Form of nitrogen input dominates N effects on root growth and soil aggregation: a meta-analysis

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Background Anthropogenic nitrogen (N) input has overtaken natural N fixation as the largest reactive N source and is predicted to stimulate ecosystem carbon (C) sequestration. Most studies of N effects on soil C balance have focused on biological processes that control C input (plant production) and C output (microbial decomposition), but few have examined the general patterns of N effects on the physiochemical processes such as soil aggregation that regulate soil organic C persistence.

Methods We synthesized results from 87 publications that examined effects of experimental N input on soil aggregation, a key process controlling soil C persistence, and its related processes.

Results Globally, N input significantly enhanced plant shoot and root biomass, and the formation of soil macroaggregates and their size (measured as mean weight diameter, MWD; $P < 0.05$). Surprisingly, N-enhancement of root biomass and soil aggregation primarily stemmed from urea applications. Although urea input reduced microaggregates, it increased macroaggregates (+6.9%) and MWD, likely due to enmeshment by urea-induced root growth (+20.5%). In contrast, other forms of N input (combined NH_4^+, NO_3^- and NH_4NO_3) did not significantly affect root biomass, microaggregates or macroaggregates, but reduced microbial biomass C. Further, N-promotion of soil aggregation occurred mainly in croplands under low to moderate N input (< 200 kg N ha^{-1} yr^{-1}).

Conclusion These results indicate that the form of N fertilizer exerts a primary control over N effects on plants, microbes, and soil aggregation. Our findings suggest that combination of urea fertilizers and reduced perturbations (e.g., reduced-tillage) may be key to enhance soil aggregation and organic C retention and persistence in vast agroecosystems.

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