results root disease 2000-2002 averaged across fertilization treatments:

Conventional =	26%	n = 47
Organic =	15%	n = 32
level of P =	***	
Conventional corn after corn or soybeans =	22%	n = 24
Organic corn after soybeans or forages =	13%	n = 28
level of P =	***	
Conventional corn after corn =	30%	n = 9
Organic corn after soybeans =	14%	n = 14
level of P =	***	



Unfertilized ground, East Troy, 2008, inoculation with
Azospirillum

no selfed ears tested	Name	inoculation	Protein (%)
11	Iodent x Iodent #12 F3S1	No	12.8
7	Iodent x Iodent #12 F3S1	Yes	13.4
5	Stiff Stalk x Stiff Stalk F2S1	No	13.3
5	Stiff Stalk x Stiff Stalk F2S1	Yes	14.0
8	Stiff Stalk inbred selection	No	13.7
7	Stiff Stalk inbred selection	Yes	15.4
7	Iodent x MN13 type F2S1	No	13.0
6	Iodent x MN13 type F2S1	Yes	14.3
7	Lancaster x Lancaster #12 xc	No	12.2
4	Lancaster x Lancaster #12 xc	Yes	14.0
38	Average	No	13.0
29	Average	Yes	14.2

Comparison of B73 (left) and LR 1 and LR 6 (right). Chlorophyll scores averaged 43, 56, and 59; root dry weight averaged 130, 100, and 57 g/plant; delta 15N of grain was 4.9, 3.8, 4.1 for the three respective varieties.



Chlorophyll scores 2009

Results from unfertilized field for chlorophyll scores in 2009.

	Number of lines	Average no. plants scored/line	Average chlorophyll score	Range in ave. score	Average standard deviation	Average % of plants with scores 50 or more
PVP lines or conventional inbred derivations	15	17	37	31 to 45	7	8
Commercial inbreds from Cooperator	23	8	40	33 to 47	5	8
MPAI breeding lines > 5 years organic	26	15	45	35 to 63	8	34
HM PI lines (exotic and primitive	13	3	54	41 to 65	4	65

Delta 15N analyses 2009

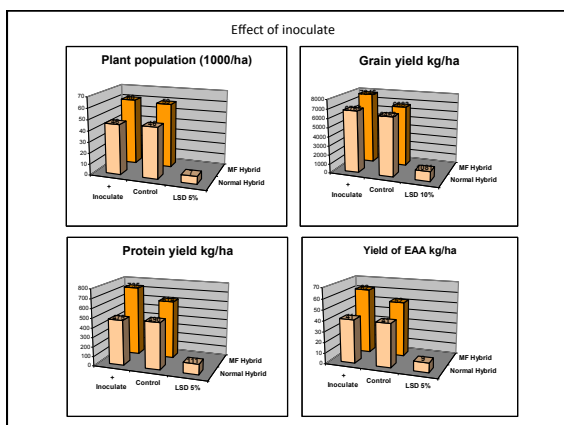
	Number of lines tested	Average delta 15N	Average standard deviation	Range	%N derived from air for best N fixer
PVP lines or conventional inbred derivations	15	4.74	0.42	3.94 to 5.41	27
Commercial inbreds from Cooperator	9	4.86	0.71	3.9 to 5.77	32
MFAL breeding lines > 5 years organic	15	5.36	0.46	4.62 to 6.14	25
HM Landraces	10	4.81	0.96	3.21 to 6.13	48

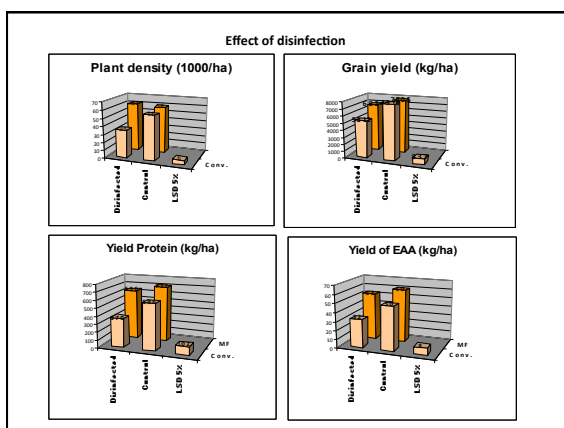
Experiment with hybrids made with N efficient corn

- 4 conventional organic hybrids compared with 4 crosses between N efficient corn (populations 1 and 3) and different MF breeding lines.
- 4 seed treatments: 1) disinfect seed; 2) disinfect and inoculate with a mix of bacteria; 3) inoculate with bacteria; 4) nothing.
- Three replications on an organic site after soybeans, East Troy, 2010.

Grain Yield 2010

Type of Hybrid	Disinfect	Disinfect + Inoculate	Inoculate	nothing	ave.
Conventional Hybrid bu/acre					
0.574	97	113	132	121	116
0.59-06N	63	92	137	113	101
Seedhouse 1	101	83	113	133	107
Seedhouse 2	59	71	123	137	97
Average	80	89	126	126	105
MF Experimental					
B73 x Pop 3	96	88	123	105	103
NG x Pop 3	83	107	94	59	86
SS1 x Pop 3	119	134	167	135	139
NSS1 x Pop 1	110	133	154	146	136
Average	102	116	135	111	116

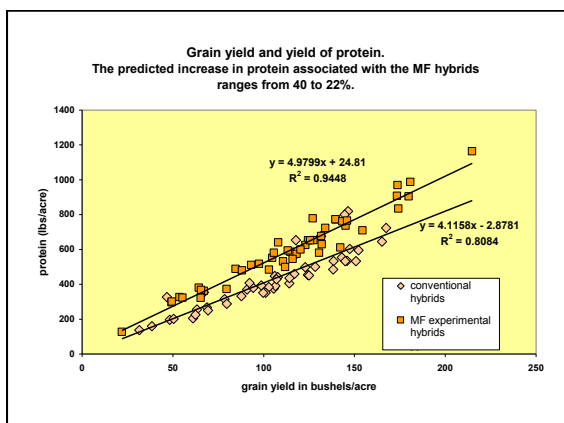




Differences between types of hybrids

	% starch	% protein	% methionine	% lysine	% cysteine
Conventional	72.9	7.5	0.18	0.28	0.17
MF hybrids	70.7	9.5	0.25	0.34	0.20
% diff MF:Conv	-3	27	42	21	20
F test prob.	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

	1000 plants/ha	Grain kg/ha	protein kg/ha	EAA kg/ha	% meth in protein
Conventional	45.9	6613	483	41	2.4
MF hybrids	59.7	7265	674	57	2.7
% diff MF:Conv	30	10	40	39	11
F test prob.	< 0.001	0.124	< 0.001	< 0.001	< 0.001

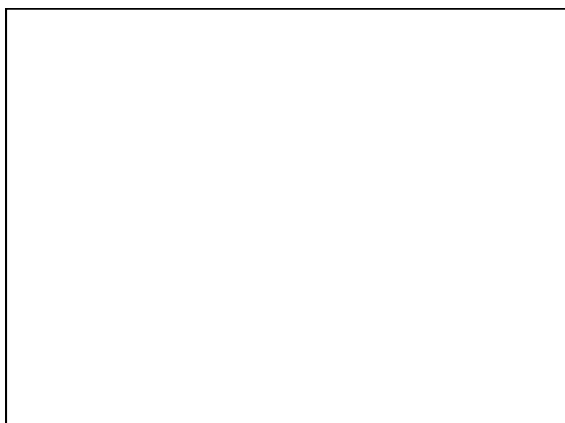


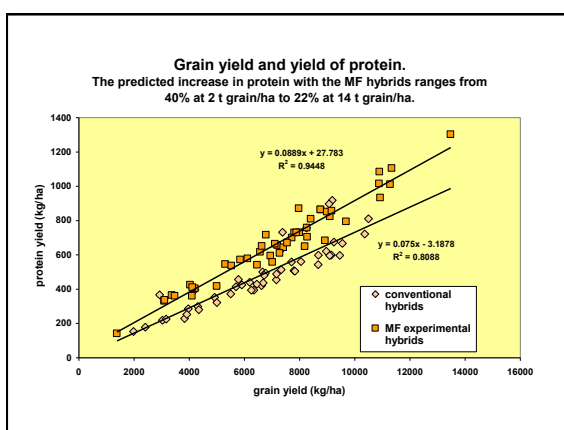
Results in 2010

- Warm, moist growing conditions did not seem to limit N uptake as there were no visual symptoms of chlorophyll deficiency.
- In a set of trials in 2010, disinfection decreased yields for four conventional hybrids but not for four hybrids made with the putative N efficient populations.
- The N efficient hybrids outyielded the conventional hybrids but only when the former were inoculated with bacteria.
- The efficient hybrids produced more protein and essential amino acids per hectare and this was strongly increased by inoculating with bacteria.
- However, natural delta ^{15}N isotope analysis gave little support for the idea that N fixation had occurred in the 2010 trials.

Thoughts on the results

- Different cultivars will respond differently to bacteria but the response will vary with environmental conditions.
- Where N is not limiting bacterial symbionts may benefit some corn cultivars by stimulating plants to take up more N from soil.
- N fixation may be facultative for some cultivars, depending on their need and their ability to foster microbial symbionts.
- It is necessary to grow corn under low organic matter conditions in order to be able to detect fixation in corn using natural isotope abundance techniques.





Grain yield 2010 (Mg/ha)

Normal Hybrids	Disinfect	Disinfect + Inoculate	Inoculate	nothing	ave.
0.574	6.1	7.1	8.3	7.6	7.3
0.59-06N	4.0	5.8	8.6	7.1	6.4
Seedhouse 1	6.3	5.2	7.1	8.3	6.7
Seedhouse 2	3.7	4.4	7.7	8.6	6.1
Average	5.0	5.6	7.9	7.9	6.6
MF Experimental					
B73 x Pop 3	6.0	5.5	7.7	6.6	6.5
NG x Pop 3	5.2	6.7	5.9	3.7	5.4
SS1 x Pop 3	7.5	8.4	10.5	8.5	8.7
NSS1 x Pop 1	6.9	8.4	9.7	9.2	8.5
Average	6.4	7.3	8.4	7.0	7.3
