NRCS	**Michigan Technical Note** **USDA-Natural Resources Conservation Service**

Topic: Agronomy #57
Subject: Nutrient Management Planning Considerations for Organic Crops
Date: October 2010

Introduction

Nutrients sources approved for use in organic production systems are given in the USDA National Organic Program (NOP), which is administered by the USDA-Agricultural Marketing Service. Many of the commonly used fertilizers for crop production are prohibited under U. S. organic law. These include urea, anhydrous ammonium, ammonium nitrate, superphosphate and diammonium phosphate (DAP). Growers need sound information to guide their nutrient management decisions on organic production practices. There are NRCS-developed technical tools that can be used to support planning and implementation of the Nutrient Management (590) conservation practice standard in organic crop production.

Disclaimer: The information given in this technical note is current as of October 2010. Producers should always consult with their organic certifying agency, to assure that they are following NOP rules. Organic production practices and materials need to be approved by a USDA-approved organic certifying agency and written into an Organic System Plan. Each certifying agency has different interpretations on approved control methods and materials.

Soil Fertility Management: "Feed the Soil to Feed the Plant"

Soil organic matter is the key component of an organic soil fertility management program. The basic precept is to 'feed the soil to feed the plant'. This is accomplished through practices designed to increase soil organic matter, soil biological activity and nutrient availability. Adding organic materials with cover crops, crop residues and composted plant material and/or manure to cultivated soils over time builds soil organic matter and improves the ability of the soil to supply nutrients. The ultimate goal is a fertile, biologically active soil with improved structure and enhanced nutrient availability.

Increasing soil organic matter is a key aspect of an organic production system. As you may recall from your soils science courses, the formation of soil organic matter is a product of decomposition of plant residues. The decomposition leads to the formation of humic substances, which constitute the majority of the organic matter in most soils. The remaining soil organic matter is composed of

a mixture of materials ranging from recently deposited residues to highly decomposed plant residues. The humus fraction of soil organic matter is the most resistant and mature fraction, which may take years to decompose. Plant residues that are high in carbon and low in nitrogen, such as straw or cornstalks, decompose slowly but are efficient producers of humus. Residues containing high levels of nitrogen, such as young cereals and legumes, decompose quickly, producing less humus.

During formation of soil organic matter, nutrients such as nitrogen, phosphorus and sulfur are incorporated into the soil structure, allowing the soil to become a reservoir for those and other plant nutrients. The decomposition of soil organic matter releases nutrients, which then become available for plant uptake. Furthermore, soil organic matter improves soil fertility through increases cation exchange capacity, which can retain nutrient cations such as ammonium (NH^{+4}), calcium (Ca^{+}), magnesium (Mg^{+}) and potassium (K^{+}). Soil aggregate formation improves soil structure and water infiltration and increases water-holding capacity.

Plant Nutrient Management

Crop nutrient requirements and the nutrient-supplying capacity of the soil are critical for successful crop production. **Soil testing** is essential for assessing nutrient levels and is required for organic certification.

Management of **phosphorus** and **potassium** should be directed at raising these nutrients to optimum levels in the soil. Compost and certain organic fertilizers are good sources of phosphorus and potassium. It is important to monitor soil phosphorus levels on a yearly basis, as soil phosphorus can build up when composts, manure or other organic amendments are used. Excessive soil phosphorus can result in high phosphorus concentrations in field runoff, which can impair surface water quality. There are nonorganic forms of potassium that have been approved for use in organic production systems.

In organic systems, **nitrogen** management is based on manipulating organic sources of nitrogen. Appropriate nitrogen management cannot be directly inferred from a simple soil test. In conventional crop production systems there are soluble, readily available nitrogen fertilizers available to meet crop nutrient needs. However, organic nitrogen must be mineralized through the action of soil microbes before it is available for plant uptake. Although this process can supply a significant quantity of nitrogen, estimating the amount and timing of nitrogen available for plant uptake can be complicated.

Factors that affect **mineralization** include soil temperature, soil moisture and tillage practices. Mineralization is minimal at a soil temperature below 50F, but above that temperature, mineralization increases as soil temperature increases. Mineralization occurs rapidly in moist soils, but is inhibited by excessively wet or dry conditions. Soil tillage stimulates temporary bursts of microbial activity which declines over the course of days or weeks. Despite the complex interaction of these factors, a rough estimate of the nitrogen available for plants can be calculated

using the Plant Available Nitrogen (PAN) Calculator (See Michigan Agronomy Technical Note #20, Plant Available N Calculator, and the accompanying Excel spreadsheet.).

Synchronizing nitrogen mineralization from soil organic matter, cover crop residues and organic amendments to maintain adequate nitrogen availability for crop production is challenging. Short-season crops with low nitrogen requirements such as radishes may produce well with the nitrogen available from soil organic matter plus crop residues and/or added compost (Table 1). Crops with higher nitrogen requirements and longer growing seasons such as potatoes or onions often need supplemental applications of organic nitrogen fertilizer. For many vegetable crops, quality is as important as yield, so nitrogen management can be critical to quality attributes such as product size, color and uniformity.

Table 1. Nitrogen requirement of vegetable crops

Crop	**Nitrogen Requirement (lb/Ac)**
Radish	50
Lettuce, leaf	100
Tomato, fresh market	120
Potato	180
Onion, dry bulb	190
Celery, fresh market	200

(Reference: MSU Bulletin E2934, Nutrient Recommendations for Vegetable Crops in Michigan)

Nutrient Sources

Cover Crops fix and trap nutrients, add organic matter to soils, and reduce nitrate leaching, nutrient runoff and soil erosion. Non-leguminous cover crops such as grasses and *brassica* species can trap nitrates and phosphate that would otherwise be lost by leaching or runoff. They grow well in cool temperatures in fall and spring. Legumes fix atmospheric nitrogen, at least when concentrations of mineral nitrogen in the soil are low, and add to the net availability of nitrogen in the cropping system. Mixtures of grasses and legumes are a common strategy. Mixtures also ensure that the cover crop is productive under a range of weather conditions.

The NRCS Cover Crops (340) conservation practice standard and specifications can fit into an organic nutrient management system. Organic certifying organizations require cover crops in crop rotations for approved organic crop production systems, in order to build soil organic matter. A legume is usually required by organic certifiers as part of the crop rotation, either as a cover crop for harvest at maturity or for use as a green manure, to supply nitrogen in the rotation. The Cover Crops (340) conservation practice standard has purposes to build soil organic matter, recycle nutrients, and fix nitrogen. When green plant materials are incorporated directly into the soil, a 10 to 14 day period is required for the rapid phase of microbial degradation to occur before planting crop seeds or transplants, in order to prevent damage to the young plants or seedlings. Landowners who are transitioning to organic or who are already certified organic should work with their

certifying organization to assure that the cover crops in their Organic System Plan meet organic certification standards.

Compost is a relatively cost-effective organic source of macro- and micronutrients. When applying compost, the challenges are to know its composition and to understand how to use it most efficiently. Mineralization rates from compost are relatively low, and compost is usually a poor short-term source of nitrogen. A longer-term program of repeated compost application would be required to increase the overall amount of soil organic nitrogen and increase nitrogen mineralization potential.

Michigan law requires that any commercially-sold fertilizer material, including organic sources such as compost, be tested for nutrient analysis and that this information be labeled or available from the supplier to the grower. The grower should know and document the composting process used by the supplier as well as the sources of raw material in the compost. Although the NRCS practice standard Composting Facility (317) has O&M plans available to the grower to process his/her own compost, the National Organic Program (NOP) has very specific standards for the compost production process, whether grower processed or from a supplier, before that compost can be certified organic.

Mulching materials like leaves, straw or hay are used for weed control and moisture retention. These organic materials will eventually break down to soil organic matter as well. They are most commonly used in small-scale vegetable or small fruit production. Refer to the Mulching (484) practice standard for NRCS requirements. The NOP requires documentation of mulch sources and types used, especially for off-farm sources.

Manure can be a good source of nitrogen and other major and minor nutrients. The NOP rules allow manure from conventional (i.e., non-organic) sources. Raw or untreated manure can only be used for organic production under the following circumstances: (1) if it is applied to perennial or non-food-crop land; (2) if it is incorporated into the soil at least 120 days prior to harvest if the edible portion of the crop is in contact with the soil, either directly or by soil splashing onto the fruit from irrigation or rain (e.g., tomatoes or carrots); or (3) if manure is incorporated into the soil at least 90 days prior to harvest if the edible portion is not in contact with the soil (e.g., sweet corn, whose edible part is protected by the husk).

A potential limitation of manure is the availability of a consistent supply of a material that is uniform enough to be confidently incorporated into a production system. As with compost, the grower will need to know and document the nutrient analysis of the manure, as well as its source. Food safety programs mandated by produce distributors may also restrict manure use. Most manure used in organic vegetable production is composted prior to field application, which minimizes food safety risks.

A number of approved **commercial organic fertilizers** are available. The National Organic Standards Board is responsible for maintaining a ‘list’ of approved and prohibited materials that can be used as fertilizers and soil amendments. This list is on the NOP website. Common examples

are listed in Table 2. Most of these materials are by-products of fish, livestock or food processing industries. These fertilizers tend to be expensive and their use is limited to situations where the application of compost and/or manure has supplied insufficient available nutrients for the crop. Their value lies in the relatively rapid availability of their nutrients. Materials such as processed liquid fish or liquid soybean meal can be applied through drip irrigation systems. Dilute liquid 'teas' from organic materials are sometimes applied to the soil or sprayed directly on the plant in an effort to improve nutrient availability. The value of many products labeled as organic soil amendments has not been clearly established in research studies.

Commercial Organic Nutrients	
Mined or Mineral Sources	
Lime- carbonate, not hydrated or burnt	
Gypsum – calcium sulfate	
Greensand – potassium (0-0-7)	
Potassium sulfate (0-0-50)	Plant Derived Sources*
Potassium magnesium sulfate (0-0-21)	Alfalfa meal (3-0.5-3)
	Soybean meal (6-1.4-2)
Animal Derived Sources	Kelp and seaweed (1-0.2-2)
Bone meal (6-12-0)	Wood ash (liming action)
Blood meal (12-0-0)	Compost (may include manure)
Fish emulsion (5-1-1)	
Fish meal (7-0-0)	
Manure – many types	
Worm castings	* Must be from non-GMO sources

Table 2. Examples of organic fertilizer materials acceptable for organic certification (Source: Biernbaum, Organic Matters lecture, December 2009)

Other Considerations when Using Organic Fertilizers

Bulk: Many organic fertilizer materials such as compost or other organic by-products are generally less concentrated sources of nutrients than conventional fertilizers. Application rates for these materials are commonly 5 to 10 tons per acre, sometimes more. Growers need to consider how they will transport, store and apply such large quantities of materials.

Nutrient Availability: Organic fertilizers often include both a small proportion of relatively available soluble nutrients and another nutrient fraction that is either unavailable to the plant or available only gradually over time. These materials need to be applied earlier in anticipation of plant nutritional needs, often two to four weeks before nutrients are needed. The availability of nutrients is dependent on microbial activity. The composition and particle size of the material can also be determining factors in the rate of microbial decomposition and nutrient availability, since more concentrated, finer textured material would decompose and release nutrients more readily than a coarser mixture.

Uniformity: Organic fertilizer materials tend to vary considerably with respect to moisture content, particle size and nutrient content and distribution. This inconsistency is inherent to the material because of the nature of the production process. Organic products will also continue to change during transport and storage due to natural processes. Growers should determine the composition of key fertilizer materials and keep records of their variations over time.

Nutrient Management Plans as a Component of an Organic System Plan

The transition period for new organic operations can be the most demanding in terms of soil fertility management. This is because the benefits of soil building and soil organic matter improvement have not yet occurred in a transitional field, but the grower is limited to only a few soluble fertilizer materials.

The Manure Management Planner (MMP) software can be used to estimate crop nutrient needs in an organic crop production system. The software estimates the plant available nitrogen from decomposition of previously grown legumes, cover crops and manure applications in rotation. It can be used in a variety of crop production systems, since a large number of field and vegetable crops are included in the crop database. Focusing a fertility program on a single crop is a poor starting point and leads to a misunderstanding of how organic farming works. Organic growers typically build an integrated rotation of different crops that (ideally) complement or compensate for each other. Such production systems are further enhanced with livestock manures, either as part of the on-farm operation or as organic fertilizers (raw and/or composted manure) from off-farm sources. Thus a multi-year tool such as MMP will most efficiently capture nutrient inputs and crop nutrient needs for each year and provide an overall picture of the farm's nutrient management program. A disadvantage of MMP is that it does not capture nitrogen availability from mineralization of soil organic matter. The MMP software allows overriding of nitrogen recommendations due to soil organic matter mineralization.

Seasonal nitrate-nitrate tests can help a producer meet crop nitrogen needs. Pre-sidedress soil nitrate testing or plant tissue testing may be useful in high-value crops to better tailor nitrogen needs.

The following example of a nutrient management plan was developed using the MMP software. It is based on a real-life organic farm operation.

Example: The landowner operates a certified organic farm in Gratiot County. His rotation is blue corn followed by food-grade soybeans (which he sells for use in soymilk), followed by spelt underseeded with red clover. After the spelt is harvested the following year he keeps the red clover, to harvest clover seed. The red clover is finally tilled under before blue corn is planted.

The landowner has acquired a small field which he is transitioning to organic. He is interested in determining whether his current nutrient management program is adequate to meet his yield goals. He uses "Chickidy Doo Doo" commercial composted chicken manure (5-3-2), which he applies each fall at 10 tons per acre. No other supplemental fertilizer is used.

The MMP program was used to estimate crop nutrient needs over the entire rotation. The program showed that there was extra nitrogen needed on corn and spelt to meet the yield goals of 90 bu/ac corn and 25 bu/ac spelt. Figure 1 shows how the MMP captures how clover reduces the nitrogen requirement for the following year's corn crop. The MMP software automatically captures the rotation effect. Notice how the nitrogen recommendation for corn dropped from 95 to 50 lb/ac after clover seeding was added to the rotation.

Crop Year	Planned Crop (Or Second Crop If Double Cropping) Crop Info... RUSLE2...	Yield Goal (/Acre)	Yield Units	Legume % Stand	Default N Rec (Lb/A)
2010	Corn grain	90	Bu		95
2011	Soybean	35	Bu		0
2012	Spelts	25	Bu		60
2013					

Crop Year	Planned Crop (Or Second Crop If Double Cropping) Crop Info... RUSLE2...	Yield Goal (/Acre)	Yield Units	Legume % Stand	Default N Rec (Lb/A)
2010	Corn grain	90	Bu		50
2011	Soybean	35	Bu		0
2012	Spelts	25	Bu		60
2013	Clover seeding	2	Ton		0

Figure 1. Default crop nutrient recommendations with and without a legume (clover seeding) in rotation.

While the MMP program can account for nitrogen carryover from the fall-applied manure and the legumes in rotation, it does not have a means to calculate nitrogen availability from mineralization of soil organic matter. In this case, the landowner may choose to add and incorporate manure in the spring before planting corn or soybeans. This decision should be made in after consultation with the organic certifier.

The conservation planner has the ability to print summary reports from MMP using the reports generators listed under the Tools tab (Figure 2). The Field Nutrient Balance report summarizes nutrient information for the field over the entire rotation. The Field Nutrient Status Details then provides year-by-year information on crop nutrient needs, nutrients applied, and resulting nutrient balances. These two reports can then be included in the Nutrient Management Components of a Conservation Plan as required by the Nutrient Management (590) conservation practice standard. Other components required include soil maps with soil map units identified, field maps with

sensitive areas identified, soil test and manure or compost test results, documentation of crop rotations and yield goals, cover crops used (if applicable), records of other fertilizers used, and the nutrient recommendations. Refer to the Nutrient Management (590) conservation practice standard for more detailed information.

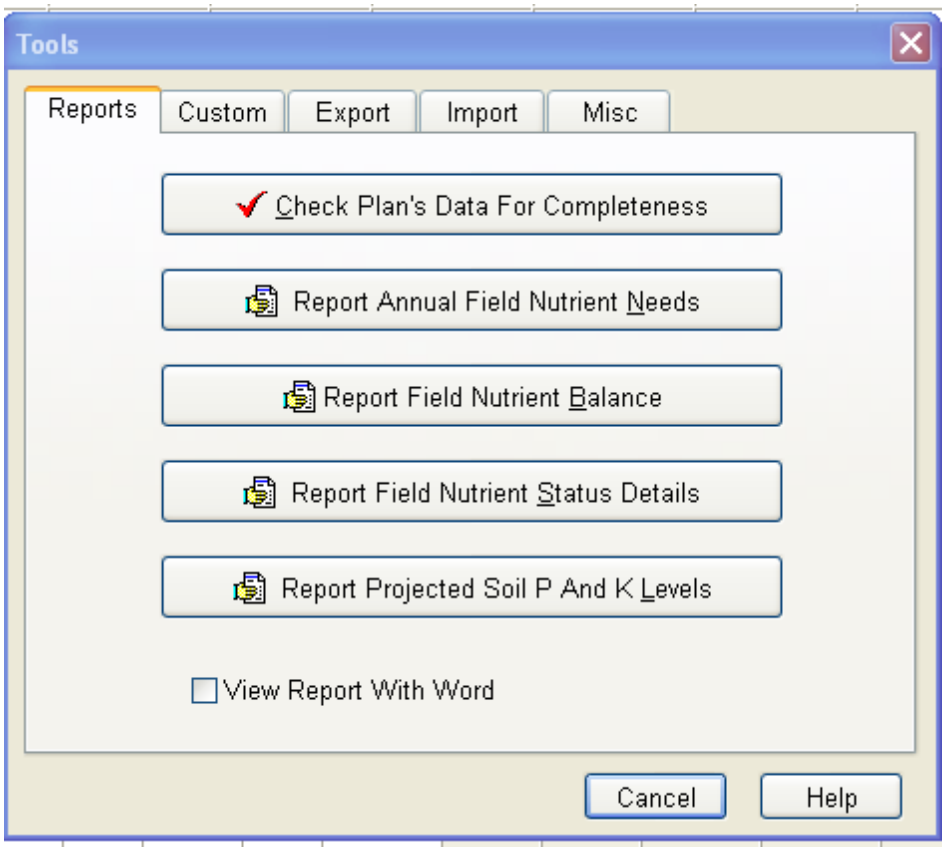

Figure 2. Reports options available using the Tools tab in MMP.

Resources Available

Michigan State University Extension Bulletin E-893, Managing Manure in Potato and Vegetable Systems, http://web2.msue.msu.edu/bulletins/Bulletin/PDF/E2893.pdf

Michigan State University Extension Bulletin E3983, Building a Sustainable Future: Ecologically Based Farming Systems

Michigan Agronomy Technical Note #20, Plant Available N Calculator

Websites

ATTRA – National Sustainable Agriculture Information Service http://www.attra.org

USDA-Agricultural Marketing Service, National Organic Program:
http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateA&navID=NationalOrganicProgram&leftNav=NationalOrganicProgram&page=NOPNationalOrganicProgramHome&acct=AMSPW