Metadata for: Data for: Comparison of in-season N-rate recommendation tools for no-till corn grown with liquid dairy manure in Pennsylvania, USA, 2021-2023.

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Dataset creators

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Abstract

Nitrogen (N) management is critical in corn (Zea mays L.) production due to its significant impact on yields, economic costs, water and air quality, and greenhouse gas emissions. Growers' practices aimed at ensuring maximum yields often lead to the application of more N than the crop can utilize. Applying manure before corn planting and then side-dressing N fertilizer later can enhance N use efficiency and reduce environmental losses. Despite these advantages, predicting the economically optimal N rate (EONR) remains challenging, often resulting in excessive side-dress N applications that increase both costs and environmental risks. Despite advancements in N recommendations, which range from sensor-based technologies like SPAD and NDVI to models that incorporate real-time weather information along with local soil and crop management factors, there remains a need to refine side-dress N recommendations due to the inherent uncertainty in estimating mineralizable N in fields with varied crop and manure management histories. While several N management tools show promise, their accuracy and reliability in side-dress applications have not been extensively evaluated in the U.S. mid-Atlantic region.

The objective of this research was to identify side-dress nitrogen (N) recommendation methods that provide accurate N recommendations across diverse crop and manure management histories. The study was conducted at Rock Springs, PA, and on-farm locations across Pennsylvania using no-till corn production systems representing 21 different prior-crop and manure management histories, including injected and surface-broadcast manure applications without incorporation. Side-dress N recommendation tools including SPAD, Adapt-N, the Cover

Crop and Soil Organic Matter (CC & SOM) N Credit Tool, NDVI, the Penn State Agronomy Guide, and the Pre-Side-dress Nitrate Test (PSNT) were evaluated at the same corn development stage from 2021 to 2023. Following tool recommendations, multiple side-dress N fertilizer rates were applied to establish N response curves and determine the economically optimal nitrogen rate (EONR) for each environment.

Keywords

Adapt-N, corn, dairy manure, Economically Optimal Nitrogen Rate (EONR), nitrogen management, nitrogen recommendation tools, no-till agriculture, Normalized Difference Vegetation Index (NDVI), Pre-Sidedress Nitrate Test (PSNT), side-dress nitrogen, Soil Plant Analysis Development (SPAD)

Award(s)

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Maintenance

Update frequency: not planned

This dataset is complete and no maintenance is planned.

Geographic coverage

The state of Pennsylvania.

west bounding coordinate	east bounding coordinate	north bounding coordinate	south bounding coordinate
-80.52072	-74.6953	42.26995	39.72027

Temporal coverage

begin date	end date
2021-01-01	2023-12-31

Taxonomic coverage

Kingdom	Phylum	Class	Order	Family	Genus	Species
Animalia	Chordata	Mammalia	Artiodactyla	Bovidae	Bos	Bos taurus
Plantae	Tracheophyta	Magnoliopsida	Fabales	Fabaceae	Medicago	Medicago sativa
Plantae	Tracheophyta	Magnoliopsida	Fabales	Fabaceae	Trifolium	Trifolium pratense
Plantae	Tracheophyta	Magnoliopsida	Poales	Poaceae	Dactylis	Dactylis glomerata
Plantae	Tracheophyta	Magnoliopsida	Poales	Poaceae	Lolium	Lolium multiflorum
Plantae	Tracheophyta	Magnoliopsida	Poales	Poaceae	Secale	Secale cereale
Plantae	Tracheophyta	Magnoliopsida	Poales	Poaceae	Zea	Zea mays

Methods

Data Repository

This metadata is a supplement to the data and metadata hosted by Penn State Data Commons at https://doi.org/10.26208/9m9m-0433.

Field Experimental Design and Site Characterization

Field experiments were conducted from 2021 to 2023 across multiple site-years on commercial farms and research sites in Pennsylvania under no-till dairy cropping systems. Each site-year represented a unique combination of soil conditions, crop rotation, manure management history, and environmental conditions. Experimental fields were typically managed with long-term no-till practices and included rotations with corn silage or grain following winter annual forage crops or cover crops such as rye, wheat, or mixed species. Site-level characteristics including previous crop, crop entry, manure application history, application method, yield

plateau, and economically optimal nitrogen rate (EONR) were documented for each environment.

Nitrogen Response Trials for Corn Yield

Nitrogen response experiments were conducted using replicated field plots subjected to a range of sidedress nitrogen application rates. Treatments included multiple nitrogen rates applied in-season to evaluate crop yield response across management systems. Plots were arranged within randomized block designs, and grain or silage yield was measured at harvest. For silage systems, total chopped biomass was weighed and subsampled to determine dry matter content, while grain yield was measured and standardized to moisture content. These data were used to generate nitrogen response curves and estimate yield plateaus and EONR values for each site-year.

Manure Management Treatments

Manure was applied prior to planting using contrasting application methods, primarily surface broadcast and shallow-disk injection, consistent with common regional practices. Application rates, timing, and methods varied by site-year and were recorded along with associated crop rotation and manure history. Injection involved placing manure below the soil surface using disk injectors, while broadcast application deposited manure on the soil surface without incorporation. These treatments influenced nitrogen availability, crop uptake, and subsequent sidedress recommendations evaluated in the dataset.

In-Season Soil Nitrogen Assessment (PSNT)

Soil nitrogen availability was quantified using the Pre-Sidedress Nitrate Test (PSNT), conducted when corn reached approximately the V6–V7 growth stage. Composite soil samples were collected to a depth of 30 cm using multiple cores per plot. For injected manure treatments, soil sampling accounted for spatial variability by collecting cores across and between injection bands. Samples were analyzed for nitrate-N concentration, and results were used to determine whether additional sidedress nitrogen fertilizer was required to meet yield goals.

Implementation of Nitrogen Recommendation Tools

Multiple nitrogen recommendation approaches were applied to each site-year to estimate sidedress fertilizer requirements. These included the Pennsylvania Agronomy Guide recommendations, PSNT-based recommendations, remote sensing approaches such as normalized difference vegetation index (NDVI), chlorophyll meter readings (SPAD), cover crop nitrogen credit methods, and process-based modeling tools (e.g., Adapt-N). Each tool produced a recommended sidedress nitrogen rate based on site conditions, crop status, or historical management. These recommendations were compiled and compared across environments to assess agreement with measured EONR.

Evaluation of Economically Optimal Nitrogen Rate (EONR)

The economically optimal nitrogen rate was estimated for each site-year using crop yield response data and standard agronomic-economic relationships. EONR represents the nitrogen

rate at which marginal fertilizer cost equals marginal yield return. Yield response curves derived from the nitrogen rate trials were used to identify yield plateaus and calculate EONR values. These values served as a benchmark for evaluating the performance of nitrogen recommendation tools and for interpreting site-level nitrogen responsiveness.

Data tables

This section contains summary information for each data table (bolded) in this repository, starting with the file name and a textual description of the table. Following that is a table where each row represents one column in the data table with metadata for that column. If the data table contained any categorical columns, there will then be a table containing descriptions of each category.

Adapt_N_tool. This table contains sidedress nitrogen fertilizer recommendations generated using the Adapt-N decision support system. Model outputs are based on site-specific inputs including weather, soil conditions, crop management, and crop growth status. Each row represents a site-year-management combination and reports the recommended nitrogen rate in kg N ha^{-1}. Number of records: 16.

attribute name	attribute definition	storage type	measurement scale standard unit
Adapt N tool pkey	A unique primary key identifier for each row in this table.	integer	dimensionless
corn environment	Environment or site name. Information about sites can be found in table site_details.	string	
crop entry	The crop entries included in the study were corn silage following a winter cereal rye cover crop in an organic grain rotation (R, Cs, O), corn silage following a winter cereal rye cover crop in a grain rotation with rye (R, Cs, R), corn silage following annual ryegrass and red clover cover crops interseeded into corn grain the previous year (Int, Cs), and corn grain following a winter cereal rye cover crop (R, Cg). Perennial forage entries were excluded because cover crop nitrogen credits were not applicable. Full abbreviations used were: A+Og = Alfalfa + Orchardgrass; Cs = Corn silage; Cg = Corn grain; Int = Interseeded annual ryegrass + clover mix; O = Oats; R = Rye cover crop; Rs = Rye silage; S = Soybean; SS = Sorghum-sudangrass. Production year notation: 1 = First full production year; 2 = Second full production year; 3 = Third full production year (for multi-year perennial crops such as alfalfa + orchardgrass).	string	
method of manure application	The method used to apply manure.	string	
recommended sidedress nitrogen rate kg n ha	Recommended sidedress nitrogen rate (kg N ha^{-1}).	float	kilogramPerHectare
rotation	The cropping system rotation in the larger Penn State LTAR Sustainable Dairy Cropping Systems experiment.	string	
tool	Sidedress nitrogen fertilizer recommendations were generated using the Adapt-N nitrogen decision support system for corn grown in no-till dairy cropping systems from 2021 through 2023.	string	
year	The calendar year for this entry. This dataset contains data from 2021-2023.	dateTime	YYYY

Adapt_N_tool. Descriptions of categories for the preceding table.

attribute name	code	definition
rotation	BAU	Business as Usual (BAU) represents the baseline conventional 6-year dairy forage rotation, consisting of alfalfa–orchardgrass, corn silage, rye cover crop, corn silage, rye cover crop, corn silage, oats, alfalfa–orchardgrass, with broadcast manure (BM) used as the manure application method.
rotation	Manure	Manure refers to the Manure Management rotation, which is a 6-year rotation. It includes alfalfa–grass, corn silage, rye silage, sorghum-sudangrass, rye cover crop, corn grain (interseeded with annual ryegrass and clover), corn silage, oats, and then alfalfa–orchardgrass. Within this rotation, the comparison is between broadcast manure (BM) and injected manure (IM) as the manure application methods; the manure treatments are maintained consistently throughout the 6-year rotation.

attribute name	code	definition
method of manure application	Surface broadcast	Surface broadcast manure.
method of manure application	Shallow-disk injection	Shallow-disk injection of manure.

Agronomy_Guide. This table contains sidedress nitrogen fertilizer recommendations generated using the Penn State Agronomy Guide framework. Recommendations incorporate crop rotation history, manure credits, expected yield, and other management factors. Each row represents a site-year-management combination, with nitrogen rates reported in kg N ha^{-1}. Number of records: 16.

attribute name	attribute definition	storage type	measurement scale standard unit
Agronomy Guide pkey	A unique primary key identifier for each row in this table.	integer	dimensionless
corn environment	Environment or site name. Information about sites can be found in table site_details.	string	
crop entry	The crop entries included in the study were corn silage following a winter cereal rye cover crop in an organic grain rotation (R, Cs, O), corn silage following a winter cereal rye cover crop in a grain rotation with rye (R, Cs, R), corn silage following annual ryegrass and red clover cover crops interseeded into corn grain the previous year (Int, Cs), and corn grain following a winter cereal rye cover crop (R, Cg). Perennial forage entries were excluded because cover crop nitrogen credits were not applicable. Full abbreviations used were: A+Og = Alfalfa + Orchardgrass; Cs = Corn silage; Cg = Corn grain; Int = Interseeded annual ryegrass + clover mix; O = Oats; R = Rye cover crop; Rs = Rye silage; S = Soybean; SS = Sorghum-sudangrass. Production year notation: 1 = First full production year; 2 = Second full production year; 3 = Third full production year (for multi-year perennial crops such as alfalfa + orchardgrass).	string	
method of manure application	The method used to apply manure.	string	
recommended sidedress nitrogen rate kg n ha	Recommended sidedress nitrogen rate (kg N ha^{-1}).	float	kilogramPerHectare
rotation	The cropping system rotation in the larger Penn State LTAR Sustainable Dairy Cropping Systems experiment.	string	
tool	Sidedress nitrogen fertilizer recommendations were generated using the Penn State Agronomy Guide for corn grown in no-till dairy cropping systems from 2021 through 2023.	string	
year	The calendar year for this entry. This dataset contains data from 2021-2023.	dateTime	YYYY

Agronomy_Guide. Descriptions of categories for the preceding table.

attribute name	code	definition
rotation	BAU	Business as Usual (BAU) represents the baseline conventional 6-year dairy forage rotation, consisting of alfalfa–orchardgrass, corn silage, rye cover crop, corn silage, rye cover crop, corn silage, oats, alfalfa–orchardgrass, with broadcast manure (BM) used as the manure application method.
rotation	Manure	Manure refers to the Manure Management rotation, which is a 6-year rotation. It includes alfalfa–grass, corn silage, rye silage, sorghum-sudangrass, rye cover crop, corn grain (interseeded with annual ryegrass and clover), corn silage, oats, and then alfalfa–orchardgrass. Within this rotation, the comparison is between broadcast manure (BM) and injected manure (IM) as the manure application methods; the manure treatments are maintained consistently throughout the 6-year rotation.
method of manure application	BM	Surface broadcast manure.

attribute name	code	definition
method of manure application	IM	Shallow-disk injection of manure.

corn_grain_N_response. This table contains plot-level observations from corn grain nitrogen response experiments conducted in 2021 and 2022. It includes sidedress nitrogen application rates, crop management descriptors, and grain yield standardized to 15.5% moisture content. Data were collected from replicated plots using a plot combine. Each row represents an individual plot within a site-year and nitrogen rate treatment, and some observations identified as outliers during quality control are retained and flagged in the dataset. Number of records: 128.

attribute name	attribute definition	storage type	measurement scale standard unit	missing value code	missing value explanation
block	The statistical block that plots had treatments randomized within.	float	number		
corn environment	Environment or site name. Information about sites can be found in table site_details.	string			
corn grain N response pkey	A unique primary key identifier for each row in this table.	integer	dimensionless		
crop entry	The crop entries included in the study were corn silage following a winter cereal rye cover crop in an organic grain rotation (R, Cs, O), corn silage following a winter cereal rye cover crop in a grain rotation with rye (R, Cs, R), corn silage following annual ryegrass and red clover cover crops interseeded into corn grain the previous year (Int, Cs), and corn grain following a winter cereal rye cover crop (R, Cg). Perennial forage entries were excluded because cover crop nitrogen credits were not applicable. Full abbreviations used were: A+Og = Alfalfa + Orchardgrass; Cs = Corn silage; Cg = Corn grain; Int = Interseeded annual ryegrass + clover mix; O = Oats; R = Rye cover crop; Rs = Rye silage; S = Soybean; SS = Sorghum-sudangrass. Production year notation: 1 = First full production year; 2 = Second full production year; 3 = Third full production year (for multi-year perennial crops such as alfalfa + orchardgrass).	string			
plot id	A unique identifier for the plot this data was collected in.	string			
rotation	The cropping system rotation in the larger Penn State LTAR Sustainable Dairy Cropping Systems experiment.	string			
sidedress nitrogen rate kg n ha	Recommended sidedress nitrogen rate (kg N ha^{-1}).	float	kilogramPerHectare	NA	Plots E321E2, E323E6, E324E7, E324W7, and E323W6 were identified as outliers due to significant damage from Mormota monax and were excluded from the analysis.
treatment	The method used to apply manure.	string			
year	The calendar year for this entry. This dataset contains data from 2021-2023.	dateTime	YYYY		
yield bu a 15 5 percent mc	Corn grain yield in bushels per acre normalized to 15.5% moisture content.	float	bushelPerAcre	NA	Plots E321E2, E323E6, E324E7, E324W7, and E323W6 were identified as outliers due to significant damage from Mormota monax and were excluded from the analysis.

corn_grain_N_response. Descriptions of categories for the preceding table.

attribute name	code	definition
rotation	BAU	Business as Usual (BAU) represents the baseline conventional 6-year dairy forage rotation, consisting of alfalfa–orchardgrass, corn silage, rye cover crop, corn silage, rye cover crop, corn silage, oats, alfalfa–orchardgrass, with broadcast manure (BM) used as the manure application method.
rotation	Manure	Manure refers to the Manure Management rotation, which is a 6-year rotation. It includes alfalfa–grass, corn silage, rye silage, sorghum-sudangrass, rye cover crop, corn grain (interseeded with annual ryegrass and clover), corn silage, oats, and then alfalfa–orchardgrass. Within this rotation, the comparison is between broadcast manure (BM) and injected manure (IM) as the manure application methods; the manure treatments are maintained consistently throughout the 6-year rotation.
treatment	BM	Surface broadcast manure.
treatment	IM	Shallow-disk injection of manure.

corn_silage_N_response. This table contains plot-level observations from corn silage nitrogen response experiments conducted from 2021–2023. It includes sidedress nitrogen application rates, crop management descriptors (rotation, crop entry, manure treatment), and measured silage yield expressed as both dry matter and 65% moisture-adjusted yield. Data were collected from replicated field plots harvested mechanically, with subsamples used to determine moisture content. Each record represents a single plot within a site-year and nitrogen rate treatment. Number of records: 312.

attribute name	attribute definition	storage type	measurement scale standard unit
block	The statistical block that plots had treatments randomized within.	float	number
corn environment	Environment or site name. Information about sites can be found in table site_details.	string	
corn silage N response pkey	A unique primary key identifier for each row in this table.	integer	dimensionless
crop entry	The crop entries included in the study were corn silage following a winter cereal rye cover crop in an organic grain rotation (R, Cs, O), corn silage following a winter cereal rye cover crop in a grain rotation with rye (R, Cs, R), corn silage following annual ryegrass and red clover cover crops interseeded into corn grain the previous year (Int, Cs), and corn grain following a winter cereal rye cover crop (R, Cg). Perennial forage entries were excluded because cover crop nitrogen credits were not applicable. Full abbreviations used were: A+Og = Alfalfa + Orchardgrass; Cs = Corn silage; Cg = Corn grain; Int = Interseeded annual ryegrass + clover mix; O = Oats; R = Rye cover crop; Rs = Rye silage; S = Soybean; SS = Sorghum-sudangrass. Production year notation: 1 = First full production year; 2 = Second full production year; 3 = Third full production year (for multi-year perennial crops such as alfalfa + orchardgrass).	string	
dry yield t a	Corn silage yield after normalizing for 0% moisture.	float	tonPerAcre
plot id	A unique identifier for the plot this data was collected in.	string	
rotation	The cropping system rotation in the larger Penn State LTAR Sustainable Dairy Cropping Systems experiment.	string	
sidedress nitrogen rate kg n ha	Recommended sidedress nitrogen rate (kg N ha^{-1}).	float	kilogramPerHectare
treatment	The method used to apply manure.	string	
year	The calendar year for this entry. This dataset contains data from 2021-2023.	dateTime	YYYY
yield t a 65 percent moisture	Corn silage yield normalized for 65% moisture.	float	tonPerAcre

corn_silage_N_response. Descriptions of categories for the preceding table.

attribute name	code	definition
rotation	BAU	Business as Usual (BAU) represents the baseline conventional 6-year dairy forage rotation, consisting of alfalfa–orchardgrass, corn silage, rye cover crop, corn silage, rye cover crop, corn silage, oats, alfalfa–orchardgrass, with broadcast manure (BM) used as the manure application method.
rotation	Manure	Manure refers to the Manure Management rotation, which is a 6-year rotation. It includes alfalfa–grass, corn silage, rye silage, sorghum-sudangrass, rye cover crop, corn grain (interseeded with annual ryegrass and clover), corn silage, oats, and then alfalfa–orchardgrass. Within this rotation, the comparison is between broadcast manure (BM) and injected manure (IM) as the manure application methods; the manure treatments are maintained consistently throughout the 6-year rotation.
treatment	BM	Surface broadcast manure.
treatment	IM	Shallow-disk injection of manure.

cover_crop_N_tool. This table contains sidedress nitrogen fertilizer recommendations derived from estimated nitrogen credits associated with cover crop biomass and soil organic matter. Nitrogen credits were estimated and subtracted from crop nitrogen requirements to calculate recommended sidedress rates. Each record corresponds to a site-year-management combination and reports recommended nitrogen rates in kg N ha^{-1}. Number of records: 9.

attribute name	attribute definition	storage type	measurement scale standard unit
corn environment	Environment or site name. Information about sites can be found in table site_details.	string	
cover crop N tool pkey	A unique primary key identifier for each row in this table.	integer	dimensionless
crop entry	The crop entries included in the study were corn silage following a winter cereal rye cover crop in an organic grain rotation (R, Cs, O), corn silage following a winter cereal rye cover crop in a grain rotation with rye (R, Cs, R), corn silage following annual ryegrass and red clover cover crops interseeded into corn grain the previous year (Int, Cs), and corn grain following a winter cereal rye cover crop (R, Cg). Perennial forage entries were excluded because cover crop nitrogen credits were not applicable. Full abbreviations used were: A+Og = Alfalfa + Orchardgrass; Cs = Corn silage; Cg = Corn grain; Int = Interseeded annual ryegrass + clover mix; O = Oats; R = Rye cover crop; Rs = Rye silage; S = Soybean; SS = Sorghum-sudangrass. Production year notation: 1 = First full production year; 2 = Second full production year; 3 = Third full production year (for multi-year perennial crops such as alfalfa + orchardgrass).	string	
method of manure application	The method used to apply manure.	string	
recommended sidedress nitrogen rate kg n ha	Recommended sidedress nitrogen rate (kg N ha^{-1}).	float	kilogramPerHectare
rotation	The cropping system rotation in the larger Penn State LTAR Sustainable Dairy Cropping Systems experiment.	string	
tool	Recommended sidedress nitrogen rates were calculated by estimating nitrogen credits from cover crop biomass and soil organic matter and subtracting those credits from crop nitrogen requirements.	string	
year	The calendar year for this entry. This dataset contains data from 2021-2023.	dateTime	YYYY

cover_crop_N_tool. Descriptions of categories for the preceding table.

attribute name	code	definition
rotation	BAU	Business as Usual (BAU) represents the baseline conventional 6-year dairy forage rotation, consisting of alfalfa–orchardgrass, corn silage, rye cover crop, corn silage, rye cover crop, corn silage, oats, alfalfa–orchardgrass, with broadcast manure (BM) used as the manure application method.
rotation	Manure	Manure refers to the Manure Management rotation, which is a 6-year rotation. It includes alfalfa–grass, corn silage, rye silage, sorghum-sudangrass, rye cover crop, corn grain (interseeded with annual ryegrass and clover), corn silage, oats, and then alfalfa–orchardgrass. Within this rotation, the comparison

attribute name	code	definition
		is between broadcast manure (BM) and injected manure (IM) as the manure application methods; the manure treatments are maintained consistently throughout the 6-year rotation.
method of manure application	BM	Surface broadcast manure.
method of manure application	IM	Shallow-disk injection of manure.

Normalized_Difference_Vegetation_Index. This table contains sidedress nitrogen fertilizer recommendations derived from NDVI-based assessments of crop canopy reflectance. NDVI measurements were collected using canopy sensors (e.g., GreenSeeker) and translated into nitrogen recommendations using associated calibration algorithms. Each record represents a site-year-management combination and includes the recommended nitrogen rate in kg N ha^{-1}. Number of records: 16.

attribute name	attribute definition	storage type	measurement scale standard unit
Normalized Difference Vegetation Index pkey	A unique primary key identifier for each row in this table.	integer	dimensionless
corn environment	Environment or site name. Information about sites can be found in table site_details.	string	
crop entry	The crop entries included in the study were corn silage following a winter cereal rye cover crop in an organic grain rotation (R, Cs, O), corn silage following a winter cereal rye cover crop in a grain rotation with rye (R, Cs, R), corn silage following annual ryegrass and red clover cover crops interseeded into corn grain the previous year (Int, Cs), and corn grain following a winter cereal rye cover crop (R, Cg). Perennial forage entries were excluded because cover crop nitrogen credits were not applicable. Full abbreviations used were: A+Og = Alfalfa + Orchardgrass; Cs = Corn silage; Cg = Corn grain; Int = Interseeded annual ryegrass + clover mix; O = Oats; R = Rye cover crop; Rs = Rye silage; S = Soybean; SS = Sorghum-sudangrass. Production year notation: 1 = First full production year; 2 = Second full production year; 3 = Third full production year (for multi-year perennial crops such as alfalfa + orchardgrass).	string	
method of manure application	The method used to apply manure.	string	
recommended sidedress nitrogen rate kg n ha	Recommended sidedress nitrogen rate (kg N ha^{-1}).	float	kilogramPerHectare
rotation	The cropping system rotation in the larger Penn State LTAR Sustainable Dairy Cropping Systems experiment.	string	
tool	Recommended sidedress nitrogen rates were generated from NDVI-based assessments of crop nitrogen status using canopy reflectance measurements and GreenSeeker (Trimble Inc., Sunnyvale, CA, USA) associated recommendation algorithms.	string	
year	The calendar year for this entry. This dataset contains data from 2021-2023.	dateTime	YYYY

Normalized_Difference_Vegetation_Index. Descriptions of categories for the preceding table.

attribute name	code	definition
rotation	BAU	Business as Usual (BAU) represents the baseline conventional 6-year dairy forage rotation, consisting of alfalfa–orchardgrass, corn silage, rye cover crop, corn silage, rye cover crop, corn silage, oats, alfalfa–orchardgrass, with broadcast manure (BM) used as the manure application method.
rotation	Manure	Manure refers to the Manure Management rotation, which is a 6-year rotation. It includes alfalfa–grass, corn silage, rye silage, sorghum-sudangrass, rye cover crop, corn grain (interseeded with annual ryegrass and clover), corn silage, oats, and then alfalfa–orchardgrass. Within this rotation, the comparison is between broadcast manure (BM) and injected manure (IM) as the manure application methods; the manure treatments are maintained consistently throughout the 6-year rotation.

attribute name	code	definition
method of manure application	BM	Surface broadcast manure.
method of manure application	IM	Shallow-disk injection of manure.

Pennsylvania_State_Nitrogen_Test. This table contains sidedress nitrogen fertilizer recommendations generated using the Pre-Sidedress Soil Nitrate Test (PSNT) following Pennsylvania State Extension interpretation guidelines. Recommendations are based on measured soil nitrate concentrations prior to sidedress application. Each row represents a site-year-management combination and reports the recommended nitrogen rate in kg N ha^{-1}. Number of records: 16.

attribute name	attribute definition	storage type	measurement scale standard unit
Pennsylvania State Nitrogen Test pkey	A unique primary key identifier for each row in this table.	integer	dimensionless
corn environment	Environment or site name. Information about sites can be found in table site_details.	string	
crop entry	The crop entries included in the study were corn silage following a winter cereal rye cover crop in an organic grain rotation (R, Cs, O), corn silage following a winter cereal rye cover crop in a grain rotation with rye (R, Cs, R), corn silage following annual ryegrass and red clover cover crops interseeded into corn grain the previous year (Int, Cs), and corn grain following a winter cereal rye cover crop (R, Cg). Perennial forage entries were excluded because cover crop nitrogen credits were not applicable. Full abbreviations used were: A+Og = Alfalfa + Orchardgrass; Cs = Corn silage; Cg = Corn grain; Int = Interseeded annual ryegrass + clover mix; O = Oats; R = Rye cover crop; Rs = Rye silage; S = Soybean; SS = Sorghum-sudangrass. Production year notation: 1 = First full production year; 2 = Second full production year; 3 = Third full production year (for multi-year perennial crops such as alfalfa + orchardgrass).	string	
method of manure application	The method used to apply manure.	string	
recommended sidedress nitrogen rate kg n ha	Recommended sidedress nitrogen rate (kg N ha^{-1}).	float	kilogramPerHectare
rotation	The cropping system rotation in the larger Penn State LTAR Sustainable Dairy Cropping Systems experiment.	string	
tool	Recommended sidedress nitrogen rates were generated according to Pennsylvania State Extension PSNT interpretation guidelines.	string	
year	The calendar year for this entry. This dataset contains data from 2021-2023.	dateTime	YYYY

Pennsylvania_State_Nitrogen_Test. Descriptions of categories for the preceding table.

attribute name	code	definition
rotation	BAU	Business as Usual (BAU) represents the baseline conventional 6-year dairy forage rotation, consisting of alfalfa–orchardgrass, corn silage, rye cover crop, corn silage, rye cover crop, corn silage, oats, alfalfa–orchardgrass, with broadcast manure (BM) used as the manure application method.
rotation	Manure	Manure refers to the Manure Management rotation, which is a 6-year rotation. It includes alfalfa–grass, corn silage, rye silage, sorghum-sudangrass, rye cover crop, corn grain (interseeded with annual ryegrass and clover), corn silage, oats, and then alfalfa–orchardgrass. Within this rotation, the comparison is between broadcast manure (BM) and injected manure (IM) as the manure application methods; the manure treatments are maintained consistently throughout the 6-year rotation.
method of manure application	BM	Surface broadcast manure.

attribute name	code	definition
method of manure application	IM	Shallow-disk injection of manure.

site_details. This table provides site-level metadata describing each corn production environment included in the study, including year, crop rotation, prior management, manure application practices, and experimental context. It also includes summary response outcomes from nitrogen rate trials, such as measured yield, statistical significance of nitrogen response, and the economic optimum nitrogen rate (EONR) derived from side-dress nitrogen response curves. Each row represents a unique site-year-treatment combination, with paired environments (e.g., A/B) indicating manure application method comparisons. Number of records: 16.

attribute name	attribute definition	storage type	measurement scale standard unit
corn environment site	Environment or site name. Information about sites can be found in table site_details.	string	
crop entry	The crop entries included in the study were corn silage following a winter cereal rye cover crop in an organic grain rotation (R, Cs, O), corn silage following a winter cereal rye cover crop in a grain rotation with rye (R, Cs, R), corn silage following annual ryegrass and red clover cover crops interseeded into corn grain the previous year (Int, Cs), and corn grain following a winter cereal rye cover crop (R, Cg). Perennial forage entries were excluded because cover crop nitrogen credits were not applicable. Full abbreviations used were: A+Og = Alfalfa + Orchardgrass; Cs = Corn silage; Cg = Corn grain; Int = Interseeded annual ryegrass + clover mix; O = Oats; R = Rye cover crop; Rs = Rye silage; S = Soybean; SS = Sorghum-sudangrass. Production year notation: 1 = First full production year; 2 = Second full production year; 3 = Third full production year (for multi-year perennial crops such as alfalfa + orchardgrass).	string	
manure application method	The method used to apply manure.	string	
manure since last harvest	Has manure been applied since the last harvest.	string	
measured EONR kg N per ha	The measured economic optimum N rate (EONR) applied at side dressing for sites was determined from experimental side dress N response curves.	integer	kilogramPerHectare
previous crop	The crop in this environment the previous year.	string	
previous crop management	Relevent details on how the previous crop in this environment was managed.	string	
rotation	The cropping system rotation in the larger Penn State LTAR Sustainable Dairy Cropping Systems experiment.	string	
side dress n responsiveness	P-value of a mixed-model ANOVA that tested for a difference in N responsiveness between sites with block as a random effect.	string	
site details pkey	A unique primary key identifier for each row in this table.	integer	dimensionless
year	The calendar year for this entry. This dataset contains data from 2021-2023.	dateTime	YYYY
yield plateau Mg per ha dry weight	The quadratic plateau function fit with PROC NLIN. The point on a response curve was used to determine the economically optimum N rate (EONR), which is considered a threshold rate or range that maximizes return on investment in N fertilizer. 4A, 4B, 5A, and 5B in 2022 did not meet the expected yield goal for the environment.	float	megagramPerHectare

site_details. Descriptions of categories for the preceding table.

attribute name	code	definition
rotation	BAU	Business as Usual (BAU) represents the baseline conventional 6-year dairy forage rotation, consisting of alfalfa–orchardgrass, corn silage, rye cover crop, corn silage, rye cover crop, corn silage, oats, alfalfa–orchardgrass, with broadcast manure (BM) used as the manure application method.
rotation	Manure	Manure refers to the Manure Management rotation, which is a 6-year rotation. It includes alfalfa–grass, corn silage, rye silage, sorghum-sudangrass, rye cover crop, corn grain (interseeded with annual ryegrass and clover), corn silage, oats, and then alfalfa–orchardgrass. Within this rotation, the comparison is between broadcast manure (BM) and injected manure (IM) as the manure application methods; the manure treatments are maintained consistently throughout the 6-year rotation.
manure application method	Surface broadcast	Surface broadcast manure.
manure application method	Shallow-disk injection	Shallow-disk injection of manure.

SPAD_chlorophyll. This table summarizes sidedress nitrogen fertilizer recommendations generated using SPAD chlorophyll meter measurements of crop nitrogen status. Recommendations are provided for each site-year-management combination based on averaged leaf greenness measurements and associated decision rules. Each row represents a single site-year and manure management condition, with recommended nitrogen rates expressed in kg N ha^{-1}. Number of records: 16.

attribute name	attribute definition	storage type	measurement scale standard unit
SPAD chlorophyll pkey	A unique primary key identifier for each row in this table.	integer	dimensionless
corn environment	Environment or site name. Information about sites can be found in table site_details.	string	
crop entry	The crop entries included in the study were corn silage following a winter cereal rye cover crop in an organic grain rotation (R, Cs, O), corn silage following a winter cereal rye cover crop in a grain rotation with rye (R, Cs, R), corn silage following annual ryegrass and red clover cover crops interseeded into corn grain the previous year (Int, Cs), and corn grain following a winter cereal rye cover crop (R, Cg). Perennial forage entries were excluded because cover crop nitrogen credits were not applicable. Full abbreviations used were: A+Og = Alfalfa + Orchardgrass; Cs = Corn silage; Cg = Corn grain; Int = Interseeded annual ryegrass + clover mix; O = Oats; R = Rye cover crop; Rs = Rye silage; S = Soybean; SS = Sorghum-sudangrass. Production year notation: 1 = First full production year; 2 = Second full production year; 3 = Third full production year (for multi-year perennial crops such as alfalfa + orchardgrass).	string	
method of manure application	The method used to apply manure.	string	
recommended sidedress nitrogen rate kg n ha	Recommended sidedress nitrogen rate (kg N ha^{-1}).	float	kilogramPerHectare
rotation	The cropping system rotation in the larger Penn State LTAR Sustainable Dairy Cropping Systems experiment.	string	
tool	Recommended sidedress nitrogen rates were generated using SPAD chlorophyll meter assessments of corn nitrogen status and associated recommendation algorithms.	string	
year	The calendar year for this entry. This dataset contains data from 2021-2023.	dateTime	YYYY

SPAD_chlorophyll. Descriptions of categories for the preceding table.

attribute name	code	definition
rotation	BAU	Business as Usual (BAU) represents the baseline conventional 6-year dairy forage rotation, consisting of alfalfa–orchardgrass, corn silage, rye cover crop, corn silage, rye cover crop, corn silage, oats, alfalfa–orchardgrass, with broadcast manure (BM) used as the manure application method.
rotation	Manure	Manure refers to the Manure Management rotation, which is a 6-year rotation. It includes alfalfa–grass, corn silage, rye silage, sorghum-sudangrass, rye cover crop, corn grain (interseeded with annual ryegrass and clover), corn silage, oats, and then alfalfa–orchardgrass. Within this rotation, the comparison

attribute name	code	definition
		is between broadcast manure (BM) and injected manure (IM) as the manure application methods; the manure treatments are maintained consistently throughout the 6-year rotation.
method of manure application	BM	Surface broadcast manure.
method of manure application	IM	Shallow-disk injection of manure.

Other entities

This section contains summary information for any other files in this repository, including the file name, description, and a download link.

This dataset has no accompanying entities.