Shrinking stems of marsh plant under elevated carbon dioxide

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Abstract: Coastal wetlands are considered as one of the most valuable ecosystems on Earth, yet sea level rise, acidification, pollution and climate change are threatening these fragile systems. Atmospheric carbon dioxide (CO_2) concentration has evidently increased 43% since 1850 and is projected to reach 985 ± 97 ppm by 2100. It is well established that CO_2 fertilization typically stimulates C3 plant photosynthesis and primary productivity in terrestrial ecosystems, basically leading to the increase in plant body size. However, whether the enhanced C uptake under rising CO_2 concentration may increase the dimension of mash plant in coastal wetlands, has not been well examined through manipulative experiment. The morphology of marsh plant plays critical roles in coastal wetlands because it shields habitats and homes from floods and hurricanes, sustains nests for waterfowls, and supplies nurseries for nektons. To investigate the effects of elevated CO_2 on the morphology of marsh plant, open top chambers (OTC, double the CO_2 concentration in the elevated chambers compared to the ambient chambers) were set up at Smithsonian Global Change Research Wetland (GCREW) in Kirkpatrick Marsh, Rhode River Estuary, Chesapeake Bay. C3 plant shoot dimension, biomass, carbon (C) and nitrogen (N) concentration were measured annually. Here after 30 years CO_2 enrichment we found a significant and 18.5% decrease in the stem leaf area but an increase of 51.9% in stem density of C3 sedge *Schoenoplectus americanus* (Pers.). The CO_2-induced stimulation of sedge productivity and litter accumulation, the depletion of soil N availability, and plant C:N shift all suggest N-limitation of the CO_2 effect. The soil N availability becomes increasingly limiting as the shift of plant C:N may not compensate CO_2 induced N deficiency. Marsh plant trends to allocate more biomass to rhizome and root for nutrient uptake so that the N limitation can be alleviated. The extending rhizome system leads to more tiller recruitment of stems, while the shrinking stem occurs along with the N depletion. Moreover, an increase of 9.6% in stem leaf area of *S. americanus* was found in another 10 years elevated CO_2 plus N addition experiment, suggesting the mitigation of N limitation can reverse the effect of elevated CO_2 on stem dimension. The results from two experiments indicate that the response of marsh plant morphology to elevated CO_2 is regulated by soil N availability and the trade-off between stem dimension and density of marsh plant.