Natural Resources Conservation Service

Practice Specification

Nutrient Management

Code 590

GENERAL

The Practice Specification (PS) Nutrient Management (Code 590) provides information needed to develop a nutrient management plan that addresses identified resource concerns (soil, water, air) and the budgeting of nitrogen, phosphorus, and potassium for all sources of nutrients being applied. Utilize the current MO 590 Nutrient Management Implementation Requirement (IR) or the Manure Management Planner (MMP) to develop and document the nutrient management plan.

Testing and Analysis

Soil Testing: When developing a new nutrient management plan, utilize a current soil test (≤ 2 years old). Collect a composite soil sample representing approximately 20 acres or less. Composite samples consist of no fewer than 10 soil cores. Recommended sampling intensity is 10 to 15 soil cores on fields with little expected variability (e.g., row crop and hayfields receiving broadcast fertilizer applications) and 15 to 20 soil cores on fields expected to have significant variability (e.g., pastures and fields with a history of banded fertilizer or manure applications).

For precision nutrient management plans, soil sampling area size may vary depending on type of grid or zone being established with each composite sample consisting of no fewer than 10 soil cores. For Basic Grid soil sampling areas, a composite sample represents 3-acres or less and for Zone Management soil sampling area represents 20-acres or less depending on the size of the zone.

Develop Zone Management areas based on a combination of two or more the following data sources:

- Historical yield maps - minimum 5 year yield history
- Historical multi-spectral satellite imagery, aerial ortho-photography, or drone (unmanned aerial system) imagery - minimum 5 year history
- Soil survey data and topography
- Electro-conductivity (EC) monitoring data
- Light sensing technologies

Manure, Organic, By-product, Biosolids Testing and Analysis: Collect and analyze manure samples at least annually to determine nutrient values from each source/storage location that is either land applied or exported from the animal feeding operation (AFO). When possible, sample and analyze manure just prior to the primary time for land application of manure so the results are available for calculating manure application rates. In some circumstances, it is only possible to get a representative sample during land application (for example, agitated manure pits). In these cases, use historic values to calculate application rates and use the manure sampled during application to contribute to the historic record of sample results.

When book values will be used for new or modified livestock operations, refer to the NRCS Agricultural Waste Management Field Handbook and Midwest Plan Service No. 18, Section 1 (2nd Edition), Manure Characteristics. For feed-based estimates of nutrient generation, refer to ASAE D384, Manure Production Characteristics. Book values are intended only for short-term use in lieu of representative manure samples from new operations. Collect and analyze manure samples within a year of beginning operation.

Sensitive Area Setbacks

Sensitive Area Setbacks have been established by the Missouri Department of Natural Resources (DNR) to protect surface and ground water resources where animal manure, compost, bio-solids or other organic materials will be applied. Setback features, application conditions, and setback distances are provided in Table 1 in the Appendix. When manure or other organic material will be applied, develop a Sensitive Areas Setback Map identifying all setback features both on and adjacent to the application site.

Manure, Compost, Bio-solids, or other Organic Materials

When the application of manure or other organic materials will be included in a nutrient management plan, develop a budget that specifies the recommended, utilized (crop removal) and residual nutrients in the soil for the entire soil test cycle (no more than 4 years). Document the source, amount, timing, and method of application of all nutrient sources, including manures and commercial fertilizers.

When developing a Comprehensive Nutrient Management Plan (CNMP), address all acres under control of the producer on which organic manures and by-products will be land-applied for plant production. Document the management of all manure nutrients produced by the AFO whether land-applied or exported off-site.

Nutrient Loss Risk Assessments

Missouri Nitrogen Leaching Index

The Missouri Nitrogen Leaching Index (N-LI) comes from Revised Universal Soil Loss Equation version 2 (RUSLE2) by inputting the climate and soils information for the site. The N-LI determines the degree to which water percolates below the root zone in certain soils. Percolating water containing dissolved nitrates and other soluble nutrients could be a hazard to ground water.

Once the climate and soils information has been included into RUSLE2 for the site, the nitrogen index rating will be located on the Profile screen under the tab Additional Results. The index rating can then be used to determine the Risk of Leaching in the table below:

Index Rating	Risk of Leaching
< 5	Low
5 to 10	Medium
> 10	High

Utilize the 590-MO-GD-001 Nitrogen Leaching Index to determine the leaching index rating for each field and required mitigation practice/techniques, when applicable.

Missouri Phosphorus Index

The Missouri Phosphorus Index (P-Index) is a tool used as part of a nutrient management plan and the conservation planning process. The P-Index provides a rating estimating the long-term potential of erosion and elevated soil test phosphorus to contribute to phosphorus loss in surface water runoff from a field.

Utilize the 590-MO-GD-002 Missouri Phosphorus Index to determine the P-Index rating for each field and required mitigation practices/techniques, when applicable.

THE 4R's OF NUTRIENT STEWARDSHIP

The management of nutrients is based on the 4R's of nutrient stewardship - apply the right nutrient source at the right rate, at the right time, and in the right place - to improve nutrient use efficiency by the crop and reduce nutrient losses to surface water, groundwater, and the atmosphere.

Develop a nutrient management plan that budgets and documents the 4Rs for all sources of nitrogen, phosphorus, and potassium for the entire soil test cycle (no more than 4 years) based on identified resource concerns. The plan will account for recommended, utilized (crop removal), and residual nutrients, including manures and commercial fertilizers. General guidance for the 4R's is provided in the Conservation Practice Standard (CPS) Nutrient Management (Code 590). The following is additional guidance to be followed when developing a nutrient management plan based on the 4R's.

Nutrient Source

When starter or pop-up fertilizers are used, include all nutrients in the overall nutrient budget and apply in accordance with University of Missouri (MU) Extension recommendations.

<u>NITROGEN</u>

1. All Sources

Credit all sources of nitrogen in the nutrient budget when calculating total nitrogen to be applied including:

- Credit any nitrogen applied in phosphorus fertilizers, such as mono-ammonium phosphate (MAP) and di-ammonium phosphate (DAP), from pre-plant or at-planting nitrogen application.
- Include nitrogen from previous legume crops. Document source and data used to determine legume contributions. MU Extension fertilizer recommendations offer a nitrogen fertilizer credit for corn following soybeans.
- Include readily available and residual nitrogen from manures, compost, bio-solids, other organic material, and irrigation water.

NOTE: Fall applications of nitrogen fertilizer for spring-seeded crops are not permitted with the specific exception of fall-applied anhydrous ammonia when utilizing a nitrification inhibitor (see anhydrous ammonia section below).

2. Anhydrous ammonia with nitrification inhibitor

Fall application of nitrogen fertilizer is a common strategy for Missouri farmers, however, weather-related conditions can lead to large losses of applied fertilizer. Those losses have negative environmental and economic impacts. MU Extension does not recommend fall application of nitrogen, but when it is utilized by a producer the only source of nitrogen recommended is anhydrous ammonia with a nitrification inhibitor. According to MU Extension guidance in order to further reduce risk, no more than half of the planned corn or grain sorghum acres should receive a fall application of nitrogen. The guidance is recommended since the nitrification inhibitor helps to reduce nitrogen loss but does not eliminate it.

In order to reduce the rate of conversion of ammonium to nitrate, MU Extension recommends waiting to apply anhydrous ammonia with a nitrification inhibitor until the 6-inch depth soil temperature reaches 40^{o}F. MU Extension states that ammonia conversion is slowed once soil temperatures drop below the level thus reducing the risk of nitrogen loss. **NOTE:** No fall application of anhydrous ammonia should be made prior to the 6-inch depth soil temperature reaching 50^{o}F. According to MU Extension, the 50-degree rule was established in states where soil cooling after 50 degrees occurs much faster than in Missouri.

Missouri has very different climate from north and south. The use of anhydrous ammonia with nitrification inhibitor is more beneficial in the most northern part of Missouri compared to other parts of the state. The Commercial Ag Program at MU Extension provides information on the 6-inch depth soil temperature data from weather stations in the counties of Atchison, Audrain, Boone, Buchanan, Carroll, Gentry, Knox, Lafayette, Linn, Monroe, Morgan, Pettis, and Saline. This information is located at the Agricultural Electronic Bulletin Board (AgEBB). The further south you go in the state, the higher the risk of nitrogen loss. Adhere to the 40ºF soil depth temperature in Central and Southern Missouri to reduce the loss of nitrogen. For additional information on anhydrous ammonia with nitrification inhibitors, refer to MU Extension Guide Sheet IPM1027 Best Management Practices for Nitrogen Fertilizer in Missouri.

Do not apply anhydrous ammonia with nitrification inhibitors after the crop is planted.

Materials applied as nitrification inhibitors must have an Environmental Protection Agency (EPA) label and be defined by the Association of American Plant Food Control Officials (AAPFCO) specifically for this purpose. Currently acceptable nitrification inhibitors are listed in Table 2.

Table 2: Acceptable Nitrification Inhibitor Products
Pronitridine (N-cyanoguanindines)
Nitrapyrin (2-chloro-6-(trichloromethyl)-pyridine)
Terrazole (5-ethoxy-3-trichloromethyl-1,2,4-thiadiazol)
DCD (Dicyandiamide)

3. Controlled- or Slow-Release Nitrogen Fertilizer

Use controlled- or slow-released nitrogen fertilizer products labeled for that purposes and listed by the AAPFCO. Currently acceptable controlled- and slow-release nitrogen fertilizer products are listed in Table 3.

Table 3: Acceptable Controlled- and Slow Release Nitrogen Fertilizer Products	
Controlled-Release	**Slow-Release**
Sulfur-coated urea	Urea-formaldehyde
Polymer-coated urea	Magnesium-ammonium phosphate
	Isobutylidene diurea (IBDU)

4. Urea Fertilizer with Urease Inhibitor

When urea is applied to the soil surface without a urease inhibitor, it undergoes rapid hydroloysis. This can result in significant nitrogen losses to the atmosphere until the urea is incorporated into the soil such as by water movement into the soil (a rain or irrigation event) or when tillage is delayed by several days after the urea application. Using a urease inhibitor extends the time available for incorporation of the urea by as much as 2 weeks.

Use urease inhibitor products that are labeled and defined by the AAPFCO specifically for that purpose. Currently acceptable Urease Inhibitors are listed in Table 4.

Table 4: Acceptable Urease Inhibitor Products
NBPT ((N-(n-butyl) thiophosphoric triamide)
PPD (Phenyl Phosphorodiamidate)

PHOSPHORUS

There are currently no enhanced efficiency fertilizer products recommended by MU Extension.

ORGANIC SOURCES (MANURE, COMPOST, BIO-SOLIDS, OR OTHER ORGANIC MATERIALS

When organic nutrient sources will be applied, specify in the nutrient management plan if the organic nutrients are being applied according to a nitrogen- or phosphorus-based plan.

Operations that import manure for application but do not generate the manure on the operation, a nutrient management plan is to be developed. For operations that generate the manure on site, such as AFO, then a CNMP is to be developed.

When developing a CNMP on an AFO, include all organic nutrient sources produced by and/or imported to the operation. The CNMP documents the management of the manure generated on-site including land application and export off-site as well as management of imported manure when applicable.

Utilize the Missouri Phosphorus Index to determine the potential for phosphorus loss from each field where the application of organic nutrient sources will be applied.

Nutrient Rate

Establish realistic yield goals and document how they were developed using the best available records and information from similar fields and management systems in the location of interest. Potential sources for utilization to provide yield documentation may include one of the following:

- Yield data collected from the field for 5 or more crop years. To calculate the mean yield, ignore the highest and lowest yield and calculate the mean of the remaining three years. Add 10 percent to the mean yield to allow for potential to improve yield.
- County average yield data collected by the National Agricultural Statistics Service.
- Soil Productivity Index utilizes the crop productivity index in Web Soil Survey and county yield estimates.
- For new crops or varieties, industry yield recommendations may be used until documented yield information is available.
- For new operations, local records and information from similar fields and management systems may be used until documented yield information is available.

Nutrient removal rates are an important part of a nutrient rate recommendation. Currently accepted removal rates for Missouri are listed in Table 5 located in the Appendix.

When utilizing nitrification or urease inhibitors based on the nitrogen source being applied, follow the manufacturer's recommended rate for the selected product.

Apply lime as indicated by the current soil test. Lime requirements less than 400 lbs. Effective Neutralizing Material (ENM)/acre may be deferred until the next soil testing cycle.

A Phosphorus Banking strategy (a multiple year phosphorus application) can be used based on the following limitations:

- Manure phosphorus can be applied at a rate to meet the recommendations of multiple years within the 4-year soil test cycle not to exceed the nitrogen recommendation for the succeeding crop.
- Commercial fertilizer can be applied at a rate to meet the phosphorus and potassium recommendations for 2-years of the soil test cycle (example 2 year corn-soybean rotation: a one-time application of phosphorus and potassium applied during the corn year that meets the phosphorus and potassium needs for both crops. Phosphorus and potassium would not be applied in the soybean year).

Do not apply manure on land with a slope greater than 20 percent.

For application of liquid organic nutrient sources to the soil surface, do not exceed the soil infiltration rate in order to minimize ponding and runoff.

For fields receiving organic nutrient sources, document in the nutrient management plan an estimate of the soil test phosphorus levels at the end of the planning period, not to exceed 4 years.

IN-SEASON NUTRIENT MANAGEMENT MONITORING

Soil types within individual fields can be highly variable and the yield potential and the amount of nitrogen provided by those different soil types can also be highly variable. As a result, when a uniform rate of nitrogen fertilizer is applied over the entire field, substantial areas can be over-fertilized while other areas are under-fertilized. Climate factors such as precipitation (both the amount and the seasonal distribution) and temperature causes yield potential and soil nitrogen to behave differently each year. This makes it very difficult to predict how much nitrogen will be available for the crop and how much supplemental nitrogen fertilizer should be added. Ideally, the amount of nitrogen fertilizer added during a given growing season should be both climate-sensitive and site-specific. When applications are made using variable rate technology (VRT), the goal is for the fertilizer rate chosen for each area in the field to optimize profitability for the farmer and minimize over-application. Unused nitrate-nitrogen can move to groundwater, or surface water bodies, or denitrify from the soil into atmospheric greenhouse gases; all are pathways that cause environmental concern. Research has shown that when nitrogen fertilizer rates exceed what is needed, there are higher levels of post-harvest soil nitrate and a high risk of N loss to the environment. In-season nitrogen monitoring can help determine the right amount of nitrogen needed that will also be quickly utilized when applied using the right source, right rate, right method, and right timing.

In-season nutrient monitoring can be broken down into three categories - plant tissue and/or soil testing, computer model driven by weather data (example Missouri Rice Degree Day program), and light sensor technologies. Currently, MU Extension does not offer the pre-sidedress nitrate testing (soil testing), but plant tissue testing (crop leaf samples) is offered. For more information on plant tissue and/or soil testing, refer to MU Extension Soil and Plant Testing Laboratory.

Light sensing technologies have been rapidly advancing over the past several years. Because nitrogen is a primary constituent of plant chlorophyll pigments and this is where photosynthesis takes place, leaf or crop canopy color can be used to evaluate crop nitrogen health. An obvious advantage of using plant color for in-season nitrogen input decisions is there is little time delay between measurement and interpretation, such as occurs in soil sampling and analysis. Further, because each plant expresses crop nitrogen status for its given location, plant sensing provides the best opportunity for quantifying detailed spatial variability of crop nitrogen need. A primary disadvantage of using the plant for assessing nitrogen need is that it narrows the window of time when nitrogen applications can take place. Listed below are different types of in-season monitoring technologies currently available. This information is only being provided for general awareness of the types of systems and how they function. It is not intended to be an all inclusive list. It is important to note that when using any of these sensor types, determining the rate of side-dress nitrogen requires sensor measurements from a sufficient-nitrogen reference area (fully fertilized). Without this reference to determine a relative difference, there is no basis for making nitrogen rate recommendations.

- Chlorophyll Meters: hand-held device that measures leaf transmittance center at near infrared (NIR) and red (R) bands to measure leaf chlorophyll. The meter is clamped onto a single leaf to prevent interference from external light. The meter senses transmittance through a very small area of leaf with each reading. While individual plant readings can be readily obtained, acquiring a representative value for a large field is time consuming. It is especially difficult to obtain representative measurements for fields with significant spatial variability plant nitrogen health. For this reason, chlorophyll meter sensing to assess production-scale crop nitrogen health and variable-rate nitrogen may not be practical for many producers.

- Passive Crop Canopy Sensors: hand-held or equipment mounted device that rely on the sun for lighting are called passive-light reflectance sensors. These sensors measure NIR and R bands from which normalized difference vegetation indices (NDVI) can be calculated. Examples of passive crop canopy sensors include cameras with NIR capabilities (commonly used on drones) and satellite imagery.
- Active Crop Canopy Sensors: hand-held or equipment mounted devices that emit their own source of modulated light onto the crop canopy at fixed wavelengths using light emitting diodes (LEDs) and then detect canopy reflectance with photodiodes. The advantage of these types of sensors over passive-light reflectance sensors is that they remove the varying effects of sunlight (e.g., sun angle and cloudiness) by having their own artificial light source. These sensors measure both NIR and R bands from which NDVI can be calculated.

Nutrient Application Timing and Placement

To reduce nitrogen losses, time the application as closely as possible with plant uptake.

- See Nitrogen section "2. Anhydrous ammonia with nitrification inhibitor" (page 3 of this PS) for guidance on proper timing of fall applied anhydrous with nitrification inhibitor in regards to 6-inch soil temperature depth.
- For split nitrogen applications, apply no more than 50% of the annual nitrogen recommendation pre-plant or at-planting with the remainder applied any time after the crop is established (defined below). **For wheat only**, apply no more than 40 pounds of the annual nitrogen recommendation pre-plant or at-planting with the remainder of the N applied before jointing.
- Crop establishment is defined as:
    - 4th - 6th leaf stage for corn or grain sorghum (milo)
    - Before jointing for wheat (late February - early April)
    - At first square (5th or 6th node) for cotton
    - At beginning jointing for rice. Follow guidance provided by the Missouri Rice Degree Day 50 (DD-50) report

NOTE: Use of a urease inhibitor, controlled- or slow-released fertilizer applied pre-plant or at-planting does not replace the split application of nitrogen after the crop is established.

To reduce phosphorus surface runoff, time planned surface application when runoff potential is low.

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

Do not surface apply manure and phosphorus fertilizers if a storm event is forecast within 24 hours.

Do not surface apply nutrients to frozen, snow-covered, or saturated (the top 2 inches) soil.

NOTE: The Missouri Department of Natural Resources (DNR) determines if a weather event is catastrophic or is a chronic weather event. Guidance for uncovered liquid wastewater storage and proper land application is provided by DNR in the publication *Wet Weather Management Practices for Concentrated Animal Feeding Operations (CAFOs) - PUB2422*.

590 PRACTICE SPECIFICATION APPENDIX

Table 1: Missouri Sensitive Area Setback Features and Distances for the Application of Manure, Compost, Bio-solids and Organic Materials (Reference: MoDNR Missouri Concentrated Animal Feeding Operation Nutrient Management Technical Standard, March 2009**,** Table A1.)

Setback feature	Application conditions	Setback Distance (ft)
Public or private drinking water well or other wells including un-plugged abandoned wells	All application methods	300
Public or private drinking water lake or impoundment	All application methods	300
Public or private drinking water intake structure	All application methods	300
Classified waters of the state not used as a water supply as defined in 10 CSR 20-7.031(1)F	Permanently vegetated buffer (≥35 feet)[1]	35
	No or insignificant vegetated buffer (<35 feet)	100
Other public and privately-owned lakes and impoundments not used as a water supply including impoundments with no outlet	Permanently vegetated buffer (≥35 feet)[1]	35
	Up-gradient, no or insufficient vegetated buffer (<35 feet)	100
	Down-gradient, no or insufficient vegetated buffer (<35 feet)	35
Other perennial streams, other intermittent streams, canals, and drainage ditches and wetlands	Permanently vegetated buffer (≥35 feet)[1]	35
	Up-gradient, no or insufficient vegetated buffer (<35 feet)	100
	Down-gradient, no or insufficient vegetated buffer (<35 feet)	35
Tile line inlet (if left un-plugged during manure application)	Up-gradient, permanently vegetated buffer	35
	Up-gradient, no or insufficient vegetated buffer	100
	Down-gradient	0
Losing stream	All application methods	300
Cave entrance	All application methods	300
Spring	All application methods	300
Active sinkhole	All application methods	300
Non-owned occupied residence	Spray irrigation only	150
Public use area including non-owned business	Spray irrigation only	150
Public road	All application methods	50
Property boundary	All application methods	50

[1]Vegetated Buffer - a permanent strip of dense perennial vegetation established parallel to the contours of and perpendicular to the dominant slope of the field for the purposes of effectively slowing water runoff, enhancing water infiltration, and minimizing the risk of any potential nutrients or pollutants from leaving the field and reaching surface waters.

Table 5: Typical Crop Removal Rates for Missouri

CROP	YIELD UNITS	NITROGEN REMOVED LBS./UNIT	P_2O_5 REMOVED LBS./UNIT	K_2O REMOVED LBS./UNIT
Alfalfa hay	Ton	50	10	45
Alfalfa new	Ton	50	10	45
Alfalfa-grass hay	Ton	50	10	45
Alfalfa-grass pasture	Ton	50	3.3	15
Barley	Bushel	0.96	0.38	0.24
Bermudagrass hay	Ton	50	9	34
Bermudagrass pasture	Ton	50	3	11.3
Birdsfoot trefoil-grass new	Ton	50	2.7	6.7
Birdsfoot trefoil-grass pasture	Ton	50	2.7	6.7
Bluegrass pasture	Ton	40	3.3	10
Buckwheat	Pound	0.05	0.007	0.003
Clover-grass hay	Ton	50	8.2	38
Clover-grass new	Ton	50	8.2	38
Clover-grass pasture	Ton	50	2.7	12.7
Cool season grass hay	Ton	40	9	34
Cool season grass new	Ton	40	9	34
Cool season grass pasture	Ton	40	3	11.3
Corn grain	Bushel	0.9	0.45	0.30
Corn silage	Ton	9	3.6	9.0
Cotton	Pound	-	0.038	0.035
Korean clover-grass hay	Ton	50	8.8	20
Korean clover-grass new	Ton	50	8.8	20
Korean clover-grass pasture	Ton	50	2.9	6.7
Oat	Bushel	0.64	0.26	0.19
Popcorn	Pound	0.016	0.008	0.005
Rice	Pound	0.013	0.0065	0.004
Rye, cereal	Bushel	1.18	0.34	0.34
Sorghum grain (Milo)	Bushel	0.78	0.52	0.34
Sorghum silage	Ton	13	4.6	10
Soybean	Bushel	3.5	0.84	1.44
Sudangrass hay	Ton	40	6.9	19
Sudangrass pasture	Ton	40	2.3	6.3
Sugar beet	Ton	4	1.33	3.33
Sunflower	Pound	0.026	0.0083	0.007
Tobacco	Pound	0.036	0.004	0.04
Warm season grass hay	Ton	40	2	14.6
Warm season grass new	Ton	40	2	14.6
Warm season grass pasture	Ton	40	0.7	4.9
Wheat	Bushel	1.26	0.60	0.30