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Land-use intensification can exaggerate the reduction of functionality with increasing soil biodiversity loss in an alpine meadow on eastern Tibetan Plateau

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Abstract: Soil biota plays a pivotal role in ecosystem functionality which is of central importance to sustainable services such as food and fiber production. Intensive land use is associated with species loss and subsequent the related functionality loss. Currently, the claim that negligible effects of soil biodiversity loss due to high functional redundancy has been questioned in the face of intense human activities. Recent studies corroborated that soil biodiversity guaranteed functionality following perturbation. Few studies have, however, attempted to explore the intensive land use on the relationship between soil biodiversity and function particularly for the region susceptible to human perturbation and climate change. With increasing demands for livestock on the Qinghai-Tibetan Plateau, extensive fertilization is a common way to fill the gap of grass productivity in the alpine meadow. However, excess chemical fertilizer can lead to the species loss and functionality degradation. Do the fertilizer-induced changes in soil biota lead to a higher risk of functionality? We predicted that fertilization would exacerbate effects of biodiversity-loss on the reduction of functionality.

Herein, a dilution-to-extinction approach was used to set up soil biodiversity loss by inoculating serially diluted soil suspension (ranging from 100 to 10-8 levels) from two long-term fertilization treatments to the sterilized soil that has never been fertilized. The two fertilization treatments represented two distinct intensification land use including the unfertilized control (NP0) and a fertilized treatment (NP120) amended with (NH4)2HPO4 annually (120 kg ha-1 yr-1) since 2002 in an alpine meadow on the eastern Qinghai-Tibetan Plateau. Soil microcosms of 2 fertilization levels crossing 8 biodiversity levels were incubated for 8 months. Then, soil community and multi-functionality parameters including carbon (C)and nutrient mineralization, plant growth and functional stability were determined.

Dilution resulted in the increasing biodiversity loss indicated by genotypic information (high-throughput sequencing), phenotypic biomarkers (phospholipid fatty acid analysis) and functional profiles enzyme activities and sole C utilization potential). Notably, the decreasing genotypic diversity with dilution was most apparent among the three measured diversity traits, showing high phenotypic and functional redundancy. Fertilization decreased biodiversity, which was associated with the initial community properties. During the 8 months of incubation, the more diversity loss led to the less respired CO_2 and correspondingly the more organic C remained in soil, supporting that biodiversity is central for the capability of resource utilization. Fertilization aggravated the decreased extent of C utilization potential particularly at lower biodiversity. Plant biomass and nutrient (nitrogen and phosphorus) uptake depended on the interactions of biodiversity loss and fertilization, showing fertilization-triggered more reductions of functionality with biodiversity loss, which was more related to the diversity and composition of phenotypic and functional profiles than molecular diversity. Out of our expectation, fertilization decreased the functional stability (measured as the decomposition of dead roots following transient heating stress) for high biodiversity treatments but increased it at lower biodiversity. Moreover, enzyme activity pattern indicated low biodiversity treatments were associated labile C transformation, while high biodiversity had high capability in utilizing recalcitrant C. We conclude that changes of community composition and biodiversity by intensive land use can increase the risk of losing diversity insurance on multifunctionality. Future work about the relationship between soil biodiversity and functionality should extrapolate to larger temporal and spatial scales. Exploring the response of fertilization-induced consequence to further biodiversity loss would contribute to understand the mechanisms of ecosystem process and sustainable manage the susceptible alpine meadow ecosystem.

Keywords: Biodiversity-ecosystem function; Land-use intensification; Plant productivity; Alpine meadow; Functional diversity