Chat GPT: Literature Review: Effects of Wood Biochar (Charcoal) on Potato (Solanum tuberosum) Yield

The use of wood-derived biochar as a soil amendment has gained attention as a sustainable alternative to conventional fertilizers. Biochar is a carbon-rich product of biomass pyrolysis that can improve soil physicochemical properties, nutrient retention, and microbial activity. This review synthesises peer-reviewed evidence on the effects of biochar application on potato yields (excluding sweet potato), with emphasis on quantified yield changes.

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1. General Effects of Biochar on Potato Yield

Across multiple studies, biochar application generally increases potato yield relative to untreated controls. The magnitude of yield improvement depends on application rate, soil type, and whether biochar is used alone or combined with other fertilizers.

A recent field study by Hou *et al.* (2024) found that combining biochar with organic fertilizer significantly enhanced potato yields. The optimal treatment (biochar:organic fertilizer ratio of 1:2) produced yields **1.48 times higher (≈ +48%)** than the control. Other treatments showed increases of **+16% (biochar alone), +28%, and +39%**, demonstrating a consistent positive response across application rates .

Similarly, Paswan *et al.* (2025) reported improved growth and yield of potato under biochar-amended soils, particularly when combined with inorganic fertilizers, although exact percentage increases varied with treatment combinations .

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2. Biochar as a Sole Amendment vs Combined Application

Evidence suggests that biochar used alone provides modest yield increases, while synergistic effects occur when combined with fertilizers.

- In Hou *et al.* (2024), **biochar alone increased yield by ~16%**, whereas combined treatments achieved up to **+48%**, indicating strong interaction effects with nutrient inputs .
- Mollick *et al.* (2020) demonstrated that biochar applied alongside recommended fertilizer doses significantly increased tuber yield and biomass compared to fertilizer-only treatments, though precise percentage gains were not consistently reported .

A study by Biswas *et al.* (2024) further supports synergistic effects, showing that biochar combined with vermicompost improved yield and quality traits beyond conventional fertilization, indicating additive or multiplicative benefits .

Overall, the literature consistently shows that **biochar enhances fertilizer efficiency**, leading to larger yield gains than when used as a standalone amendment.

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3. Influence of Application Rate and Soil Conditions

The response of potato yield to biochar is strongly dependent on application rate and environmental context.

Experimental evidence indicates that moderate application rates optimise yield. For instance, Guo *et al.* (2025) observed that intermediate biochar rates (20 t ha^{-1}) significantly improved soil quality indicators and led to linear increases in potato yield relative to soil quality improvements . Excessively high rates may not proportionally increase yield and can sometimes reduce nutrient availability due to adsorption effects.

Soil type also plays a critical role. Biochar tends to produce larger yield gains in degraded or low-fertility soils by:

- Increasing soil organic carbon
- Improving moisture retention
- Enhancing nutrient availability (N, P, K)

These mechanisms are particularly important in arid and semi-arid regions, where yield improvements are more pronounced .

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4. Mechanisms Driving Yield Increases

The observed increases in potato yield are linked to several interacting mechanisms:

1. **Improved Soil Fertility**
   Biochar increases cation exchange capacity and nutrient retention, reducing leaching losses.
2. **Enhanced Microbial Activity**
   Hou *et al.* (2024) attribute yield increases partly to improved rhizosphere microbial diversity, which enhances nutrient cycling and plant uptake .
3. **Better Soil Structure and Water Retention**
   Biochar improves aggregation and porosity, leading to enhanced root development and drought resilience.
4. **pH Regulation**
   Biochar can moderate acidic soils, creating more favourable conditions for potato growth.

These mechanisms collectively explain why yield increases are often greater when biochar is integrated with organic or inorganic fertilizers.

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5. Magnitude and Variability of Yield Changes

Across the reviewed literature, the **range of yield increases** associated with biochar application in potato cultivation is:

- **~+15–20%**: biochar applied alone
- **~+25–40%**: biochar combined with fertilizers
- **Up to ~+48%**: optimal combined treatments under controlled conditions

However, variability is high due to differences in:

- Biochar feedstock and pyrolysis conditions
- Soil characteristics
- Climate and irrigation
- Crop variety and management practices

Conclusion

Peer-reviewed evidence demonstrates that wood biochar can significantly enhance potato yields, particularly when integrated with other fertilizers. Yield increases typically range from **+16% to +48%**, with the highest gains observed under combined application strategies. The benefits are mediated through improvements in soil fertility, structure, and microbial activity. Nevertheless, outcomes are context-dependent, and optimal application rates and combinations must be tailored to local soil and agronomic conditions.

References (Harvard Style)

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