United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

CONSERVATION CROP ROTATION

CODE 328

(ac)

BROAD REVIEW

Drafted technical standard text (as sent for review) is in black and blue fonts.

National minimum requirements are in black font;
Wisconsin specific criteria is denoted with blue font.

DEFINITION

A planned sequence of crops grown on the same ground over a period of time known as the rotation cycle.

PURPOSE

This practice is applied to support one or more of the following purposes:

- Reduce sheet, rill and wind erosion
- ~~Provide increases to~~Improve soil health by increasing ~~and soil~~ organic matter content
- Protect water quality from excess nutrients
- Improve ~~soil moisture~~ efficiency of irrigation water use
- Reduce plant pest pressures
- Provide or increase forage supply during periods of low forage production or to extend the grazing season.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all cropland where a conservation crop rotation is followed.

CRITERIA

General Criteria Applicable to All Purposes

Use of this standard will comply with all applicable federal, state, and local laws and regulations and with other USDA policies, e.g., Risk Management Agency crop insurance requirements.

Plan and document the crop sequence as outlined in Plans and Specifications.

Include a minimum of two different crops for a minimum of 3 calendar years in the crop rotation.

Select crops that will produce a minimum positive trend in Soil Conditioning Index (SCI) of 0.5 SCI over the planned rotation.

For purposes of these criteria, a cover crop is considered its own crop. Reference the current WI Conservation Practice Standard (CPS) 340 Cover Crop for further details. Utilize cover crops with an overwintering component to provide adequate biomass and soil protection.

Use current erosion prediction technology (e.g., RUSLE2, WEPS, WEPP) to plan the crop rotation and crop management practices to keep sheet, rill and wind erosion estimates at or below tolerable soil loss criteria.

No ephemeral or classic gullies will be present; if present, utilize appropriate conservation practices to repair and protect concentrated flow areas.

Design the crop rotation to provide protection to the soil surface during critical runoff period(s).

Design the crop rotation for the *dominant critical soil*[1].

Identify if the planned cropland area is located in a state or locally identified environmentally critical and/or sensitive areas such as source water protection areas, high groundwater table, and/or karst bedrock. Utilize additional cropland protection measures as needed to address special resource concerns.

Where applicable, plan suitable crop substitutions when the planned crop cannot be planted due to weather, soil conditions, or other local situations.

Additional Criteria to Reduce Sheet, Rill and Wind Erosion

Select crops, a tillage system, and cropping sequences that will produce sufficient and timely quantities of biomass or crop residue which, in conjunction with other practices in the management system, will meet sheet, rill and wind erosion to the planned soil loss objectives.

Determine the amount of biomass or crop residue needed by using current approved erosion prediction technology. Manage crop residue to maintain sufficient soil surface cover.

Additional Criteria to ~~Increase~~ Improve Soil Health ~~and~~ by Increasing Organic Matter Content

~~Grow crops that will produce a positive trend in the soil Organic Matter (OM) subfactor value over the life of the rotation, as determined by a minimum of 0.5 Soil Conditioning Index (SCI). Make appropriate adjustments for additions to or subtractions for biomass.~~

Complete the In-Field Soil Health Assessment worksheet. Implement one or more associated conservation practices, such as the current WI CPS 329 Residue and Tillage Management, No Till, WI CPS 340 Cover Crop, or WI CPS 345 Residue and Tillage Management, Reduced Till, to address the identified resource concern and improve soil health indicators.

Additional Criteria to Protect Water Quality from Excess Nutrients

Use practices such as relay cropping, *interplanting*, cover cropping and/or *planting green* to maximize soil cover and to maximize living roots throughout the year in order to minimize the risk of nutrient leaching and runoff.

To recover excess nutrients from the soil profile, use crops with:

- Quick germination and root system formation as determined by a rating of “very good” or “excellent” in Table 2 of Agronomy Technical Note 7,
- A rooting depth sufficient to reach the nutrients not removed by the previous crops as determined by a rating of “very good” or “excellent” in Table 2 of Agronomy Technical Note 7,

[1] Words in the standard that are shown in italics are described in the Glossary section. The words are italicized the first time they are used in the text.

- Nutrient requirements that readily utilize the excess nutrients throughout the year.

Utilize current WI CPS 590 Nutrient Management. Credit nutrients provided by legumes and manure or organic by-products.

Additional Criteria to Improve ~~Soil Moisture~~ Efficiency of Irrigation Water Use

Select crops, varieties of crops, and the sequence of crops based on local climate patterns, soil conditions, and irrigation water availability. Utilize current irrigation tools, such as the Wisconsin Irrigation Scheduling Program (WISP) and Wisconsin Irrigation Scheduling Spreadsheet (WISS) to improve applied water use efficiencies.

Additional Criteria to Reduce Plant Pest Pressures

Design the crop sequence to suppress the lifecycle of pest(s) ~~lifecycle of~~ concern, which may include weeds, insects, and pathogens. Use university or industry standards to determine a suitable crop sequence.

Additional Criteria to Provide or Increase Forage Supply During Periods of Low Forage Production or to Extend the Grazing Season

Establish annual forage crop species and varieties to provide forage biomass to meet the nutritional needs of animals during the desired period of time.

Select crop species to produce forage during periods when other on-farm forages may not meet animal needs.

Exclude animals until the crop species achieve a proper maturity to be grazed. Manage grazing and harvesting to provide plants sufficient recovery.

Select crop species and their cultivars based upon:

- Amount of forage needed to achieve desired animal/forage balance;
- Animal nutritional needs;
- Intended grazing or harvesting intensity;
- Timing of availability and anticipated forage shortages and/or method of harvest.

CONSIDERATIONS

General Considerations

When used in combination with WI CPS 585 Stripcropping, the crop sequence should be consistent with the stripcropping design.

Crop rotation can reduce soil nutrient levels and risks to water quality. Whole plant harvest as a forage enhances soil nutrient removal as compared to grain-only harvest.

Crop rotation can include diverse relay crop plantings for grazing forages, or mechanical forage harvest.

To reduce ~~S~~soil compaction, ~~can be reduced by~~ adjust~~ing~~ crop rotations to include ~~deep rooting~~ crops with ~~deep~~diverse root structures that extend to and penetrate compacted soil layers. Minimize soil compaction from field operations using such practices as field borders and controlled wheel traffic. Avoid field operations during wet soil conditions.

~~Where improving water use efficiency on deep soils is a concern, rotating or combining deep-rooted crops with shallow rooted crops can help utilize all available water in the soil profile.~~

Select crops that have the potential to provide larger amounts of biologically fixed nitrogen.

Select crop species and varieties based upon necessary herbicide tolerance and resistance to disease or insects common to the site or location. Work with pest management advisors for specific recommendations.

Select crop species to provide increased biomass and/or crop residue, particularly during times of increased erosion and runoff risk.

Select crops to break insect, pest, weed, and pathogen life cycles.

Select plants that provide *allelopathic properties* to meet weed suppression goals.

Consider use of the following current WI CPSs, as applicable: Alley Cropping (311), Critical Area Seeding (342), Field Border (386), Herbaceous Weed Control (315), Wildlife Habitat Planting (420), Mulching (484), Nutrient Management (590), Pest Management Conservation System (595), Residue and Tillage Management, No Till (329), and Residue and Tillage Management, Reduced Till (345).

Design crop rotations and crop establishment methods (planting and tillage) to reduce the farm energy consumption.

Design crop rotations with high biomass crops with the potential for energy production.

Grape vineyard plantings are not considered compatible with this standard.

Perennial fruit trees and shrubs should not be considered crops for the purpose of this practice standard.

Tree or landscape shrub nursery plantings and potted plant stock are not considered a crop for the purpose of this standard.

Urban agriculture fields and gardens may not appear as cropped in the existing soil maps produced by the WI Soil Survey. Organic amendments, potting soil, peat moss and/or other materials may have been added to these soils and likely impact soil properties.

Consider diverse vegetable, perennial plants, and cover crop rotations for urban agricultural producers. Some crops may be long term, such as perennial flowers, perennial root crops, and vine crops.

Perennial crops may require additional practices to achieve the minimum positive trend of 0.5 SCI, such as mulching or grass field borders.

Some urban agriculture crops may be planted by seed, propagated plant plugs, transplanted plant stock, root splitting or root plantings. Annual vegetable crops may be rotated multiple times during the growing season.

Use additional practices for diverse small-scale agricultural rotations such as mulching, residue management, and cover crops to achieve a minimum of 0.5 SCI.

Additional Considerations to Reduce Sheet, Rill and Wind Erosion

When used in combination with WI CPS 329 and CPS 345 Residue and Tillage Management, selection of high-residue producing crops and varieties, use of cover crops and adjustment of plant density and row spacing can enhance production of the kind, amount, and distribution of residue needed to reduce sheet, rill and wind erosion to meet planned soil loss objectives.

Use crop rotations in combination with WI CPS 585 Stripcropping or CPS 332 Contour Buffer Strips on steeper slopes.

Additional conservation practices further reduce sheet, rill, and wind erosion, such: WI CPS 380 Windbreak-Shelterbelt Establishment and Renovation, CPS 340 Cover Crop, and CPS 589 Cross Wind Trap Strips.

Crop damage by wind erosion can be reduced with this practice by selecting crops that are tolerant to abrasion from windblown soil or tolerant to high wind velocity.

If crops sensitive to wind erosion damage are grown, the potential for plant damage can be reduced by crop residue management, field windbreaks, herbaceous wind barriers, ~~intercropping~~interplanting, and/or other methods of wind erosion control.

Additional Considerations to Improve Soil Health by Increasing Organic Matter Content

Implement principles of soil health:

- Maximize presence of living roots,
- Minimize disturbance,
- Maximize soil cover, and
- Maximize biodiversity.

Grow crops that will produce a positive trend in the soil Organic Matter (OM) subfactor value over the life of the rotation.

Consider including perennial sod crops with deep or extensive fibrous root systems to build organic matter throughout the soil profile.

Reduce the intensity of tillage and increase soil surface coverage with vegetation and crop residues. Utilize the Soil Tillage Intensity Rating (STIR) calculations to maintain the lowest possible composite value for all combined field operations.

The effects of this practice can be enhanced by utilizing animal wastes, green manure crops (cover crops), or applying non-synthetic mulches to supplement the biomass produced by crops in the rotation.

Other considerations for soil health/organic matter management include:

- ~~For at least one-third of the crop sequence (time basis) include~~ Use high-biomass annual or perennial crops for at least one-third of the crop sequence (time basis).
- Utilize cover crops and high residue production crops comprising at least one-half of the rotation sequence. Consider terminating a cover crop just before or after planting of the primary crop to ensure adequate aboveground biomass to prevent erosion. Consider planting the primary crop into a green and living cover crop, i.e. “planting green.”
- For rotations dominated by low-residue production crops, such as vegetables, include sufficient cover crops and high residue crops for at least one-half the crop rotation.
- Utilize *companion cropping*, relay cropping, or low disturbance interseeding practices such as modified low-till planters.
- Utilize minimal soil disturbance practices such as no-till or low disturbance manure injection/application (LDMI/LDMA).

~~Additional Considerations to Improve Soil Health through Increase Cropping System Biodiversity~~

Minimize the *fallow* periods in the rotation and where the climate and soils are favorable establish cover crops during the fallow periods.

For crop diversity, the planned crop sequence should contain different crop types; for example a mix of the following: warm season grass; warm season broadleaf; cool season grass; cool season broadleaf.

- A two-crop sequence that contains a warm season and a cool season crop.
- A three-crop sequence that contains warm and cool season crops. The same crop species should not be grown in successive years in the same field.
- A four-crop sequence that contains two different crop types, neither should occupy more than half of the sequence.
- Longer crop sequences (four or more years) are more effective with no more than two consecutive years with the same crop.

Design crop rotations to provide continuous living cover such as including relay cropping or intercropping.

Additional Considerations to Protect Water Quality from Excess Nutrients

Include perennial or annual legume crops in the rotation to provide nitrogen for the non-legume crops, especially in fields where manure applications are restricted by high or excessive soil phosphorus or potassium levels.

~~Use~~Return low carbon/nitrogen ratio ~~for~~ crop residues ~~returned~~ to the soil throughout the rotation. ~~This ratio~~ These residues can build the soil’s capacity to provide slow-release N to crops while minimizing N

leaching.

Include leguminous and/or low supplemental nutrient requiring annual, biennial, or perennial crops to potentially reduce the need for commercial fertilizers and/or organic by-products.

Additional Considerations to Reduce Plant Pest Pressures

Consider lengthening the rotation to include several years of perennial cover to break pest life cycles.

Design the crop rotation to manage pesticide resistance and interrupt weed germination cycles.

Select weed free plant seed or certified seed to minimize introduction of new or invasive pests.

Clean tillage, planting and harvesting equipment when entering or exiting the field.

Use a mix of crops from at least three different plant families, and allow three years or longer between successive plantings of production crops within the same family.

Enhance biological pest control by designing the crop rotation to:

- Include flowering annuals or perennials that provide food and habitat for beneficial insects.
- Include plant species that release into the soil, natural substances that suppress plant pathogens, nematodes or pests (bio-fumigation).
- Include crops in the rotation that provide habitat for natural enemies of pests.
- Retain bolting or flowering crops after harvest to provide food for beneficial insects.

Additional Considerations to Provide or Increase Forage Supply During Periods of Low Forage Production or to Extend the Grazing Season

Plan grazing and harvest activities to leave adequate aboveground biomass to reduce erosion.

Consider using current WI CPS 382 Fence and WI CPS 528 Prescribed Grazing when planning grazing.

~~**Additional Considerations to Provide Food and Cover Habitat for Wildlife, Including Pollinator Forage, and Nesting**~~

~~Crop residues may be a valuable food source for wintering wildlife where winter browse is sparse. Leaving several rows un-harvested around the edges of the field, or planting borders of various forbs, will provide protection and/or food for overwintering wildlife and for beneficial insects and pollinators.~~

~~Crop plantings may be developed to benefit particular communities, species, or life stages of wildlife. Food plots or crops for wildlife can provide part of a habitat restoration, an initial food and cover for wildlife until food and cover producing vegetation becomes established.~~

~~Retaining bolting or flowering crops after harvest may provide beneficial insects with an important food source.~~

~~Careful consideration should be given to pesticides applied to crops raised for wildlife, particularly if nesting habitat or pollinator forage species are present.~~

~~When insect-pollinated crops are part of the rotation, planting the insect- pollinated crop no more than 800 feet from their previous location may help maintain local populations of native bees that have become established because of the presence of that crop.~~

~~To maintain stable pollinator and beneficial insect populations, ensure that the same overall density of floral resources is maintained from year-to- year. For example two years of flower-rich plantings, followed by a year of only grasses, will cause a rapid decline in pollinator populations.~~

PLANS AND SPECIFICATIONS

Develop plans and specifications for each field or treatment unit according to the Criteria and Operation and Maintenance requirements of this standard. Specifications must describe the requirements to apply

this practice to achieve the intended purpose. Document the following items as a minimum:

- Field number and acres,
- Purpose(s) of the crop rotation,
- The sequence of crops to be grown,
- The crop types to be grown,
- Tillage type and season for each operation,
- Length of time each crop/crop type will be grown in the rotation,
- Total length of rotation,
- SCI value of the planned rotation,
- Suitable crop substitutions to address weather, soil conditions, market, or other situations that may prevent the planned crop from being planted.

OPERATION AND MAINTENANCE

Provide and review an operation and maintenance plan with the operator/landowner. Include the following items in the plan (and others as appropriate):

- Evaluate the crop to determine if it meets the planned purpose(s). If the crop does not meet the intended purpose(s) adjust the management, change the species of crop, or choose a different technology.
- 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 characteristics that will accomplish the purpose of the original crop.
- ~~Evaluate the rotation and the crop sequence to determine if the planned system is meeting the planned purposes.~~

REFERENCES

Colquhoun, J. 2006. Herbicide Persistence and Carryover. UW Extension. A3819. http://corn.agronomy.wisc.edu/Management/pdfs/A3819.pdf

Green, B., D. Kaminski, B. Rapp, M. Celetti, D. Derksen, L. Juras, and D. Kelner. 2005. Principles and practices of crop rotation. Saskatchewan Agriculture and Food.

Karlen, D.L., E.G. Hurley, S.S. Andrews, C.A. Cambardella, D.W. Meek, M.D. Duffy, and A.P. Mallorino. 2006. Crop rotation effects on soil quality at three northern corn/soybean belt locations. Agron. J. 98:484-495.

Liebig, M.A., D.L. Tanaka, J.M. Krupinsky, S.D. Merrill, and J.D. Hanson. 2007. Dynamic cropping systems: Contributions to improve agroecosystem sustainability. Agron. J. 99:899-903.

NRAES-177. 2009. Crop rotation on organic farms: a planning manual. C. L. Moher and S. E. Johnson. ISBN 978-1-933395-21-0.

Sherrod, L.A., G.A. Peterson, D.G. Westfall, and L.R. Ahuja. 2003. Cropping intensity enhances soil organic carbon and nitrogen in a no-till agroecosystem. Agron. J. 67:1533- 1543.

USDA-AMS National Organic Program, Final Rule 7 CFR Part 205. http://www.ams.usda.gov/AMSv1.0/nop

USDA. ARS. 2021. Interseeding alfalfa into silage corn. Fact sheet. Dr. John Grabber and Dr. Will Osterholz et al. US Dairy Forage Research Center.

USDA, NRCS. November 2019. In-Field Soil Health Assessment. https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=44419.wba

USDA NRCS East National Technology Support Center, Greensboro, NC, in cooperation with North Dakota NRCS, January 2011. Carbon to Nitrogen Ratios in Cropping Systems.

USDA, NRCS. Modified May 26, 2022. Revised Universal Soil Loss Equation Version 2 (RUSLE2) website: Washington, DC. https://data.nal.usda.gov/dataset/revised-universal-soil-loss-equation-version-2-rusle2#

USDA, NRCS. Water Erosion Prediction Project (WEPP) website: https://www.nrcs.usda.gov/resources/tech-tools/water-erosion-prediction-project

USDA, NRCS. Modified December 16, 2022. Wind Erosion Prediction System (WEPS) website: Washington, DC. https://data.nal.usda.gov/dataset/wind-erosion-prediction-system-weps

USDA, NRCS. 2011. National Agronomy Manual, 4th Ed. Washington, DC. https://www.nrcs.usda.gov/sites/default/files/2022-10/National-Agronomy-Manual.pdf

USDA, NRCS. 2014. Preventing or mitigating potential negative impacts of pesticides on pollinators using IPM and other conservation practices. Nat. Agron. Tech Note 9. Washington, DC. https://directives.sc.egov.usda.gov/opennonwebcontent.aspx?content=34828.wba

GLOSSARY

Allelopathic – Production of biochemicals by one plant resulting in the germination suppression of another plant. The plant chemicals responsible for this effect are often produced during the plant's growth or released as it decomposes.

Companion cropping – Growing two complimentary crops, comingled in a field or bed, at the same time. For example: oats and peas, or alfalfa and grass. Also known as co-planting or interseeding.

Dominant critical soil – The soil map unit within a defined field area with the highest sheet, rill or wind soil erosion potential comprising greater than 10% of the total field area.

Fallow – A deliberate period of maintaining bare soil, often involving frequent cultivation to control weeds. Fallow periods can be seasonal, weekly, or last for several months.

Interplanting – The practice of growing two or more crops in close proximity to one another. Often these crops are grown in the same bed or field, potentially in alternating rows, and are close enough for biological interaction.

Planting green – The practice of planting the primary crop into a standing, living cover crop.

Relay crop – The practice of interseeding a second crop into the first crop well before the first crop is harvested.