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Biofuel crops with CAM photosynthesis: Economic potential on moisture-limited lands

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As the demand for food and renewable energy increases, the intelligent utilization of marginal lands is becoming increasingly critical. In marginal lands classified by limited rainfall or soil salinity, the cultivation of traditional C3 and C4 photosynthesis crops often is economically infeasible. However, in such lands, nontraditional crops with crassulacean acid metabolism (CAM) photosynthesis show great economic potential for cultivation. CAM crops including Opuntia (prickly pear) and Ananas (pineapple) achieve a water use efficiency which is three fold higher than C4 crops such as corn and 6-fold higher than C3 crops such as wheat, leading to a comparable annual productivity with only 20% of the water demand. This feature, combined with a shallow rooting depth and a high water storage capacity, allows CAM plants to take advantage of small, infrequent rainfall amounts in shallow, quickly draining soils. Furthermore, CAM plants typically have properties (e.g., high content of non-structural carbohydrates) that are favorable for biofuel production.

Here, for marginal lands characterized by low soil moisture availability and/or high salinity, we assess the potential productivity and economic benefits of CAM plants. CAM productivity is estimated using a recently developed model which simulates CAM photosynthesis under a range of soil and climate conditions. From these results, we compare the energy and water resource inputs required by CAM plants to those required by more traditional C3 and C4 crops (corn, wheat, sorghum), and we evaluate the economic potential of CAM crops as sources of food, fodder, or biofuel in marginal soils. As precipitation events become more intense and infrequent, we show that even though marginal land area may increase, CAM crop cultivation shows great promise for maintaining high productivity with minimal water inputs. Our analysis indicates that on marginal lands, widespread cultivation of CAM crops as biofuel feedstock may help alleviate existing tensions between food and fuel production.