Water and nitrogen co-limitation of plant primary production in a semiarid grassland of Inner Mongolia

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In the water and nutrients co-limited semiarid grassland of Inner Mongolia, grazing intensity and soil resources availability interactively constrain primary production and plant community dynamics. In order to study the effects of additional water and N supplementation on grassland productivity and vegetation dynamics as subject to grazing managements, we conducted three experiments in Inner Mongolia steppe: We conducted water and N fertilization addition experiments on two sites with long-term moderately grazed and heavily grazed management history (long-term grazing effect), and on sites with well established on going grazing intensities (short-term grazing effect). We also investigated the effects of topographical microclimates on litter decomposition hilly grassland.

Our finding convinces a primary water limitation and secondary N limitation on plant aboveground net primary production (ANPP) in Inner Mongolia grassland. Effect of N addition on ANPP is much stronger under condition of high water availability. According to plant nutrients ratios, K is not a limiting factor for plant production whereas P limitation will only occur when low soil P sites are subject to additional water and N supplementations. Plant N:P ratio is a useful indicator for the relative potential of N and P limitation as affected by water and N addition, and soil fertility in semiarid grassland.

Under the altered conditions of water and soil N availability, there is a strong tradeoff between intrinsic water use efficiency (WUE_i) and N use efficiency of individual species. These adjustments occur at the leaf level and relate to the responses of leaf N concentration and specific leaf area to water and N addition. Leaf N content per area is the main determinant of WUE_i of the dominant species.

Topographical microclimate affects plant litter decomposition in hilly grassland. Plant shoot and root decay can be best predicted by soil temperature and soil water content, respectively. Northern positions have higher carbon sequestration than southern and top positions, plant root contribute more to nitrogen availability and C sequestration than shoot.

Water and N fertilizer additions accelerate grassland recovery from grazing. Water and N additions increase grassland ANPP but not belowground net primary production (BNPP) thus decrease the fraction of BNPP to net primary productivity. Water and N additions also increase tiller weight and leaf area index, which mainly contribute to the increasing of plant aboveground biomass. Our results suggest that water and N fertilizer addition can be used to restore plant production, thus more attentions on the water and N management for degraded rangeland should be drawn. Such as a small amount of N fertilizer addition in wet years can effectively promote rangeland recovery from grazing.