Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

NUTRIENT MANAGEMENT

CODE 590

(ac)

DEFINITION

Manage rate, source, placement, and timing of plant nutrients and soil amendments while reducing environmental impacts.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Improve plant health and productivity
- Reduce excess nutrients in surface and ground water
- Reduce emissions of objectionable odors
- Reduce emissions of particulate matter (PM) and PM precursors
- Reduce emissions of greenhouse gases (GHG)
- Reduce emissions of ozone precursors
- Reduce the risk of potential pathogens from manure, biosolids, or compost application from reaching surface and ground water
- Improve or maintain soil organic matter

CONDITIONS WHERE PRACTICE APPLIES

All fields where plant nutrients and soil amendments are applied. Does not apply to one-time nutrient applications at establishment of permanent vegetation.

CRITERIA

General Criteria Applicable to All Purposes

Develop a nutrient management plan for nitrogen (N), phosphorus (P), and potassium (K), which accounts for all known measurable sources and removal of these nutrients.

Sources of nutrients include, but are not limited to, commercial fertilizers (including starter and in-furrow starter/pop-up fertilizer), animal manures, legume fixation credits, green manures, plant or crop residues, compost, organic by-products, municipal and industrial biosolids, wastewater, organic materials, estimated plant available soil nutrients, and irrigation water.

When irrigating, apply irrigation water in a manner that reduces the risk of nutrient loss to surface and ground water.

Follow all applicable State requirements and regulations when applying nutrients near areas prone to contamination, such as designated water quality sensitive areas, (e.g., lakes, ponds, rivers and streams,

sinkholes, wellheads, classic gullies, ditches, or surface inlets) that run unmitigated to surface or groundwater.

Soil and tissue testing and analysis
Base the nutrient management plan on current soil test results in accordance with University of Nebraska (UNL) guidance, or industry practice when recognized by the UNL. Use soil tests no older than 2 years when developing new nutrient management plans. Nitrate samples, if required, must be taken after harvest of the previous crop and before manure or fertilizer is applied. Use plant tissue tests or in-season soil tests, when applicable, for monitoring or adjusting the nutrient management plan in accordance with UNL guidance, or industry practice when recognized by UNL.

For nutrient management plan revisions and maintenance, take soil tests at intervals recommended by UNLas outlined in the Nutrient Management Practice Specification (590 PS), or as required by local rules and regulations.Soil samples shall be collected and prepared according to UNL guidelines (see NebGuide G1740 “Guidelines for Soil Sampling”) and 590 PS. Complete soil sampling prior to the first application of commercial fertilizer or manure for the planned crop year.

Collect, prepare, and ship all soil and tissue samples following UNLguidance or industry standards. Testing shall include analyses for any nutrients for which specific information is needed for developing, monitoring or amending the annual nutrient management plan. Follow UNL guidelines regarding required analyses and test interpretations.

For soil test analyses, use laboratories successfully meeting the requirements and performance standards of the North American Proficiency Testing Program under the auspices of the Soil Science Society of America and NRCS or use an alternative NRCS- or State-approved certification program that considers laboratory performance and proficiency to assure accuracy of soil test results. Alternative certification programs must have solid stakeholder support (e.g., State department of agriculture, UNL, water quality control entity, NRCS State staff, growers, and others) and be State or regional in scope.

Maintain soil pH within ranges which enhance the adequate level for plant or crop nutrient availability and utilization. Refer to UNL documentation for guidance.

Manure, organic by-product, and biosolids testing and analysis
Collect, prepare, store, and ship all manure, organic by-products, and biosolids following UNL guidance or industry practice when recognized by UNL. In the absence of such guidance, test at least annually, or more frequently if needed to account for operational changes (e.g., feed management, animal type, manure handling strategy, etc.) impacting manure nutrient concentrations. If no operational changes occur and operations can document a stable level of nutrient concentrations for the preceding 3 consecutive years, manure may be tested less frequently, unless Federal, State, or local regulations require more frequent testing. Follow UNL guidelines regarding required analyses and test interpretations. Analyze, as a minimum, total N, total ammonium-nitrogen, total organic nitrogen (test at least for two of three nitrogen characteristics), total P or P_2O_5, total K or K_2O, and percent solids (or percent moisture).

When planning for new or modified livestock operations, and manure tests are not available yet, use the output and analyses from similar operations in the geographical area if they accurately estimate nutrient output from the proposed operation or use “book values” recognized by the NRCS (e.g., NRCS Agricultural Waste Management Field Handbook) and UNL.

For manure analyses, use laboratories successfully meeting the requirements and performance standards of the Manure Testing Laboratory Certification program under the auspices of the Minnesota Department of Agriculture or other NRCS-approved program that considers laboratory performance and proficiency to assure accurate manure test results.

For nutrient management plans developed as a component of a comprehensive nutrient management plan for an animal feeding operation (AFO) follow policy in NRCS directive General Manual (GM) 190,

Part 405, “Comprehensive Nutrient Management Plans.” These plans must include documentation of all nutrient imports, exports, and on-farm transfers.

Nutrient loss risk assessments
Use current NRCS-approved nitrogen, phosphorus, and soil erosion risk assessment tools to assess the site-specific risk of nutrient and soil loss.

See Nutrient Management Practice Specification (590 PS) for additional information.

Complete an NRCS-approved nutrient risk assessment for N on all fields where nutrient management is planned .

Complete an NRCS-approved nutrient risk assessment for P when any of the following conditions are met:

- Soil phosphorus test levels are high, and the P application rate exceeds the P uptake by the planned crops in the rotation.
- Manure application is planned.

Any fields excluded from a P risk assessment must have a documented agronomic need for P, based on soil test P and UNL nutrient recommendations.

For fields receiving manure, where P risk assessment resultbased on the Nebraska P-Index is:

- LOW —Manure can be applied at rates to supply P at greater than crop removal not to exceed the N requirement for the succeeding crop.
- MEDIUM —Manure can be applied to supply P at rates not to exceed crop removal for the planned crops in rotation unless filter strips are present, or state required 100-foot setbacks are applied.
    - Nitrogen application rates cannot exceed the N requirement for the succeeding crop.
- HIGH —Manure can be applied to supply Pat rates not to exceed crop removal for the planned crops in rotation if the following requirements are met:

    - Nitrogen application rates cannot exceed the University of Nebraska recommended nitrogen application rate during the year of application for non-legume crops.
    - Nitrogen application rates cannot exceed nitrogen removal in harvested plant biomass during the year of application for legume crops.
    - A soil P drawdown strategy has been developed, documented, and implemented for the crop rotation.
    - Implementation of all mitigation practices determined to be needed by site-specific assessments for nutrients and soil loss to protect water quality.
    - Any deviation from these high-risk requirements that would increase the risk of P runoff requires the approval of the Chief of the NRCS.
- **VERY HIGH** – No manure application is allowed until risk rating is lowered. Implement soil phosphorus drawdown and erosion/runoff reduction strategy in developing a plan to reduce Phosphorus-Index rating to a medium within five to ten years, dependent on Phosphorus-Index numerical score.

The 4Rs of nutrient stewardship
Manage nutrients based on the 4Rs of nutrient stewardship—apply the right nutrient source at the right rate at the right time in the right place—to improve nutrient use efficiency by the crop and to reduce nutrient losses to surface and groundwater and to the atmosphere.

Nutrient source

Choose nutrient sources compatible with application timing, tillage and planting system, soil properties, crop, crop rotation, soil organic content, and local climate to minimize risk to the environment.

Determine nutrient values of all nutrient sources (e.g. commercial fertilizers, manure, organic by-products, biosolids) prior to land application.

Determine nutrient contribution of cover crops, previous crop residues, and soil organic matter.

For operations following USDA's National Organic Program, apply and manage nutrient sources according to program regulations.

For enhanced efficiency fertilizer (EEF) products, use products defined by the Association of American Plant Food Control Officials as EEF and recommended for use by UNL.

In areas where salinity is a concern, select nutrient sources that limit the buildup of soil salts. When manures are applied, and soil salinity is a concern, monitor salt concentrations to prevent potential plant or crop damage and reduced soil quality.

Apply manure or organic by-products on legumes at rates no greater than UNL estimated N removal rates in harvested plant biomass, not to exceed P risk assessment limitations. See Additional Criteria below related to the use of Manure, Municipal and Industrial Biosolids, Compost and other Organic By-products as a source of plant nutrients.

For any single application of nutrients applied as liquid (e.g., liquid manure, nutrients in irrigation water, fertigation)—

- Do not exceed the soil's infiltration rate or water holding capacity.
- Apply so that nutrients move no deeper than the current crop rooting depth.
- Avoid runoff or loss to subsurface tile drains.

Exceptions to the above are allowed for confined animal feeding operations (CAFO) that possess a current National Pollutant Discharge Elimination System (NPDES) permit; the operation has complied with the terms of the permit; and the operation is experiencing a 25-year, 24-hour rainfall event or chronic wet period.

Nutrient application rate

Plan nutrient application rates for N, P, and K using UNL recommendations. For new crops or varieties where UNL guidance is unavailable, university recommendations from adjacent states or industry-demonstrated yield and nutrient uptake information may be used.

Lower-than-recommended nutrient application rates are permissible if the client's objectives are met.

At a minimum, determine the rate based on crop/cropping sequence, current soil test results, realistic yield goals, and NRCS- approved nutrient risk assessments.

Realistic yield goals shall be clearly documented for each field and established using the best available records and information from similar fields and management capabilities. Realistic yield goals must be attainable yields and should be based on expected yields as follows:

- The average of the previous five years' yields using actual records such as scale tickets, yield monitors, certified crop insurance yield documentation, or Farm Service Agency (FSA) certified yields plus 5%. Do not include any records significantly influenced by hail, drought, wind damage, etc.
- If actual records are not available, use five-year county average yields from FSA or the National Agricultural Statistic Service plus 5%

Maximum applied rates of N fertilizers will match University of Nebraska recommendations as closely as possible. Applied N rates will not exceed the University of Nebraska recommendation by more than 10% not to exceed 10 lbs/ac.

Additional guidance regarding nutrient application rates can be found in the practice specification (590-PS).

Nutrient application timing and placement

Consider the nutrient source, management and production system limitations, soil properties, weather conditions, drainage system, soil biology, and nutrient risk assessment to develop optimal timing of nutrients.

To minimize nutrient losses:

- For N, time the application as closely as practical with crop uptake.
- For anhydrous ammonia, to avoid losses during application apply when soil moisture conditions are conductive to proper injection and sealing. For fall application, wait until soil temperatures are consistently 50 degrees Fahrenheit or lower.
- For P, time surface application for when runoff potential is low. Phosphorus materials should be injected when the risk of runoff potential is high.
- Apply nutrients uniformly to application area(s), except when variable rate application is employed using site specific management.

Time the application of all nutrients to minimize potential for soil compaction.

For crop rotations or multiple crops grown in one year, do not apply additional P if it was already added in an amount sufficient to supply all crop nutrient needs.

To avoid salt damage, follow UNLrecommendations for the placement and rate of starter fertilizers(see NebGuide G361 “Using Starter Fertilizer for Corn, Grain Sorghum, and Soybeans”).

Any irrigation distribution system through which chemical fertilizers, manure (liquid manure) or pretreatment wastes (municipal effluent) are distributed shall be equipped with properly designed and operating valves and components to prevent backflows into the water source(s) and/or contamination of groundwater, surface water or soil.

All local, state and federal applicable laws and regulations must be followed for fertigation where:

- Persons planning to apply commercial fertilizer through an irrigation system must contact the local Natural Resource District (NRD) to determine what permits are necessary.

In addition to contracting the local NRD, persons applying for liquid wastes or municipal effluent through an irrigation system must contact the Nebraska Department of Environment and Energy to determine if any permits are necessary.

Do not surface apply nutrients when there is a risk of runoff, including when—

- Soils are frozen.
- Soils are snow-covered.
- The top 2 inches of soil are saturated.

Exceptions for the above criteria related to surface-applied nutrients when there is a risk of runoff can be made when specified conditions are met and adequate conservation measures are installed to prevent the offsite delivery of nutrients (See 590 PS). Guidance for the adequate treatment level and specified conditions for winter applications of nutrients are provided in 590 PS. At a minimumthe following site and management factors must be considered:

- Climate (long-term)
- Weather (short-term)
- Soil characteristics
- Slope
- Areas of concentrated flow
- Organic residue and living covers
- Amount and source of nutrients to be applied
- Setback distances to protect local water quality

Additional Criteria to Minimize Agricultural Nonpoint Source Pollution of Surface and Groundwater

Apply conservation practices to avoid nutrient loss and control and trap nutrients before they can leave the field(s) by surface, leaching, or subsurface drainage (e.g., tile, karst) when there is a significant risk of transport of nutrients.

Additional Criteria to Reduce the Risk of Potential Pathogens From Manure, Biosolids, or Compost Application From Reaching Surface and Groundwater

When applicable, follow proper biosecurity measures as provided in NRCS directives GM-130, Part 403, Subpart H, “Biosecurity Preparedness and Response.”

Follow all applicable Federal, Tribal, State, and local laws and policies concerning the application of manure, biosolids, or compost in the production of fresh, edible crops.

Apply manure, biosolids, or compost with minimal soil disturbance or by injection into the soil unless it is being applied to an actively growing crop, a minimum of 30 percent residue exists, or there is a living cover that has a fibrous root system with 75 percent or more cover. Do not surface apply manure if a storm event is forecast within 24 hours.

Additional Criteria to Reduce Emissions of Objectionable Odors, PM and PM Precursors, and GHG and Ozone Precursors

To address air quality concerns caused by odor, N, sulfur, and particulate emissions; adjust the source, timing, amount, and placement of nutrients to reduce the negative impact of these emissions on the environment and human health.

Do not surface apply solid nutrient sources, including commercial fertilizers, manure, or organic by-products of similar dryness/density when there is a high probability that wind will blow the material and emissions offsite. Do not surface apply liquid nutrient sources when there is a high probability that wind will blow the liquid droplets applied from sprinklers or other applicable methods offsite.

Reduce the potential for volatilization by applying sources subject to volatilization during cooler, higher humidity conditions or by placement that minimizes vulnerability to volatilization.

Additional Criteria to Improve or Maintain Organic Matter

Design the plant or crop management systems so the soil conditioning index (SCI) organic matter subfactor is positive.

Apply manure, compost, or other organic nutrient sources at a rate and with minimal disturbance that will improve soil organic matter without exceeding acceptable risk of N or P loss.

For low residue plant or cropping systems, apply adequate nutrients to optimize plant or crop residue production to maintain or increase soil organic matter.

CONSIDERATIONS

General Considerations

Consider development of nutrient management plans by conservation management unit (CMU). A CMU is a field, group of fields, or other land units of the same land use and having similar treatment needs and planned management. A CMU is a grouping by the planner to simplify planning activities and facilitate development of conservation management systems.

Develop site-specific yield maps using a yield monitoring system, multispectral imagery or other methods. Use the data to further delineate low- and high-yield areas, or zones, and make the necessary management changes. Use variable rate nutrient application based on site-specific factor variability. See NRCS Agronomy Technical Note 3, “Precision Nutrient Management Planning.”

Use the adaptive nutrient management learning process to improve nutrient use efficiency on farms as outlined in NRCS’ national nutrient policy in GM-190, Part 402, “Nutrient Management.” Consider using an adaptive approach to adjust nutrient rate, timing, form, and placement as soil biologic functions and soil organic matter changes over time. See NRCS Agronomy Technical Note 7, “Adaptive Nutrient Management Process.”

When developing new nutrient management plans, consider using soil test information no older than 1 year rather than 2 years.

Consider developing a whole farm nutrient budget (nutrient mass balance), including all imported and exported nutrients. Imports may include feed, fertilizer, animals and bedding, while exports may include crop removal, animal products, animal sales, manure, and compost.

Modify animal feed diets to reduce the nutrient content of manure following guidance contained in Conservation Practice Standard (CPS) Feed Management (Code 592).

Provide a nutrient analysis of all nutrient source exports (manure or other materials).

Excessive levels of some nutrients can cause induced deficiencies of other nutrients, (e.g., high soil test P levels can result in zinc deficiency in corn).

Use soil tests, plant tissue analyses, and field observations to check for secondary plant nutrient deficiencies or toxicity that may impact plant growth or availability of the primary nutrients.

Do not apply K in situations where an excess (greater than soil test K recommendation) causes nutrient imbalances in crops or forages.

Use bioreactors and multistage drainage strategies to mitigate nutrient loss pathways, as applicable.

Use legume crops and cover crops to provide N through biological fixation. Cover crops with a carbon to nitrogen ratio below 20:1 can release a large amount of soluble N after being plowed or tilled into the soil when an actively growing crop is not present to take up nutrients, leading to increased risks of nitrate movement and nitrous oxide emissions. The nitrous oxide emissions often occur in high soil moisture conditions, such as when a legume cover crop is plowed down in fall or early spring. To avoid these losses, use grass-legume or grass-legume-forbs mixtures with a more balanced carbon to nitrogen ratio.

Use winter hardy grass cover crops to take up excess N after the cash crop growing season and promote contribution of the nitrogen to next plant or crop.

Use conservation practices that slow runoff, reduce erosion, and increase infiltration (e.g., filter strip, contour farming, or contour buffer strips).

Use application methods, timing, technologies or strategies to reduce the risk of nutrient movement or loss, such as—

- Split nutrient applications.
- Banded applications.
- Injection of nutrients below the soil surface.
- Incorporate surface-applied nutrient sources when precipitation capable of producing runoff or erosion is forecast within the time of a planned application.
- High-efficiency irrigation systems and technology.
- Enhanced efficiency fertilizers
    - Slow or controlled release fertilizers
    - Nitrification inhibitors
    - Urease inhibitors.
- Drainage water management.
- Tissue testing, chlorophyll meters, or real-time sensors.
- Pathogen management considerations.

When a recycled product (e.g., compost) is to be used as a nutrient source on food crops or as food for humans or animals, make sure that pathogen levels have been reduced to acceptable levels (reference the Food and Drug Administration's Food Safety Modernization Act). www.fda.gov/FSMA When the recycled product has come from another farming operation, implement biosecurity measures and evaluate the risk of pathogen transfer that could cause plant or animal diseases.

Use manure treatment systems that reduce pathogen content from manure.

Implementing a soil health management system that reduces tillage or other soil disturbance, includes a diverse rotation of crops and cover crops, keeps roots growing throughout the year, and keeps the soils covered to reduce nutrient losses, and improves—

- Nutrient use efficiency, rooting depth, and availability of nutrients.
- Soil organic matter levels.
- Availability of nutrients from organic sources.
- Aggregate stability and soil structure.
- Infiltration, drainage, and aeration of the soil profile.
- Soil biological activity.
- Water use efficiency and available moisture.

Use targeted or prescribed livestock grazing to enhance nutrient cycling and improve soil nutrient cycling functions.

Elevated soil test P levels may lead to reduced mycorrhizal fungal associations and immobilize some micronutrients, such as iron, zinc, and copper.

Apply manure, compost, or other nutrient sources with minimal soil disturbance and at a rate that will improve soil organic matter without exceeding acceptable risk of N or P loss.

Safety Considerations:

Workers should be protected from and avoid unnecessary contact with plant nutrient sources. Extra caution must be taken when handling anhydrous ammonia or when dealing with organic wastes stored in unventilated enclosures. **NEVER enter a manure deep storage pit unless absolutely necessary and only when proper safeguards have been taken!**

Material generated from cleaning nutrient application equipment should be utilized in an environmentally safe manner. Excess material should be collected and stored, or field applied in an appropriate manner.

Nutrient containers should be recycled in compliance with State and local guidelines or regulations.

Consider the development of a farm operational safety plan with emergency phone numbers and farm 911 address. Post near business telephones and review with employees.

PLANS AND SPECIFICATIONS

The following components must be included in the nutrient management plan:

- Field maps for each budget area to including aerial imagery or site map(s), a soil survey map of the site, and a topographic map of the field. Include site boundaries and legal descriptions.
- Soil information including: soil type, surface texture, slope steepness, drainage class, permeability, available water capacity, depth to water table, restrictive features, and flooding and ponding frequency.
- Location of designated sensitive areas and the associated nutrient application restrictions and setbacks.
- Location of nearby residences, or other locations where humans may be present on a regular basis, that may be impacted if odors or PM are transported to those locations.
- Results of approved risk assessment tools for N, P, and erosion losses.
- Current and planned plant production sequence or crop rotation.
- All available test results (e.g. soil, water, compost, manure, organic by-product, and plant tissue sample analyses) upon which the nutrient budget and management plan are based.
- Realistic yield goals for the crops .
- Nutrient recommendations for N, P, and K for the entire plant production sequence or crop rotation.
- Application method and timing for all nutrient sources (including all enhanced efficiency fertilizer products) that are planned for use and documentation of all nutrient imports, exports, and onsite transfers.
- For fields with planned or past manure application that have high and very high P-index risk levels, a long-term strategy and proposed implementation timeline for reducing soil P to medium levelsthat includes the implementation of planned management and/or conservation practices to protect water quality.
- Guidance for implementation, operation and maintenance, and recordkeeping.

For variable rate nutrient management plans, also include—

- Geo-referenced field boundary and data collected that was processed and analyzed as a GIS layer or layers to generate nutrient or soil amendment recommendations per management zone. Must include site-specific yield maps using soils data, current soil test results, and a yield monitoring system with GPS receiver to correlate field location with yield.
- Nutrient recommendation guidance and recommendation equations used to convert the GIS base data layer or layers to a nutrient source material recommendation GIS layer or layers.
- After implementation, provide application records per management zone or as applied map within individual field boundaries (or electronic records) documenting source, timing, method, and rate of all nutrient or soil amendment applications.

OPERATION AND MAINTENANCE

Review or revise plans periodically to determine if adjustments or modifications are needed. At a minimum, review and revise plans as needed with each soil test cycle, changes in manure management, volume or analysis, plants and crops, or plant and crop management.

Monitor fields receiving animal manures and biosolids for the accumulation of heavy metals and P in accordance with UNL guidance and State law.

For animal feeding operation, significant changes in animal numbers, management, and feed management will necessitate additional manure analyses to establish a revised average nutrient content. These changes may also require the existing nutrient management plan and/or comprehensive nutrient management plan be re-examined and potentially revised.

Calibrate application equipment annually to ensure accurate distribution of material at planned rates. For products too dangerous to calibrate, follow UNLor equipment manufacturer guidance on proper equipment design, plumbing, and maintenance.

Document the nutrient application rate. When the applied rate differs from the planned rate, provide appropriate documentation to explain the difference.

Protect workers from and avoid unnecessary contact with nutrient sources. Take extra caution when handling anhydrous ammonia or when managing organic wastes stored in unventilated tanks, impoundments, or other enclosures.

Use material generated from cleaning nutrient application equipment in an environmentally safe manner. Collect, store, or field apply excess material in an appropriate manner.

Recycle or dispose of nutrient containers in compliance with State and local guidelines or regulations.

Maintain records for at least 5 years to document plan implementation and maintenance. Records must include—

- All test results (soil, water, compost, manure, organic by-product, and plant tissue sample analyses) upon which the nutrient management plan is based.
- Nutrient budget for each field, including crop, realistic yield goals, nutrient credits and planned rates.
- Listing and quantification of all nutrient sources (including all enhanced efficiency fertilizer products) that are planned for use and documentation of all nutrient imports, exports and onsite transfers.
- For all imported manure, wastewater, compost, by-products, or biosolids, the quantities, type (i.e. beef-solids, swine-slurry, etc.), source (name and address), import date(s), and respective nutrient analysis reports.
- Date(s), method(s), and location(s) of all nutrient applications.
- Weather conditions and soil moisture at the time of application, elapsed time from manure application to rainfall or irrigation event(s).
- Plants and crops planted, planting and harvest dates, yields, nutrient analyses of harvested biomass, and plant or crop residues removed.
- Dates of plan review, name of reviewer, and recommended adjustments resulting from the review.

For variable rate nutrient management plans, also include—

- Maps identifying the variable application location, source, timing, amount, and placement of all plant and crop nutrients applied.
- GPS-based yield maps for crops where yields can be digitally collected.

REFERENCES

Association of American Plant Food Control Officials (AAPFCO). 2017. AAPFCO Official Publication no. 70. AAPFCO Inc., Little Rock, AR.

Ferguson, R.B., G.W. Hergert, C.A. Shapiro, and C.S. Wortmann. 2007. Guidelines for soil sampling. University of Nebraska Extension NebGuide G1740.

Follett, R.F. 2001. Nitrogen transformation and transport processes. In Nitrogen in the environment; sources, problems, and solutions, (eds.) R.F. Follett and J. Hatfield, pp. 17–44. Elsevier Science Publishers. The Netherlands. 520 pp.

Hergert, G.W., C.S. Wortmann, R.B. Ferguson, C.A. Shapiro, and T.M.Shaver. 2012. Using starter fertilizer for corn, grain sorghum, and soybeans. University of Nebraska Extension NebGuide G361 revised.

Schepers, J.S., and W.R. Ruan, (eds.) 2008. Nitrogen in agricultural systems. Agron. Monogr. no. 49, American Society of Agronomy (ASA), Crop Science Society of America (CSSA), Soil Science Society of America (SSSA). Madison, WI.

Sims, J.T. (ed.) 2005. Phosphorus: Agriculture and the environment. Agron. Monogr. no. 46. ASA, CSSA, and SSSA, Madison, WI.

Stevenson, F.J. (ed.) 1982. Nitrogen in agricultural soils. Agron. Series 22. ASA, CSSA, and SSSA, Madison, WI.

USDA, NRCS. Agronomy Technical Note 3, Precision Nutrient Management Planning. 2010. Washington, DC. NRCS eDirectives under Technical Notes, Title 190 https://policy.nrcs.usda.gov/.

USDA, NRCS. Agronomy Technical Note 7, Adaptive Nutrient Management Process. 2013. Washington, DC. NRCS eDirectives under Technical Notes, Title 190 https://policy.nrcs.usda.gov/.

USDA, NRCS. Nutrient Management Technical Note 7, Reducing Risk of E. coli O157:H7. 2007. Washington, DC. NRCS eDirectives under Technical Notes, Title 190 https://policy.nrcs.usda.gov/.

USDA, NRCS. Title 190, General Manual, (GM), Part 402, Nutrient Management. 2011. Washington, DC. NRCS eDirectives under General Manual, Title 190 https://policy.nrcs.usda.gov/.

USDA, NRCS. Title 190, National Instruction (NI), Part 313, Nutrient Management Policy Implementation. 2017. Washington, DC. NRCS eDirectives under National Instruction, Title 190 https://policy.nrcs.usda.gov/.