The role of C.A.M. in improving rangeland productivity

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World food production is constrained by both the productivity of conventional agriculture and the area of land suitable for cultivation. Endemic world famine, public concern at clearing rainforest to facilitate expanded agriculture both in Australia and other continents, and probable future diversion of existing agricultural land to support biomass fuel production will place increasingly greater demands on the capacity of world agriculture to supply adequate quantities of food. One way of ameliorating future problems would be to increase the area devoted to food production, but if existing wilderness areas are not to be sacrificed, little land remains which is neither too cold nor too dry, by existing standards. The following considers the potential for improving productivity in arid and semi-arid rangelands, which comprise approximately 40% of the world's land surface, but at present are used only for extensive grazing.

Crop production in advanced countries ranges between 10 and 80 tonnes D.M. $ha^{-}lyr^{-1}$. Rangeland productivity in C_3 and C_4 plant is an order of magnitude smaller, ranging between 0.4 and 4.1 tonnes D.M. ha yr^{-1} (1) but falling even lower during protracted droughts. The disparity is due to the greater evaporative potential and lower rainfall in arid, relative to humid, environments and results in a far lower water use efficiency in rangeland plants. If water use efficiency could be improved, so could productivity.

In contrast to C_3 and C_4 plants in which energy capture and gas exchange proceed simultaneously, plants photosynthesising via C.A.M. (crassulacean acid metabolism) engage in gas exchange by night and energy capture by day. While C.A.M. allows only relatively slow rates of photosynthesis and is less efficient in terms of CO_2 fixed per unit of photosynthetically active radiation, it has a water use efficiency more than 10 times greater than in C_3 and C_4 plants growing in semi-arid and arid environments. Conservative extrapolation from gas exchange data for the C.A.M. species Agave deserti indicates a potential productivity of 18 tonnes DM $ha^{-1}yr^{-1}$, which is substantially greater than present rangeland productivity and would require only 260 mm rain, assuming 75% loss via direct soil evaporation.

The principal obstacle to realising the potential productivity of C.A.M. plants is the presence of competition from C_3 and C_4 species which rapidly transpire the available soil moisture via their faster but less water efficient photosynthetic pathways. Thus in natural conditions C.A.M. photosynthesis is largely restricted to xeric environments in which C_3 and C_4 systems cannot maintain a positive carbon balance. If a herbicide specific to C_3, and C_4, plants became available, obligate C.A.M. plants might be used to increase rangeland productivity. Stocking rates, and thus livestock production, could be increased at least 10 times.

Over 600 C.A.M. species have been recorded and more are certain to be discovered in the future. Selection of species suitable for forage production should be readily achieved. Developing obligate C.A.M. crop plants is a more demanding objective, but may be met in the longer term in view of the rapidly developing technologies of genetic manipulation. Success in such a programme would revolutionize the use of the drier regions of the earth.

1. Brown, R.F. 1981. Proc. Nat. Conf. on Fuels from Crops 33.1-33.7, Melbourne, 28-29th September.