



**Northern New York Agricultural Development Program
2025 Project Final Report**

**The Potential for Symbiotic Nitrogen Fixation in Corn
Through the Use of Commercially-Available Biological Products**

PROJECT LEADER:

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BACKGROUND:

Nitrogen is the most limiting nutrient in crop production; it is also one of the biggest farm expenses related to the production of field crops. Recently, numerous biological products have entered the market that are sold as having the ability to fix atmospheric nitrogen on corn or to improve nitrogen use efficiency so that less nitrogen needs to be applied to the crop.

There are many questions among farmers, agronomists, and researchers over what role biological products have in replacing nitrogen fertilizer. Our objective with this project was to test five commercially-available biological products and evaluate the potential effect they might have on the yield and quality of a corn silage crop grown under nitrogen-limiting conditions.

METHODS:

An eight-plot study with eight replications was established on May 27, 2025, in a randomized complete block design at Miner Institute (Chazy, New York; Roundabout silt loam). The plots were two rows wide and approximately 37.5 ft long. The same commercial corn hybrid (P9823Q) was used in all plots.

A total of 8 treatments were tested: 5 commercial products in combination and in isolation compared to a positive (30 units additional N, no product) and a negative (no additional N, no product) control treatment. Products were applied at different stages of corn development in accordance with label instructions.

While not all products included are bacterial inoculants, all advertise that they promote symbiotic nitrogen fixation in corn. The treatments included in the study were:

- T1. *Klebsiella variicola* & *Kosakonia sacchari* (Proven[®] G3 OS, Pivot Bio Inc, Berkeley, CA).
- T2. *Methylobacterium symbioticum* (Utrisha[™], Corteva Inc, Wilmington, DE).
- T3. *Gluconacetobacter diazotrophicus* (Envita[™], Azotic North America, Raleigh, NC).
- T4. *Azospirillum* spp (Boost, The American Root Company, LLC.
1576 SE N St., Grants Pass, OR 97526 USA).
- T5. Maltol lactone (Source[™], Sound Agriculture Company, Emeryville, CA).
- T6. All products in combination.

T7. Negative control (no product applied, reduced N).

T8. Positive control (no product applied, additional 30 units N).

Note: The use of brand names or any mention/listing of specific commercial products or services herein is solely for educational purposes and does not imply endorsement by the Northern New York Agricultural Development or project collaborators, nor discrimination against similar brands, products, or services not mentioned.

Nitrogen was managed with the intention of maintaining a tight nitrogen supply during the growing season. After an initial nitrogen application of 20 units/acre (50 for T8), nitrate (PSNT) samples showed sufficient soil nitrogen reserves for the growing season (25 ppm average).

When the corn reached the proper maturity for silage (October 6, 2025), plots were harvested with a two-row forage harvester for the determination of yield and forage quality. Samples were sent to a local laboratory (Dairy One, Ithaca, New York) for stalk nitrates (package 161) and NIR forage composition (package 321). These metrics were subjected to an analysis of variance (ANOVA, SAS JMP software) that included the fixed effect of treatment and the random effect of repetition. Moisture and stalk nitrate level were used as covariates for the analysis when significant. Statistical significance was declared at $\alpha = 0.05$. The Tukey HSD (Honestly Significant Difference) test was used for means separation in the case of statistical significance. Orthogonal contrast statements were used to test two planned comparisons that were informed by a previous year of testing. Contrast 1 tested T1 and T2 against T7 (negative control). This group was selected because previous testing showed that these two treatments tended toward higher feeding value relative to the control. Contrast 2 tested all biologicals treatments (T1-T6) relative to the negative control (T7).

RESULTS:

While the numerical results look positive for some products (Table 2), a statistically significant treatment effect was not found for the majority of the parameters measured in this study (Table 1). This includes yield, moisture, protein, fiber digestibility, and many other metrics that are meaningful to forage producers. This does not mean that the biological treatments did not cause any differences in these parameters, but, rather, that any differences they caused were too small and/or inconsistent for us to confidently describe them. However, a significant treatment effect was detected for acid detergent fiber. This fiber fraction was highest in T3, T4, T5, and T7 (negative control) and lowest in T1, T2, and T8 (positive control). Since lower fiber content is associated with higher quality and feeding value, it appears that biological treatments 1 and 2 outperformed the others in this regard. Furthermore, these two products had a significantly lower acid detergent fiber content than the untreated control (T7).

Another forage quality metric that showed a significant treatment effect was lignin content. Lignin was highest in T5 and lowest in T2 with all other treatments being similar in lignin content. In-vitro true digestibility was lowest in T5, but highest in T6. When compared to the untreated control (T7), all biologicals treatments (T1-T6) had slightly higher In-vitro true digestibility when grouped together.

Nutrient Uptake

One area that stood out in the data that was unexpected was nutrient uptake as evidenced by nutrient content. When grouped together, all of the biologicals treatments (T1-T6) had slightly greater levels of phosphorus (P), potassium (K,) and chlorine (Cl) as compared to the control

(T7). T1 stood out as having the best ability to improve plant P levels, while T3 and T5 stood out as the top performers when it comes to plant Cl content.

Table 1. Statistical test results specifying measures where numerical differences are likely more than just random chance.

Measurement	Treatment	Contrast 1 (T1+T2 vs T7)	Contrast 2 (T1-T6 vs T7)
Yield, wet tons/acre	NS ¹	NS	NS
Dry biomass yield, US t/a	NS	NS	NS
Digestible yield, dry t/a	NS	NS	NS
Protein yield, US tons/acre	NS	NS	NS
Moisture, %	NS	NS	NS
Acid detergent fiber, %	0.044	0.032	NS
Neutral det. fiber (aNDF), %	NS	NS	NS
Lignin, %	0.030	NS	NS
Non-fiber carbohydrates, %	NS	NS	NS
Starch, %	NS	NS	NS
Starch digestibility, %	NS	NS	NS
Water soluble carb., %	NS	NS	NS
Ash, %	NS	NS	NS
Crude fat, %	NS	NS	NS
In-vitro digestibility, %	0.003	0.004	0.049
aNDF digestibility, % NDF	NS	NS	NS
Crude protein, %	NS	NS	NS
Neutral det. ins. protein, %	NS	NS	NS
Ca, %	NS	NS	NS
Cl, %	0.005	0.004	0.000
K, %	0.045	0.042	0.028
Mg, %	NS		
P, %	0.004	0.000	0.000
S, %	NS	NS	NS
Net energy-lactation, mcals/lb	NS	NS	NS
Predicted milk, lbs/ton	NS	NS	NS
Total digestible nutrients, %	NS	NS	NS

¹NS signifies cases where the *P* – Value was above the threshold for statistical significance (0.05). Differences in these measures may be due to random chance due to variability in the data and inconsistency of the treatment effect.

Table 2. Plot study results table depicting averages (LSM) and standard error values for the various agronomic metrics used to evaluate five different biologicals products that are marketed to promote symbiotic nitrogen fixation.

Measure ¹	T1	T2	T3	T4	T5	T6	T7	T8
Yield, wet tons/acre	26.0±0.6	24.5±0.6	23.8±0.6	24.9±0.6	24.4±0.6	24.6±0.6	24.7±0.6	25.3±0.6
Dry biomass yield, US t/a	9.1±0.2	8.6±0.2	8.3±0.2	8.7±0.2	8.5±0.2	8.6±0.2	8.6±0.2	8.9±0.2
Digestible yield, dry t/a	7.6±0.2	7.0±0.2	6.8±0.2	7.1±0.2	6.9±0.2	7.1±0.2	7.1±0.2	7.3±0.2
Protein yield, US tons/acre	0.63±0.03	0.57±0.03	0.56±0.03	0.58±0.03	0.55±0.03	0.60±0.03	0.56±0.03	0.59±0.03
Moisture, %	60.4±0.6	61.2±0.6	60.9±0.6	60.9±0.6	60.8±0.6	60.6±0.6	60.4±0.6	60.3±0.6
Acid detergent fiber, %	19.7±0.5	19.5±0.5	21.1±0.5	21.2±0.5	21.1±0.5	20.0±0.5	20.9±0.5	19.7±0.5
Neutral det. fiber (aNDF), %	36.5±0.7	36.2±0.7	38.0±0.7	37.8±0.7	38.3±0.7	36.9±0.7	37.2±0.7	36.7±0.7
Lignin, %	2.6±0.1 ^{ab}	2.4±0.1 ^a	2.7±0.1 ^{ab}	2.6±0.1 ^{ab}	2.8±0.1 ^b	2.6±0.1 ^{ab}	2.7±0.1 ^{ab}	2.6±0.1 ^{ab}
Non-fiber carbohydrates, %	49.9±0.7	50.9±0.7	49.2±0.7	49.0±0.7	48.4±0.7	49.6±0.7	49.4±0.7	50.1±0.7
Starch, %	41.0±0.8	41.8±0.8	39.8±0.8	39.6±0.8	39.8±0.8	40.3±0.8	40.3±0.8	41.2±0.8
Starch digestibility, %	58.0±1.9	59.5±1.9	57.6±1.9	61.0±1.9	59.1±1.9	57.8±1.9	59.8±1.9	60.6±1.9
Water soluble carb., %	4.0±0.3	3.7±0.3	4.5±0.3	4.0±0.3	4.2±0.3	4.5±0.3	4.0±0.3	4.2±0.3
Ash, %	3.4±0.2	3.2±0.2	3.4±0.2	3.3±0.2	3.3±0.2	3.4±0.2	3.6±0.2	3.1±0.2
Crude fat, %	3.2±0.1	3.3±0.1	3.2±0.1	3.2±0.1	3.2±0.1	3.2±0.1	3.3±0.1	3.3±0.1
In-vitro true digestibility, %	82.8±0.3 ^{ab}	82.5±0.3 ^{ab}	82.0±0.3 ^{ab}	81.5±0.3 ^{ab}	81.4±0.3 ^b	82.8±0.3 ^a	81.5±0.3 ^{ab}	82.3±0.3 ^{ab}
aNDF digestibility, % aNDF	52.0±0.7	51.9±0.7	52.4±0.7	51.1±0.7	51.7±0.7	53.1±0.7	50.6±0.7	51.8±0.7
Crude protein, %	6.9±0.2	6.6±0.2	6.6±0.2	6.7±0.2	6.5±0.2	6.9±0.2	6.4±0.2	6.7±0.2
Neutral det. ins. protein, %	1.23±0.04	1.14±0.04	1.15±0.04	1.14±0.04	1.20±0.04	1.20±0.04	1.09±0.04	1.19±0.04
Ca, %	0.17±0.01	0.17±0.01	0.18±0.01	0.17±0.01	0.18±0.01	0.18±0.01	0.18±0.01	0.17±0.01
Cl, %	0.17±0.01 ^{ab}	0.16±0.01 ^{ab}	0.18±0.01 ^a	0.16±0.01 ^{ab}	0.18±0.01 ^a	0.19±0.01 ^a	0.12±0.01 ^b	0.16±0.01 ^{ab}
K, %	0.77±0.03	0.70±0.03	0.72±0.03	0.70±0.03	0.74±0.03	0.76±0.03	0.67±0.03	0.69±0.03
Mg, %	0.13±0.00	0.13±0.00	0.13±0.00	0.13±0.00	0.13±0.00	0.14±0.00	0.13±0.00	0.13±0.00
P, %	0.22±0.01 ^a	0.20±0.01 ^{ab}	0.20±0.01 ^{ab}	0.20±0.01 ^{ab}	0.20±0.01 ^{ab}	0.21±0.01 ^a	0.18±0.01 ^b	0.20±0.01 ^{ab}
S, %	0.09±0.00	0.09±0.00	0.09±0.00	0.09±0.00	0.08±0.00	0.09±0.00	0.09±0.00	0.09±0.00
Net energy-lactation, mcal/lb	0.80±0.01	0.81±0.01	0.79±0.01	0.79±0.01	0.79±0.01	0.80±0.01	0.79±0.01	0.81±0.01
Predicted milk, lbs/ton	3235±26	3257±27	3196±27	3191±26	3183±26	3240±26	3177±26	3239±26
Total digestible nutrients, %	76.0±0.5	76.3±0.5	75.5±0.4	75.1±0.4	74.9±0.4	76.1±0.4	74.7±0.5	75.9±0.5

¹ Letters generated from Tukey HSD test means separation procedure ($\alpha=0.05$). Levels not connected by the same letter are significantly different. Least squares means with the same or no letters are not statistically different from each other.

CONCLUSIONS:

Although limited, the results of this study demonstrate that biological products can have an effect on corn grown in northern New York. While we cannot say that they consistently boosted yield, they did slightly improve the in-vitro true digestibility of the silage and boosted plant P, K, and Cl levels at harvest. T1 and T2 appeared to be the products that are most likely to improve the nutritive value of corn silage; however, due to the size of the trial and a lack of statistical significance, we do not have compelling evidence that any of these products provided additional N to the crop during the growing season. These results should be considered as well in light of the control treatment with 30 units of additional N also failing to show statistically higher yield.

Recommendations:

- Farms seeking to use biological products to improve N supply on their farms should include check strips in treated fields to help determine local product effectiveness.
- Caution should be used when treating a single crop with multiple biological N fixation products. While complementary combinations may exist, we did not see any additional value in combining multiple products in this study. Products may compete with each other and even be antagonistic in some cases.

- Nitrogen fixation expectations should be conservative. While biological products may have some fertilizer replacement value, any additional yield they produce may be the result of additional modes of action such as nutrient solubilization and biostimulation.
- Biological systems are highly complex, and testing results of biological N fixation products are often variable. While this inherent variability may reduce the attractiveness of biological products to the farming community, it also reduces our ability to characterize their benefits. Additional trials would help inform decision-making (see Next Steps).

OUTREACH:

These results will be summarized and shared in the Miner Institute Farm Report and at summer grower meetings throughout the region.

NEXT STEPS:

More data is needed to further characterize biological products and their utility on northern New York farms. Specifically, field trials should be set up in order to provide greater experimental power than is typical for agronomic studies. This will help overcome the variability of biological products and pick up small differences in yield that may be meaningful at a large scale.

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APPENDIX

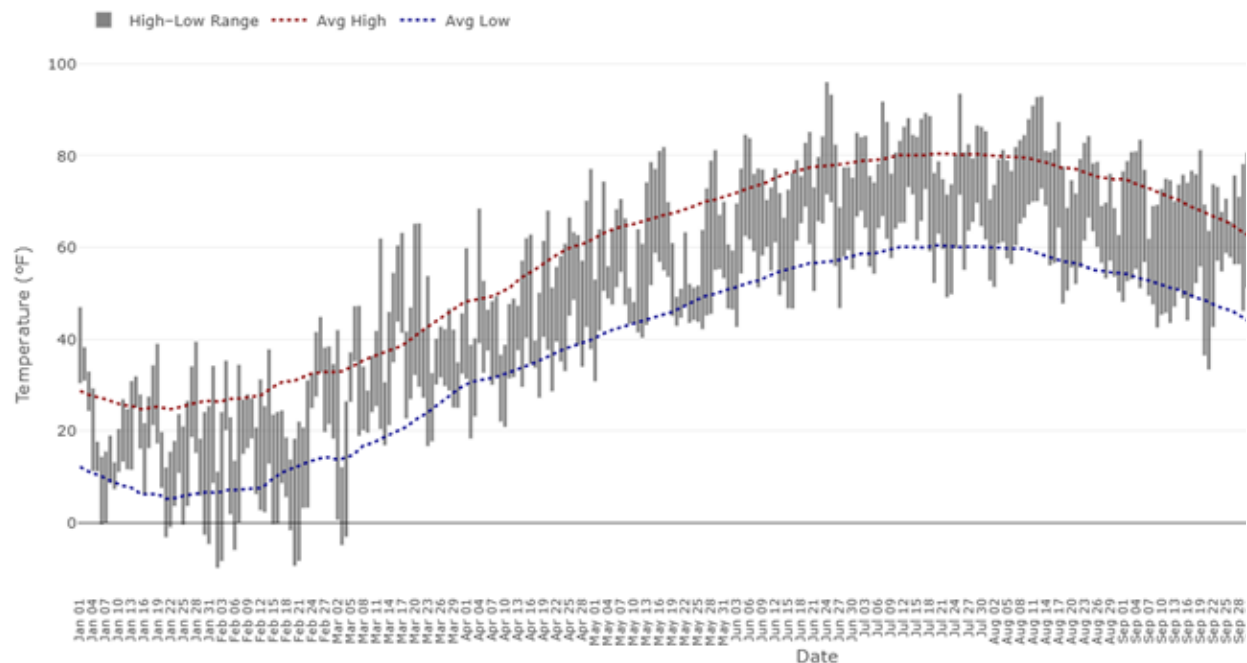


Figure 1. Average daily temperature for Miner Institute during the 2025 growing season at Chazy, New York.

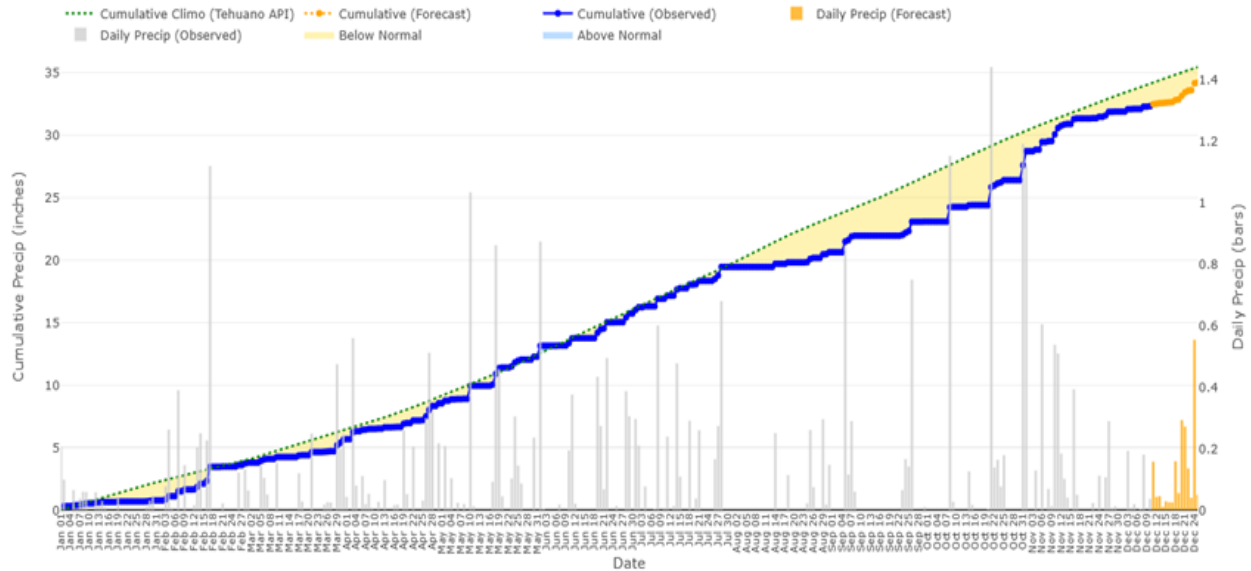


Figure 2. Daily precipitation during the 2025 growing season at Chazy, NY. The season started out with near normal precipitation, then turned unseasonably dry in August. Furthermore, very few precipitation events exceeded one inch (most less than 0.4 inches). We believe this year's weather patterns represent conservative conditions such that the benefit of tile on an average year is likely to meet or exceed the benefits observed in this study.

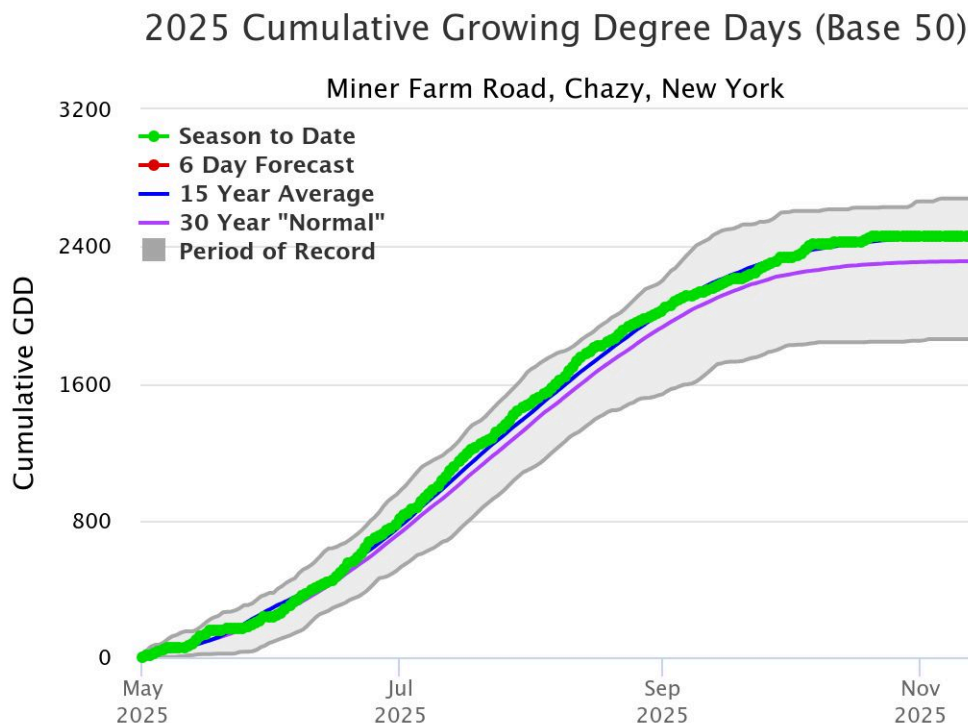


Figure 3. Seasonal growing degree day (heat unit) accumulation throughout the 2025 growing season in Chazy, NY. Degree days followed the 15-year average for most of the growing season and even approached the upper end of the range following hot spells during the summer.



Photo 1. A photo of the The Potential for Symbiotic Nitrogen Fixation in Corn Through the Use of Commercially-Available Biological Products plot area after harvest was completed. All plots were chopped with a two-row silage chopper and samples were collected from each plot as they were harvested. Photo: Allen Wilder.