Field evaluation of biological nitrogen fixing (BNF) products for non-legumes

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Background:

There is great interest in biological nitrogen fixation (BNF) for non-legumes as a way to improve crop profitability and reduce the environmental footprint of current nitrogen production and application systems.
A number of biological products are currently entering the marketplace, prompting this basic evaluation of their field effectiveness in 2021 (a drought year).

Small Plot Evaluation

Small plot evaluations:

- Spring wheat, canola, corn and soybeans were treated with foliar applications of Utrisha (*Methylobacterium symbioticum)* and Envita (*Gluconacetobacter diazotrophicus)* with a handboom sprayer. Application rates were 135g/ac Utrisha and 95 ml/ac Envita (with 0.1% Agral 90 non-ionic surfactant) in 76 l/ac (20 US gpa).
- Plots were sprayed in the morning when stomata were open and to avoid the heat of the day
- Nitrogen sufficiency of the crop was evaluated a number of ways – through GreenSeeker NDVI (vegetation index) , SPAD chlorophyll content, leaf nitrogen content (single composite, so not statistically analysed), visual leaf deficiency ratings, and protein for wheat.
- Plots were harvested with plot combine (canola, Portage corn) or hand harvested and threshed later.
- Treatments were replicated four times and statistically analysed

Small Plot Results:

Spring wheat
Prosper spring wheat sprayed on June 15 (10 am) as flagleaf was emerging. This wheat crop was severely drought stressed. The crop area had received 110 lb N/ac the previous fall. There were no treatment differences.

Figure 1. Wheat plots at application.

Table 1. Wheat response to BNF products.

	Yield bu/ac	% Protein
Control	21.2	16.5%
Utrisha	21.4	16.7%
Envita	22.1	16.9%
CV%	7.0	
P Value	0.68 = ns	

Figure 2. Can you say drought?

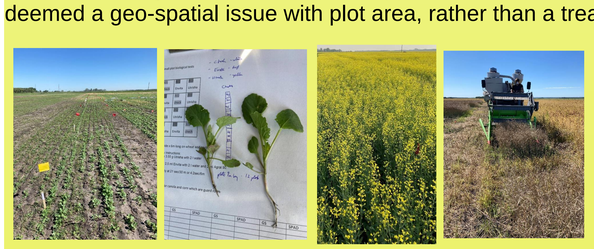
Canola
Plots were the guard rows of existing research plots conducted by University of Manitoba. The nitrogen rate was a low rate at 50 lb N/ac, surface applied as SuperU in June. Both sites received foliar treatments the morning of June 22; the St Claude site at the 5 leaf stage and the Roseisle site at the 4-5 leaf stage.

Table 2. Canola response to BNF at Roseisle (left) and St Claude (right).

	NDVI (July 15)	Yield bu/ac
Control	0.42	48.5
Utrisha	0.44	46.8
Envita	0.45	42.4
CV%	6.1	12.1
P Value	0.28 = ns	0.35 = ns

	NDVI (July 15)	Yield bu/ac
Control	0.41	26.9
Utrisha	0.40	25.8
Envita	0.42	25.6
CV%	2.0	18.8
P Value	0.015 = *	0.945 = ns

There were no yield differences. The apparent difference in NDVI at St Claude was deemed a geo-spatial issue with plot area, rather than a treatment difference.)



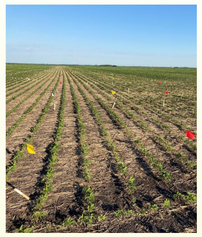
Figures 3-6. Canola application stage, flowering and harvest.

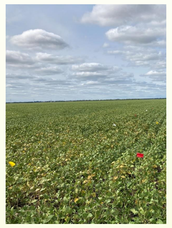
Small Plot Results (continued):

Soybeans
An unfertilized field of soybeans was sprayed with foliar treatments early morning June 23 at the 3rd trifoliate stage. Yields were severely affected by drought.

Table 3. Soybean response to BNF products.

	NDVI (July 15)	NDVI (Aug 13)	SPAD (Aug 13)	Tissue N% (Aug 13)	Yield bu/ac
Control	0.40	0.54	44.4	3.03	25.5
Utrisha	0.40	0.53	45.1	3.21	26.5
Envita	0.38	0.54	44.6	3.10	26.5
CV%	9.7	5.6	1.9		11.0
P Value	0.62 = ns	0.64 = ns	0.84 = ns		0.497 = ns





Figures 7-8. Soybean application stage and midseason growth.

Corn – St Claude
The nitrogen rate was a low rate at 50 lb N/ac, surface applied as SuperU in June. Foliar treatments were sprayed the morning of June 22 at the V4 stage. Leaf deficiency ratings are # plants in 10 with visible leaf yellowing. Yields were depressed by drought and an insufficient base N application.

Table 4. Corn response to BNF products (St Claude).

	NDVI (July 15)	SPAD (Aug 16)	Tissue N% (Aug 13)	Leaf def'y rating (Sept 7)	Yield bu/ac
Control	0.40	40.0	1.62	5.0	82.8
Utrisha	0.40	41.5	1.72	6.0	89.5
Envita	0.38	40.5	1.90	3.5	86.9
CV%	7.1	5.3		42.5	6.4
P Value	0.912 = ns	0.651 = ns		0.296 = ns	0.312 = ns

Corn – Portage
Corn was seeded May 4 after a blanket fertilizer application with 120 Lb N/ac was applied. Designated plots received a further N application after seeding to total 170 lb N/ac. Nitrogen rates represented 100% (170 lb N/ac) and 70% (120 lb N/ac) of full rates. Foliar treatments were applied the morning of June 23 to corn at the V4 stage.

Table 5. Corn response to N fertilizer and BFN (Portage).

	NDVI (July 15)	SPAD (July 21)	Tissue N% (July 21)	Leaf def'y rating (Sept 7)	Yield bu/ac
Factor A – N rate					
70%N	0.77	59.4	3.01	7.4	130.8
100%N	0.76	60.0	2.91	5.0	144.6
P Value - N rate	0.586 = ns	0.49 = ns		0.053 = *	0.00 = **
Factor B - BNF					
Control	0.77	59.9	2.97	5.5	141.4
Utrisha	0.76	58.7	3.14	6.3	136.6
Envita	0.76	60.6	2.77	6.1	136.7
P Value - BNF	0.96 = ns	0.092 = ns		0.759 = ns	0.287 = ns
N X BNF Interaction	0.92 = ns	0.894 = ns		0.649 = ns	0.788 = ns

Full N rates had significantly less N deficiency symptoms and higher yield. There was no affect from BNF products.

On-Farm-Test Evaluation

Utrisha was applied to 3 commercial corn fields with commercial spray equipment. Treatments were applied 3-4 times in replicated strips. There were no differences in N status or yield at any of the sites.

McGregor, MB
Blumenfeld sand loam, 120 lb N/ac applied
Seeded May 4 to Thunder 7578
Sprayed June 29 at 12.4 gpa
Harvest Oct 26

Table 6. Corn response to BNF – McGregor, MB

	NDVI (July 15)	SPAD (July 27)	Tissue N% (July 27)	Leaf deficiency rating (Sept 9)	Yield bu/ac
Control	0.69	57.2	2.85	0.6	142.4
Utrisha	0.66	57.9	3.69	0.4	138.5
LSD (0.10)	ns	ns		ns	ns

Lenore, MB
Rathwell clay loam, 130 lb N/ac applied
Seeded May 5
Sprayed July 10 at 20 gpa in the morning
Harvest Oct 8

Table 7. Corn response to BNF – Lenore, MB

	NDVI (July 16)	SPAD (July 27)	Tissue N% (July 27)	Leaf deficiency rating (Sept 9)	Yield bu/ac
Control	0.66	55.6	2.74	4.6	120.3
Utrisha	0.67	55.9	2.45	4.6	123.8
LSD (0.10)	ns	ns		ns	ns

Homewood, MB
Carroll clay loam,
Seeded Pioneer P7211AM
Sprayed; July 6
Harvest Oct 8

Table 8. Corn response to BNF – Homewood, MB

	NDVI (July 23)	SPAD (July 29)	Tissue N% (July 29)	Yield bu/ac
Control	0.65	59.6	2.77	108.5
Utrisha	0.65	61.6	3.26	106.8
LSD (0.10)	ns	ns		ns

Summary:

Plant N status and yield was not influenced by the BNF products.

Why is this?

- Under general drought conditions, nitrogen (N) often was not limiting yield
- If the advantage is in increasing plant N efficiency, the BNF may need to be tested at a reduced rate of N (as in Portage small plot site)
- Perhaps benefits will be inconsistent in our environment and soils with the foliar application
- With more BNFs coming to market, the following steps should be part of a validation process:

1. Detailed site soil and environment descriptions. Whole plant N analysis should be done across all replicates.
2. Replicating more than the traditional 3-4 replicates is often needed when the expected magnitude of yield difference is expected to be low.
3. BNFs need to be applied across a range of reduced N rates to quantify how much N they replace, if any,

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