Accelerating Conservation Adoption in the River Raisin

Best Management Practice Design, Installation and Certification Guidelines

2/5/2019

Accelerating Conservation Adoption in the River Raisin
Best Management Practice Design, Installation and Certification Guidelines

The following guidelines will be used to design, install and certify the contracted Best Management Practice (BMP). The manual will fully explain what is needed in order to have successfully completed installing the chosen BMP. Job Sheets and/or other support documentation will be included depending on what BMP the producer has chosen.

The following practices are all accepted BMPs that can be installed under the guidelines of this project.

1. Conservation Crop Rotation
2. Cover Crops
3. No-Till
4. Reduced Tillage
5. Filter Strip
6. Nutrient Management
7. Apply Phosphorus at draw down rates
8. Apply all Phosphorus at planting time
9. Band or inject all Phosphorus

Each practice has specific requirements that need to be met in order to be certified for payment. See below for detailed information on each practice and refer to page 4 for a reference checklist of practice requirements.

1. **Conservation Crop Rotation** - This practice will be clearly defined using the "328 – Conservation Crop Rotation Implementation Requirements." The rotation must include adding wheat or other small grain to the rotation that has not been part of the rotation for the past 5 years or more (followed by an overwintering multi-species mix cover crop which can be contracted for separately). The small grain must be planted during the contract period.

2. **Cover Crops** - This practice will be clearly defined using the "Cover Crops MI Conservation Sheet" (use the Excel version, which includes both certification sheet and cover crop calculator available at https://efotg.sc.egov.usda.gov/references/public/MI/Cover_Crop_Seeding_Calculator(2-16-16).xlsm). The Cover Crop must be overwintering and may be single or multiple species. Cover crop variety and planting dates will be very critical. Please use the NRCS cover crop calculator (see above) to discuss and plan planting rates. We recommend selecting a planned seeding rate that is above the minimum required seeding rate in the event actual seeding rates are lower than the planned rate. Planting dates can have some adjustment depending on weather conditions. MSU Enviro Weather can be used to determine if a larger planting window will be feasible.

We highly recommend that producers purchase certified seed to expedite the verification process. Seed tags and invoices will be used to verify seeding rates. Invoices must be kept to document the total amount of seed purchased (this is especially important in instances where farmers purchase seed from other farmers - documentation must show that enough seed was purchased to cover all fields planted). The certification worksheet should document the actual seeding rates used the by producer. This can be calculated using the pure live seed analysis from the seed tags: Total amount of seed planted (lbs) x percent of seed in mix (if using multi-species mix) x germination rate divided by acres planted (Ex: 2000 lbs seed x .9 germination rate x .8 in mix / 50 acres = 28.8 lbs/acre). If seed tags are not available for the purchased seed, a post-emergence count will be used to verify the practice (count number of seeds in a square foot area and compare to the seed/square foot rate specified on the NRCS seeding calculator). Note in situations where "acts of god" prevented verification of the practice, payment is only guaranteed when seeds tags with pure live seed analysis are provided.

Two sets of pictures are required. The first set will be of initial planting. At least one picture should be a close up showing the soil surface with planter marks and/or seed on the soil surface. Use an item in the close up picture to show scale (a coin, ruler, etc). At least one picture will be a wide view of the field. Be sure to include a tree, piece of typography, or other feature (building, fence line, ditch, lane, etc.) that makes the location identifiable. The second set of pictures will be of the growing cover crop. Again, take at least one close up photo and one wide view photo as described above. The second set of photos will be taken on or after December 10 but before spring tillage/burndown of the cover crop. If the technician is not able to get both sets of pictures, a date stamped picture from the producer is required.

Any establishment failures should be well documented on the conservation sheet as to the cause. In cases where the practice is unable to be verified due to "acts of God" (e.g., cold weather that limits growth, torrential rains after planting, a wildfire that burned the field, etc.) the farmer may still receive compensation for agreed costs of practice implementation per the contract. Documentation required for establishment failures includes pictures as described above as well as a description of the "act of God" (e.g., x inches of rain over a y hour period, fire on date z, temperature records). Establishment failure caused by the farmer (such as planting too late, planting too deep, purchasing low-quality seed, etc.) will not qualify for payment.

3. **No-Till** - This practice will be clearly defined using the "Residue Management Plan." Eligible fields have less than 30% residue cover after planting prior to implementation and will have over 60% residue cover after planting following implementation. All applications of phosphorus must be applied subsurface (banded, injected, etc.) and may be included in the contract using "Nutrient Management" or "Band or Inject all Phosphorus." Use of the line transect tool ("Line Transect Residue and Cover Estimates") is required along with photo documentation (at least one picture of the field showing residue coverage).

4. **Reduced Tillage** - This practice will be clearly defined using the "Residue Management Plan." Eligible fields have less than 30% residue cover after planting prior to implementation and will have over 30% residue cover after planting following implementation. Use of the line transect tool ("Line Transect Residue and Cover Estimates") is required along with photo documentation (at least one picture of the field showing residue coverage).

5. **Filter Strips** - This practice will be clearly defined using the "Filter Strip Conservation Sheet." The Filter Strip may consist of either native or introduced species. If the Filter Strip is not harvested, payments may be contracted at the "foregone income" rate. This practice has a very lengthy tech guide information sheet; as well a job sheet that is very detailed. These will provide a good resource when working to help the producers install the practices as well as certification. Certification will include photo documentation, measurements of the installed area, seed tags, and invoices. Photos should be dated with associated field identifiers and include a before and after photo of the filter strip. Seed tags and invoices will be used to verify seeding rates.

6. **Nutrient Management** – This practice will be clearly defined using the "Nutrient Management 590 Specification Sheet." Use "Basic" payment rates unless the producer applies plant nutrients using Variable Rate Technology (VRT) based on Soil Management Zones of 6 acres or less. Required documentation includes current soil tests as well as the timing, rate, placement, form, sources, and method of nutrient applications.

7. **Apply Phosphorus at draw down rates** – This practice will be clearly defined using the "Nutrient Management 590 Specification Sheet" and must include source, form, rate, timing and placement of **phosphorus** applications. Eligible fields have pH levels in the normal range (no lime application recommended or already applied in prior years) and soil test levels above those identified in "Suggested Nutrient Management Practices for Individual Crops" starting on page 26 of E-2904 MSU Nutrient Recommendations for Field Crops in Michigan. Fields contracted for this practice are not eligible for Nutrient Management. Use "Basic" payment rates unless the producer applies plant nutrients using Variable Rate Technology (VRT) based on Soil Management Zones of 6 acres or less. Required documentation includes current soil tests as well as the timing, rate, placement, form, sources, and method of phosphorus and lime applications.

8. **Apply all Phosphorus at planting time** – This practice will be clearly defined using the "Nutrient Management 590 Specification Sheet" and must include source, form, rate, timing and placement of **phosphorus** applications. Eligible fields are those where the most recent phosphorus application was at times other than at planting and have pH levels in the normal range (no lime application recommended or already applied in prior years). Fields contracted for this practice are not eligible for Nutrient Management. Use "Basic" payment rates unless the producer applies plant nutrients using Variable Rate Technology (VRT) based on Soil Management Zones of 6 acres or less. Required documentation includes current soil tests as well as the timing, rate, placement, form, sources, and method of phosphorus and lime applications.

9. **Band or inject all Phosphorus** - This practice will be clearly defined using the "Nutrient Management 590 Specification Sheet" and must include source, form, rate, timing and placement of **phosphorus** applications. Eligible fields are those where the most recent phosphorus application was surface applied and have pH levels in the normal range (no lime application recommended or already applied in prior years). Fields contracted for this practice are not eligible for Nutrient Management. Use "Basic" payment rates unless the producer applies plant nutrients using Variable Rate Technology (VRT) based on Soil Management Zones of 6 acres or less. Required documentation includes current soil tests as well as the timing, rate, placement, form, sources, and method of phosphorus and lime applications.

Accelerating Conservation Adoption in the River Raisin Verification Checklist

1. Conservation Crop Rotation
    a. Signed 328 – Conservation Crop Rotation Implementation Requirements (NRCS - Nov 2015)
2. Cover Crops
    a. Signed Cover Crop Specifications with actual seeding rates (2nd tab NRCS Cover Crop Calculator)
    b. Cover crop calculator used to plan seeding rates (1st tab NRCS Cover Crop Calculator)
    c. 2 initial dated planting pictures (one close up and one wide view)
    d. 2 pre-burn dated down pictures (one close up and one wide view taken on or after 12/9/19)
    e. Seed tags and invoices that verify seeding rates (total seed amount and PLS analysis). If no PLS analysis, provide documentation of post emergence measurement of cover crop plant population (count germinated seeds in square foot area and compare to seed/ft^2 rate specified on NRCS seeding calculator).
3. No-till
    a. Design Criteria page (NRCS Residue Management Plan - July 1997) signed by technician stating that the practice has been implemented as documented and meets program requirements.
    b. Field Residue Estimates (NRCS Line Transect Residue and Cover Estimates, May 1997)
    c. Photo of each field showing residue coverage
4. Reduced Tillage
    a. Design Criteria page (NRCS Residue Management Plan - July 1997) signed by technician stating that the practice has been implemented as documented and meets program requirements.
    b. Field Residue Estimates (NRCS Line Transect Residue and Cover Estimates, May 1997)
    c. Photo of each field showing residue coverage
5. Filter Strips
    a. Filter Strip Job Sheet (NRCS Filter Strip Conservation Sheet – October 2006) signed by technician stating that the practice has been implemented as documented and meets program requirements.
    b. Dated photos before and after the completed practice
    c. Measurements of the installed area
    d. Seed tags or invoices that verify seeding rates (amount and PLS analysis). If no PLS analysis, provide documentation of post emergence measurement of plant population
6. Nutrient Management
    a. Completed Nutrient Management 590 Specification Sheet (NRCS spreadsheet). Provide signed statement by technician that the practice has been implemented as documented and meets program requirements.
7. Apply Phosphorus at draw down rates
    a. Completed Nutrient Management 590 Specification Sheet (NRCS spreadsheet). Provide signed statement by technician that the practice has been implemented as documented and meets program requirements.
8. Apply all Phosphorus at planting time
    a. Completed Nutrient Management 590 Specification Sheet (NRCS spreadsheet). Provide signed statement by technician that the practice has been implemented as documented and meets program requirements.
9. Band or inject all Phosphorus
    a. Completed Nutrient Management 590 Specification Sheet (NRCS spreadsheet). Provide signed statement by technician that the practice has been implemented as documented and meets program requirements.

United States Department of Agriculture

328 – Conservation Crop Rotation Implementation Requirements

Producer:	Click here to enter text.	**Project or Contract:**	Click here to enter text.
Location:	Click here to enter text.	**County:**	Click here to enter text.
Farm Name:	Click here to enter text.	**Tract Number:**	Click here to enter text.

PracticeLocationMap

(showingdetailedaerialviewofwherepracticeistobeinstalledonfarm/site,showingallmajorcomponents,stationing,relativelocationtoanylandmarks,andsurveybenchmarks)

Index

- ☐ Cover Sheet
- ☐ Specifications
- ☐ RUSLE2 or WEPS printouts
- ☐ Operation & Maintenance

Utility Safety/
One-Call System
Information

Click here to enter text.

Description of work:

Click here to enter text.

NRCSReviewOnly

Designed By:	Click here to enter text.	**Date**	Click here to enter a date.
Checked By:	Click here to enter text.	**Date**	Click here to enter a date.
Approved By:	Click here to enter text.	**Date**	Click here to enter a date.

328 – Conservation Crop RotationImplementation Requirements

Practice Purpose(s):(check all that apply)

☐ (1) Reduce erosion from wind and water.
☐ (2) Improve soil health.
☐ (3) Manage the balance of plant nutrients.
☐ (4) Supply nitrogen through biological nitrogen fixation to reduce energy use.
☐ (5) Manage saline seeps.
☐ (6) Manage plant pests (weeds, insects, and diseases).
☐ (7) Conserve water.
☐ (8) Provide feed for domestic livestock.
☐ (9) Provide annual crops for bioenergy feedstocks.
☐ (10) Provide food and cover for wildlife, including pollinator forage, cover, and nesting.

Complete Table Displaying the Crop Rotation Design, OR, attach a RUSLE2 or WEPS printout that shows rotation sequence by field.
☒**Printouts attached**.

Field(s)	Acres	Purpose(s) (#s from above)	Crops to be grown	Length each crop grown in the rotation	Crop sequence	Total length of rotation in years
Field	Acres	Purpose	Crops	Length	Sequence	Years
Field	Acres	Purpose	Crops	Length	Sequence	Years
Field	Acres	Purpose	Crops	Length	Sequence	Years
Field	Acres	Purpose	Crops	Length	Sequence	Years
Field	Acres	Purpose	Crops	Length	Sequence	Years
Field	Acres	Purpose	Crops	Length	Sequence	Years
Field	Acres	Purpose	Crops	Length	Sequence	Years
Field	Acres	Purpose	Crops	Length	Sequence	Years

If Tillage Is Used, Specify Time and Type of Primary Tillage for Each Crop, OR, attach a RUSLE2 or WEPS printout that shows rotation sequence by field.
☐**Printouts attached.**

Field(s)	Type of Primary Tillage	Time of Primary Tillage	Crop
Field	Tillage type	Tillage time	Crops
Field	Tillage type	Tillage time	Crops
Field	Tillage type	Tillage time	Crops
Field	Tillage type	Tillage time	Crops

Field(s)	Type of Primary Tillage	Time of Primary Tillage	Crop
Field	Tillage type	Tillage time	Crops
Field	Tillage type	Tillage time	Crops
Field	Tillage type	Tillage time	Crops
Field	Tillage type	Tillage time	Crops

OPERATION AND MAINTENANCE

☐ Rotations shall provide for acceptable substitute crops in case of crop failure or shift in planting intentions for weather related or economic reasons. Acceptable substitutes are crops having similar properties that will accomplish the purpose of the original crop.

Planned Crop Substitutions

Field(s)	Planned crop	Substitute crop	Additional Criteria (e.g., may need a cover crop)
Field	Planned crop	Substitute crop	Additional criteria
Field	Planned crop	Substitute crop	Additional criteria
Field	Planned crop	Substitute crop	Additional criteria
Field	Planned crop	Substitute crop	Additional criteria
Field	Planned crop	Substitute crop	Additional criteria
Field	Planned crop	Substitute crop	Additional criteria
Field	Planned crop	Substitute crop	Additional criteria
Field	Planned crop	Substitute crop	Additional criteria

☐ Evaluate the rotation and the crop sequence to determine if the planned system is meeting the planned purposes.

Certification Statement:
I certify that implementation of this conservation practice is complete, meets criteria for the stated purpose(s), and meets the NRCS conservation practice standard and specifications.

X _____

Planner/Technical Service Provider

Cover Crops

MI Conservation Sheet ***340***

Natural Resources Conservation Service (NRCS) **June 2010**

WHAT ARE COVER CROPS?

Grasses, legumes, forbs, or other herbaceous plants established for seasonal cover and conservation purposes. Cover crops reduce erosion by water or wind by disrupting the impact of raindrops and the stinging forces of wind blown soil particles. Cover crops with tall above ground growth can help increase soil organic matter. Cover crops can capture and recycle excess nutrients like free nitrogen in the soil profile. Legume cover crops can be inter-seeded during the growing season to fix nitrogen for the next year's crop. Some cover crops can attract beneficial insects and provide over-wintering sites for the next year. Because of the potential allelopathic effect of weed seedlings rye and ryegrass cover crops can suppress weed populations. In addition cover crops can increase available soil moisture by providing insulating mulch if at least a 50% or more cover is maintained after planting.

CONSIDERATIONS

Timing:

Sow cover crops in a timely manner to maintain a good stand. See the MI NRCS 340 Cover Crop Standard for seeding rates and dates.

Maintain an actively growing cover crop as late as feasible to maximize plant growth, allowing time to prepare the field for the next crop.

Aerial seeded cover crops into soybeans, especially wheat, rye, and oats, are best if seeded prior to soybean leaf drop.

Aerial seeding of oats into soybeans (seeded prior to harvest) can add additional residue cover without the need to kill the cover crop the following spring.

Aerial seeded wheat or cereal rye into corn is best if seeded during the early dent stage. This generally occurs the last week of August to mid-September. Caution must be used when broadcasting or aerial seeding treated seed into a crop that is standing (to yet be harvested). Treated seed could show up in the harvested grain and result in rejection.

Consider potential herbicide carryover when selecting the species of the cover/green manure crop. Of the cover crops, rye is most tolerant of triazine carryover, followed by wheat, then oats, and lastly legumes. Legumes are extremely sensitive to triazine carryover released by liming low pH soils. Delay seeding legumes for one year if more than 1 pound of triazine was used the previous year and lime was recently applied.

Cereal rye will grow longer in the fall and begin growth earlier in the spring than wheat.

Crop Rotations

Crops planted late enough in spring to allow sufficient growth of cover crops prior to tillage are dry beans, soybeans, sweet corn, snap beans, cabbage, cucumbers, tomatoes, and late potatoes.

Inter-seed cover crops at the last weed control cultivation in corn, cabbage, cauliflower, peppers, or eggplant. Inter-seed into snap beans 10 days before the first harvest of beans. Or drill in cover crops and sow primary crop then kill cover with herbicides.

Consider sowing cover crops after the following crops: corn silage, dry beans, cucumbers, early soybeans, early corn, beets, spinach, carrots, lettuce, and potatoes.

Early planted crops such as carrots, beets, direct seeded cabbage, and early potatoes do not allow sufficient growth of cover crops in spring.

Consider cover crops after corn silage to reduce soil erosion, replace organic matter losses, and capture nitrogen where manure is fall applied.

Consider grass cover crops when a legume, like soybeans, is planned following the cover crop.

Consider legume cover or a green manure crop when a grass crop, like corn, is planned the following year.

Erosion Control:

Aerial seeded and early no-till established cover crops provide more erosion control the year of establishment.

Cover crop sown using conventional tillage for seedbed preparation after mid-October can cause more erosion during the establishment year than if a cover crop was not planted.

To obtain maximum erosion control from cover crops after soybeans or corn, allow them to mature to the specified height per the criteria for erosion control. No-till and mulch-till compliment the use of cover crops for controlling erosion.

Early planted crops such as carrots; beets, direct seeded cabbage, and early potatoes do not allow sufficient growth of cover crops in spring.

Interseeding of cover crops can be used with chemical suppression to reduce wind erosion and plant loss on sand or muck soils. Two rows of spring or winter barley are sown between carrot or onion rows to protect young seedlings from wind abrasion and burial loss.

Disease and Pests

Avoid cover crop species that harbor or carryover potentially damaging diseases or insects.

It is not recommended to plant mustards on the same field for more than two years in a row. Oil seed radish may be susceptible to club root disease or cabbage root maggot and should not be used in a rotation with vegetable crops susceptible to these pests.

Hairy vetch and clovers can serve as a host to the Soybean Cyst Nematode (SCN). Consider alternative cover crops when SCN is a concern in the rotation. Other SCN host plants include: common Mullen, wild mustard, chickweed, pokeweed, canola, purple deadnettle, shepard's purse and field pennycress. *Caution- Hairy Vetch can also be a weed in future wheat*.

For controlling sugar beet cyst nematodes, sow Colonel or Adagio oil seed radish varieties for trap crops after small grain harvest before planting sugar beets. Do not use Daikon or Common oilseed radish varieties as they lack the sugar beet cyst nematode trap crop properties.

For controlling root lesion, dagger or other herbivore nematodes Pacific Gold Mustard is the recommended Brassica cover crop before planting an orchard or potatoes.

Soil Quality

Cover crops may be used to improve site conditions for establishment of perennial species.

Use plant species for enhanced bio-fuel opportunities and replace removed crop residue with cover crops to maintain soil organic matter.

Pollination

Use plant species that enhance forage opportunities for pollinators. Crimson clover and buckwheat make excellent bee forage cover crops.

Grazing Concern

There is potential to kill livestock with prussic acid poisoning and nitrate poisoning from the young growth of Sudan grass and sorghum-Sudan grass hybrids used in rotational grazing or supplemental feeding.

OPERATION, MANAGEMENT AND MAINTAINENCE

Management:

Use weed-free and disease-free seed and establish cover crops by over-seeding, frost seeding, aerial seeding, broadcast seeding, air-flow broadcasting, drilling or manure slurry seeding.

Control growth of the cover crops to reduce competition from volunteer plants and shading.

Control weeds in cover crops by mowing or other pest management techniques.

Control soil moisture depletion by selecting water efficient plant species and terminating the cover crop before excessive transpiration.

Burn-down, chop, mow, or till to kill cover crops when planting corn prior to corn emergence. Cover crops such as rye can produce an alleopathic effect that can slow the germination and growth of corn and other competition. It may be best to kill some grass cover about a week prior to planting the corn to reduce alleopathic effects.

Frost seed legumes into small grain crops, from mid-March to mid-April or drill into small grain stubble after grain harvest

When seeding legumes it is best to inoculate just prior to planting and ensure the proper legume inoculant is used at planting time.

In row crops, over-seeding of legumes or small grains can improve soil tilth. In corn, spray an herbicide in a 10-inch band over the row and then follow by two cultivations. Over-seed cover crops at the second row cultivation. Timing is very important to successfully establishing a cover crop by over-seeding. Sow legumes between corn growth stages V-4 and V-6. Annual ryegrass should be seeded at V-6 to V-8. Small grains (rye) can be aerial seeded just prior to senescence (leaf drop) in soybeans and corn.

Nutrient management

Use deep-rooted species to maximize nutrient recovery.

Fertilize a green manure/cover crop in the spring with a high nitrogen fertilizer for maximum growth ahead of planting high nitrogen demanding vegetable crops. The recovery of the nitrogen applied to a green manure crop will amount to about 40 percent for the first vegetable crop.

Residual nitrogen is likely to be present after a dry season of below normal rainfall. A fall soil nitrate test or stalk nitrate test is recommended to determine the availability of nitrogen, as excess nitrates can be flushed from the soil into tile systems or groundwater. Rye, oil seed radish, or other small grains can capture about 50 percent of the available nitrates and prevent nitrogen losses.

To prevent nitrate leaching after corn/seed corn maturation on sandy soil, especially under irrigation, aerial seed ryegrass/rye in standing corn or broadcast after harvest.

Nitrate leaching can occur after winter wheat. Frost seed red clover or red/sweet clover mixes in mid-March or mid-April to alleviate this problem.

To reduce nitrate leaching and phosphorus runoff from fall manure applications, aerial seed rye/ryegrass or apply rye with liquid manure or oil seed radish (Manure Slurry Seeding). Direct drill rye/ryegrass after harvest.

To reduce nitrate leaching and phosphorus runoff from vegetable crops, broadcast or direct drill oil seed radish, ryegrass, or rye.

To reduce potassium leaching on muck and sandy soils, plant rye or ryegrass cover. Aerial seed cover crops into standing row crops; broadcast seed, and till 2-3 inches deep after harvest; or direct drill into crop residue.

Nitrogen credits from legume cover crops will be accounted for in the nutrient management plan. Credit for nitrogen produced by legumes is to be included in crop nutrient budgets.

Crownvetch can be living mulch in crop rotations with corn, hay, and small grain. See the Penn State University Bulletin, Crownvetch and No-Tillage Crop Production for Soil Erosion Control.

Erosion Control

To increase surface residue cover in no-till, ridge till, or strip till residue management systems seeded with small grain cover crops, delay killing the crop until it reaches a height of 8-10 inches. In mulch-till systems, to achieve the planned percent cover after planting, use secondary tillage only once to prepare a seedbed with adequate cover. Soil finishing combination tools work best for till then plant.

To increase surface residue cover in no-till, ridge till, or strip till residue management systems seeded with legumes as the cover crop, delay killing the cover until it reaches a height of 6-8 inches. In mulch-till systems, limit tillage to two passes (one primary tillage-chisel or deep disking and a secondary tillage pass), or two other trips.

To maintain organic matter in low residue producing crop systems like vegetables, sow Sorghum, Sorghum-Sudan hybrids, Sudan grass, or corn to produce a high level of biomass. Use a rate of nitrogen (100 lbs/ac) to get maximum growth. Kill the cover crop in late summer/early fall with herbicides or shallow tillage and drill a rye cover to increase organic matter and improve soil tilth Alfalfa, sweet clover, rye, ryegrass, and clovers in the crop rotation are excellent choices to help build or maintain organic matter in the soil.

To enhance carbon sequestration, use crop rotations with high residue producing crops such as corn, small grain, or alfalfa; plus no-till or mulch till; plus cover crops; plus straw bedded manure.

Weed and Pest Suppression

Cereal rye and annual ryegrass have alleopathic effects on weed seedlings. Allow rye or ryegrass to reach a minimum 8-inch height before killing with herbicides or tillage to encourage alleopathic effect.

When brassicas are seeded as bio-fumigants a mixture of brown, white and yellow mustard should be planted and allowed to reach green pod stage before incorporation. The goal is to prevent the brassicas from producing viable seed and the soil should be sealed after incorporation to increase the effectiveness of the glucosinolates bio-fumigation.

For long term weed suppression, including on sites to be planted to trees etc. perennials and biennial species can be used.

US Department of Agriculture
Natural Resources Conservation Service

Cover Crops 340
June 2013

Michigan Cover Crop Certification Worksheet

Note: Yellow areas indicate required data. Blue areas indicate optional data.

Name:
Address:
Field No.:
Section: **Township:** **Range:**

Program:
Contract #:
Contract Item No.:
Acres:

Indicate the decision-maker's objective(s) for applying cover crop, in priority order (1, 2, 3,etc.)

______ Reduce Erosion
______ Biological Nitrogen Fixation
______ Pest Suppression
______ Increase Soil Organic Matter
______ Increase Biodiversity
______ Utilize Excess Soil Moisture
______ Minimize or Reduce Soil Compaction
______ Capture Nutrients
______ Reduce Crop Abrasion
______ Other______________________

Cover Crop Certification Worksheet

Name: ______________________________
Address: ______________________________
Site location: ______________________________
Section: **Township:** **Range:**

Program: ______________________
Contract #: ______________________
Contract Item #: ______________________
Acres Planted:

Instructions: Document producer's actual cover crop planting information below. Attach or include photos of the cover

Species	**Total**	**Plants per**
Total Lbs:	0	

Practice Check Out Conditions

Site Preparation:

Fertility Used:

Date Planted: ____________

Planting Depth: ______ **inches**

Planting Method: **Drilled** **Broadcast** **Aerial** (circle one)

Weed Control (chemical/mechanical):

Termination Method:

Cover Crop Height at Termination: ______ **inches**

Irrigated: **Yes** **No** (circle one)

Notes and Comments:

______________________________ ______________________
Producer Signature **Date**

I certify that the above information **does / does not** meet NRCS specifications for design and installation.

______________________________ ______________________
NRCS Signature **Date**

Planner:			**Date:**
Name:		**Program**	
Address:		**Contract #**	
Field No.:		**Item #**	
Section:	**Twp:**	**Range:**	**Acres:**

Conservation Planning

Primary Crop		Soil Type	
Fertilizer Rate		Existing SCI	
Seeding Method		Planned SCI	
Termination Method		Δ Erosion	

Drilled	**Life***	**1000seeds**	**lb/ac**	2	**Cost**	**Cost**	**1000Seeds**
Species	**Cycle**	**/Pound**	***alone***	**SPECIES**	**/ lb.**	**/ac**	/acre
Legumes				**LB/AC**			
☐ Alfalfa	p	220	9 to 25	0.0	*5.49*	$ -	0
☐ Alfalfa Non-Dormant	a	220	12 to 16	0.0	*2.50*	$ -	0
☐ Alsike Clover	b/p	680	6 to 8	0.0	*3.99*	$ -	0
☐ Annual Medic	a	300	10 to 39	0.0	2.00	$ -	0
☐ Berseem Clover	sa	200	9 to 20	0.0	1.49	$ -	0
☐ Birdsfoot Trefoil	p	375	5 to 6	0.0	*4.99*	$ -	0
☐ Crimson Clover	sa	140	10 to 15	0.0	3.99	$ -	0
☐ Cowpeas	sa	3	45 to 60	0.0	*0.85*	$ -	0
☐ Field (W) Peas	a	3	60 to 90	0.0	*1.49*	$ -	0
☐ Hairy Vetch	p	20	15 to 22	0.0	*4.00*	$ -	0
☐ Ladino Clover	p	800	2 to 6	0.0	*5.49*	$ -	0
☐ Red Clover	p	280	8 to 12	0.0	*3.99*	$ -	0
☐ Soybeans	a	5	45 to 60	0.0	*2.99*	$ -	0
☐ Sweet Clover	b/p	260	6 to 10	0.0	*3.50*	$ -	0
☐ White Clover	p	800	2 to 6	0.0	*4.99*	$ -	0
☐ 60/40 SWC	b/p	270	8 to 12	0.0	*3.25*	$ -	0
☑ 80/20 SWC	b/p	216	8 to 12	7.0	*3.25*	$ 22.75	1512
Non legumes			***alone***	**LB/AC**			
☑ Annual Ryegrass	a	227	20 to 30	12.5	*0.50*	$ 6.25	2838
☐ Winter Barley	a	14	60 to 150	0.0	*0.25*	$ -	0
☐ Buckwheat	a	20	45 to 60	0.0	1.99	$ -	0
☐ Winter Cereal Rye	a	18	28 to 170	0.0	*0.50*	$ -	0
☐ Japanese Millet	a	86	20 to 25	0.0	*1.00*	$ -	0
☐ Pearl Millet	a	86	20 to 25	0.0	*1.00*	$ -	0
☐ Oats	a	13	30 to 100	0.0	*0.50*	$ -	0
☐ Sunflower	a	7	5 to 10	0.0	*0.45*	$ -	0
☐ Sudan Grass	a	55	25 to 30	0.0	*1.99*	$ -	0
☐ Winter Triticale	a	13	60 to 150	0.0	*0.21*	$ -	0
☐ Winter Wheat	a	12	60 to 150	0.0	*0.50*	$ -	0
Brassicas			***alone***	**Lbs/ac**			
☐ Dwarf Essex Rape	a	157	2 TO 5	0.0	*1.10*	$ -	0
☐ Forage Rape	a	270	2 TO 5	0.0	*3.99*	$ -	0
☐ Forage Turnip	a	270	1 TO 4	0.0	*3.99*	$ -	0
☐ Oilseed Radish	a	34	5 to 12	0.0	*3.99*	$ -	0
☐ Mustard	a	157	4 TO 8	0.0	*3.50*	$ -	0
Total				**Mix #/acre**		Mix $/acre	Seed/sqft
				19.5		$ 29.00	100

Line 41 OSR	sow only 1 lb/ac where P loss is a concern
*Life Cycle	p= Perennial a=Annual sa=Semiannual b/p=Biannual/Perrenial

RESIDUE MANAGEMENT PLAN

CONSERVATION MANAGEMENT SHEET

AGRONOMY SERIES JULY 1997

Natural Resources Conservation Service

Michigan

Mulch tillage in wheat residue with chisel

What is Residue Management?

Crop residue is a resource providing erosion control and environmental protection. Operators can manage moisture, and residue with various conservation tillage systems such as: No-till, Zone till, Strip till, Mulch till, and Ridge till.

How Residue Management Works

Residue cover that is left on the soil surface provides protection from wind and water erosion. Residue intercepts raindrops and serves as an umbrella to dissipate the energy of rain as it strikes the soil surface. It also intercepts and armors the soil surface against the bouncing and abrading action of wind-blown soil particles, especially sand. Residue cover also keeps the soil cooler and moister.

Where Residue Management Applies

Residue management can be applied on cropland where wind and water erosion are identified as a resource concern or water quality is degraded by sedimentation. Residue management reduces water runoff from a field. Crop residues help protect water quality, improve soil tilth and increase organic matter content.

Where to Get More Assistance

Additional local assistance may be obtained from the local office of a Michigan Conservation District or the USDA Natural Resources Conservation Service (NRCS) office at:

_____

_____

_____

Design Criteria

Tillage System Schedule:

Tillage Systems Planned

A. ____

B.____

Date: ____________________________________

Farm Name:________________________________

Assisted by: ______________________________

C. ____

D.____

Field Tillage Number	Crop	Previous Residue	System	Year	Planned Percent Cover after planting	Actual Percent Cover after planting

Note: Prior to tillage, measure residue levels
[*see NRCS Conservation Manaagement sheet "Line Transect Residue and Cover Estimates* "]

Considerations for Design

Harvest until Primary tillage

Landowner Objectives
1- Review tillage schedule and residue goals
2- Improve soil structure/reduce compaction
3- Apply fertilizer/manure according to crop needs and field conditions
4- Make structural improvements prior to planting such as repairing waterways or leveling ruts
5. Control perennial weeds

Residue effects: Mulch till leaving 20% residue cover after planting may reduce erosion as much as 50%; 30% residue cover after planting may reduce erosion as much as 65%. Larger residue pieces are more valuable from an erosion standpoint because they cover more ground, decompose more slowly, don't get buried as easily and are harder to wash or blow away.

Recognize differences in crop residue
Coulters/disks may need to be adjusted for each field. There is a difference between fragile and nonfragile residue. Fragile residue tends to be more brittle, break into smaller pieces easily and decomposes quickly. Non-fragile residue tends to be more durable and remain in larger pieces. If residue is crimped and sized it deteriorates faster. Overwinter decomposition decreases the amount of fragile residue as much as 70-80%; nonfragile residues as much as 80-95%. Examples of fragile and non-fragile residue are as follows:

non-fragile residues:	***fragile residues:***
corn (grain or seed)	*soybeans*
alfalfa or legume hay	*corn silage*
wheat, oats, rye, barley	*dry beans and snap beans*
grasses and pasture	*sugar beets and potatoes*
	fall seeded cover crops
	sorghum silage

Leave fragile residues undisturbed on all soils; leave non-fragile residues undisturbed on well-drained soils to maximize residue levels.

Residue management checklist:
1. Minimize fall tillage and don't till wet soils.
2. Larger pieces of residue are more valuable because they cover more ground, decompose more slowly, don't get buried as easily and are harder to wash or blow away.
3. When harvesting, spread crop residue evenly.
4.Maintain surface residue cover by operating equipment as shallow as possible. Also, use wider shank spacing or wider blade spacing and reduced gang angle.
5. Use low crown sweeps or spikes rather than wide or twisted shovels.
6. Till fields on the contour or across slopes to avoid furrows which channel water down hills.

Agronomic Considerations

1-Soil test and plan fertility programs.
2-Make application of manure, fertilizer, lime and some herbicides prior to planting and secondary tillage.
3-Alleviate compaction, level ruts/ridges and leave as much residue as possible.
4. Control perennial weeds

Fertilizer management can be more challenging because...
-soil moisture is increased
-soil temperature is decreased
-stratification of fertilizer can occur, especially with insoluble materials like P and K
-surface applications are more prone to loss/tie-up, especially with nitrogen
-perrenial weeds are tough to control

1. Where P and K are low, consider pimary tillage to help mix fertilizer into the soil profile.

2. Applying fall/early spring fertilizer needs with primary tillage has the following benefits:
-incorporation is better
-planting time workload is reduced
-compaction is less due to drier/firmer soils

3. Manure must be incorporated to capture the full fertility value because as much as 85% of manure nitrogen can be lost when surface applied. And phophorus incorporation reduces runoff loss.

4. Management options for better utilization of manure to prevent volatilization and loss via runoff include:
-injecting
-broadcasting prior to tillage
-enriching manure with anhydrous, if necessary, and using nitrogen stabilizer
-putting heavy applications of manure on for more than one crop in the rotation

5. Weed management is critical.
To prevent buildup of perennial weed populations, spot treat with Roundup or use Roundup resistant crop varieties. Make sure field is level (no mild

ridges or ruts) to allow uniform herbicide applications on first spring tillage pass

6. Prevent Soil Compaction.
Don't drive on wet fields and minimize trips by prioritizing and combining operations. Eliminate unnecessary traffic and use wide tires, duals or tracks to spread weight across a greater surface area.

Equipment Considerations

Combining field operation to get an even residue layer is critical to good residue management. Two main options exist for spreading residue: straw spreaders or straw choppers.

Straw spreaders work best with grain heads under 15 feet and when tillage can be used to further spread residue. Spreaders leave residue intact.

Straw choppers are better for heads over 15 feet or when residue will plug tillage or planting equipment. Choppers will break residue into smaller pieces that can deteriorate more quickly.

Consider adding a chaff spreader to improve seed-soil contact, especially after high residue crops (wheat) are followed with a no-till system.. Chaff can also cause alellopathic seedling problems.

Even residue distribution:
-promotes even drying and warm-up in the spring for timely seedbed preparation.
-exposes more weed seeds to herbicide and improves residual herbicide activity.
-prevents tie-up of fertilizer in heavy residue mats
-minimizes residue bunching which can plug tillage machines.
-reduces alellopathic effect

Primary tillage tools

Primary tillage is from 3" up to 20" deep and is generally performed after harvest in the fall or early spring.

Disks- invert soil,: size and mix residue, level rough surfaces, incorporate chemicals and nutrients evenly into soil.
Operating tips: Operate in moist to dry soils. Use scrapers in heavier soils. Slower speeds bury *less* residue. Deeper tillage buries *more* residue. Best performance is achieved with speeds of 5-5 1/2 MPH
Attachments: Coil tine harrow provide stirring and leveling action. Spike tooth harrow breaks clods and provides some stirring and leveling action, spreads residue.

Residue management adjustments: Four factors determine residue levels: blade spacing, gang angle, speed and depth.
Blade spacing: Wider blade spacing (11") leaves more residue than narrow blade spacing (9").
Gang angle: Less angle (20 degrees or less) leaves more residue .
Speed: lower speeds (5 1/2 MPH) or less leave more residue.
Depth: Shallower depth (3" or less -finger length) leaves more residue than 3-6" depth.
Concave shape of disk: more concave disks throw more soil and residue
V-Rippers- shatter soil of tillage/plow pan up to 20 inches deep for aeration and moisture infiltration. Coulters can be used in heavy residue to minimize plugging. Narrow points will disturb the soil surface less, leave more residue and require less horsepower than wider points. Shanks are usually set on 20 inch spacing.
Operating tips: Determine tillage/plow pan depth when soil is moist with a penetrometer, shovel, soil auger or post hole digger to a depth of 2 feet. Set depth in soil 1 inch below pan to maximize shattering. Under ideal conditions each shank will shatter the soil at a 45 degree angle, (i.e. for each 1 inch of depth, shatter should be 2 inches wide). For example, a shank set 1 foot deep should shatter the surface 1 foot in each direction from the shank. O*n hilly land, operate on the contour in the fall, to prevent water erosion down the shank path.*

Disk Rippers or combination deep tillage tools- size residue, mix organic matter into the soil, shatter the plow/till pan up to 15 inches and leave a level, but rough, surface profile. *They are generally recommended on level soils that have low erosion potential and apt to be shallow compacted by wheel traffic and excessive tillage*. Lesser gang angle, lesser disk depth, narrower points and slower operating speed leaves more residue and requires less horsepower.
Operating tips: Determine till/pan plow depth, as with V-rippers above. Adjust disk gang depth for desired tillage depth and residue level needed to reduce erosion.
Attachments: Levelers may be needed to level out ridges and valleys left from primary tillage.

Chisel Plows provide deeper tillage than disks and with less horsepower; till and mix soil up to 10" deep, leave a rough surface, and handle most residue at the wider shank spacing, 12-16" is the normal spacing. Spikes, points, and shovels penetrate better and give more action than sweeps, but bury more

residue. Sweeps undercut perennial weeds and leave more residue.

Operating tips: Low crown sweeps leave more residue. Twisted shovels bury the most residue and provide the best mixing. Slower speeds leave more residue. Use narrow chisel points to penetrate hard ground. Chiseling when soil is wet creates clods. *Residue flow in heavy residue can often be improved by operating at a 10 degree angle to the harvest operation or planted row.*

Attachments: Levelers, such as S-tine levelers, may be needed to level out ridges and valleys left from primary tillage. Leveling during primary tillage is important for one pass preplant herbicide applications to insure uniform incorporation to the proper depth.

Disk Chisels (Mulch tillers)- till up to 12"deep with coulters in front cut and bury residue, leave surface rough and when equipped with sweeps saves up to 80% of initial residue. Coulters size residue for better flow with very little burial. Hydraulic coulters give flexibility to retract on-the -go when not needed. Sweeps lift and shatter soil but do very little inversion. Shovels, points, and spikes invert the soil for better working action, but leave less residue.

Operating tips: Use coulters only when residue sizing is needed to improve residue flow

Attachments: S-tine levelers level soil profile by reducing ridges and valleys. Disk levelers level soil profile by reducing ridges and valleys.

Seedbed Preparation

Landowner Objectives

1- provide a uniform seedbed
2- maintain surface residue
3- incorporate fertilizer, pesticides or manure
4- mechanically control weeds

Residue Effects

Most soil erosion takes place during spring and early summer. On sloping land it's critical that tillage systems maximize surface cover. Spring is a good time for establishing contour lines, contour strip cropping, waterways, field borders, filter strips, buffer strips and other conservation practices. Seedbed preparation is a critical time to manage crop residue. However, even the best plans may need to be modified or fine-tuned if weather conditions, crop rotation needs , weeds or other factors have made the plan less practical.

Residue Management Checklist

Remember: every pass with tillage equipment, fertilizer injectors or planters buries residue. Once it's buried, residue is generally hard to recover.

1. Choose the sweeps, shanks, coulters, and attachments, that best maintain surface residue.
2. Make sure equipment operation is level to avoid running too deeply.
3. Use wider gang spacing to allow easier residue flow and minimize burial.
4. Dont till any deeper than necessary. Deep tillage with disks causes more sizing of residue and deeper blade compaction. Shank implements moves more soil to bury residue.
5. Operate equipment at recommended speeds.
6. Avoid tilling wet soils.

Secondary tillage tools

Disks-Handles a wide range of residues in secondary tillage. Disks are marginal for one-pass herbicide incorporation. Disk blades size residue and invert soil, which can bury a lot of residue. Disks with narrower spacing (9 inches or less) and higher gang angles tend to bury more residue and leave larger soil aggregates. Disk blades generally outlast sweeps and shovels.

Operating tips: Operate only deep enough to incorporate chemicals. *This is generally twice the recommended chemical incorporation depth.* Disks perform best at 5 to 5 1/2 MPH. Best incorporation is achieved when the disk is level fore-to-aft and side-to -side. Use minimum gang angle to retain residue.

*Attachments: Coil tine harrow*s provides stirring and leveling action. *Spike tooth harrow* breaks clods and provides some stirring and leveling. *Spray attachments* can be mounted in front of gangs for immediate incorporation of fertilizer and chemicals.

Mulch Finishers are 3-element combination tools with disk gangs, field cultivator shanks, and tine or spike tooth harrows, that handle a wide range of residue, surface, and soil conditions. Mulch finishers can save up to 90% of pre-tillage residue. *Disk gangs* size residue to improve flow but can be raised to leave more residue or lowered for heavier soils *Shanks* on 8 inch spacing can be equipped with spikes or sweeps. *Spikes* break up clods whereas sweeps incorporate. *Tine tooth harrows* substituted for shanks stir soil for better incorporation and leveling also, handle high residue.better. *Rolling baskets* provide good leveling, incorporation and soil firming.

Operating tips: Mount spray attachments in front of shanks in rough fields and high residue/weed level; mount in front of disk gangs in less weedy fields. Operate 5-7 MPH with shank depth at 2X required chemical incorporation depth.

Field Cultivators handle moderate residue (50-60%) and save up to 90% of pre-tillage residue, and are

marginally effective for one-pass incorporation. For shank choices there are two designs: *C-shank or S/K tines*.
C-shanks give rigid action to cut weeds, mix soil, hold depth and shed residue in clay soils. *S/K tines* vibrate for mixing action, to uproot weeds, level soil, and create a seedbed in lighter soils. Use narrow sweeps/shovels for crusted hard soils; wide sweeps/shovels for up rooting weeds, retaining residue and mixing of chemicals/fertilizers.
Operating Tips: Set deep enough to incorporate chemicals (2X required chemical incorporation) @ 6-7MPH.
Field cultivator attachments include: Tine tooth harrow, spike tooth harrow or rolling basket.
Tine tooth harrow stirs/levels soil and handle moderate residue. *Spike tooth harrow* breaks clods, stirs and levels some, and handles moderate residue. *Rolling baskets* are good for leveling and firming seedbed, but not recommended in rocky, high residue or wet conditions.

Planter Attachments
Use a coulter to cut residue and till a narrow zone of soil. Various blade options available include: bubble blades, fluted coulters, and multiple coulter options.
-*bubble blades* cut residue with minimum tillage.
-*1"-8 flute blades* will maximize tillage at faster planting speeds (5 1/2MPH).
-*3/4"-13 flute blades* will do zone tillage with less slabbing.
-*2/3" 25 flute blades* will do slightly narrower zone tillage.

Conservation disk furrowers and row cleaners clear the planting zone of residue and clods for faster soil warming and uniform seed placement. Unit-mounted row cleaners sweep residue to the side and give the opener system a smoother path down the row. They also increase soil warm-up, reduce hair-pinning of residue in the seed furrow and remove decaying, toxic residue away from the seed zone..

Coulter and row cleaner combinations give zone tillage with residue removal for more aggressive action in high residue conditions. These should be set to move residue, not soil, and are not recommended where preplant or surface herbicides are applied. However, *triple coulter arrangements* have been used to incorporate PPI herbicides successfully. And when combined with row crop cultivation and band application successful weed control has resulted.

Rubber closing wheels can close and firm the seed trench in most conditions; use cast iron wheels in tougher conditions.

Heavy duty down pressure springs can keep planting units from bouncing on rough seedbeds and improve planter penetration in trash and hard soil conditions.

Operating tips:
-Set coulters, row cleaners or furrowers on planters and drills in high residue situations to clean row for planting without burying extra residue.
-Limit the use of residue attachments in moderate residue levels.
-Avoid furrowers in hilly situations to prevent creation of water carrying channels.
-Reduce down pressure and weights when planting in moist soils to prevent side-wall compaction of the seed furrow.
-Consider narrow row planting or drilling to accelerate and maximize crop canopy.
-Maximize surface residue remaining from operation like row crop cultivation, by using fewer shanks and low crown sweeps.

Considerations

A number of effects to environmental conditions will occur from cultural operations used on fields where residue management is applied. A consideration of these effects will allow for incorporation of companion planning elements to achieve an ecosystem-wide conservation plan for the area in which the plant residue and/or ground cover is established. Effects which may be considered include: sheet and rill erosion - RUSLE, wind erosion - WEQ, ephemeral gully (tons/ac/yr.), soil tilth, crusting, infiltration,. organic matter maintenance, soil compaction, plant productivity, plant health and vigor, nutrient and pesticide runoff.

Where air quality can be diminished from spray drift, consider impregnating broadcast fertilizer with insecticides or herbicides and spreading prior to secondary tillage. This is an important consideration in residential areas and where rural roads have been impacted by strip development. It also can eliminate an operation during secondary tillage and keep weeds from emerging prior to planting.

Natural Resource area(s) expected to be addressed by the use/application of this conservation sheet:

[x] Soil, [x] Water, [x] Air, [x] Plants,
[x] Animals, [x] Human Socio-economics.

Maintenance

1. Where residue accumulates greater than 2 inches deep due to runoff or flooding, consider one of the following operations prior to planting:
-extra tillage to bury the residue
-baling the residue or chopping
-loading the residue into a manure spreader and spreading it over a larger area
-spot burning
-raking into windrows
2. Try to maintain even amounts of residue on driveways, headlands, loading areas, and where possible avoid spreading on grassed waterways, field strips and filter strips.
3. Partial removal of residue by baling or grazing shall be limited to retain the amount needed according to the residue management plan.
4.Cover crops such as small grains may be required to meet the planned residue objectives, especially after fragile (low) residue producing crops.
5. A contact herbicide may be needed prior to secondary tillage if emerged weeds get too big to control with planned tillage. Or are difficult to control with the planned crop rotation.
6. Drilling soybeans, using narrow rows in corn and selecting tall bean or corn varieties can aid in achieving planned residue objectives. All can provide a quicker and more complete canopy for better erosion and weed control.

Insect pressure will change under high residue management conditions. Use of Integrated Pest Management scouting techniques for insect pests such as: black cutworm, armyworm, stalkborer, wireworm, seed corn maggot and slugs may increase under cool , wet soil conditions that delay crop emergence or weedy conditions that encourage insect development.

Weed problems may change under residue management systems. More weed seeds are left near the surface and if allowed to germinate weed problems can intensify. High residue levels result in cooler and wetter soil in early spring. This may influence weed seed germination, delaying germination of warm-temperature weeds like pigweed, crabgrass or barnyardgrass. Annual grasses such as giant foxtail or foxtails favor less tillage conditions. Early planting of soybeans ahead of perennial emergence can prevent use of Roundup to provide season long weed control. Use of Roundup Ready varieties will improve perennial weed control where early planting is used. Winter annual weeds often infesting no-till fields include marestail or horseweed, purselane, speedwell, field pennycress, daisy fleabane, and shepherds purse. Non-selective herbicides such as Gramoxone or Roundup control most of these weeds. Also, 2, 4-D applied before planting has provided excellent control.

This Conservation Information Sheet

Prepared By:
Jerry Grigar, Jr State Agronomist USDA NRCS (MI)

Technical Review By: Jerry Lemunyon, South Central Region Nutrient and Pest Management Specialist

Reference/File Indexes

Topic Application:
[ ] Construction
[X] Design
[X] Fact
[ ] Information
[ ] Management
[ ] _____

Resource Series:
[X] Agronomy
[ ] Biology
[ ] Engineering
[ ] Forestry
[ ] Hayland
[ ] Livestock
[ ] Pastureland
[ ] Recreation
[ ] _____

FOCS (MI) Reference Number:
CS _____

References:
Conservation Cropping Systems Mulch-Till Farming for the 90's and Beyond Dow Elanco, Deere & Company and USDA SCS
Weed Problems May Change In Conservation Tillage Dr. Richard Fawcett. *Farm Chemicals, Feb. 1985*
USDA-ARS Ag Handbook 703
USDA-NRCS RUSLE Manual

USDA NRCS (MI) Conservation Practice Associations:
(327) Conservation Cover
(329A) Residue Mgt. No-till and Strip Till
(329B/C) Residue Mgt. Mulch Till/Ridge Till
(340) Cover cropss

USDA NRCS (MI) Associated Conservation Sheets:
Line Transect Residue and Cover Estimates

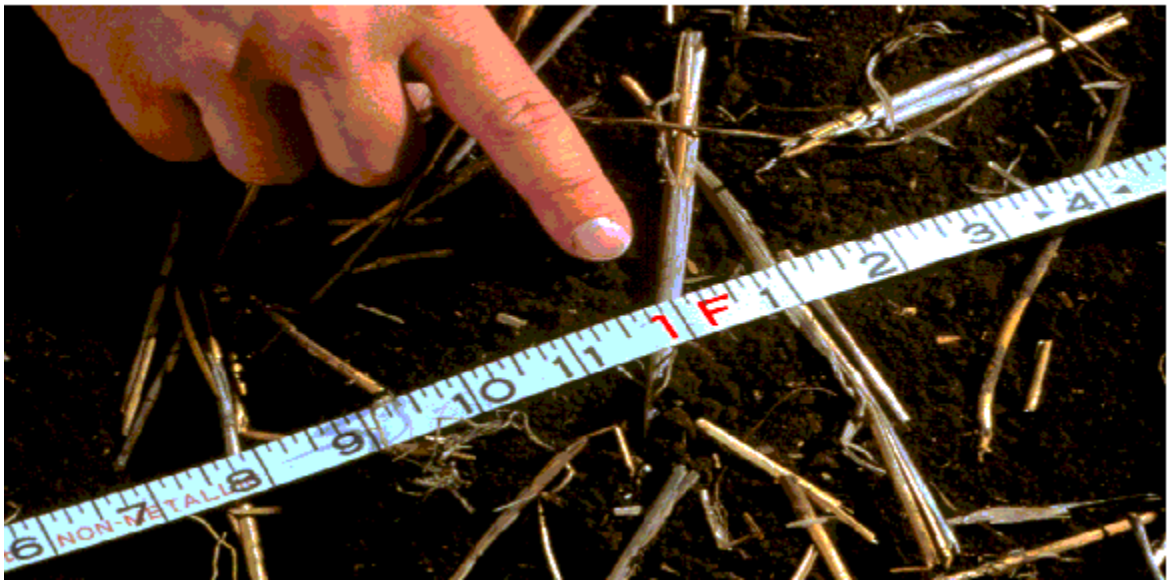
LINE TRANSECT
RESIDUE AND COVER ESTIMATES

CONSERVATION MANAGEMENT SHEET

AGRONOMY SERIES May 1997

Natural Resources Conservation Service

Michigan



Line Transect showing method for estimating ground cover

What is a Line Transect?

A Line Transect is a field measurement technique that has been proven effective in estimating the percent of ground surface covered by plant residue. It is most accurate when the residue is lying flat on the soil surface and is evenly distributed across the field. Also, it may be used to estimate crop residue, live plant cover and other ground cover at any time.

How a Line Transect Works

A marked cable, line, or tape measure is placed across the surface of a field for which an estimate of the percentage of ground cover is desired. Careful observation of the number of marks which occur above various types of ground residue and/or cover may be counted and extrapolated into an estimate of protective cover for the entire field. This is then used
to predict the impact on sheet and rill erosion.

Where a Line Transect Applies

A Line Transect method of estimating the amount of plant residue, or ground cover, remaining on the surface of a field may be used at any time it is necessary, or desirable to know the amount of residues and cover on that field. Typically, it is applied to agricultural fields shortly after a field has been planted into an annual small grain or row crop, usually before crop emergence.

Where to Get More Assistance

Additional local assistance may be obtained from the local office of a Michigan Conservation District or the USDA Natural Resources Conservation Service (NRCS) office at:

_____

_____

_____

Design Criteria

Design Elements:

1. A commercially available 50- or 100-foot-long cable, line, or tape measure with 100 equally spaced beads, knots, or other graduations over which to sight may be used.

2. The cable, line, or tape measure will be tautly stretched across the surface of a representative portion of the field on which an estimate of plant residue and ground cover is being made. The line may be perpendicular to the row direction or in a direction at least 45 degrees off the row direction. End rows, field borders, and parts of the field that are not representative of the entire field should be avoided. Measurement location should be randomly selected. The cable, line, or tape measure must not be moved during the following procedure.

3. Walk along the cable, line, or tape measure stopping at each mark. sight directly down across the edge of a single, selected point on the mark (i.e., a small portion of the mark about the size of a needle point-corner, top edge, etc. of the mark). **Use the same reference point on each mark**.

Considerations for Design

1. Count all of the marks along the cable, line, or tape measure (100 total) for which only the selected reference portion of the e mark (not any other part of the mark) is directly above plant residue, living or dead , or *other surface cover*.
NOTE: Surface cover is defined as any material in contact with the soil surface that might intercept raindrops and slow surface runoff. Surface cover includes rock fragments, live vegetation, and particles of plant (or other) residue. Crop residue must be attached to the surface or be of sufficient size that it will intercept raindrops and not be removed by runoff. [RULE OF THUMB: Count only surface cover particles that are 3/32 inch in diameter, or larger.] The number of possible marks counted (out of 100 total) equals the percent of ground covered by plant residue and/or other ground cover.

2. Repeat the Transect 3-5 times in a single field and average the results for and estimate of plant residue and/ or ground cover on the field. Five transacts are recommended on each field.

NOTE: Three transects will provide an estimate accurate to within +/-32 percent of the mean. Five transects will provide an estimate to within +/-15 percent of the mean. (Example: an averaged estimate of five measurements which suggest a plant residue and/ or ground cover of 50% on a field can be expected to actually be estimated between 42.5% and 57..5% at the 95% confidence level.

Other Considerations

A number of effects to environmental conditions will occur from cultural operations used on fields where a Line Transect field measurement technique is used to estimate the percent of plant residue and/or ground cover that is there. A consideration of these effects will allow for incorporation of companion planning elements to achieve an ecosystem-wide conservation plan for .the area in which the plant residue and/or ground cover estimates are made. Effects which may be considered include: sheet and rill erosion wind erosion ephemeral gully(tons/ac/yr.), tilth, crusting, infiltration. organic matter maintenance , :soil compaction, plant productivity, plant heath and vigor, etc.

Natural Resource area(s) expected to be addressed by the use/application of this conservation sheet:

[x] Soil, [x] Water, [x] Air, [x] Plants,
[ ] Animals, [x] Human Socio-economics.

Maintenance

The cable, line or tape measure used must be kept repaired. All marks must be present and visible.

For More Information

Additional information about the application and use of the Line Transect method to estimate the percent of plant residue and/or ground cover on a field may be obtained from the world wide web
(http: //www.minrcs.usda.gov).

Field Residue Estimates

Date:____/____/____
Assisted by:_____

Client and Location: County_____
Client Name:_____
Township :_____
Farm name_____
Field No._____ Tract No._____

1. Field Number:_____ Field Crop:_____.
Field Condition: [ ] Idle, [ ] Fallow, [ ] No-tilled,
. [ ] Plowed, [ ] Disked, [ ] Dragged, [ ] Planted
[ ] Cultivated, [ ] Manure, [ ] Other_____

Marks counted (each transect)

_____,_____,_____,_____,_____ = _____ / 5 =
Estimated plant residue and/or ground cover_____%.

.....

2. Field Number:_____ Field Crop:_____.
Field Condition: [ ] Idle, [ ] Fallow, [ ] No-tilled,
. [ ] Plowed, [ ] Disked, [ ] Dragged, [ ] Planted
[ ] Cultivated, [ ] Manure, [ ] Other_____

Marks counted (each transect)

_____,_____,_____,_____,_____ = _____ / 5 =
Estimated plant residue and/or ground cover_____%.

.....

3. Field Number:_____ Field Crop:_____.
Field Condition: [ ] Idle, [ ] Fallow, [ ] No-tilled,
. [ ] Plowed, [ ] Disked, [ ] Dragged, [ ] Planted
[ ] Cultivated, [ ] Manure, [ ] Other_____

Marks counted (each transect)

_____,_____,_____,_____,_____ = _____ / 5 =
Estimated plant residue and/or ground cover_____%.

.....

4. Field Number:_____ Field Crop:_____.
Field Condition: [ ] Idle, [ ] Fallow, [ ] No-tilled,
. [ ] Plowed, [ ] Disked, [ ] Dragged, [ ] Planted
[ ] Cultivated, [ ] Manure, [ ] Other_____

Marks counted (each transect)

_____,_____,_____,_____,_____ = _____ / 5 =
Estimated plant residue and/or ground cover_____%.

.....

5. Field Number:_____ Field Crop:_____.
Field Condition: [ ] Idle, [ ] Fallow, [ ] No-tilled,
. [ ] Plowed, [ ] Disked, [ ] Dragged, [ ] Planted
[ ] Cultivated, [ ] Manure, [ ] Other_____

Marks counted (each transect)

_____,_____,_____,_____,_____ = _____ / 5 =
Estimated plant residue and/or ground cover_____%.

.....

6. Field Number:_____ Field Crop:_____.
Field Condition: [ ] Idle, [ ] Fallow, [ ] No-tilled,
. [ ] Plowed, [ ] Disked, [ ] Dragged, [ ] Planted
[ ] Cultivated, [ ] Manure, [ ] Other_____

Marks counted (each transect)

_____,_____,_____,_____,_____ = _____ / 5 =
Estimated plant residue and/or ground cover_____%.

.....

7 Field Number:_____ Field Crop:_____.
Field Condition: [ ] Idle, [ ] Fallow, [ ] No-tilled,
. [ ] Plowed, [ ] Disked, [ ] Dragged, [ ] Planted
[ ] Cultivated, [ ] Manure, [ ] Other_____

Marks counted (each transect)

_____,_____,_____,_____,_____ = _____ / 5 =
Estimated plant residue and/or ground cover_____%.

.....

8. Field Number:_____ Field Crop:_____.
Field Condition: [ ] Idle, [ ] Fallow, [ ] No-tilled,
. [ ] Plowed, [ ] Disked, [ ] Dragged, [ ] Planted
[ ] Cultivated, [ ] Manure, [ ] Other_____

Marks counted (each transect)

_____,_____,_____,_____,_____ = _____ / 5 =
Estimated plant residue and/or ground cover_____%.

.....

This Conservation Information Sheet

Prepared By:
Jerry Grigar, Jr. State Agronomist USDA NRCS (MI)
Michigan's sUPerior Watershed Team USDA NRCS (MI)

Technical Review By: Dr. Jerry Lemunyon
USDA NRCS *Grazing Lands Institute (TX)*

Reference/File Indexes

Topic Application:

[ ] Construction
[X] Design
[ ] Fact
[ ] Information
[ ] Management
[ ] _____

Resource Series:

[X] Agronomy
[ ] Biology
[ ] Engineering
[ ] Forestry
[ ] Hayland
[ ] Livestock
[ ] Pastureland
[ ] Recreation
[ ] _____

FOCS (MI) Reference Number:
CS _____

References:

USDA NRCS Ag Handbook 703
USDA-NRCS National Agronomy Manual
USDA-NRCS RUSLE Handbook

USDA NRCS (MI) Conservation Practice Associations:

327 Conservation Cover
329A Residue Mgt. No-till and Strip Till
#329B Residue Mgt. Mulch Till
#329C Residue Mgt. Ridge Till

USDA NRCS (MI) Associated Conservation Sheets:

FILTER STRIP

CONSERVATION SHEET – Agronomy Series **393**

Natural Resources Conservation Service

Michigan

Definition
Filter strips are areas of herbaceous vegetation situated between cropland, grazing land, forest land, or disturbed land and environmentally-sensitive areas. Sensitive areas include streams, lakes, wetlands, and other water bodies and areas susceptible to damage by water-borne pollutants, including sediment, particulate organics, sediment-adsorbed contaminants, and dissolved contaminants.

Purposes
Filter strips function by: 1) reducing sediment, particulate organics, and sediment-adsorbed contaminant loadings in runoff; 2) reducing dissolved contaminant loadings in runoff; 3) serving as Zone 3 of a Riparian Forest Buffer (see Practice Standard 391); 4) restoring, creating, or enhancing herbaceous habitat for wildlife and beneficial insects; and 5) maintaining or enhancing watershed functions and values.

Where Used
Filter strips are used on cropland, grazing land, forest land, or disturbed land.

Multiple filter strips can be strategically located in a watershed to reduce and slow runoff and increase infiltration and groundwater recharge. A filter strip is designated as a vegetated area to treat runoff and is not part of the adjacent cropland rotation. A strip is designed to filter surface sheet flow. Concentrated flows need to be dispersed before water enters a strip. A filter strip is typically positioned at the down-slope edge of a field or disturbed area. Filter strips are normally only used when adjacent and up-gradient areas have slopes gradients between 1 and 10 percent. To the extent practical, an individual filter strip is placed on the approximate contour, with its upper edge ideally not exceeding a 0.5 percent gradient (measured perpendicular to the flow length). When establishing a filter strip, consider using vegetation that is tolerant to herbicides used in the adjacent crop rotation.

Resource Management System

Filter strips are normally established concurrently with other practices as part of a resource management system for a conservation management unit. They should be installed only below areas where sheet and rill erosion have been reduced to an acceptable level and where other practices are in place that slow runoff and contaminant delivery. A filter strip is influenced by but is not considered part of the adjacent crop rotation.

Wildlife

Filter strips can enhance wildlife objectives depending on the vegetative species used and management practiced. Using native or adapted vegetative species can improve the wildlife values of a filter strip area as well as biodiversity. Avoid mowing during nesting periods.

Operation and Maintenance

Mow filter strips (and harvest if possible) as necessary to encourage dense vegetative growth. If established for wildlife habitat, avoid mowing during the nesting period of ground-nesting wildlife. Control undesirable weed species. Inspect and repair after storm events to fill in gullies, remove flow-disrupting sediment accumulation, reseed disturbed areas, and take other measures to prevent concentrated flow into and across the filter strip. Lime and fertilize to soil test recommendations to maintain a vigorous stand. Exclude livestock and vehicular traffic from filter strips during wet periods of the year to reduce compaction that will limit infiltration. This type of traffic should be excluded at all times to the extent practical. Restoration is required if the filter strip has accumulated sediment to a point that it no longer functions effectively.

Specifications

Site-specific requirements are listed on the specifications sheet. Additional provisions are entered on the job sketch sheet. Specifications are prepared in accordance with the NRCS Field Office Technical Guide. See practice standard Filter Strip, code 393.

Filter Strip – Job Sheet

Landowner_____ Field number_____

Purpose (check all that apply)	
☐ Reduce sediment, particulate organics, and sediment-adsorbed contaminant loadings in runoff	☐ Reduce sediment, particulate organics, and sediment-adsorbed contaminant loadings in surface irrigation tailwater
☐ Reduce dissolved contaminant loadings in runoff	☐ Restore, create, or enhance herbaceous habitat for wildlife and beneficial insects
☐ Serve as Zone 3 of a Riparian Forest Buffer (391)	☐ Maintain or enhance watershed functions and values

Layout	Strip 1	Strip 2	Strip 3
Strip width (feet)			
Strip length (feet)			
Area in strip (acres)			
Field slope (%)			

Plant Materials (species/cultivars)	Seeding Rate (lbs/acre of pure live seed)	Seeding Date
Strip 1:		
Strip 2:		
Strip 3:		

Soil Amend. and Fertilization	Strip 1	Strip 2	Strip 3
Lime per Soil Test (tons/acre)			
N Fertilizer per Soil Test – (lbs/acre)			
P_2O Fertilizer per Soil Test – (lbs/acre)			
K_2O Fertilizer per Soil Test – (lbs/acre)			

Site Preparation

Prepare a firm seedbed. Apply lime and fertilizer as indicated by soil testing. Additional requirements:

Planting Methods

Drill grass and legume seed _____ inches deep uniformly over area. Establish vegetation according to the specified seeding rate. If necessary, mulch newly seeded area with _____ tons per acre of mulch material. A small grain crop may be needed as a companion crop at the rate of _____ pounds per acre (clip or harvest before it heads out). Additional requirements:

Operation and Maintenance

Maintain original width and length of the filter strip. Harvest, mow, reseed, and fertilize as necessary to maintain plant density and vigorous plant growth. Inspect after major storms, remove trapped sediment, and repair eroding areas. Shut off pesticide sprayers when turning on a filter strip. Additional requirements:

Filter Strip – Job Sheet

If needed, an aerial view or a side view of the practice can be shown below. Other relevant information, complementary practices and measures, and additional specifications may be included.

Scale 1"=_____ ft. (NA indicates sketch not to scale: grid size=1/2" by 1/2")

Additional Specifications and Notes:

Nutrient Management 590 Specification Sheet

Manager:		**Field Location:**	
Assisted by:			
		Date:	2/16/2018

Purpose (Check all that apply)

	Budget & supply nutrients for plant production		Use animal waste as a nutrient source
	Minimize agricultural nonpoint source pollution		Maintain or improve soil condition

Table 1 Field Conditions and Recommendations

Crop sequence/rotation	Yield Goal	Year

Current soil test levels - PPM ( ) or lbs./ac (X)

N	P	K	pH	L Index	CEC	SOM%		

Recommended nutrients/amendments to meet expected yield (lbs./ac)

N	P_2O_5	K_20	Lime (Ca)	Lime (Mg)	Zn	Mn	B	Cu

Table 2 Nutrient Sources

Credits	N	P_2O_5	K_20
	Pounds per acre		
1. Starter fertilizer			
2. Broadcast fertilizer			
3. N credits from previous. legume crop			
4. Current Manure application			
5. Residual from long-term manure applied			
6. Irrigation Water			
7. Other (e.g., atmospheric depositions)			
8. **Total credits**	0	0	0

Plant available nutrients applied			N		P_2O_5		K_20	
(Circle column that is landowners decision)			Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
9. Credits (from row 8 above)			0	0	0	0	0	0
Fertilizer	**Kind**	**Rate/ac**						
10. Starter								
10. Starter								
10. Starter								
10. Starter								
11. Broadcast								
12. Broadcast								
13. Manure etc.								
14. Sidedress								
15. **Subtotal (sum of lines 9-14)**			0	0	0	0	0	0
16. **Nutrients recommended (from table 1)**			0	0	0	0	0	0
17. **Nutrient Status (subtract line 16 from line 15)**			**0**	**0**	**0**	**0**	**0**	**0**

if line 17 is a positive number, this is the amount by which the available nutrients exceed the crop recommendations

if line 17 is a negative number, this is the amount of additional nutrients needed to meet the crop recommendations

Nutrient Management Specifications

Amount to be applied (lbs./ac)	N		P_2O_5		K_20	
Method, form, and timing of application:	**0**		**0**		**0**	

NUTRIENT MANAGEMENT (Acre) 590

DEFINITION

Managing the amount (rate), source, placement (method of application), and timing of plant nutrients and soil amendments.

PURPOSE

- To budget, supply, and conserve nutrients for plant production.
- To minimize agricultural nonpoint source pollution of surface and groundwater resources.
- To properly utilize manure or organic by-products as a plant nutrient source.
- To protect air quality by reducing odors, nitrogen emissions (ammonia, oxides of nitrogen), and the formation of atmospheric particulates.
- To maintain or improve the physical, chemical, and biological condition of soil.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all lands where plant nutrients and soil amendments are applied. This standard does not apply to one-time nutrient application to establish perennial crops.

CRITERIA

General Criteria Applicable to All Purposes

A nutrient budget for nitrogen, phosphorus, and potassium must be developed that considers all potential sources of nutrients including, but not limited to, green manures, legumes, crop residues, compost, animal manure, organic by-products, biosolids, waste water, organic matter, soil biological activity, commercial fertilizer, and irrigation water.

Enhanced efficiency fertilizers, used in the State must be defined by the Association of American Plant Food Control Officials (AAPFCO) and be accepted for use by the State fertilizer control official, or similar authority, with responsibility for verification of product guarantees, ingredients (by AAPFCO definition) and label claims.

For nutrient risk assessment policy and procedures see Title 190, General Manual (GM), Part 402, Nutrient Management, and Title 190, National Instruction (NI), Part 302, Nutrient Management Policy Implementation.

To avoid salt damage, the rate and placement of applied nitrogen and potassium in starter fertilizer must be consistent with land-grant university guidelines, or industry practice recognized by the land-grant university.

The NRCS-approved nutrient risk assessment for nitrogen must be completed on all sites. Refer to the Michigan Leaching Index (LI) found in Section II of the FOTG.

The NRCS-approved nutrient risk assessment for phosphorus must be completed on all sites. Refer to the Michigan Phosphorus Risk Assessment tool found in Section IV of the FOTG.

On organic operations, the nutrient sources and management must be consistent with the USDA's National Organic Program.

Areas contained within minimum application setbacks (e.g., sinkholes, wellheads, gullies, ditches, or surface inlets) must receive nutrients consistent with the setback restrictions.

Applications of irrigation water must minimize the risk of nutrient loss to surface and groundwater.

Soil pH must be maintained in a range that enhances an adequate level for crop nutrient availability and utilization. Refer to MSUE Bulletin E471, Lime for Michigan Soils.

Soil, Manure, and Tissue Sampling and Laboratory Analyses (Testing)

Nutrient planning must be based on current soil, manure, and (where used as supplemental information) tissue test results developed in accordance with land-grant university guidance, or industry practice, if recognized by the university

Current soil tests are those that are no older than 3 years, but may be taken on an interval recommended by the land-grant university or as required by State code. The area represented by a soil test must be that acreage recommended by the land-grant university. Refer to MSUE Bulletin E498 and E498S

In vegetable crop and other high value cropping systems, sample soil and test at least every two years, but annual testing is encouraged. Where high value crops are rotated with field crops, soils sample and test after the high value crop is harvested.

Sod production fields should be soil sampled and tested prior to crop establishment.

For fields where perennial woody ornamentals are grown, sample and test soils every two to three years.

Where a conservation management unit (CMU) is used as the basis for a sampling unit, all acreage in the CMU must have similar soil type, cropping history, and management practice treatment.

The soil and tissue tests must include analyses pertinent to monitoring or amending the annual nutrient budget, e.g., pH, electrical conductivity (EC) and sodicity where salts are a concern, soil organic matter, phosphorus, potassium, or other nutrients and test for nitrogen where applicable. Follow land-grant university guidelines regarding required analyses.

Soil test analyses must be performed by laboratories successfully meeting the requirements and performance standards of the North American Proficiency Testing Program-Performance Assessment Program (NAPT-PAP) under the auspices of the Soil Science Society of America (SSSA) and NRCS, or other NRCS-approved program that considers laboratory performance and proficiency to assure accuracy of soil test results. Alternate proficiency testing programs must have solid stakeholder (e.g., water quality control entity, NRCS State staff, growers, and others) support and be regional in scope.

Nutrient values of manure, organic by-products and biosolids must be determined prior to land application.

Manure analyses must include, at minimum, total nitrogen (N), ammonium N, total phosphorus (P) or P_2O_5, total potassium (K) or K_2O, and percent solids, or follow land-grant university guidance regarding required analyses.

Manure, organic by-products, and biosolids samples must be collected and analyzed at least annually, or more frequently if needed to account for operational changes (feed management, animal type, manure handling strategy, etc.) impacting manure nutrient concentrations. If no operational changes occur, less frequent manure testing is allowable where operations can document a stable level of nutrient concentrations for the preceding three consecutive years, unless federal, State, or local regulations require more frequent testing.

Samples must be collected, prepared, stored, and shipped, following land-grant university guidance or industry practice.

When planning for new or modified livestock operations, acceptable "book values" recognized by the NRCS [e.g., NRCS Agricultural Waste Management Field Handbook or Midwest Plan Service (MWPS-18)] and the land-grant university, or analyses from similar operations in the geographical area, may be used if they accurately estimate nutrient output from the proposed operation.

Manure testing analyses must be performed by laboratories successfully meeting the requirements and performance standards of the Manure Testing Laboratory Certification program (MTLCP) 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.

Nutrient Application Rates

Planned nutrient application rates for nitrogen, phosphorus, and potassium must not exceed land-grant university guidelines or industry practice when recognized by the university. Refer to Michigan State University Extension (MSUE) nutrient recommendations given in the References section. For organic operations refer to University of Georgia Circular 853.

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

If the land-grant university does not provide specific guidance that meets these criteria, application rates must be based on plans that consider realistic yield goals and associated plant nutrient uptake rates.

Realistic yield goals must be established based on historical yield data, soil productivity information, climatic conditions, nutrient test results, level of management, and local research results considering comparable production conditions.

Estimates of yield response must consider factors such as poor soil quality, drainage, pH, salinity, etc., prior to assuming that nitrogen and/or phosphorus are deficient.

For new crops or varieties, industry-demonstrated yield, and nutrient utilization information may be used until land-grant university information is available.

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

Applications of biosolids, starter fertilizers, or pop-up fertilizers must be accounted for in the nutrient budget.

Nutrient Sources

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

Nutrient Application Timing and Placement

Timing and placement of all nutrients must correspond as closely as practical with plant nutrient uptake (utilization by crops), and consider nutrient source, cropping system limitations, soil properties, weather conditions, drainage system, soil biology, and nutrient risk assessment results.

Nutrients must not be surface-applied if nutrient losses offsite are likely. This precludes manure application when the top 2 inches of soil are saturated from rainfall or snow melt.

Winter manure application is allowed on frozen or snow-covered ground if a field specific assessment using the Michigan NRCS Manure Application Risk Index (MARI) ranks the field "Low" or "Very Low". A "Medium" MARI rating may be used if additional conservation and management practices are chosen to bring the MARI score up to "Low" ranking. The additional practices must be documented in the conservation plan. Fields with a "High" rating shall not be used for winter manure application. Refer to Michigan NRCS Agronomy Technical Note #35, 'The MARI Excel Spreadsheet.

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

Planners must use the current NRCS-approved nitrogen, phosphorus, and soil erosion risk assessment tools to assess the risk of nutrient and soil loss. Identified resource concerns must be addressed to meet current planning criteria (quality criteria). Technical criteria for risk assessments can be found in NI-190-302.

When there is a high risk of transport of nutrients, conservation practices must be coordinated to avoid, control, or trap manure and nutrients before they can leave the field by surface or subsurface drainage (e.g., tile). Use conservation practices that slow runoff, reduce erosion, and increase infiltration, e.g., filter strips, cover crops, or residue and tillage management. These practices can also reduce the loss of nitrates or soluble phosphorus.

The number of applications and the application rates must also be considered to limit the transport of nutrients to tile.

Nutrients must be applied with the right placement, in the right amount, at the right time, and from the right source to minimize nutrient losses to surface and groundwater. The following nutrient use efficiency strategies or technologies must be considered:

- slow and controlled release fertilizers
- nitrification and urease inhibitors
- enhanced efficiency fertilizers
- incorporation or injection
- timing and number of applications
- soil nitrate and organic N testing
- coordinate nutrient applications with optimum crop nutrient uptake
- Corn Stalk Nitrate Test (CSNT), Pre-Sidedress Nitrate Test (PSNT), and Pre-Plant Soil Nitrate Test (PPSN)
- tissue testing, chlorophyll meters, and spectral analysis technologies

Additional Criteria Applicable to Properly Utilize Manure or Organic By-Products as a Plant Nutrient Source

When manures are applied, and soil salinity is a concern, salt concentrations must be

monitored to prevent potential crop damage and/or reduced soil quality.

The total single application of liquid manure:

- must not exceed the soil's infiltration or water holding capacity
- be based on crop rooting depth
- must be adjusted to avoid runoff or loss to subsurface tile drains.

Crop production activities and nutrient use efficiency technologies must be coordinated to take advantage of mineralized plant-available nitrogen to minimize the potential for nitrogen losses due to denitrification or ammonia volatilization.

Nitrogen and phosphorus application rates must be planned based on risk assessment results as determined by NRCS-approved nitrogen and phosphorus risk assessment tools.

For fields receiving manure, where the Michigan Phosphorus Risk Assessment results equate to LOW risk and the soil test phosphorus is less than 150 ppm Bray P1, manure application rates may be based on the nitrogen fertilizer recommendation. If the field is LOW risk, two, three or four crop years of phosphorus removal may be applied, but no additional fertilizer or manure P can be applied for the second, third or fourth crop year. The calculated manure application rate shall not apply more plant-available nitrogen than the amount of the nitrogen fertilizer recommendation for the crop to be grown the first year.

For fields receiving manure, where the Michigan Phosphorus Risk Assessment results equate to MEDIUM risk, manure shall be applied at the phosphorus removal rate. Up to two crop years of phosphorus removal may be applied, but no additional fertilizer or manure phosphorus can be applied for the second crop year. The calculated manure application rate shall not apply more plant-available nitrogen than the amount of the nitrogen fertilizer recommendation for the crop to be grown the first year.

For fields receiving manure, where the Michigan Phosphorus Risk Assessment results equate to HIGH risk, *no manure or phosphorus fertilizer* may be applied except for starter fertilizer on corn under the following conditions (MSUE bulletin E2904):

- Fertilizer shall only be banded, not broadcast;
- Starter fertilizer shall only be applied when Bray P1 soil test is less than 60 ppm;
- A maximum of 25 lbs P2O5/ acre may be applied in low residue fields or up to 40 lbs P2O5/ acre when planting into heavy residue.

Manure application of greater than four crop year's phosphorus removal is not allowed.

Regardless of the Michigan Phosphorus Risk Assessment score, if field soil test phosphorus is greater than 150 ppm, then no manure application is allowed, with the exception of dilute wastewater. The following restrictions on application of on-farm generated wastewater must be followed:

- The on-farm generated wastewater must have one percent or less solids;
- Application is limited to rates that supply 75 percent or less of the annual phosphorus removal for the current crop or next crop to be harvested;

- Annual sampling of the applied wastewater to determine its P content;
- No other phosphorus can be applied to the crop field from other sources;
- Soil P test levels must show a progressive decline over time;
- Irrigated wastewater shall use irrigation scheduling to avoid overapplication.

Manure or organic by-products may be applied on legumes at rates equal to the estimated removal of nitrogen in harvested plant biomass.

In pasture systems where the grazed forage is the sole feed source for livestock, nutrients from manure deposited by the grazing livestock will not exceed the nutrient requirements of the pasture forage. Pasture systems utilizing supplemental feed often result in manure nutrient deposition in excess of pasture forage requirements. Quantify available nutrient deposition based on livestock feed balance.

Additional Criteria to Protect Air Quality by Reducing Odors, Nitrogen Emissions and the Formation of Atmospheric Particulates

To address air quality concerns caused by odor, nitrogen, sulfur, and/or particulate emissions; the source, timing, amount, and placement of nutrients must be adjusted to minimize the negative impact of these emissions on the environment and human health. **One or more of the following may be used:**

- slow or controlled release fertilizers
- nitrification inhibitors
- urease inhibitors
- incorporation
- injection

Manure applications shall be managed to avoid and minimize nuisance odor conditions. **One or more of the following conditions will be implemented:**

- Avoid spreading when wind is blowing towards populated areas;
- Avoid spreading on weekend/holidays when neighbors are likely to be engaged in nearby outdoor or recreational activities;
- Use available weather information to minimize risk of offsite movement of nuisance odor;
- Establish natural vegetation barriers such as windbreaks, and utilize natural vegetative barriers such as woodlots as air filters and visual screens.

Do not apply poultry litter, manure, or organic by-products of similar dryness/density when there is a high probability that wind will blow the material offsite.

Additional Criteria to Improve or Maintain the Physical, Chemical, and Biological Condition of the Soil to Enhance Soil Quality for Crop Production and Environmental Protection

Time the application of nutrients to avoid periods when field activities will result in soil compaction.

In areas where salinity is a concern, select nutrient sources that minimize the buildup of soil salts.

CONSIDERATIONS

Elevated soil test phosphorus levels are detrimental to soil biota. Soil test phosphorus

levels should not exceed State-approved soil test thresholds established to protect the environment.

Use no-till/strip-till in combination with cover crops to sequester nutrients, increase soil organic matter, increase aggregate stability, reduce compaction, improve infiltration, and enhance soil biological activity to improve nutrient use efficiency.

Use nutrient management strategies such as cover crops, crop rotations, and crop rotations with perennials to improve nutrient cycling and reduce energy inputs.

Use variable-rate nitrogen application based on expected crop yields, soil variability, soil nitrate or organic N supply levels, or chlorophyll concentration.

Use variable-rate nitrogen, phosphorus, and potassium application rates based on site-specific variability in crop yield, soil characteristics, soil test values, and other soil productivity factors.

Develop site-specific yield maps using a yield monitoring system. Use the data to further diagnose low- and high- yield areas, or zones, and make the necessary management changes. See Title 190, Agronomy Technical Note (TN) 190.AGR.3, Precision Nutrient Management Planning.

Use manure management conservation practices to manage manure nutrients to limit losses prior to nutrient utilization.

Consider applying manure at a rate that will result in an “improving” Soil Conditioning Index (SCI) without exceeding acceptable risk of nitrogen or phosphorus loss

Use legume crops and cover crops to provide nitrogen through biological fixation and nutrient recycling.

Excessive levels of some nutrients can cause induced deficiencies of other nutrients, e.g., high soil test phosphorus 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.

Use the adaptive nutrient management learning process to improve nutrient use efficiency on farms as outlined in the NRCS’ National Nutrient Policy in GM 190, Part 402, Nutrient Management.

Potassium should not be applied in situations where an excess (greater than soil test potassium recommendation) causes nutrient imbalances in crops or forages.

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.

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.

Considerations to Minimize Agricultural Nonpoint Source Pollution of Surface and Groundwater

Use application methods and timing strategies that reduce the risk of nutrient transport by ground and surface waters, such as:

- split applications of nitrogen to deliver nutrients during periods of maximum crop utilization,
- banded applications of nitrogen and/or phosphorus to improve nutrient availability,
- drainage water management to reduce nutrient discharge through drainage systems, and
- incorporation of surface-applied manures or organic by-products if precipitation capable of producing runoff or erosion is forecast within the time of planned application.

Use the agricultural chemical storage facility conservation practice to protect air, soil, and water quality.

Use bioreactors and multistage drainage strategies when approved by the land-grant university.

Considerations to Protect Air Quality by Reducing Nitrogen and/or Particulate Emissions to the Atmosphere

Avoid applying manure and other by-products upwind of inhabited areas.

Use high-efficiency irrigation technologies (e.g., reduced-pressure drop nozzles for center pivots) to reduce the potential for nutrient losses.

PLANS AND SPECIFICATIONS

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

- aerial site photograph(s)/imagery or site map(s), and a soil survey map of the site,
- soil information including: soil type surface texture, pH, drainage class, permeability, available water capacity, depth to water table, restrictive features, and flooding and/or ponding frequency,
- location of designated sensitive areas and the associated nutrient application restrictions and setbacks,
- for manure applications, location of nearby residences, or other locations where humans may be present on a regular basis, and any identified meteorological (e.g., prevailing winds at different times of the year), or topographical influences that may affect the transport of odors to those locations,
- results of approved risk assessment tools for nitrogen, phosphorus, and erosion losses
- documentation establishing that the application site presents low risk for phosphorus transport to local water when phosphorus is applied in excess of crop requirement.
- current and/or planned plant production sequence or crop rotation,
- soil, water, compost, manure, organic by-product, and plant tissue sample analyses applicable to the plan,
- when soil phosphorus levels are increasing, include a discussion of the risk associated with phosphorus accumulation and a proposed phosphorus draw-down strategy,
- realistic yield goals for the crops,
- complete nutrient budget for nitrogen, phosphorus, and potassium for the plant production sequence or crop rotation,
- listing and quantification of all nutrient sources and form,

- all enhanced efficiency fertilizer products that are planned for use,
- in accordance with the nitrogen and phosphorus risk assessment tool(s), specify the recommended nutrient application source, timing, amount (except for precision/variable rate applications specify method used to determine rate), and placement of plant nutrients for each field or management unit, and
- guidance for implementation, operation and maintenance, and recordkeeping.

In addition, the following components must be included in a precision/variable rate nutrient management plan:

- Document the 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.
- Document the 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.
- Document if a variable rate nutrient or soil amendment application was made.
- 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 applications that resulted from use of the precision agriculture process for nutrient or soil amendment applications.
- Maintain the electronic records of the GIS data layers and nutrient applications for at least 5 years.

If increases in soil phosphorus levels are expected (i.e., when N-based rates are used), the nutrient management plan must document:

- the soil phosphorus levels at which it is desirable to convert to phosphorus based planning,
- the potential plan for soil test phosphorus drawdown from the production and harvesting of crops, and
- management activities or techniques used to reduce the potential for phosphorus transport and loss,
- for AFOs, a quantification of manure produced in excess of crop nutrient requirements, and
- a long-term strategy and proposed implementation timeline for reducing soil P to levels that protect water quality,

OPERATION AND MAINTENANCE

Conduct periodic plan reviews to determine if adjustments or modifications to the plan are needed. At a minimum, plans must be reviewed and revised, as needed with each soil test cycle, changes in manure volume or analysis, crops, or crop management.

Fields receiving animal manures and/or biosolids must be monitored for the accumulation of heavy metals and phosphorus in accordance with land- grant university guidance and State law.

Significant changes in animal numbers, management, and feed management will necessitate additional manure analyses to establish a revised average nutrient content.

Calibrate application equipment to ensure accurate distribution of material at planned rates.

Document the nutrient application rate. When the applied rate differs from the planned rate, provide appropriate documentation for the change.

Records must be maintained for at least 5 years to document plan implementation and maintenance. As applicable, records include:

- soil, plant tissue, water, manure, and organic by-product analyses resulting in recommendations for nutrient application,
- quantities, analyses and sources of nutrients applied,
- dates, and method(s) of nutrient applications, source of nutrients, and rates of application,
- weather conditions and soil moisture at the time of application; lapsed time to manure incorporation; rainfall or irrigation event,
- crops planted, planting and harvest dates, yields, nutrient analyses of harvested biomass, and crop residues removed,
- dates of plan review, name of reviewer, and recommended changes resulting from the review, and
- all enhanced efficiency fertilizer products used.

Additional records for precision/variable rate sites must include:

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

REFERENCES

Association of American Plant Food Control Officials (AAPFCO). 2011. AAPFCO Official Publication no. 64. AAPFCO Inc., Little Rock, AR.

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.

McLaurin W., W. Reeves. 2000. How to Convert an Inorganic Fertilizer Recommendation to an Organic One. The University of Georgia Circular 853.

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.

U.S. Department of Agriculture, Natural Resources Conservation Service. 1997. Agricultural Waste Management Field Handbook, Chapter 4 – Agricultural Waste Characteristics.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2010. Agronomy Technical Note, (TN) 190-AGR-3, Precision Nutrient Management Planning. Washington, DC.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2011.

Title 190, General Manual, (GM), Part 402, Nutrient Management. Washington, DC.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2011, Title 190, National Instruction (NI), Part 302, Nutrient Management Policy Implementation. Washington, DC

Hanson, E., 1996. Fertilizing Fruit Crops. MSUE Bulletin E-852.

Hanson, E. and J. Hancock. 1996. Managing the Nutrition of High-bush Blueberries. MSUE Bulletin E-2011

Michigan Commission of Agriculture. Generally Accepted Agricultural and Management Practices for Manure Management and Utilization.

Michigan Commission of Agriculture. Generally Accepted Agricultural and Management Practices for Nutrient Utilization.

Midwest Plan Service, 1993. Livestock waste Facilities Handbook, 3rd Ed. MWPS-18, Midwest Plan Service, Iowa State University, Ames, IA

Midwest Plan Service, 2000. Manure Characteristics, MWPS-18, Section I, 2nd Ed, Midwest Plan Service, Iowa State University, Ames, IA

Warncke, D.D., 2000. Sampling Soils for Fertilizer and Lime Recommendations. MSUE Bulletin E-498 and E-498S

Warncke, D., L. Bast and D. Christenson. 2010. Lime for Michigan Soils. MSUE Bulletin E-471.

Warncke, D. and J. Dahl. 1994. Nutrient Recommendations for Vegetable Crops in Michigan. MSUE Bulletin E-2934.

Warncke, D., J. Dahl and L. Jacobs, 2009. Nutrient Recommendations for Field Crops in Michigan. MSUE Bulletin E-2904.

Smith, E.M., 1989. Fertilizing Landscape and Field Grown Nursery Crops. Extension Bulletin 650, The Ohio State University, Columbus, OH.

Hanson, E. and J. Jull, 1994. Plant Tissue Sampling for Determining Fertilizer Needs of Fruit Crops. MSUE Bulletin E-2482.

.Meints, V.W. and L.S. Roberson. 1983. Soll; Sampling for No-till and Conservation Tillage Crops. E-1616

Franzen, D.W. and NCERA-103 Committee. 2011. Nitrogen Extenders and Additives for Field Crops. SF-1581.North Dakota State University, Fargo ND

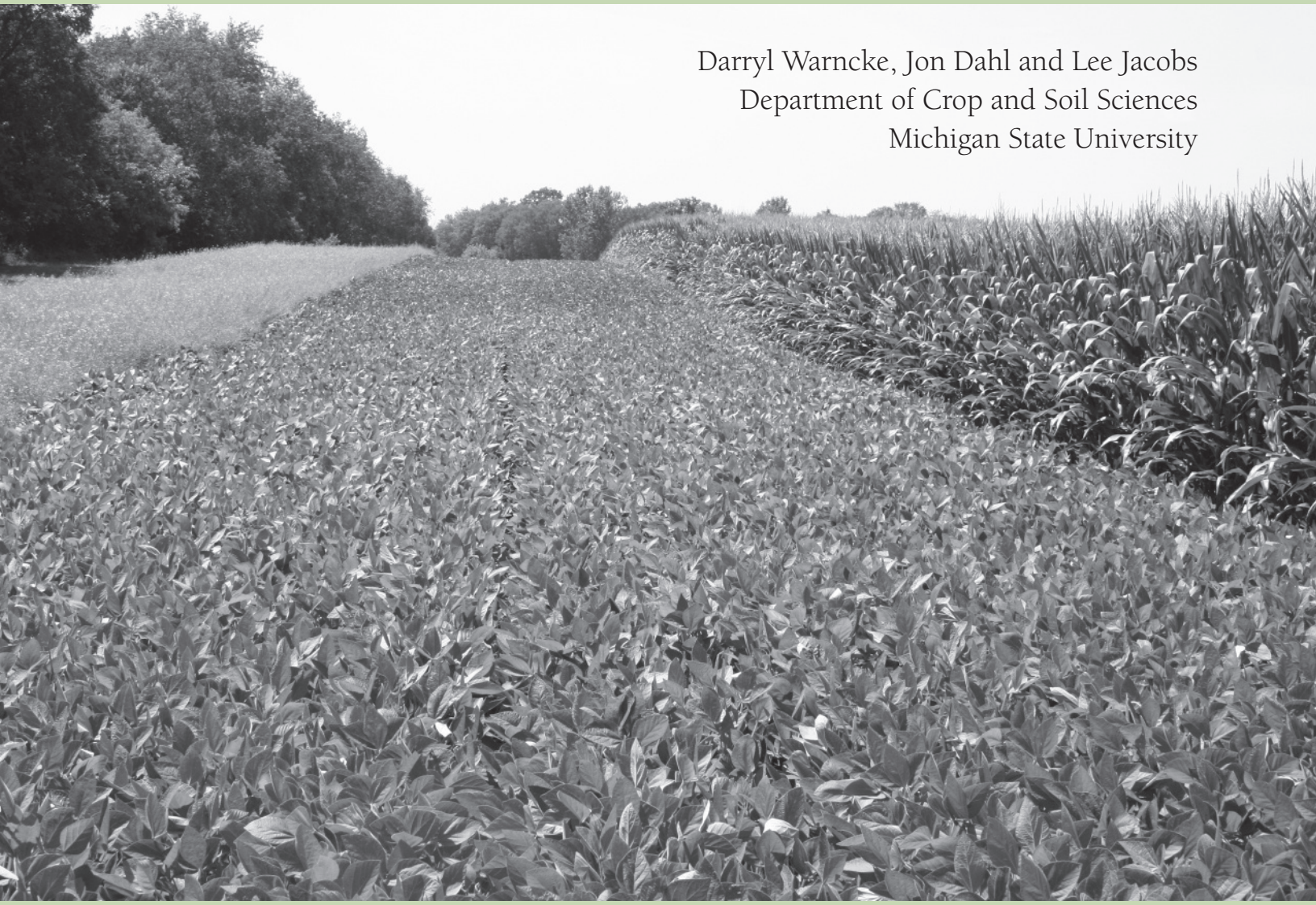
Snapp, S. D, Smucker and M. Vitosh. 2002. Nitrogen Management for Michigan Potatoes. MSUE Bulletin E-2779.

Michigan Department of Agriculture and Rural Development. Generally Accepted Agricultural and Management Practices for Manure Management and Utilization.

Michigan Department of Agriculture and Rural Development. Generally Accepted Agricultural and Management Practices for Nutrient Utilization.

Extension Bulletin E2904 • Revised August 2009

Nutrient Recommendations for Field Crops in Michigan



Darryl Warncke, Jon Dahl and Lee Jacobs
Department of Crop and Soil Sciences
Michigan State University

MICHIGAN STATE UNIVERSITY EXTENSION

Suggested Nutrient Management Practices for Individual Crops

Soil test to determine lime and nutrient requirements!

Corn Grain and Corn Silage

Nitrogen recommendations are based on field data and are designed to provide the maximum return on the investment in N. These recommendations are given in Table 6. The total amount of N to apply depends on the soil productivity (potential yield based on a five-year running average, disregarding unusual lows and highs), previous crop and the N cost:corn price ratio ($/lb N:$/bu corn). The N recommendations for silage corn are those used for the N:corn price ratio of 0.10 with the break between low/medium yields and high/very high yields being 19 ton/a.

Phosphorus and K recommendation guidelines are given in Tables 14, 15, 16 and 17.

In Michigan, soils are usually quite cool when much of the corn is planted. Placement of fertilizer 2 inches to the side and 2 inches below the seed at planting can enhance early growth. At this placement, the starter fertilizer can supply up to 40 pounds of N, 100 pounds of phosphate (P_2O_5) and 100 pounds of potash (K_2O) per acre. Applying an amount of P_2O_5 equal to crop removal will help maintain the available P level in the soil when the soil test value is above the critical value of 15 ppm. Inclusion of P in starter fertilizer when the soil P level is high may enhance early growth but seldom increases grain yield. Potassium in the starter fertilizer is most beneficial when planting no-till or planting into soil with a heavy layer of surface residue. Broadcast and incorporate preplant amounts of P and K required to build up the soil levels. (See Tables 7 and 9.)

Nitrogen may be managed with a combination of application times: preplant, planting time and/or sidedress. Apply preplant N as close to planting time as possible to reduce the risk of N loss. Fall application of N is not recommended because of the potential for leaching loss, even with a nitrification inhibitor. Sidedress N application made on the basis of the PSNT when the corn is 3 to 12 inches tall provides the most efficient use of N inputs. Irrigating corn increases the yield potential and the fertilizer requirements. A significant portion of the N may also be applied through the irrigation system. One approach is to apply two-thirds of the N in some combination of preplant, planting-time and/or sidedress applications and the remainder through the irrigation system.

Soybeans

Phosphorus and K recommendations are given in Tables 18 and 19.

Soybean is a legume that can meet its N needs by symbiotic fixation of atmospheric nitrogen. In general, soybeans will not benefit from supplemental N application. Soybeans are widely grown in Michigan. Most fields have adequate indigenous populations of the appropriate Bradyrhizobia bacteria strains that cause effective nodulation of soybean roots and N fixation.

Table 14. Phosphorus recommendations for selected yields of corn (mineral soils).

	Yield (bu/a)	
Soil test	140	180
ppm	— lb P_2O_5/a —	
5	102	117
10	77	92
15-30	52	67
35	26	33
40	0	0

Numbers highlighted are maintenance amounts.

Table 15. Phosphorus recommendations for selected yields of corn silage (mineral soils).

	Yield (t/a)	
Soil test	140	180
ppm	— lb P_2O_5/a —	
5	116	149
10	91	124
15-30	66	99
35	33	50
40	0	0

Numbers highlighted are maintenance amounts.

Table 16. Potassium recommendations for selected yields of corn (mineral soils).

Soil test	CEC	140 bu/a				180 bu/a			
		4	8	12	16	4	8	12	16
ppm		— lb K_2O/a —				— lb K_2O/a —			
40		92	115	142	173	103	126	153	184
80		44	59	78	101	55	70	89	112
85		38	52	70	92	49	63	81	103
95		38	38	54	74	49	49	65	85
105		38	38	38	56	49	49	49	67
115		38	38	38	38	49	49	49	49
125		19	38	38	38	25	49	49	49
135		0	19	38	38	0	25	49	49

Numbers highlighted are maintenance amounts.

Table 17. Potassium recommendations for selected yields of corn silage (mineral soils).

Soil test	CEC	20 t/a				30 t/a			
		4	8	12	16	4	8	12	16
ppm		— lb K_2O/a —				— lb K_2O/a —			
40		214	237	264	295	294	300	300	300
80		166	181	200	223	246	261	280	300
85		160	174	192	214	240	254	272	294
95		160	160	176	196	240	240	256	276
105		160	160	160	178	240	240	240	258
115		160	160	160	160	240	240	240	240
125		80	160	160	160	120	240	240	240
135		0	80	160	160	0	120	240	240

Numbers highlighted are maintenance amounts.
Maximum annual recommendation is 300 lb K_2O/a.

Where soybeans have not been grown recently, inoculation of the soybean seed with soybean-specific Bradyrhizobia strains is essential for effective nitrogen fixation.

Soybeans are more sensitive to fertilizer placement and rate than corn. Starter fertilizer placed 2 inches to the side and 2 inches below the seed can contain up to 100 pounds of phosphate (P_2O_5) and 60 pounds of potash (K_2O) per acre. Placement of fertilizer with the seed may cause serious injury and reduced plant stands. When soybeans are drilled (7- to 10-inch spacing), broadcast and incorporate all the P_2O_5 and K_2O before planting. The P_2O_5 and K_2O required for soybeans may also be broadcast prior to the previous corn crop. For no-till soybeans, use a band-placed starter fertilizer or broadcast the required fertilizer before planting. On lake-bed soils and dark-colored soils where the soil pH is above 6.5, Mn application will usually improve soybean growth and yields. Include 2 lb Mn/a (or the recommended amount based on a soil test) in the starter fertilizer, or apply one or two applications of 1 to 2 lb Mn/a to the foliage. Broadcast applications made to the soil are not effective.

Table 18. Phosphorus recommendations for selected yields of soybean (mineral soils).

Soil test	Yield (bu/a) 40	60
ppm	— lb P_2O_5/a —	
5	82	98
10	57	73
15-30	32	48
35	16	24
40	0	0

Dry Edible (Field) Beans

Phosphorus and K recommendations are given in Tables 20 and 21.

Dry beans, like soybeans, are legumes and can fix N. Nitrogen fixation in dry bean can be unreliable, however, because of environmental conditions and variability among varieties. Therefore, applying 40 to 60 lb N/a is recommended to achieve maximum yield. Apply 60 lb N/a for beans grown in narrow rows (less than 23 inches) and for colored beans grown under irrigation. For beans grown with less intense management systems, apply 40 lb N/a. Applying ex-

Table 19. Potassium recommendations for selected yields of soybean.

Soil test CEC	40 bu/a 4	8	12	16	60 bu/a 4	8	12	16
ppm	— lb K_2O/a —				— lb K_2O/a —			
40	110	133	160	191	138	161	188	219
80	62	77	96	119	90	105	124	147
85	56	70	88	110	84	98	116	138
95	56	56	72	92	84	84	100	120
105	56	56	56	74	84	84	84	102
115	56	56	56	56	84	84	84	84
125	28	56	56	56	42	84	84	84
135	0	28	56	56	0	42	84	84

Numbers highlighted are maintenance amounts.

Table 20. Phosphorus recommendations for selected yields of dry edible beans (mineral soils).

Soil test	Yield (cwt/a) 20	30
ppm	— lb P_2O_5/a —	
5	74	86
10	49	61
15-40	24	36
45	12	18
50	0	0

Table 21. Potassium recommendations for selected yields of dry beans (mineral soils).

Soil test CEC	20 cwt/a 4	8	12	16	30 cwt/a 4	8	12	16
ppm	— lb K_2O/a —				— lb K_2O/a —			
40	86	109	136	167	102	125	152	183
80	38	53	72	95	54	69	88	111
85	32	46	64	86	48	62	80	102
95	32	32	48	68	48	48	64	84
105	32	32	32	50	48	48	48	66
115	32	32	32	32	48	48	48	48
125	16	32	32	32	24	48	48	48
135	0	16	32	32	0	24	48	48

Numbers highlighted are maintenance amounts.

cess N can delay bean maturity and may increase potential for white mold if the crop canopy is dense.

Dry beans are sensitive to low levels of available Zn. Providing adequate amounts of Zn fertilizer, if needed, is important because even mild Zn deficiency can delay maturity. Use a soil test to determine available Zn levels, and calculate the amount to apply from the equation on page 27. In the absence of a soil test, apply 1 lb Zn/a if the previous crop was sugar beets or if the soil pH is above 6.5.

Dry beans do not tolerate fertilizer applied with the seed. Up to 40 lb N/a, all of the P_2O_5 and 60 lb of K_2O/a may be included in a starter fertilizer placed in a band 2 inches to the side and 2 inches below the seed. Before planting, broadcast and incorporate any additional fertilizer that is needed. Additional N may also be sidedressed two weeks after planting.

Bean yield may be affected by nutrient management and cropping systems. Dry beans grown after sugar beets often experience Zn deficiency, which results in delayed maturity and reduced yield. Dry beans rely on a symbiotic relationship with mycorrhizal fungi to assist the plant in taking up nutrients. Sugar beets do not host these fungi. Reduced numbers of mycorrhizae after sugar beets result in Zn deficiency because the bean plant can not take up enough Zn on its own.

Dry beans are also more sensitive to soil compaction than some other crops, particularly soybean. So take care to avoid soil compaction after primary tillage.

Small Grains: Barley, Canola, Spelt, Oats, Rye, Wheat

Nitrogen recommendations for small grains can be calculated using the equations on page 9.

Phosphorus and K recommendations for wheat and barley are given in Tables 22, 23, 24 and 25. Phosphorus and potassium recommendations for oats are about 10 lb P_2O_5/a and 5 lb K_2O/a more than those for barley at the same yield level. Recommendations for the other cereal grains can be calculated from the equations on pages 14 and 16 and the information in Tables 8 and 10.

Many grain drills deliver fertilizer in direct contact or close proximity with the seed. Large amounts of fertilizer may adversely affect germination and seedling establishment, especially if the soil is dry. To minimize the potential for injury, apply no more than 100 lb/a of nutrients (N + P_2O_5 + K_2O) in contact with the seed in sandy soils and no more than 140 lb/a in fine-textured soils. Where greater amounts of fertilizers are needed,

Table 22. Phosphorus recommendations for selected yields of wheat (mineral soils).

	Yield (bu/a)	
Soil test	60	90
ppm	— lb P_2O_5/a —	
5	138	157
10	113	132
15	88	107
20	63	82
25-40	38	57
45	19	28
50	0	0

Numbers highlighted are maintenance amounts.

Table 23. Phosphorus recommendations for selected yields of barley (mineral soils).

	Yield (bu/a)	
Soil test	50	80
ppm	— lb P_2O_5/a —	
5	69	80
10	44	55
15-30	19	30
35	10	15
40	0	0

Numbers highlighted are maintenance amounts. For oats, add 10 lb/a.

Table 24. Potassium recommendations for selected yields of wheat (mineral soils).

Soil		60 bu/a				90 bu/a			
test	CEC	4	8	12	16	4	8	12	16
ppm		— lb K_2O/a —				— lb K_2O/a —			
40		76	99	126	157	87	110	137	168
80		28	43	62	85	39	54	73	96
85		22	36	54	76	33	47	65	87
95		22	22	38	58	33	33	49	69
105		22	22	22	40	33	33	33	51
115		22	22	22	22	33	33	33	33
125		11	22	22	22	17	33	33	33
135		0	11	22	22	0	17	33	33

Numbers highlighted are maintenance amounts.

Table 25. Potassium recommendations for selected yields of barley (mineral soils).

Soil		50 bu/a				80 bu/a			
test	CEC	4	8	12	16	4	8	12	16
ppm		— lb K_2O/a —				— lb K_2O/a —			
40		67	90	117	148	74	97	124	155
80		19	34	53	76	26	41	60	83
85		13	27	45	67	20	34	52	74
95		13	13	29	49	20	20	36	56
105		13	13	13	31	20	20	20	38
115		13	13	13	13	20	20	20	20
125		7	13	13	13	10	20	20	20
135		0	7	13	13	0	10	20	20

Numbers highlighted are maintenance amounts.
For oats, add 5 lb/a.

broadcast and incorporate the additional fertilizer before planting. The alternative is to broadcast and incorporate all the required fertilizer nutrients before planting.

For winter wheat or barley, apply no more than 25 lb N/a in the fall. This may be included in either the pre-plant broadcast or planting-time fertilizer. In the spring, before green-up, topdress additional N on the basis of the yield potential of the field. For high-yielding wheat varieties and sites, this is usually 80 to 100 lb/a. Another option is to split the N between pregreen-up and Feeke's stage 5 or 6. Wheat does best following soybeans, dry edible beans or silage corn.

For rye grown for grain, apply 40 lb/a before spring green-up. No N is recommended for rye grown as a cover crop. For spring-seeded grains (barley, oats, millet and buckwheat), broadcast and incorporate the required amounts of N, P_2O_5 and K_2O before seeding.

When small grains are grown on slightly acidic sandy soils, application of Mg may be beneficial. If the soil Mg level is marginal or low (below 35 ppm), including 10 lb Mg/a in the broadcast fertilizer or foliar application of 1 to 2 lb Mg /a may be beneficial.

Wheat, oats and barley may benefit from Mn application when grown on lake-bed soils and dark-colored soils where the soil pH is above 6.5. Manganese is best applied in the planting-time fertilizer or as a spray on the actively growing foliage. Manganese that is broadcast and incorporated is readily bound into unavailable forms. Test these soils for Mn and apply recommended amounts.

Sugar Beets

Nitrogen recommendations for sugar beets can be calculated from the following equations:

N rec. = 4 x YP

When corn is the previous crop: N rec. = (4 x YP) + 30

where: YP is yield potential

Phosphorus and potassium recommendations for sugar beets are given in Tables 26 and 27.

Nitrogen management in sugar beet production is critical to maximize sugar yield. Nitrogen is needed to produce high yields of beets, but too much N reduces the sugar quality of the harvested beet. Sugar yield is maximized by balancing high yield and quality. In general, 80 to 100 lb N/a will maximize yield and sugar quality. The majority of research that went into developing this recommendation was for beets following beans. When beets are grown after corn, increase the N application rate by 30 lb N/a because corn is not a legume as dry bean and soybean are. Recent research results support this recommendation.

Table 26. Phosphorus recommendations for selected yields of sugar beets (minerals soils.

Soil test	Yield (t/a) 20	28
ppm	— lb P_2O_5/a —	
5	126	136
10	101	111
15	76	86
20	51	61
25-40	26	36
45	13	18
50	0	0

Numbers highlighted are maintenance amounts.

Table 27. Potassium recommendations for selected yields of sugar beets (mineral soils).

Soil test	CEC	20 t/a 4	8	12	16	28 t/a 4	8	12	16
ppm		— lb K_2O/a —				— lb K_2O/a —			
40		120	143	170	201	146	169	196	227
80		72	87	106	129	98	113	132	155
85		66	80	98	120	92	106	124	146
95		66	66	82	102	92	92	108	128
105		66	66	66	84	92	92	92	110
115		66	66	66	66	92	92	92	92
125		33	66	66	66	46	92	92	92
135		0	33	66	66	0	46	92	92

Numbers highlighted are maintenance amounts.

Sugar beets need a majority of their N early in the season to obtain canopy closure; relatively small amounts are required for canopy maintenance. Having adequate N early in the season is important for the crop to get off to a good start. Starter fertilizers (2- by 2-inch band placement) should provide 30 to 40 lb N/a. Alternatively, the N can be applied before planting. Some experiences suggest that, to reduce the risk of fertilizer burn adversely affecting germination, growers should apply no more than 50 lb N/a preplant.

Beets generally will not respond to P fertilizer when soil test values are greater than 30 ppm. On high-P soils, P is not needed in a starter fertilizer. If one wishes to use a starter fertilizer containing P_2O_5, the amount of P_2O_5 applied should be less than crop removal (approximately 30 lb P_2O_5 /a). Beets are sensitive to low levels of available Mn, particularly when the soil pH is higher than 6.5. Use a soil test to determine available Mn levels and the amount of Mn to apply. Manganese applications are most effective in starter fertilizers. Foliar applications of Mn (1 lb/a) can be used to remediate deficiencies that appear after crop establishment. Sugar beets grown on sandy loams will benefit from application of 2 lb B/a in the starter or broadcast fertilizer. On finer textured soils, applying 1 lb B/a may be a good preventive practice — some deficiencies have been observed recently on these soils.

Sugar beets grow best when the soil pH is between 6.0 and 7.0. Preliminary research in another beet-growing region of the United States suggests that soil pH above 6.5 decreases the incidence of root diseases.

Forage Crops

Legumes

Phosphorus and potassium recommendations for alfalfa and clover are given in Tables 28, 29, 30, 31 and 32.

For alfalfa, be sure to adjust the soil pH to near 7.0 by applying the appropriate rate of limestone. For other legumes, adjust pH to 6.5. This is best done by applying and incorporating the lime about six to 12 months before seeding. When no-till seeding legumes on erosive sites, broadcast the lime without incorporation. Broadcast and incorporate the required P_2O_5 and K_2O during seedbed preparation or apply it through the seeder, basing rates on soil tests. When fertilizer is applied with the seeding unit, allow the seed to fall on the top of the soil above the fertilizer band and to be firmed in no more than ½ inch deep with press wheels or cultipacker. Fertilizer placed 1 to 1½ inches below the seed may supply all the recommended P_2O_5 and up to 150 lb K_2O/a. For fertilizer placed directly with the seed, limit the amounts to 100 lb P_2O_5/a and 50 lb K_2O/a. Planting-time N is not necessary for legume seedings, but be sure to inoculate the seed with the appropriate strains of

Table 28. Phosphorus recommendations for selected yields of alfalfa (mineral soils).

Soil test	Yield (t/a) 4	6	8
ppm	— lb P_2O_5/a —		
5	152	178	200
10	127	153	179
15	102	128	154
20	77	103	129
25-40	52	78	104
45	26	39	52
50	0	0	0

Numbers highlighted are maintenance amounts.

Table 29. Phosphorus recommendations for selected yields of clover hay (mineral soils).

Soil test	Yield (t/a) 3	6
ppm	— lb P_2O_5/a —	
5	105	135
10	80	110
15	55	85
20-35	30	60
40	15	30
45	0	0

Numbers highlighted are maintenance amounts.

Table 30. Phosphorus recommendations for selected yields of clover-grass hay (mineral soils).

Soil test	Yield (t/a) 3	6
ppm	— lb P_2O_5/a —	
5	114	153
10	89	128
15	64	103
20-35	39	78
40	20	39
45	0	0

Numbers highlighted are maintenance amounts.

Table 31. Potassium recommendations for selected yields of alfalfa hay (mineral soils).

Soil test	CEC	4 t/a				8 t/a			
		4	8	12	16	4	8	12	16
ppm		— lb K_2O/a —				— lb K_2O/a —			
40		254	277	300	300	300	300	300	300
80		206	221	240	263	300	300	300	300
85		200	214	232	254	300	300	300	300
95		160	200	216	236	300	300	300	300
105		120	160	200	218	240	300	300	300
115		80	120	160	200	160	240	300	300
125		40	80	120	160	80	160	240	300
135		0	40	80	120	0	80	160	240

Numbers highlighted are maintenance amounts.
Maximum annual recommendation is 300 lb K_2O/a.

Table 32. Potassium recommendations for selected yields of clover and clover-grass hay (mineral soils).

Soil test	CEC	3 t/a				6 t/a			
		4	8	12	16	4	8	12	16
ppm		— lb K_2O/a —				— lb K_2O/a —			
40		174	197	224	255	294	300	300	300
80		126	141	160	183	246	261	280	300
85		120	134	152	174	240	254	272	294
95		120	120	136	156	240	240	256	276
105		120	120	120	138	240	240	240	258
115		120	120	120	120	240	240	240	240
125		60	120	120	120	120	240	240	240
135		0	60	120	120	0	120	240	240

Numbers highlighted are maintenance amounts.

Rhizobia before planting. Including 20 lb N/a in the broadcast or planting-time fertilizer may improve seedling establishment in cool soils but generally provides little benefit.

Legumes are more difficult to establish when using a small grain as a nurse crop rather than by clear seeding, although frost seeding red clover can be done successfully. The small grain nurse crop is best harvested early as silage to reduce competition with the new legume seeding. The P and K fertilizer applied for the small grain is usually sufficient to carry the legume through the first season. If a cutting is taken off, apply amounts of P_2O_5 and K_2O equal to crop removal. Legumes remove large amounts of K_2O (45 to 60 lb/ ton) from the soil. Weathering of the soil minerals releases potash in the soil over the winter. To minimize luxury consumption of K by alfalfa, it is best to wait and make the first application of K_2O after the first cutting. To replace potassium removed by the crop, topdress K_2O after the first and third or fourth cutting. Needed P can be applied along with the K_2O when it is spread. On loamy sands and sands, where significant leaching may occur, do not apply K_2O in the late fall. It is suggested to limit single applications to no more than 200 lb K_2O/a and yearly applications to 300 lb K_2O/a.

Boron is needed annually on sandy soils (CEC < 8.0) at a rate of 2 lb/a per year. Fine-textured soils can usually supply adequate B, so B applications have seldom proven beneficial. Where B is needed, apply it in the topdress fertilizer. Boron deficiency sometimes occurs during the growth period of the second or third cutting. When this occurs, spray the foliage with 0.25 lb B/a.

Grass Hay or Pasture

The N recommendation for a grass hay and for an intensively grazed (rotational grazing) grass pasture is 160 to 200 lb N/a. Nitrogen should be applied in split applications of 40 to 50 lb N/a at green-up, June 1, August 1 and September 1. Phosphorus and potassium recommendations are presented in Tables 33 and 34 for bromegrass. Phosphorus recommendations for other grasses are similar to those of bromegrass, but K recommendations are different because the various grasses take up different amounts of K. (See Table 3.)

Table 33. Phosphorus recommendations for selected yields of bromegrass hay (mineral soils).

Soil test	Yield (t/a) 4	Yield (t/a) 6
ppm	— lb P_2O_5/a —	
5	102	128
10	77	103
15-30	52	78
35	26	39
40	0	0

Numbers highlighted are maintenance amounts.

Table 34. Potassium recommendations for selected yields of bromegrass hay (mineral soils).

Soil test	CEC	4 t/a 4	4 t/a 8	4 t/a 12	4 t/a 16	6 t/a 4	6 t/a 8	6 t/a 12	6 t/a 16
ppm		— lb K_2O/a —				— lb K_2O/a —			
40		258	281	300	300	300	300	300	300
80		210	225	244	267	300	300	300	300
85		204	218	236	258	300	300	300	300
95		204	204	220	240	300	300	300	300
105		204	204	204	222	300	300	300	300
115		204	204	204	204	300	300	300	300
125		102	204	204	204	153	300	300	300
135		0	102	204	204	0	153	300	300

Numbers highlighted are maintenance amounts.
Maximum annual recommendation is 300 lb K_2O/a.

When grass is seeded for hay or pasture, the fertilizer may be broadcast and incorporated before seeding or applied at the time of seeding. Base the amounts to apply on a soil test. When fertilizer is applied with the seed, limit the total amount of nutrients (N + P_2O_5 + K_2O) to 100 lb/a on sandy soils and 140 lb/a on fine-textured soils. Broadcast and incorporate any additional amounts of phosphate and potash. Include 30 to 40 lb/a in the preplant or planting-time fertilizer.

For grass hay, annually topdress 200 lb N/a in split applications (50 lb N/a at green-up and after each of the first three cuttings) plus maintenance amounts of phosphate and potash. For grass-legume hay with more than six legume plants per square foot, no additional N is needed. As the percent legume decreases, the need for N increases. With a legume stand of less than 40 percent (fewer than three plants per square foot), apply 100 lb N/a.

For timothy hay, apply 100 lb N/a just before green-up. Timothy has a shallow root system, so unless soil moisture is adequate, there is little regrowth. When soil moisture is adequate for reasonable regrowth and a second cutting, apply an additional 50 lb N/a after taking the first cutting.

Grass Pasture

Annually topdress with N plus maintenance amounts of P_2O_5 and K_2O. Apply, in split applications (at green-up, June 1, August 1 and September 1), 160 lb N/a for intensively grazed pastures (rotational grazing) and 200 lb N/a for extensively grazed pastures. Extensively grazed pastures require more N because the continuous grazing results in less regrowth of the grasses, and the additional N is needed to help stimulate regrowth. Intensive (rotational) grazing systems allow an adequate rest period for better regrowth and productivity of the pasture grasses and better utilization of N between grazing events. When pastures contain more than 40 percent legume, additional N is not recommended.

Brassicas for Forage

Several of the brassica species (kale, rape, swedes, turnips) can be used as a fall forage crop to be grazed. They are frequently planted after the harvest of small grains. Apply a total of 100 lb N/a. Broadcast and incorporate the recommended amounts of P_2O_5 and K_2O before planting.

Grass Waterways and Critical Areas

Grass waterways, highly erodible soils and other critical areas need good fertility to maintain a dense, uniform cover through the year. Follow the guidelines for grass hay. Because there will be no crop removal, the amount of fertilizer to apply will be that for building the soil test values up to the critical level. Broadcast and incorporate 40 lb N/a and the required amounts of P_2O_5 and K_2O before seeding, or, if the crop is already established, broadcast the fertilizer. To maintain vigor, annually top-dress with up to 25 lb N/a.

Conservation Reserve

The Conservation Reserve Program (CRP) provides cost sharing for the establishment of long-term, resource-conserving ground covers to improve water quality, control soil erosion and enhance wildlife habitat. Native cool- or warm-season grasses alone or in combination with a legume are frequently seeded for CRP plantings. For establishment and maintenance of long-term vegetative covers, adjust the soil pH to above 6.0 before seeding. Required soil P and K levels are lower than those for forage hay production because there is no removal of biomass. Apply the amounts of P_2O_5 and K_2O needed to build the soil level to the critical level (10 ppm P, 95 ppm K). No N is recommended for establishment of warm- or cool-season grasses with or without a legume. Studies have shown that N application increases weed competition. No maintenance fertilization is needed once ground cover is established because nutrients taken up by the plants will be recycled as the biomass dies and decomposes.

Potato

Recommended N can be calculated as follows:

N rec = 150 + [(YP – 300) x 0.3]
where YP is yield potential in cwt/a

For Russet Burbank, Snowden and other late-maturing varieties, increase the N recommendation by 40 lb N/a. Phosphorus and K recommendations are given in Tables 35 and 36.

Apply up to 60 lb N/a, all of the P_2O_5 and up to 100 lb K_2O/a in starter bands 2 inches to the side and level with or slightly below the seed pieces. Placing bands on both sides of the seed pieces is more effective than

Table 35. Phosphorus recommendations for selected yields of potato (mineral soils).

Soil test	Yield (cwt/a) 350	400	450
ppm	— lb P_2O_5/a —		
20	200	200	200*
40	200	200	200
60	120	127	133
75-150	45	52	58
175	23	26	29
200	0	0	0

*Recommendation is capped at 200 lb P_2O_5/a.
Numbers highlighted are maintenance amounts.

Table 36. Potassium recommendations for selected yields of potato (mineral soils).

Soil test	CEC	350 cwt/a 4	8	12	16	450 cwt/a 4	8	12	16
ppm		— lb K_2O/a —				— lb K_2O/a —			
40		274	297	300	300	300	300	300	300
80		226	241	260	283	289	300	300	300
85		220	234	252	274	283	297	300	300
95		220	220	236	256	283	283	299	300
105		220	220	220	238	283	283	283	300
115		220	220	220	220	283	283	283	283
125		110	220	220	220	142	283	283	283
135		0	110	220	220	0	142	283	283
145		0	0	110	220	0	0	142	283
155		0	0	0	110	0	0	0	142
165		0	0	0	0	0	0	0	0

Numbers highlighted are maintenance amounts.
Maximum annual recommendation is 300 lb K_2O/a.

banding on just one side. Before planting, broadcast and incorporate needed K_2O in excess of the amount applied in the fertilizer bands. Fall application of K on sandy and organic soils is not recommended because of the potential for leaching loss. Incorporating a legume cover crop or animal manure can significantly reduce the amount of supplemental N needed. Nitrogen broadcast before planting has an increased risk of loss by leaching. Nitrogen applied after planting is used more efficiently than N applied preplant. For best N management, supply needed N through a combination of applications at planting time, hilling and topdressing, or through irrigation. (For more information on nutrient management of potatoes, see MSU Extension bulletin E-2779.) After harvest, establish a cover crop to take up any residual N and to protect against wind erosion.

Manganese may be needed when the soil pH is above 6.5 on mineral soils and above 5.8 on organic soils. Use a soil test to determine the amount of Mn needed. Include the required amount of Mn in the starter fertilizer and/or spray the foliage with 1 to 2 lb Mn/a at least twice during active growth. On organic soils, foliage application is essential.