Response of an alfalfa-timothy mixture grown in open-top chambers

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The increase in atmospheric carbon dioxide concentration ([CO2]) and consequent increase in air temperature is expected to have significant effects on plant growth and nutritive value. Studies examining the effects of elevated [CO2] on plants under field conditions have been limited by the inherent difficulty to modify air composition in open air. We designed an efficient and inexpensive open-top chamber (OTC) system to study the effects of elevated atmospheric [CO2] and temperature on perennial alfalfa-timothy mixture. Eight OTCs, each with 1.2 m2 of ground area (four with elevated [CO2] and four with ambient [CO2]) were built and four control plots of the same dimension were also used to assess the chamber effects on plant responses to [CO2]. To compare the environment inside the OTCs to that of the surrounding area, growing conditions were determined in all chambers and control plots. Adequate light transmission was observed in OTCs compared to control plots (93%) and the temperature increase was 0.7oC on average. Furthermore, the [CO2] in elevated-CO2 chambers was
within ± 20% of the targeted 600 µmol mol^{-1} CO_2 93% of the time. After two growing seasons of continued use, this system has proven its effectiveness for studying the effects of CO_2 and climate change in the field at low cost.
Using the OTC design, we examined the effects of elevated [CO_2] on forage DM yield and nutritive value, fall organic reserve accumulation and winter survival, as well as root degradability of an alfalfa-timothy mixture grown in the field. Plants were transplanted in an uniformly distributed 50:50 mixture and were grown under ambient (near 400 µmol mol^{-1}) and elevated (600 µmol mol^{-1}) [CO_2] during two growing seasons (2013 and 2014). A single cut was taken during the establishment year and four cuts were taken when alfalfa reached the 10% flowering during production year. An average forage yield increase of 18% under elevated [CO_2] was accompanied by a significant increase in acid detergent fiber and neutral detergent fiber concentrations, and a slight decrease in *in vitro* true digestibility. Non-structural carbohydrates in the forage mixture were unaffected by elevated [CO_2], and the total nitrogen concentration was slightly decreased, although the effect was only significant in alfalfa. Root degradability of alfalfa was increased under elevated [CO_2] in spite of unaffected root carbon and nitrogen concentrations, indicating a lower potential for carbon sequestration. Overall, the positive effect of increasing yields under elevated [CO_2] were partly offset by a decreased forage digestibility. Elevated [CO_2] had no effect on fall organic reserve accumulation nor on winter survival.