Differential Effects of Nitrogen and Phosphorus Additions on the Ecology of Soil and Vegetation of Dry Tropical Forests and Derived Savanna Ecosystems in India

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Key words: landscape transformation, atmospheric nutrient deposition, natural forest, savanna, dry tropics

Introduction Landscape transformation and atmospheric nutrient depositions, important global change drivers, are rapidly occurring in Indian dry tropical regions supporting natural forest and derived savanna ecosystems. The Vindhyan Plateau, extending across the central part of India, potentially supports tropical deciduous forests have now been degraded into savannas due to anthropogenic influences through centuries. As a result the regional landscape shows vast expanses of savanna, bears intense cattle grazing especially during rainy season, interspersed with variously sized patches of forests (Singh 1989). Atmospheric nitrogen (N) and phosphorus (P) deposition values in these ecosystems range from 9.1-27.1 kg ha^{-1} yr^{-1} and 1.4-4.2 kg ha^{-1} yr^{-1}, respectively (Singh and Tripathi 2000). The objectives of this study are to understand the potential effects of N and P additions for eight years (from 1994-2001) on plant growth, tissue nutrient concentration, carbon (C) flux, soil nutrient availability and soil microbial biomass (C, N and P) in forest, ecotone and savanna ecosystems in dry tropical Vindhyan region.

Materials and methods The present study was carried out at three study sites, namely, natural forest, ecotone and savanna located in the Marihan Range of Mirzapur Forest Division (24° 55′ to 25° 10′ N lat. and 82° 30′ to 82° 45′ E long; elevation 150-250 m amsl). At each study site, a sample area measuring 100m × 100m was marked. Within each sample area, 9 randomly located permanent plots (each 12m × 12m) were demarcated, of which 3 plots were added with N (Urea applied @ 150 kg N ha^{-1}), 3 plots received single super phosphate (@ 50 kg P ha^{-1}), and three plots without additions were treated as control. Beginning 1994, in each annual cycle (July-June), except in control plots, N and P additions were made in soil during July/August within 2-3 days after the occurrence of first significant rains.

Results Nutrient addition increased (about 1.5-2.5 times) density and aboveground plant biomass of herbs in these ecosystems. N addition considerably decreased the diversity of herbaceous vegetation, whereas the P addition has little effect. N addition increased the proportion of graminoids, whereas the P addition increased the abundance of few dicot forbs. Herb shoots nutrient content increased rapidly after initial nutrient addition. While N addition significantly increased the tissue N concentration in grasses, the P addition increased the concentrations of N and P in legumes in these ecosystems. Most of the tree species did not respond to first year nutrient addition. However, the responses were evident in few species in 2nd and 3rd year of nutrient addition. The fine root biomass responded positively to N addition with greater proportions in upper (0～10 cm) soil depth. The effect of P addition on fine root was less marked. Ammonification was dominant over nitrification in the forest and ecotone while the reverse was true in the savanna. Available nutrient status, N- mineralization rate and microbial biomass (C, N and P) were significantly affected by nutrient additions. Savanna ecosystem soil responded more rapidly to nutrient addition than the forest and ecotone. However, the responses were retained for a longer period in the forest and ecotone soils than in the savanna. Addition of N significantly increased the proportion of macroaggregates in forest and ecotone soils, whereas the same input decreased the proportion considerably in the savanna. Besides, N addition also altered the biological and chemical qualities of soil aggregates. The effect of P addition on soil aggregate stability was marginal. In the current scenario of N loading, continued soil N loading in forest may lead to increased macroaggregates with associated microbial biomass C and N and greater aggregate stability. In contrast, the extensively distributed savannas may show over all reverse trends leading to nutrient loss and reduction in its carrying capacity.

Conclusions We conclude that when either N or P are added to tropical forest and savanna ecosystems the soil and plants are affected differently depending on the amount and the quality of organic matter present in the soil. Contrary to the general belief, N addition seems to have more powerful control on the structural and the functional qualities of soil and vegetation than the addition of P in these dry tropical ecosystems.

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