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Ecosystem disruption from crop residue burning: A systematic review

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Abstract

Crop residue burning, a widespread practice followed by millions of farmers across South Asia and other regions, has serious negative consequences for crop productivity, human health, agrobiodiversity, and ecosystem functions. While emissions from crop residue burning have been estimated and their human health impacts documented, the ways in which crop residue burning affects agrobiodiversity remain underexplored. This qualitative systematic review aims to cover this gap. From the 41 publications that met the selection criteria of our systematic review, we recorded 233 trait-level responses, the measurable characteristics of organisms such as species abundance, density, occurrence frequency and/or microbial activity, to assess the impact of residue burning on biodiversity in agroecosystems. These organisms mainly include soil bacteria and fungi, arthropods (such as insects and spiders), nematodes (roundworms), and annelids (e.g., earthworms), all of which affect soil health and agricultural productivity.

Although most studies were conducted in Asia, research from major residue-burning countries like China and India was relatively limited. As species responses to residue burning varied across agroecologies, the lack of studies in these countries is a major research gap. About 40 % of species trait instances showed a positive response to non-burning practices, whereas 27 % showed a negative response. Non-burning practices, such as residue incorporation and retention, when compared with burning, promote greater soil biodiversity, supporting beneficial soil macrofauna such as earthworms, spiders, and predatory mites, which enhance nutrient cycling and natural pest control. On the other hand, residue burning reduces the population of these organisms, disrupts reproductive cycles, causes mortality in sensitive species (e.g., frogs), and increases the prevalence of plant-parasitic nematodes. These findings highlight the ecological benefits of alternatives to residue burning, especially for soil health and sustainable agroecosystems.

Policy recommendations of the present review are manifold: promoting residue incorporation, incentivising biodiversity-inclusive carbon credits, expanding payment for ecosystem services, and strengthening the ban on open-field burning. Addressing geographical and taxonomic biases in research, particularly in the Global South, is critical for advancing sustainable and resilient agroecosystems. This study highlights the need to integrate biodiversity conservation into residue management strategies.

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