

HydroSoil: Transforming Agriculture Through Biological Soil Enhancement

Field Performance
Evaluation

Regenerative Soil Management Through
Concentrated Biological Nutrition

Winter Wheat and Corn Silage Trials at
Mendonsa Farms, Tipton, California

2024-2025 Growing Season

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1. Executive Summary

Farmers worldwide face a challenging combination of reduced crop revenues, rising fuel and labor costs, and changing weather patterns. Meanwhile, they are under increasing pressure to protect soil and water resources from agricultural operations. The American Farm Bureau reports that the cost of one input in particular—fertilizer—remains volatile and is trending higher due to global trade uncertainty, geopolitical tensions, and natural gas market fluctuations. Fertilizer prices are expected to remain elevated throughout 2026, even as crop receipts weaken, leaving farmers with lower margins and less room to absorb higher costs.

Fertigation is a popular fertility strategy because it can improve nutrient-use efficiency and raise yields while conserving water. But fertigation requires high upfront and management costs for equipment, sensors, and skilled labor. Moreover, poorly calibrated fertigation systems can still cause nutrient loss through leaching and runoff, contributing to water pollution and eutrophication of surface and groundwater. And long-term fertigation can degrade soil organic matter and microbial diversity, increase compaction risk, and encourage nutrient stratification, salt accumulation, and soil acidification.

Manure is often cheaper and locally available, making manure-based fertility systems a compelling alternative in an era of escalating costs. Manure improves soil organic matter and microbial activity, and provides a slow nutrient release. However, long-term heavy application of manure can still result in significant nutrient imbalances, salt accumulation, pH drift, and compaction.

A core challenge for many farms is maintaining yields while managing the long-term consequences of heavy and expensive fertility systems that no longer deliver reliable performance. HydroSoil was developed as a fundamentally different approach to soil fertility management. It is a concentrated, biologically active fertilizer that delivers nutrients in balanced, plant-available forms.

While compost typically exhibits carbon-to-nitrogen (C:N) ratios of 15-25:1 and raw manure 10-20:1, HydroSoil's exceptionally low C:N ratio of 5.7:1 ensures rapid mineralization and nutrient release synchronized with crop demand rather than long-term immobilization. Its granulized format ensures uniform distribution and eliminates the need for deep incorporation. Applied at just 3,000 pounds per acre, HydroSoil reduces handling needs while improving uptake.

This report details the results from winter wheat and corn silage trials demonstrating how HydroSoil helps farmers move beyond manure-heavy fertility systems while improving crop yields, enhancing soil health, lowering operational costs, and enabling a transition to low-till and no-till production. Unlike manure, which demands multiple tillage passes and contributes to soil compaction and excess nutrients, HydroSoil delivers nutrients in a biologically available form that crops can rapidly absorb, without requiring deep incorporation.

At a trial farm, decades of applying 25 tons of dairy manure per acre created extreme nutrient imbalances: phosphorus reached 4-8× recommended levels, potassium 4-7×, and sulfur more than 10×. Yet plant tissue samples still showed deficiencies in nitrogen, potassium, calcium, and sulfur because nutrients were chemically locked away. Manure application also required deep incorporation and multiple tillage passes, raising fuel costs, damaging soil structure, and increasing compaction.

HydroSoil changed this system by providing a uniform, concentrated nutrient source applied at only 1,400–3,000 pounds per acre. Despite the significantly lower material volume, HydroSoil improved crop yields and nutrient uptake.

Performance Highlights

Winter Wheat

Wheat yields increased 4.7–7.5 percent, and profitability improved dramatically. The manure system generated a loss of \$134 per acre, while HydroSoil generated profits between \$186 and \$259 per acre.

Nitrogen use efficiency rose from 10 percent with manure to 94–110 percent with HydroSoil—meaning the crop used nearly all applied nitrogen and accessed bound nitrogen from soil.

	Yields	Profitability	Nitrogen Use Efficiency
Manure System	–	-\$134 per acre	10%
HydroSoil	↑ 4.7% – 7.5%	+\$186 – \$259 per acre	94% – 110%

Corn Silage

Corn silage performance improved in several important quality metrics. Digestible protein concentration rose 31 percent, crude protein concentration increased 14.5 percent, lignin concentration decreased 25 percent, and acid detergent fiber concentration fell 68 percent.

These shifts significantly increase feed value and reduce the need for protein supplements. When applied at scale, these improvements can enhance dairy profitability by increasing milk production and lowering feed costs.

Quality Metric	Value
Digestible Protein Concentration	↑ 31%
Crude Protein Concentration	↑ 14.5%
Lignin Concentration	↓ 25%
Acid Detergent Fiber Concentration	↓ 68%

The field trial results suggest that HydroSoil can support a progressive shift to low-till or no-till production systems. Farmers can reduce tillage intensity immediately and eliminate one or more tillage passes in the first year. Over time, fuel use may decline by up to 70 percent and tillage time by 75 percent. Reduced tillage preserves soil structure, improves water infiltration, and protects microbial communities.

In summary, HydroSoil offers a practical, profitable, and biologically grounded alternative to heavy manure-based systems. It improves yields, quality, soil function, and profitability while simplifying operations.

However, HydroSoil is more than a fertilizer alternative. It enables a fundamental transformation of farming systems from high-disturbance, high-input, extractive production to low-disturbance, precision-managed, regenerative agriculture—all without sacrificing production.

Triple Paradigm Shift

Three interconnected transformations to redefine agricultural production:

From Intensive Tillage to Conservation Systems

HydroSoil eliminates the requirement for deep incorporation of manure, enabling future transition to low-till or no-till practices that would preserve soil structure, maintain biological communities, and reduce operational costs.

From Volume to Value

HydroSoil replaces massive nutrient inputs with concentrated, balanced nutrition that improves efficiency and profitability while reducing material handling.

From Degradation to Regeneration

HydroSoil shifts the production system from extractive to regenerative, building soil organic matter, sequestering carbon, and enhancing biological activity.

2. Introduction

California's Central Valley is one of the world's most productive agricultural regions, yet decades of intensive farming have created significant soil health and nutrient management challenges. Mendonsa Farms, located in Tipton, California, embodies both the historical success and emerging problems of traditional high-input organic fertility management systems. Farms like Mendonsa rely on manure as fertilizer because it is abundant and familiar, but long-term heavy use creates nutrient imbalances, salt accumulation, pH drift, and compaction. This paradox—nutrient deficiency amid excessive soil reserves—is a widespread challenge for farms in regions with concentrated animal feeding operations and readily available manure resources.

For multiple decades, Mendonsa has maintained productivity through annual applications of approximately 25 tons per acre of dairy cattle manure, combined with one ton per acre of gypsum—a practice designed to build soil fertility through massive organic matter additions. This approach, while initially successful, has reached a critical inflection point. By the 2024–2025 growing season, soil testing at Mendonsa revealed that decades of heavy manure application have created severe chemical imbalances that now limit rather than enhance crop productivity.



Phosphorus tested at 4–8× recommended levels, potassium at 4–7×, and sulfur at more than 10×. Despite these soil nutrient values, plant tissue tests still showed deficiencies in nitrogen, potassium, calcium, and sulfur—clear signs of dysfunctional nutrient cycling. These data illustrate a fundamental failure of traditional management practices: nutrients exist in the soil, but they remain unavailable to crops due to chemical antagonism, pH-induced fixation, and ionic imbalances.

Degraded soil health and nutrient cycling has increased production costs at Mendonsa through the additional passes, labor, and fuel required throughout the growing season. This economic failure, combined with agronomic underperformance and environmental concerns about nutrient runoff, prompted Mendonsa to evaluate alternative fertility approaches.

Given the documented failures of traditional management and the theoretical advantages of concentrated biological nutrition, Mendonsa Farms initiated comprehensive field trials of HydroSoil during the 2024–2025 growing season.

Trial Objectives

- 1 Compare yields, crop quality, and nutrient uptake efficiency between traditional management and HydroSoil treatment across multiple crop types.
- 2 Assess the complete economic impact including input costs, yield response, quality premiums, and long-term soil health benefits.
- 3 Identify the biological, chemical, and physical mechanisms through which HydroSoil influences crop performance and soil health.
- 4 Create practical, economically justified application programs for commercial implementation.

Testing Framework

The trials encompassed two major crop systems—Winter Wheat and Corn Silage—representing different nutritional demands and economic drivers, and comparing the Grower Standard Practice (GSP) to HydroSoil application.

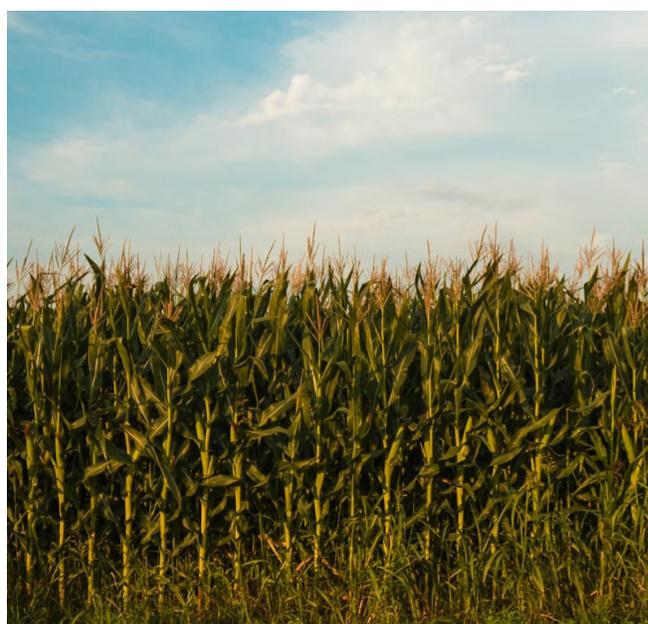
Winter Wheat

- Total treatment area: 36.75 acres
- Three treatments in adjacent blocks of 12.25 acres each:
 - Control (GSP)
 - HydroSoil at 1,400 lbs/acre (TRT1)
 - HydroSoil at 2,000 lbs/acre (TRT2)
- Focus on grain yield, protein content, and nutrient use efficiency
- Economic analysis of commodity grain production



Corn Silage

- Total treatment area: 68.1 acres
- Four adjacent blocks of 17.03 acres each, alternating between Control (GSP) and HydroSoil treatment (TRT) to account for natural soil variability
- HydroSoil treatment (TRT) at 3,000 lbs/acre
- Focus on feed quality, digestible nutrients, and dairy nutrition value
- Economic analysis for livestock feed production



3. Materials & Methods

HydroSoil Product and Application

HydroSoil is produced through multiple treatment steps to create dairy food waste digestate, followed by drying and forming into a uniform, flowable granule with concentrated nutrients and approximately 90 percent dry matter.

Its granulized form allowed precise, streak-free broadcast application comparable to high-quality synthetic dry fertilizers. All treatments were incorporated within 48 hours, though HydroSoil's design does not require deep incorporation.

HydroSoil contains 7.15 percent total nitrogen—primarily organic—alongside 70 percent organic matter and a low carbon-to-nitrogen ratio of 5.7:1, which supports rapid mineralization without nitrogen immobilization.

HydroSoil Product Characteristics

Parameter	Value	Significance
Total Nitrogen	7.15%	High concentration enables low application rates
Organic Nitrogen	6.2%	Slow-release, minimizes losses
Phosphorus (P)	5.06%	Balanced P without excessive accumulation
Potassium (K)	1.59%	Moderate K prevents further imbalance
Sulfur	0.74%	Essential for protein synthesis
Organic Matter	70.24%	Builds soil carbon and biological activity
C:N Ratio	5.7:1	Rapid mineralization without N immobilization
pH	6.3	Mildly acidic, beneficial in alkaline soils

Experimental Design

The HydroSoil trials took place at Mendonsa Farms, where alkaline clay-loam soils, high cationexchange capacity, and decades of heavy manure application created a uniquely consistent environment for evaluating alternative fertility systems. The farm's long-standing practice of applying 25 tons of dairy manure plus one ton of gypsum per acre each year had produced extreme nutrient accumulation. Because the fields share the same rotation, tillage program, irrigation schedule, and management history across more than a decade, they provided a controlled setting for testing whether a concentrated biological fertilizer could outperform manure on yield, soil function, and crop nutrient status.

Two commercial-scale studies were conducted in the 2024–2025 season:

- 36.75-acre winter wheat trial comparing GSP (25 tons/acre manure) to two HydroSoil rates (1,400 and 2,000 lbs/acre)
- 68.1-acre corn silage trial using four alternating blocks of GSP and HydroSoil (3,000 lbs/acre) to account for natural soil variability

Pre-trial soil tests confirmed uniformity across all treatment areas. HydroSoil supplied only 100–143 lbs of nitrogen per acre compared to roughly 500 lbs from manure, allowing a direct comparison of nutrient-use efficiency and crop performance under dramatically different nitrogen loads.

Soil Sampling Protocol

Soil sampling followed a systematic protocol designed to characterize both spatial variability and temporal dynamics of nutrient availability. Baseline sampling in October 2024 occurred immediately after fertilizer application and incorporation but before crop planting, establishing initial nutrient status under each treatment.

Each sampling event collected 15–20 individual cores per treatment area using a standard 0.75-inch diameter soil probe to 6-inch depth. Individual cores were thoroughly mixed to create composite samples representative of each treatment area.

Pre-harvest sampling in May 2025 provided comprehensive nutrient analysis at crop maturity, capturing the cumulative effects of crop uptake and continued mineralization. Post-harvest sampling following grain and silage removal quantified residual nutrient status and established the starting point for subsequent crop cycles.

Winter Wheat Nutritional Values

By improving soil nutrient bioavailability, HydroSoil enables a corresponding improvement in grain quality. During the winter wheat trial, the expected nutritional content of the wheat plants was calculated by analyzing soil nutrient bioavailability and biology after GSP, HydroSoil TRT1, and HydroSoil TRT2 treatments.

Winter Wheat Yield Determination

Winter wheat harvest occurred in June 2025 when grain moisture reached 13-14 percent, optimal for immediate storage without artificial drying. Harvest employed a commercial combine harvester equipped with calibrated yield monitoring equipment that recorded grain flow rates and GPS position at 1-second intervals. This precision agriculture technology enabled detection of within-field variability and verification that treatment areas showed uniform productivity patterns apart from the intended fertilizer effects.

All yield data underwent correction to standard 13.5 percent moisture content for accurate comparison across treatments and alignment with commodity marketing standards.



Corn Plant Tissue Analysis

Corn tissue sampling occurred at silking stage (R1) in June 2025, collecting the ear leaf from 20-25 plants per treatment area. This timing corresponds with peak nutrient demand and provides the strongest correlation between tissue nutrient concentrations and final yield potential.

All tissue samples underwent immediate transport to the laboratory in paper bags to prevent moisture condensation and potential nutrient leaching. Samples were dried at 65°C for 48 hours, ground to pass a 1-millimeter screen, and analyzed for complete nutrient content including nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, and micronutrients.

Laboratory analytical methods followed standard procedures established by the North American Proficiency Testing program to ensure accuracy and comparability across laboratories.

Corn Silage Assessment

Corn silage harvest in September 2025 targeted the optimal moisture window of 64-68 percent for proper fermentation and storage. Harvest timing decisions incorporated both whole-plant moisture monitoring and kernel milk-line assessment to ensure maximum digestible nutrient capture.

Each load of harvested material was weighed on certified truck scales, with random moisture samples collected throughout harvest to verify consistent dry matter content across treatments.

Representative samples from each treatment underwent comprehensive nutritional analysis at commercial forage testing laboratories. Near-infrared spectroscopy provided rapid determination of crude protein, acid detergent fiber, neutral detergent fiber, and lignin content. These primary measurements enabled calculation of total digestible nutrients, net energy values for maintenance, gain, and lactation, and relative feed value indices critical for ration formulation in dairy and beef operations.

The substantial differences in digestible protein and energy density between treatments demonstrated that HydroSoil's influence extended beyond simple yield effects to fundamental changes in crop metabolic processes and nutrient partitioning.



4. Winter Wheat Trial Results

Yield Performance and Economic Analysis

Yield Outcomes

The winter wheat harvest in June 2025 produced definitive evidence of HydroSoil’s superiority over traditional management, though the advantages manifested primarily through economic efficiency and nutrient stewardship rather than dramatic yield increases.

Total harvest from the 36.75-acre trial area reached 67.1 tons, with clear differentiation among the three fertility treatments that demonstrated a positive response to HydroSoil application rate.

Treatment TRT2 with 2,000 pounds per acre of HydroSoil achieved the highest yield at 1.89 tons per acre, representing a 7.5 percent improvement over the GSP control yield of 1.76 tons per acre. This yield advantage of 0.13 tons per acre, equivalent to approximately 7 bushels per acre, generated additional gross revenue of \$45.50 per acre at prevailing wheat prices of \$6.50 per bushel.

Treatment TRT1 with 1,400 pounds per acre of HydroSoil produced intermediate results at 1.84 tons per acre, demonstrating a dose-response relationship between HydroSoil application rate and crop productivity.

The consistency of yield rankings across all treatments, with both HydroSoil rates exceeding traditional management, indicates reliable performance rather than random variation.

The magnitude of yield improvement, while agronomically significant, falls within the range typically associated with improved nutrient availability and uptake efficiency rather than correction of severe deficiency. This suggests that HydroSoil’s primary value proposition extends beyond simple yield enhancement to encompass broader agronomic and economic benefits.

Treatment	Application	Area acres	Total Harvest tons	Yield tons/acre	Yield bu/acre	Change
GSP Control	25 tons manure + 1 ton gypsum	12.25	21.5	1.76	93.3	Baseline
TRT1	1,400 lbs HydroSoil	12.25	22.5	1.84	97.5	+4.7%
TRT2	2,000 lbs HydroSoil	12.25	23.1	1.89	100.2	+7.5%

Economic Performance Analysis

The economic analysis reveals that yield differences represent only one component of HydroSoil's financial advantage. The dramatic reduction in input costs combined with modest yield improvements created substantial economic benefits that transformed wheat production from a loss-generating enterprise under traditional management to a profitable operation with HydroSoil treatment.

The GSP control treatment operated at a staggering net loss of \$133.55 per acre, with fertilizer input costs of \$590 per acre overwhelming the modest revenue generated by the 93.3 bushel per acre yield. This economic failure demonstrates that traditional high-input management has become fundamentally nonviable at current commodity prices and input costs. The fertilizer expense alone consumed 97 percent of gross revenue, leaving insufficient margin to cover other production costs.

Treatment TRT1 generated the highest net revenue at \$258.75 per acre despite producing lower absolute yield than TRT2. This superior economic performance resulted from the optimal balance between input cost reduction (\$365 per acre savings) and yield improvement (4.7 percent increase). The return on fertilizer investment reached 115 percent, meaning each dollar invested in HydroSoil-based fertility generated \$2.15 in net return above all production costs.

Treatment TRT2, while achieving the highest yield, produced lower net revenue of \$186.30 per acre due to higher product costs. The incremental expense of increasing HydroSoil application from 1,400 to 2,000 pounds per acre (\$90 additional cost) exceeded the incremental revenue from 2.7 additional bushels per acre (\$17.55), demonstrating the importance of optimizing application rates for economic rather than purely agronomic objectives.



Soil Chemical Dynamics

Baseline Nutrient Status

Soils under the GSP treatment showed extreme nutrient accumulation from decades of manure use: phosphorus 5–8×, potassium 4–7×, and sulfur 10× above recommended levels. These imbalances created severe nutrient antagonisms that inhibited plant uptake despite apparent abundance. Sodium levels (312–483 ppm) posed additional risks by degrading soil structure, reducing infiltration, and competing with potassium at root uptake sites—all factors contributing to weaker crop performance under the GSP system. In contrast, HydroSoil plots began with moderate nutrient levels closer to agronomic sufficiency ranges, setting the stage for more balanced nutrient cycling.

Temporal Nutrient Dynamics

Season-long sampling revealed that manure-driven nitrogen mineralization overwhelmed crop demand, causing nitrate to accumulate 99 percent in GSP soils (18.9 → 37.6 ppm). This reflected both poor crop uptake and significant environmental risk. HydroSoil plots showed the opposite pattern: nitrate declined 78 percent (18.0 → 4.0 ppm), demonstrating exceptional synchronization between nutrient release and crop demand. This efficient nutrient capture is a key factor in HydroSoil's superior agronomic and environmental performance.

Nutrient Uptake Efficiency

Calculating nutrient uptake efficiency based on the relationship between soil availability, plant tissue concentrations, and grain removal provides quantitative evidence of HydroSoil's superior nutrient management. These calculations demonstrate that effective fertility management depends not on maximizing soil nutrient levels but on optimizing availability and uptake efficiency.

The nitrogen use efficiency calculations reveal the fundamental dysfunction of traditional management. Despite applying approximately 500 pounds of nitrogen per acre in manure, the GSP crop captured only 50 pounds, representing 10 percent efficiency. The remaining 450 pounds either remained in slowly mineralizing organic forms, accumulated as soil nitrate vulnerable to leaching, or volatilized as ammonia during the extended period between application and incorporation. This represents both massive economic waste and significant environmental liability.

HydroSoil treatments achieved dramatically superior nitrogen use efficiency, with TRT1 showing 110 percent efficiency, indicating uptake of both applied nitrogen and some soil reserves. TRT2 achieved 94 percent efficiency, capturing essentially all applied nitrogen with minimal losses. This ten-fold improvement in nitrogen use efficiency compared to traditional management demonstrates that nutrient management success depends on synchronizing availability with crop demand rather than overwhelming the system with excess inputs.

Grain Quality and Market Value

The expected nutritional value of the wheat crop was calculated by analyzing soil nutrient bioavailability and biology after GSP, HydroSoil TRT1, and HydroSoil TRT2 treatments. These grain quality calculations suggested that HydroSoil's influence extends beyond yield to include fundamental improvements in wheat protein content, the primary determinant of wheat grade and price premiums.

Protein content in wheat from TRT2 plots was calculated to be 11.6 percent, exceeding the 11 percent threshold for premium pricing in commodity markets. This 18 percent increase over the 9.8 percent protein in GSP wheat translates to approximately \$10-15 per ton in price premiums, adding \$19-28 per acre in value beyond the yield improvement.

The higher protein content reflects superior nitrogen uptake and translocation to developing grain, enabled by the balanced nutrition and absence of antagonistic interactions under HydroSoil treatment.

Test weight improvements under HydroSoil treatment, reaching 60.1 pounds per bushel in TRT2 compared to 58.2 in GSP, indicate better kernel fill and higher flour extraction potential.

The increased thousand kernel weight from 28.3 grams in GSP to 32.1 grams in TRT2 demonstrates that improved nutrition supported both kernel number and individual kernel development, contributing to both yield and quality enhancement.

Parameters	GSP Control	TRT1	TRT2	Market Impact
Test weight (lbs/bu)	58.2	59.8	60.1	Premium for >60
Crude protein (% @ 12% moisture)	9.8	11.2	11.6	Premium for >11%
Falling number (seconds)	285	310	318	Acceptable >250
Kernel hardness index	72	75	76	Hard wheat classification
Thousand kernel weight (g)	28.3	31.2	32.1	Larger kernels

5. Corn Silage Trial Results

Yield Performance and Statistical Analysis

Total Yield Assessment

The corn silage trial harvested in September 2025 produced 553.4 tons of silage from 68.1 acres, achieving an average yield of 8.13 tons per acre at 64.7 percent moisture content.

While the overall yield difference between treatments was modest at 2.0 percent, this marginal tonnage increase masks the profound transformation in feed quality and nutrient composition that represents HydroSoil's primary value proposition for livestock producers.

The modest yield advantage of 5.42 tons across the entire trial, equivalent to 0.13 tons per acre, would generate approximately \$7.15 per acre in additional revenue at typical silage prices of \$55 per ton. This marginal economic benefit from tonnage alone would not justify the transition from traditional management. However, the yield data represents only the beginning of the economic story, with feed quality improvements providing the compelling justification for HydroSoil adoption in forage production systems.

The consistency of results across replicated blocks strengthens confidence in the observed treatment effects. Test block 1 under HydroSoil treatment produced 134.18 tons while the adjacent control block 2 yielded 133.74 tons, a difference of less than 0.5 percent that could be attributed to normal field variability.

However, test block 3 under HydroSoil treatment substantially outperformed control block 4, producing 145.23 tons versus 140.25 tons, a 3.6 percent advantage that suggests HydroSoil enabled better performance under whatever favorable conditions existed in that portion of the field.

Treatment	Test Blocks	Total Area	Total Yield	Yield/Acre	Change
		acres	tons	tons	
GSP Control	2 & 4	34.0	273.99	8.06	Baseline
HydroSoil (TRT)	1 & 3	34.1	279.41	8.19	+2.0%
Total/Average	All	68.1	553.40	8.13	-

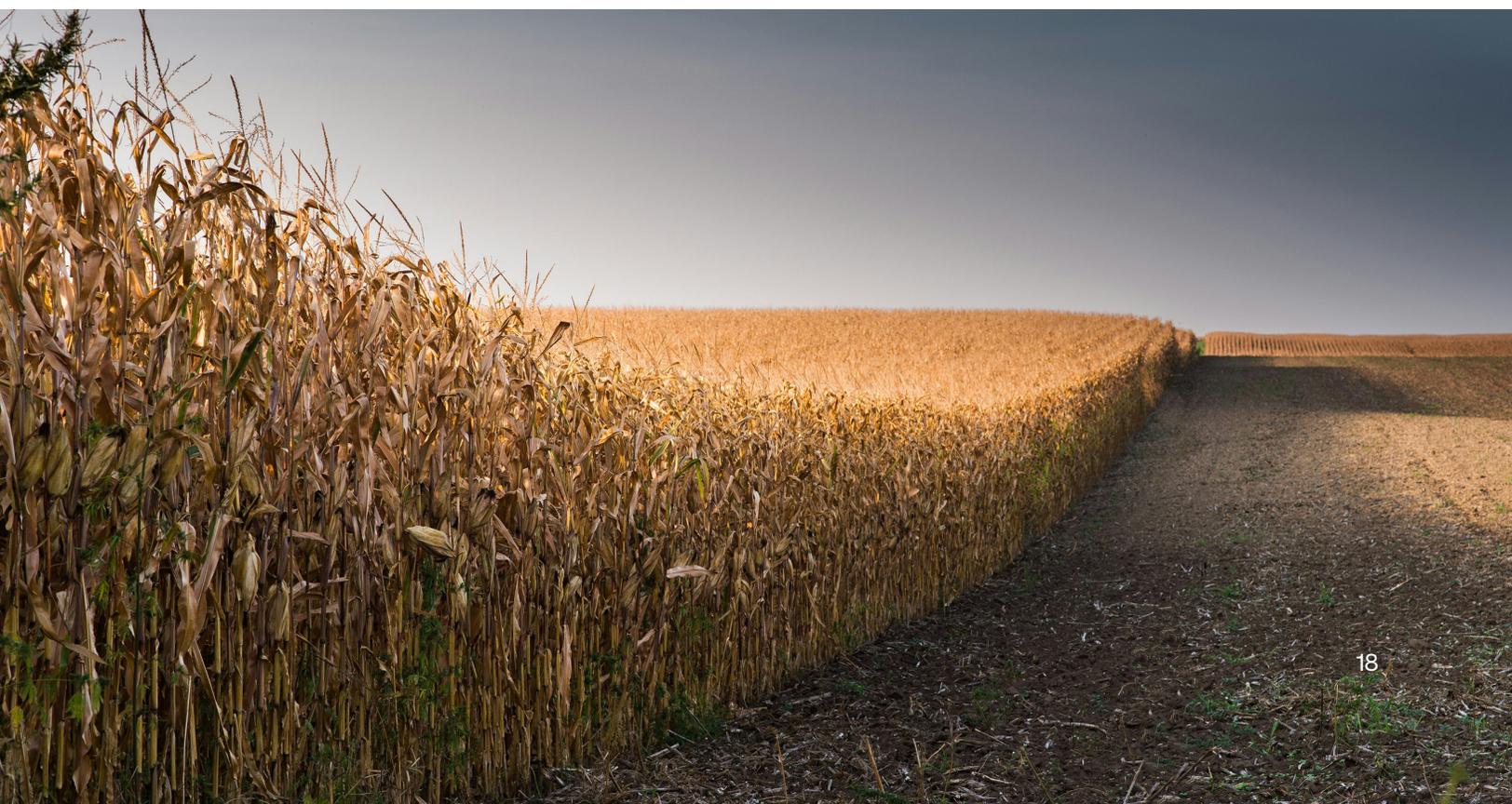
Dry Matter Production Analysis

Converting yields to a dry matter basis provides more accurate comparison of actual biomass production and nutritional output between treatments.

At the measured moisture content of 64.7 percent, the dry matter yield averaged 2.87 tons per acre across all treatments, within the expected range for Central Valley corn silage production under full irrigation.

The critical insight from dry matter analysis emerges when examining nutrient yield per acre rather than simple tonnage. HydroSoil treatment produced 364 pounds of crude protein per acre compared to 318 pounds in control plots, a 14.5 percent increase that far exceeds the 2 percent difference in total yield. Even more dramatically, digestible protein yield reached 121 pounds per acre under HydroSoil treatment versus only 91 pounds in control plots, a 33.3 percent (dry weight) increase in the most valuable component for dairy nutrition.

Parameters	GSP Control	HydroSoil	Change
Fresh weight yield (tons/acre)	8.06	8.19	+0.13
Moisture content (%)	64.7	64.7	None
Dry matter yield (tons/acre)	2.84	2.89	+0.05
Crude protein yield (lbs/acre)	318	364	+46
Digestible protein yield (lbs/acre)	91	121	+30
TDN yield (lbs/acre)	5,192	5,368	+176



Feed Quality Transformation

Laboratory analysis showed that HydroSoil dramatically improved silage quality. Digestible protein (dry weight) increased 33.3 percent, crude protein 14.5 percent, ADF decreased 68.4 percent, and lignin decreased 25 percent, creating a feed with significantly higher nutritional density.

These changes translate directly to animal performance: a 1,000-cow dairy could gain 2,000–3,000 lbs of additional milk/day, worth \$360–540/day, from digestible protein alone. Lower fiber and higher energy density also increase dry matter intake, feed efficiency, and milk yield.

Comprehensive Feed Quality Analysis (Dry Matter Basis)

Parameter	GSP	HydroSoil	Absolute Change	Change	Significance
Protein Fractions					
Crude Protein (%)	5.6	6.3	+0.7	+12.5%	Major improvement
Digestible Protein (%)	1.6	2.1	+0.5	+33.3%	Exceptional gain
Acid Detergent Insoluble Protein (%)	0.8	0.6	-0.2	-25.0%	Better availability
Fiber Components					
Acid Detergent Fiber (%)	1.9	0.6	-1.3	-68.4%	Dramatic Reduction
Neutral Detergent Fiber (%)	9.9	9.1	-0.8	-8.1%	Improved Digestability
Lignin (%)	1.2	0.9	-0.3	-25.0%	Less indigestible %
Energy Values					
TDN (%)	91.5	92.9	+1.4	+1.5%	Higher energy density
Net Energy Maintenance (Mcal/cwt)	103.51	105.34	+1.83	+1.8%	Improved efficiency
Net Energy Gain (Mcal/cwt)	71.90	73.42	+1.52	+2.1%	Better weight gain
Net Energy Lactation (Mcal/cwt)	96.20	97.74	+1.54	+1.6%	More milk potential
Quality Indices					
Relative Feed Value	820	903	+83	+10.1%	Premium classification
Relative Forage Quality	298	341	+43	+14.4%	Superior rating

Protein Quality and Amino Acid Implications

HydroSoil did more than increase total protein—it improved protein quality.

Digestible protein represented a larger share of total protein (33.3 percent vs. 28.6 percent), indicating formation of more bioavailable protein fractions and a superior amino-acid profile.

HydroSoil silage also contained a higher proportion of bypass (undegradable) protein, which supports milk protein synthesis in high-producing dairy cows more efficiently than rumen-degraded protein. These improvements confirm that HydroSoil alters plant nitrogen metabolism, increasing the crop's biological efficiency.

Protein Fraction Analysis (Dry Matter Basis)

Protein Component	GSP Control	HydroSoil	Interpretation
Total Crude Protein (%)	5.6	6.3	12.5% increase
True Protein (%)	4.8	5.6	More amino acids
Non-protein nitrogen (%)	0.8	0.7	Less ammonia/urea
Digestible Protein (%)	1.6	2.1	Superior availability
Digestibility coefficient	28.6%	33.3%	Better utilization
Undegradable protein (%)	1.8	2.2	More bypass protein



Nitrogen Use Efficiency Analysis

Soil Nitrate Dynamics

HydroSoil produced a nitrogen-uptake pattern aligned precisely with crop demand. At silking, HydroSoil plots held 378 ppm nitrate-N, substantially more than the control's 236 ppm, supporting vigorous grain development. By harvest, HydroSoil plots dropped to 11.2 ppm, compared to 37.6 ppm in the control, a 70 percent reduction in residual nitrate. This demonstrates that the crop captured nearly all available nitrogen, converting it into valuable protein rather than leaving it vulnerable to leaching.

Nitrogen Balance and Environmental Implications

Nitrogen budgeting revealed that manure-based management lost 258 lbs N/acre (41 percent of total applied N), costing growers an estimated \$155/acre in unrealized nutrient value. HydroSoil, despite much lower applied N, achieved an apparent uptake efficiency of 130 percent by stimulating mineralization of native soil organic nitrogen. HydroSoil's lower losses (101 lbs/acre) significantly reduced environmental risk and demonstrated superior nutrient conservation.

Soil Health Improvements

Organic Matter and Carbon Dynamics

One year after application, HydroSoil increased soil organic matter from 4.2 percent to 4.8 percent—a 14.3 percent gain equivalent to 12,000 lbs of organic matter and 7,000 lbs of carbon per acre. This sequestration represents 25,700 lbs CO₂/acre, potentially worth \$230–580/acre in emerging carbon markets. Higher active carbon and a 38 percent increase in respiration indicate a more biologically active soil system capable of faster nutrient cycling, better aggregation, and improved water-holding capacity.

Cation Exchange Capacity and Nutrient Retention

Nitrogen-use efficiency revealed the system-level contrast: GSP achieved only 10 percent efficiency, with most nitrogen remaining unused or vulnerable to loss. HydroSoil achieved 94–110 percent efficiency, meaning crops captured virtually all applied nitrogen and additional soil reserves. This ten-fold improvement underscores HydroSoil's capacity to convert soil nutrients into yield rather than leaving them stranded in unavailable chemical pools.

Economic Analysis for Livestock Operations

Dairy Enterprise Economics

For dairy producers, HydroSoil's feed-quality improvements are far more valuable than its yield gains. Enhanced digestible protein and energy density could increase milk output by 3.7 lbs/cow/day, generating \$203,000/year for a 1,000-cow dairy.

Reduced reliance on purchased protein supplements adds another \$51,000/year in savings, and improved digestibility contributes an additional \$36,500/year through better feed efficiency.

Economic Impact: 1,000-Cow Dairy

Economic Factor	Calculation Basis	Annual Value	Per Cow Impact
Milk Production Increases			
Digestible protein advantage	0.5% units × 0.5 lbs milk/0.1% protein	2.5 lbs/cow/day	\$164/cow
Energy density improvement	1.54 Mcal/cwt × 50 lbs DMI × 0.31 efficiency	1.2 lbs/cow/day	\$79/cow
Total milk increase	3.7 lbs/cow/day × 305 days × \$18/cwt	\$203,085	\$203/cow
Feed Cost Savings			
Reduced protein supplement	0.7% CP increase × 50 lbs × \$400/ton	\$51,100	\$51/cow
Lower ADF/higher intake	2% DMI increase × 50 lbs × \$0.12/lb	\$36,500	\$37/cow
Total Annual Benefit	Combined value	\$290,685	\$291/cow

Beef Feedlot Economics

Feedlots benefit from faster gains and better feed conversion. Improved protein and energy availability can shorten feeding periods by ~7 days, reducing yardage costs and improving marbling scores enough to raise carcass premiums. For a 5,000-head feedlot, these advantages could total \$465,000/year, demonstrating HydroSoil's substantial economic value beyond row-crop performance alone.

Performance Impact: Beef Feedlot

Performance Metric	GSP Control Silage	HydroSoil Silage	Improvement	Economic Value
Average daily gain (lbs)	3.2	3.35	+4.7%	\$18/head
Feed:gain ratio	6.8:1	6.5:1	-4.4%	\$22/head
Days to market	165	158	-7 days	\$14/head
Hot carcass weight (lbs)	825	835	+10 lbs	\$24/head
Choice grade (%)	68%	72%	+4%	\$15/head
Total value/head	-	-	-	\$93/head



5. Comparative Analysis

Consistent Themes Across Crops

In both the wheat and corn trials, HydroSoil delivered highly consistent benefits beyond crop yield.

Both systems left minimal residual nitrate, indicating that improved crop quality resulted from superior nutrient use rather than nutrient oversupply.

Nitrogen-use efficiency rose sharply in both crops: wheat achieved 94–110 percent efficiency by capturing nearly all applied N, while corn reached 130 percent apparent efficiency by stimulating mineralization of soil organic N.

Performance Category	Winter Wheat	Corn Silage	Consistent Pattern
Yield Response			
Yield increase vs control	4.7-7.5%	2.0%	Modest gains
Economic significance of yield	Secondary	Minimal	Quality > quantity
Protein Enhancement			
Crude protein increase	18.4%	12.5%	Substantial improvement
Digestible protein increase	-	33.3%	Substantial improvement
Protein-related value	\$19-28/acre	\$51/cow	High economic impact
Nitrogen Efficiency			
Residual soil NO ₃ -N reduction	78-89%	70.2%	Superior uptake
N use efficiency	94-110%	130%	Near-complete utilization
Environmental benefit	Reduced leaching	Reduced leaching	Consistent stewardship
Soil Health			
Organic matter change	-2% to +2%	+14.3%	Building over time
CEC enhancement	+4-38%	+4.4%	Improved retention
Biological activity	Enhanced	+38% respiration	Stimulated cycling

Differential Responses and Crop-Specific Considerations

While overall patterns remained consistent, certain responses showed crop-specific variation that provides insight into optimization strategies for different production systems. Understanding these differences enables tailored management recommendations that maximize the value of HydroSoil applications for specific cropping situations.

Winter wheat showed more severe sulfur limitation than corn, with post-harvest soil analysis revealing near-complete depletion to 4-6 parts per million. This reflects wheat's high sulfur requirement for synthesis of sulfur-containing amino acids in grain protein, particularly important for bread-making quality. Supplementing HydroSoil with 60 pounds per acre of elemental sulfur would address this wheat-specific limitation.

Corn silage, harvested before complete grain maturity, showed less sulfur stress, though supplementation would likely still prove beneficial.

The economic drivers differed substantially between crops, with wheat benefiting primarily from dramatic fertilizer cost reduction (\$365 per acre savings), while corn silage value emerged through feed quality premiums worth \$200-290 per cow annually. This difference reflects the commodity versus value-added nature of the two products, with wheat sold into bulk grain markets while corn silage feeds directly into livestock production systems where quality translates immediately to animal performance.



The HydroSoil Shift

Primary Mechanisms of Action

Five interacting mechanisms explain HydroSoil's cross-crop superiority:

1

Breaking nutrient accumulation cycles by replacing 25 tons of manure with 1–2 tons of balanced HydroSoil, reducing excessive P, K, and Na that previously blocked nutrient uptake.

2

Synchronized nutrient release via a very low C:N ratio of 5.7:1, ensuring nitrogen availability aligns with crop demand.

3

Enhanced microbial mineralization supporting rapid nutrient turnover.

4

Improved root-zone chemistry as antagonisms decline.

5

Uniform, predictable nutrient supply free from manure's variability.

Together, these mechanisms shift soils from dysfunctional overloading toward balanced productivity.

Beyond the primary mechanisms, numerous secondary effects contribute to HydroSoil's superior performance. These often represent consequences of the primary mechanisms but deserve recognition as they may provide important benefits in specific situations or over longer time horizons.

The enhanced biological activity stimulated by HydroSoil's readily decomposable organic matter likely produces numerous plant growth-promoting substances including auxins, cytokinins, and humic acids. While not directly measured in these trials, the vigorous crop growth and extensive root development observed suggest beneficial biological interactions beyond simple nutrient supply. The 38 percent increase in soil respiration indicates a thriving microbial community capable of producing these beneficial compounds.

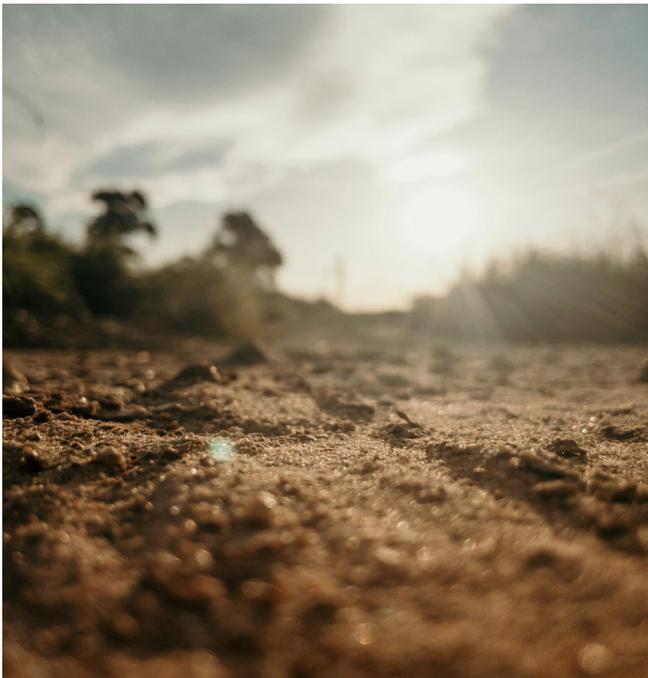
Soil Microbial Community Impacts

A comprehensive soil biome analysis provided critical insight into how HydroSoil influences soil microbial communities during the transition from high-volume manure management to concentrated biological fertility. The analysis, performed on wheat trial soil samples, quantified 25 distinct microbial functional groups and nutrient cycling activities, revealing both expected adaptations and important monitoring priorities for long-term soil health management.

Biome analysis showed reduced arbuscular mycorrhizal (AM) fungi (32–53 percent) under HydroSoil, but this reflected the trial site's excessively high phosphorus levels rather than a negative biological effect. Bacterial populations remained stable, preserving core nutrient-cycling functions such as N-fixation, nitrification, and phosphorus solubilization. HydroSoil's balanced nutrition and improved soil chemistry reduced the need for AM-mediated phosphorus acquisition while maintaining overall biological function.

Even with reduced AM fungi, HydroSoil produced higher yields, higher protein, and better quality in both crops, confirming that balanced nutrition and efficient N uptake outweighed any reduction in fungal symbiosis. This aligns with research showing that AM benefits diminish in high-phosphorus soils, where they can become a net carbon cost to the plant.

The reduction in fungi represents a transition state, not degradation. As excessive phosphorus declines and tillage intensity is reduced under HydroSoil management, AM populations are expected to rebound. Rising soil organic matter (+8.6–14.3 percent) and compatibility with reduced tillage support re-establishment of a resilient microbial community over time. Functional diversity remained strong across all HydroSoil treatments, indicating a healthy biological foundation.



Recommendations for Biological Monitoring

Monitoring is essential during transition. Recommended practices include annual AM root colonization sampling, periodic comprehensive biome analysis, respiration tests, tissue analysis, and tracking earthworm and soil-structure indicators. These measures will document recovery and guide optimization as the soil system rebalances.

Beyond the Farm Gate: Protecting Watersheds Through Reduced Nutrient Loading

The environmental benefits of HydroSoil treatment extend beyond the farm gate to encompass watershed-scale improvements in water quality through reduced nutrient loading to surface and groundwater resources.

The UN has warned that nitrogen pollution has reached critical levels in major farming regions—including North America, Western Europe, and parts of Asia—after decades of fertilizer overuse and misuse. A January 2025 UN report emphasizes that improving nitrogen-use efficiency is now essential to protect human health, prevent soil degradation, and curb water contamination.

In the Mendonsa Farms field trials, the most immediate and measurable indicator was a 70 percent reduction in residual soil nitrate, which translated to 37 pounds per acre less nitrogen available for leaching to groundwater.

Across a 1,000-acre farm, this would translate to 37,000 pounds of nitrogen retained in the production system rather than contaminating water resources. At the watershed scale, widespread adoption of HydroSoil could substantially reduce the nitrogen load contributing to groundwater contamination and surface water eutrophication.

Phosphorus risk reduction, while less immediately visible than nitrogen, provides equally important environmental benefits. At Mendonsa Farms, reducing soil phosphorus from 220-248 parts per million to 82-115 parts per million shifted the fields from the “excessive” category with high runoff risk to the “optimum to high” range with minimal environmental concern. The phosphorus saturation index, which predicts the likelihood of phosphorus desorption and loss, decreased from above 50 percent in traditional management to below 25 percent with HydroSoil, crossing the threshold from high risk to acceptable risk.



Environmental Impact Comparison

Parameter	Traditional Mgmt.	HydroSoil	Reduction	Watershed Impact
Nitrogen Losses				
Residual NO ₃ -N (ppm)	376	11.2	70.2%	Less groundwater contamination potential
Residual NO ₃ -N (lbs/acre)	52	15	37 lbs	Reduced loading
Leaching Potential	High	Low	Substantial	Improved water quality
Phosphorus Risk				
Soil test P (ppm)	220-248	82-115	58%	Substantial improvement
P saturation index	>50%	<25%	Safe range	Remarkably consistent
Soluble P potential	High	Moderate	Decreased	High economic impact
Carbon Footprint				
C sequestered (lbs/acre)	Minimal	7,000	Substantial	Climate mitigation
CO ₂ equivalent removed	None	25,700 lbs	Major benefit	Carbon negative
Transport emissions	High (25 tons)	Low (2 tons)	92% less	Reduced fuel use

7. Recommendations

Optimized Application Programs

Trial results show that optimized HydroSoil programs should target the nutrient limitations unique to each crop. Winter wheat requires 60 lbs/acre of elemental sulfur plus potassium sulfate to correct the severe sulfur deficiency documented in the trial and to support yields approaching 110 bu/acre with >12 percent protein. For corn silage, nutrient supplementation is lower because harvesting whole plants recycles more potassium; 100 lbs/acre potassium sulfate + 40 lbs sulfur supports the 33.3 percent increase in dry weight digestible protein that drives HydroSoil's feed-quality advantage. These targeted additions maintain HydroSoil's strong cost advantage while resolving crop-specific constraints.

Transition from Traditional Management

Both fertigation and manure-based systems can degrade soils over time. Operations with long histories of fertigation or manure require phased transitions as soils recover and recalibrate from excessive nutrient loading. Year 1 demands the highest HydroSoil rate (2,500 lbs/acre) to meet crop N needs while encouraging the crop to draw down legacy soil N and P. Eliminating all P additions is essential to reverse antagonisms created by extreme phosphorus levels. Tissue testing at key stages and post-harvest soil monitoring document progress and prevent deficiencies. As soil nutrient excess declines, HydroSoil rates can be reduced and supplementation fine-tuned.



Soil Testing and Monitoring Protocols

Comprehensive Soil Analysis Schedule

Effective HydroSoil management relies on regular chemical and biological soil testing. Annual postharvest Mehlich III panels track nutrient rebalancing, while pre-plant, mid-season, and post-harvest nitrate tests guide nitrogen decisions. Because HydroSoil stimulates biological nitrogen cycling, monitoring residual nitrate becomes the most important indicator of nitrogen-use efficiency and environmental performance.

Interpretation Guidelines for HydroSoil Systems

HydroSoil-managed fields require modified interpretation thresholds. Enhanced microbial activity and improved mycorrhizal function mean that crops can thrive at lower soil test P and K levels than conventional guidelines suggest. Maintaining organic matter and good biological activity is therefore essential, as HydroSoil's advantages depend on active microbial cycling rather than heavy synthetic nutrient inputs.

Integration with Existing Farm Operations

Equipment and Infrastructure Modifications

HydroSoil simplifies operations by replacing 50,000 lbs of manure with 2,000 lbs of granulated material, allowing uniform application with standard fertilizer spreaders. Its precision, storability, and compatibility with variable-rate technology improve placement and reduce operational costs.

Storage needs are minimal, enabling purchase during favorable pricing windows and eliminating lagoon or pad requirements. However, certain equipment and infrastructure adjustments can optimize application efficiency and uniformity.

Operation	Traditional Manure	HydroSoil	Advantage
Storage	Lagoons, concrete pads	Covered bins/buildings	95% less volume
Loading	Large loaders, long time	Small loader, quick	92% time reduction
Transport	Multiple trucks/wagons	Single spreader load	Fewer trips
Application	Manure spreaders	Fertilizer spreader	Better uniformity
Incorporation	Heavy disks required	Standard cultivation	Less compaction
Calibration	Difficult, variable	Simple, consistent	Precise rates
Maintenance	High wear, corrosion	Normal wear	Lower costs

Crop Rotation

Optimizing crop rotations for HydroSoil management involves selecting sequences that maximize nutrient cycling efficiency while building soil health over time. The enhanced biological activity under HydroSoil management particularly benefits rotations that include diverse crop types with complementary nutrient requirements and residue characteristics.

Including legume crops in the rotation provides an opportunity to reduce HydroSoil application rates while benefiting from biological nitrogen fixation. Alfalfa, with its deep taproot system, can access nutrients that have moved below the shallow rooting zone of annual crops, effectively recycling these nutrients back to the surface. During alfalfa years, HydroSoil applications can focus on phosphorus, potassium, and sulfur maintenance rather than nitrogen supply.

Cover crops following cash crops can capture residual nutrients, particularly nitrogen, preventing losses while building soil organic matter. Winter cover crops following corn silage harvest prove particularly valuable, as they can utilize any nitrogen mineralized during fall and winter months. The cover crop biomass then contributes additional organic matter when incorporated before the next cash crop, reinforcing the soil health improvements initiated by HydroSoil.

Adaptive Management Strategies

HydroSoil rates and supplemental needs will decline as soils rebalance. Continuous monitoring allows producers to optimize for cost and performance rather than follow fixed prescriptions. Adaptive strategies accelerate the shift from dysfunctional manure-based fertility toward efficient, biologically driven nutrient cycling.

An adaptive management approach recognizes that optimal HydroSoil rates and supplementation needs will change as soil health improves and nutrient reserves rebalance. Fields recovering from extreme manure accumulation may require higher initial rates and minimal supplementation, while fields reaching balanced fertility may benefit from reduced HydroSoil rates with targeted nutrient additions. This flexibility enables optimization for specific field conditions and economic objectives rather than following rigid prescriptions.

Economic Analysis

Making informed decisions about HydroSoil adoption requires comprehensive economic analysis that accounts for all costs and benefits across multiple years.

The following framework enables producers to evaluate the economic implications for their specific operations.

Category	Manure System	HydroSoil System	Calculation Method
Direct Input Costs			
Fertilizer material	\$375-450/acre	\$195-315/acre	Volume x Price
Application Cost	\$65/acre	\$15/acre	Equipment + Labor
Supplemental nutrients	Variable	\$50-100/acre	Based on soil tests
Yield Response			
Grain crops	Baseline	+4-8%	Historical x Improvement
Forage crops	Baseline	+2-3% yield, +31% protein	Value per quality unit
Quality Premiums			
Protein content	Standard	+\$10-28/acre	Market premiums
Feed value	Baseline	+\$250/cow/year	Dairy enterprise
Long-term Benefits			
Soil OM building	Declining	+0.6% points	Improved drought tolerance
Reduced erosion	Standard	Improved	Prevented soil loss
Risk Factors			
Environmental compliance	High	Low	Regulatory probability
Price volatility	High Exposure	Reduced	Input cost stability
Production variability	Standard	Reduced	Yield stability

Five-Year Investment Return Projection

(per acre)

The economic framework should be customized for specific operations by incorporating actual yield history, local input costs, and relevant market premiums.

For dairy operations, the feed quality improvements provide the dominant economic benefit, potentially worth \$250-290 per cow annually. For cash grain operations, the combination of modest yield improvements and dramatic input cost reductions drives profitability.

Environmental compliance benefits, while difficult to quantify precisely, may become increasingly valuable as nutrient management regulations tighten.

Long-term financial projections demonstrate that HydroSoil investment provides attractive returns through multiple value streams that compound over time. The following analysis projects returns over a five-year transition and optimization period.

The projection demonstrates that HydroSoil investment pays back completely within the first year through input cost savings alone, with all subsequent benefits representing pure profit improvement. The compounding nature of soil health improvements means that benefits accelerate over time as organic matter accumulates, biological activity intensifies, and nutrient cycling efficiency improves.

By year five, the cumulative return on investment exceeds 650 percent, not accounting for additional benefits such as improved drought resilience, reduced erosion, and enhanced operational efficiency.

Year	Investment	Direct Return	Cumulative	ROI
1	\$390 (transition)	\$285 savings + \$45 yield	\$330	85%
2	\$365 (optimized)	\$275 savings + \$65 yield	\$670	183%
3	\$315 (adjusted)	\$275 savings + \$85 yield + \$50 quality	\$1,080	343%
4	\$315 (stable)	\$275 savings + \$85 yield + \$75 quality	\$1,515	481%
5	\$315 (mature)	\$275 savings + \$85 yield + \$100 quality + \$100 carbon	\$2,075	659%

The Tillage Paradigm Shift

From High Disturbance to Conservation Systems

Traditional manure management locks producers into intensive tillage because 25 tons per acre of raw manure must be aggressively incorporated, which destroys soil structure, accelerates organic matter loss, damages biological communities, and consumes large amounts of fuel and labor. HydroSoil's concentrated, granulized nutrition eliminates this requirement: it can be surface-applied or lightly incorporated, allowing farmers to break the link between fertility and deep tillage and setting the stage for low-till or no-till systems.

Biological Benefits of Future Low-Till Systems

As tillage intensity drops under HydroSoil, soil biology can recover and amplify the product's benefits. Undisturbed mycorrhizal networks extend farther into the soil to acquire phosphorus and water, earthworms rebuild pore networks that improve infiltration and aeration, and more stable aggregates protect organic matter from rapid oxidation. Over time, these biological processes provide "biological tillage" that improves structure, nutrient access, and resilience more effectively than repeated mechanical disturbance.

Operational and Economic Advantages

The operational and economic gains from reducing tillage are substantial even before accounting for yield or quality improvements. Eliminating multiple tillage passes can save roughly \$36/acre in fuel alone and 1.5–2.5 labor hours per acre, while reducing the need for heavy tillage equipment by hundreds of thousands of dollars in capital. Improved timeliness of planting and better moisture conservation under residue cover further increase yields and stability, making HydroSoil-enabled conservation systems economically superior to conventional high-disturbance programs.

Implementing a Tillage Transition

Year 1

Conduct a final deep tillage pass only if needed to relieve existing compaction, then begin HydroSoil at 2,500 lbs/acre with surface broadcast or minimal incorporation. Keep crop residues on the surface, monitor nitrogen and sulfur with tissue tests, and scout closely for any short-term pest or residue-management issues as the system adjusts.

Years 2-3

Reduce HydroSoil rates to 1,500–2,000 lbs/acre as biological cycling improves, invest in appropriate no-till or strip-till planting equipment, and integrate cover crops to keep living roots and surface cover in place. Use strip-till or zone-till as needed while tracking improvements in structure, infiltration, and biological activity to guide further reductions in disturbance.

Long-Term

Maintain 30–70 percent surface residue cover, rotate crops to vary rooting patterns and residue types, and use cover crops and controlled traffic to build and protect soil structure. Continue soil health monitoring (aggregate stability, infiltration, respiration) to document progress and fine-tune HydroSoil rates and rotations as the system stabilizes. Over time, this integrated fertility–tillage transformation becomes one of HydroSoil's most valuable benefits, delivering sustained gains in profitability, resilience, and environmental performance at the whole-farm scale.

HydroSoil allows farms to transition from intensive tillage to long-term conservation, which affects every aspect of the production system from soil biology to equipment requirements to carbon sequestration potential. Combining reduced tillage with documented improvements in nutrient efficiency, crop quality, and economic returns, HydroSoil is a comprehensive solution for the sustainable intensification of agricultural production.

8. The Path Forward

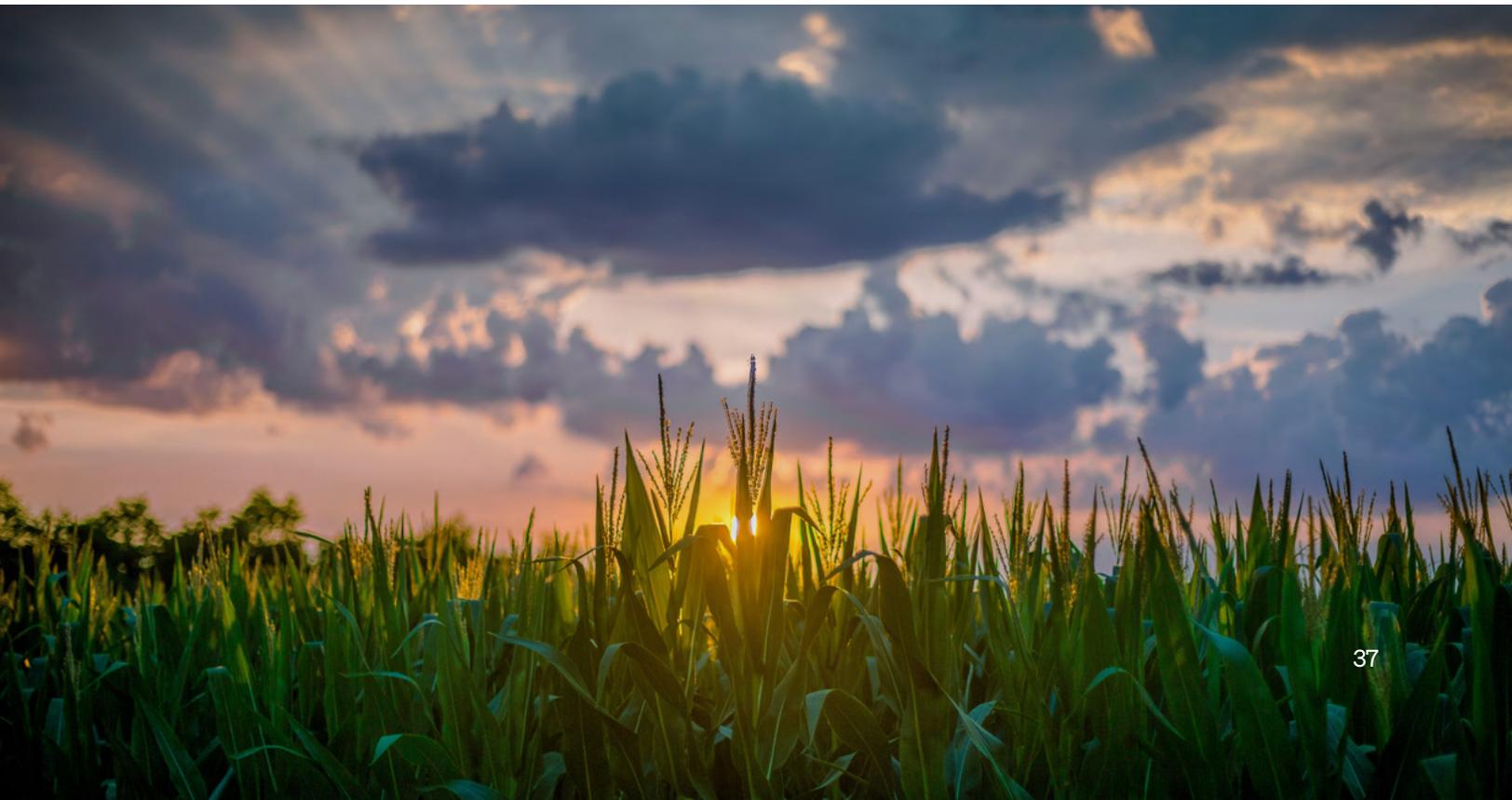
Agricultural System Transformation

The traditional approach of overwhelming crops with massive nutrient inputs in hopes of maximizing yield has reached its economic and environmental limits. Rising input costs, tightening environmental regulations, and consumer demand for sustainable production necessitate a new approach. HydroSoil provides this alternative by demonstrating that moderate, balanced nutrition synchronized with crop demand produces superior economic returns while building rather than depleting soil resources.

The comprehensive field trials conducted at Mendonsa Farms during the 2024-2025 growing season demonstrate that HydroSoil fertilizer unlocks a paradigm shift in agricultural nutrient management, particularly for operations transitioning from excessive traditional organic amendments to balanced, efficient fertility programs.

The trials demonstrated that decades of applying 25 tons per acre of dairy manure plus gypsum had created a fundamentally dysfunctional production system characterized by severe nutrient imbalances, economic losses, and environmental liabilities that HydroSoil successfully addresses through multiple synergistic mechanisms.

Protein enhancement across both crop types suggests that HydroSoil influences fundamental aspects of nitrogen metabolism and protein synthesis that transcend species-specific differences. This predictable response enables producers to confidently project feed quality improvements and associated economic benefits when considering HydroSoil adoption. The consistency also validates the mechanistic understanding that enhanced nitrogen uptake efficiency, rather than simply increased nitrogen supply, drives the observed quality improvements.



Recap: Trial Outcomes

The economic advantages of HydroSoil extend far beyond yield increases to encompass dramatic input cost reductions, quality premiums, and long-term soil health benefits that compound over time.

Winter wheat production transformed from a money-losing enterprise under traditional management at negative \$134 per acre to a profitable operation generating \$186-259 per acre with HydroSoil.

For dairy operations, the feed quality improvements alone justify adoption with annual benefits of \$250-290 per cow, while additional advantages in reduced supplementation costs and improved animal health provide supplemental value.

HydroSoil is more than an alternative fertilizer product; it is a catalyst for a new agricultural model that is operationally efficient, economically superior, environmentally regenerative, biologically diverse, and climate resilient.

As nutrient costs rise and environmental pressures intensify, HydroSoil lets cost-burdened farmers transition from high-volume, low-efficiency nutrient inputs and intensive tillage to precision management, efficiency, and soil regeneration.

By eliminating manure incorporation and reducing reliance on excessive nutrients, HydroSoil aligns growers with regenerative practices, sustainability markets, and a growing pressure for nutrient accountability.

The evidence is clear: the time for incremental improvements has passed—HydroSoil makes full system transformation both possible and profitable.

Performance Metric	Winter Wheat	Corn Silage	Advantage
Yield Response	+4.7 to 7.5%	+2.0%	Modest but consistent gains
Protein Enhancement	+18.4% crude	+12.5% crude	Major quality improvement
Digestible Protein	-	+33.3%	Major quality improvement
Economic Advantage	+\$285-358/acre	+\$250-290/cow	Compelling returns
Input Cost Reduction	-61%	-59%	Dramatic savings
N Use Efficiency	94-110%	130%	Near-complete utilization
Residual NO₃-N	-78-89%	-70.2%	Environmental benefit
Soil Organic Matter	Variable	+14.3%	Long-term building
Return on Investment	59-115%	Not calculated	Exceptional returns