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RESEARCH FACT SHEET · SOIL HEALTH

Biochar: What the Research Shows for Growers

Key findings from peer-reviewed meta-analyses, IPCC assessments, USDA research and land-grant university field trials, including a decade of results from Pacific Northwest dryland wheat.

PACIFIC NORTHWEST DRYLAND RESULT · OREGON STATE UNIVERSITY, CBARC (PENDLETON, OR)

One application. Soil carbon gains that lasted more than 10 years.

95–207%
more soil organic carbon right after application, and stocks stayed higher

10+ yrs
the gains persisted from a single 2013 application in dryland wheat

The trial also found improved CEC and better availability of zinc, calcium, magnesium and potassium in a winter wheat–spring pea rotation. *Machado, Ramírez & Singh, 2026, Frontiers in Sustainable Food Systems*

WATER RETENTION

+45%

more plant-available water in sandy, coarse-textured soils (+21% in medium-textured soils).

Razzaghi et al., 2020, Geoderma (meta-analysis)

NITROGEN EFFICIENCY

26% less N leaching

Plant N uptake up 11% and N_2O emissions down 32%, across 208 studies.

Liu et al., 2018, Plant and Soil (meta-analysis)

CROP YIELDS

+15%

yield over fertilizer alone when paired with fertilizer, and +31% over 3+ years after one application.

Ye et al., 2020, Soil Use and Management (field meta-analysis)

CARBON SEQUESTRATION

65–89%

of biochar carbon is assumed to remain after 100 years under the IPCC's greenhouse gas inventory method.

IPCC, 2019 Refinement to the 2006 Guidelines

MATCHING THE SOIL

pH: adjusted to your soil

Acidic soils: biochar raises pH. On a Rockford, WA farm with pH in the low 4s, high-ash biochar roughly tripled wheat yield over unamended soil.

Phillips & Trippe, 2024, Washington Soil Health Initiative

High-pH soils: BaseMix, Plenterra's charged biochar blended with SKM (raw sulfur, potassium and micronutrients), brings pH down.

Plenterra's approach, not a research finding

Also recognized by the IPCC as a carbon dioxide removal method that can improve soil properties, productivity and resilience. *IPCC AR6 WGIII, 2022*

How biochar fits NRCS practices 336 and 590

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CPS 336 · Soil Carbon Amendment

- **Purposes:** improve soil organic matter, sequester carbon, improve aggregate stability and habitat for soil organisms.
- **Biochar criteria:** made above 350 °C by pyrolysis or gasification; IBI Certified or meets Table 3 (organic C >10%, H:C_{org} <0.7, Cr <1,200 mg/kg).
- **Soil test** before application; SOM or SOC re-test 1–3 years after.
- **NRCS FAQ:** 4–10 cubic yards per acre is a good place to start; pairing with compost likely gives greater soil-health benefits.

CPS 590 · Nutrient Management

- **The 4Rs:** right source, rate, timing and placement to improve nutrient use efficiency and cut losses to water and air.
- **Research fit:** lower nitrate leaching and N_2O, higher plant N uptake, better P availability, and higher yields with fertilizer.
- **Planning:** soil testing and N adjustments within a 590 plan help capture these benefits.
- **Together:** CPS 336 can be contracted with CPS 590. CPS 590 is required with 336 only when policy calls for a Conservation Nutrient Management Plan.

Summarized from the national standards (CPS 336, Nov 2022; CPS 590, May 2019) and the national CPS 336 FAQ (Apr 2026). **State-adapted versions in the NRCS Field Office Technical Guide (eFOTG) and guidance from your local NRCS field office govern planning, eligibility and payment.**

Top 10 studies

1. **Schmidt et al. (2021).** Systematic review of 26 global meta-analyses. GCB Bioenergy. doi.org/10.1111/gcbb.12889 ›
2. **Joseph et al. (2021).** How biochar works, and when it doesn't. GCB Bioenergy; cited in CPS 336. doi.org/10.1111/gcbb.12885 ›
3. **Nabuurs et al. (2022).** IPCC AR6 WGIII, Ch. 7: Agriculture, Forestry and Other Land Uses. doi.org/10.1017/9781009157926.009 ›
4. **Ye et al. (2020).** Crop yields with and without fertilizer: field meta-analysis. Soil Use and Management. doi.org/10.1111/sum.12546 ›
5. **Jeffery et al. (2017).** Biochar boosts tropical but not temperate crop yields. Environmental Research Letters. doi.org/10.1088/1748-9326/aa67bd ›
6. **Liu, Q. et al. (2018).** How does biochar influence soil N cycle? Plant and Soil. doi.org/10.1007/s11104-018-3619-4 ›
7. **Razzaghi et al. (2020).** Does biochar improve soil water retention? Geoderma. doi.org/10.1016/j.geoderma.2019.114055 ›
8. **Machado, Ramírez & Singh (2026).** SOC and acidity gains persist after 10 years (OSU, CBARC). Frontiers in Sustainable Food Systems. doi.org/10.3389/fsufs.2026.1638625 ›
9. **Jeffery et al. (2011).** Quantitative review of biochar effects on crop productivity. Agriculture, Ecosystems & Environment. doi.org/10.1016/j.agee.2011.08.015 ›
10. **Liu, X. et al. (2013).** Crop productivity and experimental conditions: meta-analysis. Plant and Soil. doi.org/10.1007/s11104-013-1806-x ›

WHERE IT WORKS BEST Greatest gains on sandy, low-organic-matter or degraded soils. Biochar raises pH in acidic soils; in alkaline soils, Plenterra's BaseMix lowers it, matched to soil tests (Plenterra's approach, not a research finding).

Dive deeper: the full 62-study library, with links to every study

Open the study library (62 studies) ›

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Prepared by Plenterra LLC, November 2026. This fact sheet summarizes published research and does not represent the views of USDA-NRCS or any other agency. NRCS sets program eligibility, practice requirements and payment rates; please consult your local NRCS field office for current state requirements.