Claude: The Effect of Wood Biochar on Potato (Solanum tuberosum L.) Yields: A Literature Review

Introduction

The potato (Solanum tuberosum L.) is one of the world's most important food crops, and sustaining its productivity under conditions of soil degradation and declining organic matter is a growing challenge for global agriculture. Wood biochar — a carbon-rich material produced by the pyrolysis of woody biomass under limited oxygen — has attracted considerable scientific interest as a soil amendment capable of improving fertility, water retention and microbial activity. This review synthesises peer-reviewed evidence on the effects of wood biochar application on potato tuber yield, with particular attention to quantified yield changes.

Effects of Wood Biochar on Potato Yield

The body of experimental literature generally shows that wood biochar amendments produce significant positive effects on potato yield, though the magnitude of these gains varies considerably with application rate, pyrolysis temperature, soil type, and whether biochar is used in isolation or combined with chemical or organic fertilisers.

A two-year field experiment conducted in the arid and semi-arid Yinshan region of northern China by Wang et al. (2025) evaluated wood biochar produced at three pyrolysis temperatures (300 °C, 500 °C, and 700 °C) and three application rates (10, 20, and 30 t ha^{-1}). The study found that biochar produced at a medium pyrolysis temperature of 500 °C applied at 20 t ha^{-1} produced the largest yield increase, achieving a 27.15% rise in potato yield compared to the unamended control. The authors attributed this improvement primarily to enhanced soil hydraulic characteristics, including increased field capacity and plant-available water content. Higher pyrolysis temperatures or application rates were found to reduce these gains, indicating that an optimal treatment window exists.

In Ethiopia, Dawerasha et al. (2024) investigated the combined application of coffee-husk biochar and inorganic NP fertiliser on potato grown on acidic soils in Southwestern Ethiopia. Although coffee-husk rather than wood was the biochar feedstock, the study provides directly relevant mechanistic context. Combined application of 7.5 t ha^{-1} biochar with 165 kg N and 60 kg P ha^{-1} resulted in a total tuber yield of 42.64 t ha^{-1}, representing a 28.99% increase over recommended NP fertiliser alone and a 76.6% increase over the unfertilised control. Improvements were attributed to biochar-mediated amelioration of soil pH, cation exchange capacity (CEC), organic matter content, and available phosphorus — all critical constraints on acidic tropical soils.

Mawof et al. (2021) studied the effects of biochar and a biochar-compost mix as soil amendments on potatoes irrigated with wastewater in Canada. Their results demonstrated that soil quality indicators — including organic matter, bulk density and nutrient availability — were improved by biochar treatments, with associated positive effects on tuber yield. This finding underlines the capacity of biochar to function beneficially even under the additional abiotic stress of wastewater irrigation, broadening its potential applicability.

Mollick et al. (2020), in a field experiment at Sher-e-Bangla Agricultural University, Bangladesh, evaluated nine treatment combinations combining recommended fertiliser doses with biochar applied at rates of 2.5 to 10 t ha^{-1} on the potato cultivar Diamant (BARI Alu-7). Results indicated that biochar application significantly ($p < 0.05$) increased tuber weight, total tuber yield, tuber dry matter content, and tuber specific gravity relative to controls. A general

trend of increasing yields with increasing biochar application rates was observed, and the combination of recommended fertiliser with biochar consistently outperformed fertiliser or biochar alone.

Hou et al. (2024) examined a gradient of four ratios of biochar to organic fertiliser applied to potato crops on yellow dryland soils in Inner Mongolia, China, using the equal carbon input method. Soil fertility indicators and rhizosphere bacterial diversity were both improved by combined biochar-organic fertiliser application, with the optimal ratio (biochar:organic fertiliser = 1:2, equating to 0.66 t ha^{-1} biochar and 4.46 t ha^{-1} organic fertiliser) producing the greatest potato yield. The study demonstrated through structural equation modelling that bacterial diversity directly improved yield while soil fertility exerted an indirect positive effect — providing mechanistic insight into why biochar-amended soils produce higher yields.

Mechanisms of Yield Improvement

Across the reviewed studies, several common mechanisms account for yield increases. Wood biochar consistently reduces soil bulk density, increases porosity, and improves water retention capacity — particularly plant-available water — which is especially beneficial in sandy or drought-prone soils (Wang et al., 2025). It also raises soil pH in acidic soils, increases CEC, and enhances the availability of nutrients including nitrogen, phosphorus, and potassium (Dawerasha et al., 2024; Mawof et al., 2021). The porous structure of biochar provides habitat for beneficial soil microorganisms, supporting higher microbial biomass and enzymatic activity, which in turn facilitates nutrient cycling (Hou et al., 2024).

Limitations and Contextual Variation

Not all studies report unambiguous yield benefits. Marat (2023), working on sod-podzolic sandy loam soils in Russia using wood biochar from aspen, alder, and birch pyrolysed at 550 °C, found that biochar had no significant independent effect on potato yield, though it measurably improved soil moisture and mineral nitrogen content. This cautionary finding suggests that biochar's effects are context-dependent, and that soil type, climate, and application strategy are critical determinants of whether yield gains are realised. In nutrient-rich soils, the marginal benefit of biochar may be limited compared to its effect on degraded or acidic soils.

Conclusion

The weight of published evidence indicates that wood biochar application can meaningfully increase potato tuber yields, with documented gains ranging from approximately 27% to over 76% compared to untreated controls under optimal conditions. The most consistent and pronounced benefits occur when biochar is combined with complementary nitrogen, phosphorus or organic fertilisers, when applied to degraded, sandy or acidic soils, and when pyrolysis temperature and application rate are optimised. Further long-term field trials across diverse soil and climate conditions, including temperate systems such as those found in the United Kingdom, are needed to refine application recommendations and assess the economic viability of wood biochar for commercial potato production.

References

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