United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

SOIL CARBON AMENDMENT

CODE 336

(ac)

DEFINITION

Application of carbon-based amendments derived from plant residues or treated animal byproducts

PURPOSE

Use this practice to accomplish one or more of the following purposes:

- Improve or maintain soil organic matter
- Sequester carbon and enhance soil carbon (C) stocks
- Improve soil aggregate stability
- Improve habitat for soil organisms

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all land uses where organic carbon amendment applications will improve soil conditions, with the following exceptions:

- Do not use this practice to apply amendments where changes to the plant community could be undesirable or unknown (e.g., changing a native or an established desired community etc.).
- Do not apply amendments when nutrients in the amendment will not be directly used (e.g., nutrient-rich amendment applications to fallow land or fields without existing or planned vegetative cover).
- To apply raw manure, biosolids, or other amendments that may have environmental impact(s), use NRCS Conservation Practice Standard (CPS) Nutrient Management (Code 590).

CRITERIA

General Criteria Applicable to All Purposes

Plan, design, and implement carbon amendment applications in compliance with all federal, state, and local laws and regulations. The owner or operator is responsible for securing all required permits or approvals and for applying in amendment in accordance with such laws and regulations.

Evaluate site using appropriate planning criteria, assessment tools, or evaluation activities for the intended land use to determine where soil carbon amendments will achieve the intended purpose(s).

Test the soil prior to amendment application. Use laboratories meeting current requirements and performance standards of the North American Proficiency Testing Program under the auspices of the Soil Science Society of America or use an alternative State-approved certification program that considers laboratory performance and proficiency to ensure accuracy of soil test results.

Follow Land Grant University (LGU) or industry guidance to collect, prepare, store and ship soil samples. Ensure sampling protocol and laboratory soil test methods are the same as those required by the State-adapted NRCS Conservation Practice Standard (CPS) Nutrient Management (Code 590).

At a minimum, measure the following soil properties:

- Soil pH
- Soil organic matter or soil organic carbon
- Extractable phosphorus, potassium, calcium, sulfur, and magnesium
- Cation exchange capacity

Test for any of the following properties when applicable to local conditions or conservation objectives:

- Aluminum, sodium, and soluble salts (electrical conductivity)
- Bulk density
- Aggregate stability
- Available water capacity
- Iron, manganese, copper, zinc

Additional Criteria for All Amendments

Document the physical and chemical analysis (i.e., composition and properties) of amendment per amendment category near the time of application. Current amendment analysis documentation shall be provided by the party who produces the amendment.

Apply carbon amendments with minimal disturbance at a rate and time that will achieve the intended purpose.

Evaluate the landscape, soil properties, amendment composition, plant nutrient needs, and application rate to determine if NRCS CPS Nutrient Management (Code 590) is needed to address nutrient-related resource concerns.

Do not use this practice for the application of raw manure alone or non-pyrolyzed or non-gasified biosolids.

Do not apply high-salt materials where salinity is a concern.

Do not apply amendments:

- Produced from crop residues that could otherwise provide soil protection and improve soil health (e.g., stover or straw) or from woody residue that is necessary to sustain forest health and support wildlife habitat as referenced in NRCS CPS Forest Stand Improvement (Code 666)
- During high wind events
- Where soil, site, climate, or condition pose a significant risk of loss due to slope, runoff potential, rainfall or irrigation intensity, or other factor
- To areas where negative impacts on air or water resources or nutrient cycling may occur
- That may contain undesirable plant propagules or seeds

For operations certified under USDA's National Organic Program (NOP), apply and manage amendments according to program regulations, including but not limited to compost temperature and carbon to nitrogen ratio (C:N) requirements under 7 CFR §205.203. Operations should consult their certifying agent to ensure compliance with NOP standards (or other certification programs or marketing agreements) prior to application.

Consult state rangeland or grazing specialists when planning soil carbon amendments on rangelands.

Evaluate the cumulative impacts of critical amendment components such as nutrients, nutrient interactions, toxicants, or contaminants when planning repeat applications. Include a monitoring plan as appropriate based on risk.

Report values for all parameters listed in Table 1. Do not apply amendments if the maximum allowable levels listed are exceeded.

Table 1. Parameters for All Carbon Amendments

Parameter	**Range**	**Unit**
Feedstock	Report[1]	Type by %
pH	Report	pH units
Electrical Conductivity (EC)	Report	dS/m
Moisture	Report	%
Organic Matter/Carbon	Report	% DW[2]
Total Nitrogen	Report	% DW
Particle Size	Report	% per size class
Phosphorus	Report	mg/kg[4] DW
Potassium	Report	mg/kg DW
Calcium	Report	mg/kg DW
Magnesium	Report	mg/kg DW
Arsenic[3]	<41	mg/kg DW
Cadmium	<39	mg/kg DW
Copper	<1500	mg/kg DW
Lead	<300	mg/kg DW
Mercury	<17	mg/kg DW
Nickel	<420	mg/kg DW
Selenium	<100	mg/kg DW
Zinc	<2800	mg/kg DW

[1]Report results, also see criteria under amendment type

[2]DW = Dry weight

[3]Pollutant concentration limit values from US EPA Title 40 Part 503 STANDARDS FOR THE USE OR DISPOSAL OF SEWAGE SLUDGE. Follow state and local laws and regulations.

[4]milligrams per kilogram (mg/kg) = parts per million (ppm) = grams per ton (g t^{-1})

Compost

Use compost that is produced by the controlled aerobic, biological decomposition of biodegradable feedstocks. Use compost with the US Composting Council's Seal of Testing Assurance Program (STA) or that meets the following criteria in Table 2 below as determined by the Test Methods for the Examination of Composting and Compost (TMECC) or by LGU recognized methods.

Document:

- Origin of compost
- Parameters for All Carbon Amendments in Table 1
- Parameters for Compost Amendments in Table 2

Table 2. Parameters for Compost Amendments

Parameter	Range	Unit
C:N	Report[1]	unitless
Organic matter	Report	% DW
Fecal coliform	<1000	MPN[2] per g dry compost
Salmonella spp.	<3	MPN per 4 g dry compost
[1]Report = Required results only, no threshold or range needs to be met [2]MPN = Most Probable Number		

Use laboratories successfully meeting the current requirements and performance standards of the STA or use an alternative State-approved certification program that considers laboratory performance and proficiency to ensure accuracy of laboratory analyses.

Ensure compost is screened to remove contaminants such as glass, metal fragments, film plastic, hard plastic, and sharps.

Do not apply compost when a phosphorus risk assessment indicates a high or very high risk for phosphorus transport.

Ensure mitigating conservation practices to prevent runoff are in place at the time of application if compost is spread on cropland with slopes greater than 8% and within 100 feet of a surface water body.

Do not apply compost to rangelands except where it is facilitating CPS Range Planting (Code 550) or CPS Critical Area Planting (Code 342).

Biochar

Use biochar that is produced by heating biomass to a temperature in excess of 350 °C under conditions of controlled and limited oxygen concentrations to prevent combustion (i.e., pyrolysis or gasification). Use biochar with the International Biochar Initiative (IBI) Certified biochar seal or that meets the criteria in Table 3 as determined by the methods in IBI Standards (version 2.1), or by LGU recognized methods.

Document:

- Origin of biochar and production method (e.g., verification of temperature and limited oxygen conditions).
- Parameters for All Carbon Amendments in Table 1
- Parameters for Biochar Amendments in Table 3

Table 3. Parameters for Biochar Amendments

Parameter	Range	Unit
Total Ash	Report[1]	% of total mass, dry basis
Liming equivalent	Report	% $CaCO_3$
Organic Carbon (C_{org})	>10	% DW
H:C_{org}	<0.7	Molar ratio
Chromium	<1200	mg per kg DW
[1]Report = Required results only, no threshold or range needs to be met		

Use laboratories successfully meeting the current requirements and performance standards of the IBI Seal or use an alternative State-approved certification program that considers laboratory performance and proficiency to ensure accuracy of laboratory analyses.

Apply biochar under weather conditions using application methods that reduce risk of off-site movement and follow worker safety precautions, including use of appropriate Personal Protective Equipment (PPE).

Other carbon amendments
Use regionally-appropriate carbon-based materials to fulfill the purpose(s). Other carbon amendments may include but are not limited to waste plant materials that would otherwise not provide a conservation benefit (e.g., harvested invasive aquatic species), wood chips, pulverized paper, bagasse, or distillation residue.

Follow State specific criteria for regionally appropriate carbon-based materials.

Additional Criteria to Maintain or Improve Soil Organic Matter and Sequester Carbon

Apply amendments at a minimum rate of 3 tons per acre (12 cubic yards per acre) and with minimal soil disturbance that will improve soil organic matter without exceeding acceptable risk of N or P loss.

Additional Criteria to Improve Aggregate Stability

Apply amendments with minimal soil disturbance and when soil is not excessively wet to avoid damage to soil structure.

Additional Criteria to Improve Soil Organism Habitat

Apply compost or other carbon amendments with a C:N approximately 24:1 or biochar with high surface area and porosity at a minimum rate of 1 ton per acre (4 cubic yards per acre) with minimal disturbance.

CONSIDERATIONS

General Considerations

Add mature, stable compost (i.e., based on maturity index, respirometry, or documented time and temperature of composting process) that will increase soil biological activity and diversity to enhance root health and promote resistance to pathogenic organisms.

Apply low $H:C_{org}$ biochar (<0.7) to maximize soil carbon sequestration.

Inoculate biochar with compost, compost tea, or manure to balance nutrients and nutrient interactions, stabilize pH, and improve amendment moisture content to aid application.

Adjust nutrient management and pest management plans as needed for the specific amendment type and purpose.

- Compost or other amendments with C:N greater than 30:1 can immobilize nutrients, especially nitrogen, and may necessitate supplemental nitrogen applications for plant growth.
- Compost or other amendments with C:N below 20:1 are likely to mineralize N and should be used at a time when plant N demand will prevent N loss.
- Biochar with high adsorptive capacity can reduce the effectiveness of some pesticides.

When feedstocks have higher risk of synthetic organic or heavy metals contaminants, evaluate amendment as appropriate for contaminant and amendment type (e.g. processed municipal waste feedstocks that may contain pesticide residues, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyl's (PCBs), polyfluoroalkyl substances (PFAS), etc.).

Time operations to minimize potential soil compaction and evaluate traffic routes to prevent erosion. Consider coordinating amendment applications with other operations to minimize traffic (e.g., seed and

apply compost at the same time). Disturbed areas should be appropriately treated to minimize potential erosion.

Consider potential contamination pathways to crops typically consumed raw, water distribution systems, etc. when applying amendments that may contain pathogens (e.g., biological soil amendments of animal origin including composted manure, composted carcasses; reference the Food and Drug Administration's Food Safety Modernization Act at www.fda.gov/FSMA).

Reduce risk of off-site movement or spontaneous ignition by properly storing and handling amendments. When staging materials for application, locate piles where they will not increase risk of material or leachate loss to sensitive areas.

Additional Considerations to Maintain or Improve Soil Organic Matter and Sequester Carbon

When applying soil carbon amendment with diesel-powered equipment and vehicles, consider using Tier 3 or Tier 4 emissions certified diesel engines to minimize nitrous oxides and particulate matter emissions from diesel exhaust and to maximize climate benefits.

Consider life cycle analysis of the amendment that evaluates the feedstock source, processing and transportation impacts on carbon and greenhouse gas accounting.

Consider using COMET-Farm or COMET-Planner to estimate changes in carbon and greenhouse gas emissions of planned practices.

On cropland, soil organic carbon is related to the volume of soil disturbed, intensity of the disturbance, soil moisture content, and soil temperature at the time the disturbance occurs. To make this practice most effective at increasing soil organic carbon stocks, improving soil health and reducing carbon loss:

- Perform any deep soil disturbance, such as ripping, subsoiling, or fertilizer injection, so the vertical slot created by the implements is closed at the surface.
- Perform soil disturbance at a time when exposed soil carbon is less likely to be oxidized and lost as CO_2 (e.g., when soil temperatures are below 50º F or when soil is not excessively wet or excessively dry).

PLANS AND SPECIFICATIONS

In the soil carbon amendment plan, include:

- Purpose of practice
- Assessment of soil health resource concerns using State-approved tools for the appropriate land use
- Results of laboratory soil health tests that include, at a minimum soil organic matter or soil organic carbon and include other soil health properties based on the purpose(s) and resource concern(s) to be addressed
- Map and site description of conservation management units receiving amendments (e.g., crop rotation, native vegetation, etc.)
- Aerial photos that include locations of sensitive areas and setbacks, as applicable
- Soil survey map of the site
- Soil information including but not limited to soil type, surface texture, slope, runoff class, drainage class, flooding and ponding frequency and duration, or soil interpretations designed for general land use planning which provide dynamic soil property information and/or soil health response to carbon amendments (i.e., Dynamic Soil Properties Response to Biochar found in Web Soil Survey under Suitabilities and Limitations tab)
- Plant information including but not limited to existing, invasive, noxious, rare, or wetland plant species as noted in the PLANTS database, as applicable

- Complete amendment analysis (See General Criteria for each amendment type)
- Application rate, method, timing, and when applicable, method of incorporation
- Monitoring plan for amendment effectiveness for the planned purpose(s) using appropriate monitoring activities (e.g., Soil Health Testing CEMA 216). Include a soil organic matter or soil organic carbon test to determine the effectiveness of the application for improving soil health and soil organic carbon 1 to 3 years after application. Soil testing at least 3 years or more after application may monitor longer-term impacts.

OPERATION AND MAINTENANCE

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

Inspect and evaluate surface applied amendments after the first heavy precipitation event to ensure the material is stable and does not impact non-target areas.

Evaluate the effectiveness of the amendment (application, amount of cover provided, durability, etc.) and adjust future management or type of amendment to better meet the intended purpose(s).

REFERENCES

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