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Could Agave be the Species of Choice for Climate Change Mitigation?

by

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Abstract

Agave is to the drier parts of the world what bamboo is to its wetter zones. Capturing atmospheric CO2 in vegetation is severely limited by the availability of land and water. The best choice would be species that can utilize lands unfit for food production and yet make the dynamics of carbon sequestration faster. As much as 40 % land on earth is arid and semi arid and on almost half of these lands, with a minimum annual rainfall of about 250 mm, many species of agave grow reasonably well since its Crassulacean Acid Metabolism photosynthetic pathway permits it higher productivity on lands with severely restricted water availability and prolonged droughts. Agave sugar is a rich source of bioethanol for renewable energy. And agave can also be used for carbon sequestration projects under CDM even though by itself it does not constitute a tree crop and can not provide the minimum required tree crown cover to create a forest as required under CDM rules. But if the minimum required crown cover is created by planting an adequate number of suitable tree species in agave plantations then the carbon sequestered in the agave plants will also be eligible for measurement as above ground dry biomass and provide handsome carbon credits. This makes agave an excellent CDM crop for bioethanol as well as for afforestation over poor quality arid lands giving both permanent carbon credits for bioenergy and temporary credits of

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forestry for carbon sequestration. It causes no threat to food security and places no demand for the scarce water and since it can be harvested annually after a short initial gestation period of establishment, and yields many products that have existing markets, it is also well suited for eradication of poverty.

Key words: Climate Change Mitigation, CDM, Agave, Bamboo.

By now it is clear that for making a meaningful progress in checking the continuous rise in the global temperatures removing carbon dioxide from the atmosphere would be atleast as important as reducing its emission. But capturing atmospheric carbon dioxide and sequestering it in the vegetation is limited by the availability of land and the lack of water poses even greater problem. With the world population projected to cross 9 billion mark well before 2050 it is inconceivable that land presently under agriculture can be brought under tree cultivation for carbon sequestration and storage without severely affecting the availability of food, something which is already making the FAO deeply nervous.

A limited answer may perhaps lie in using the lands that are unfit for food production and making the dynamics of carbon sequestration quicker. The large extent of arid and semi-arid lands provide a glimmer of hope if one could find appropriate species that can come up in these lands of low moisture availability. As much as 40 % land on earth is arid and semi arid, largely in the tropics but also in the cool temperate zones up north. And on almost half of these lands, with a minimum annual rainfall of about 250 mm and soils that are slightly refractory, the very valuable species of agave grows reasonably well.

Agave is to the drier parts of the world what bamboo is to its wetter zones. The hundreds of species of agave were the source of food, fiber, medicine and even roof material for the Aztecs just as similarly large number of bamboo species have supported civilizations in the wetter parts of Asia. The fact that arid zones provide few options, unlike the lands rich in rains, could only enhance its importance. That it also provides sugar, and the much loved Tequila and the Pulque, made agave even more attractive to the kings and the commoners alike and the reason for its generic name after the illustrious Greek Princess Agaue, daughter of the union between the Founder King Cadmus of Thebes and goddess Harmonia.

And just as bamboo occupy the nether lands between woods and the non-woods, agave can also claim a lignified existence, if only briefly towards the end. As its life cycle nears completion, which can be just about 7 years for some species to as long as 100 years for others (and hence the name Century Plant), the agave plant flowers and the flower stem grows tall and strong by adding lignin to the stem fibers. After flowering and drying stem is a preferred raw material for musical instruments ranging from large drums to the more discrete flutes.

To the students of life sciences the three processes of photosynthesis, C3, C4 and CAM are well known. C3 plants follow a photosynthesis pathway in which the carbon dioxide is initially bound in molecules of phosphoglyceric acid containing three carbon atoms as against C4 plants in which the photosynthesis initially binds the CO2 in molecules of oxaloacetic acid with four C atoms. Agaves are even more special in that they follow a path that could be called a very refined time separated combination of the C3 and C4 termed Crassulacean Acid Metabolism (CAM).

And CAM probably does what large parts of earth need the most today. This is the ideal photosynthetic pathway for places with low moisture availability. The CAM pathway is able to function in low moisture because the plants open their stomata only during night time thus limiting transpiration by a huge extent. In arid and semiarid lands the soil nutrition is also very limited which is, in itself, a consequence of low moisture availability. CAM plants have got over these handicaps by two major adaptations. One is closing stomatal openings during the hot day time and the other having surface roots that are able to access the moisture from the rare rains and the dew along with whatever little nutrition available on the surface soil. But surface roots also impose a high cost in terms of poor anchorage. So in windy arid lands one does not come across taller CAM plants.

There has been much research on the cultivated agricultural crops that use CAM photosynthetic pathway though little work has been done under natural forest conditions. Still the agriculture research can be a good guide for us. Results suggests that for an average above ground biomass productivity of between 35 – 50 tonnes of dry biomass per hectare per year the water use efficiency in the CAM plants was 8-12 times higher than C3 plants and 4-5 times higher than in C4 plants and the crop water demand was in the range of 2580 to 6450 tons per hectare per year for CAM crops compared to 14000 to 42000 tons per hectare per year for the C3 and C4 crops (Borland et al 2009).

	CAM crops	C3 crops	C4 crops
Above-ground productivity	43 ton/ha/yr	35 ton/ha/yr	49 ton/ha/yr
Water use efficiency	4 to 10	0.5 to 1.5	1 to 2
Crop water demand	2580 to 6450 ton/ha/yr	14000 to 42000 ton/ha/yr	14000 to 28000 ton/ha/yr

In contrast to the usual forest tree crops the above ground biomass productivity of agave looks astonishingly high. Dr Arturo Velez, Director, Agave Project, Mexico City, Mexico, who has been involved deeply in field research on a number of Agave species for the past many years, has informed this author in a personal communication that in Mexico as many as 40 agave species are in use commercially for fiber and alcohol of which one of the most promising one is *Agave americana* individual plants of which can reach over 1.2 tons in weight at very close spacing. In a specific experimental plantation he got a yield of 64 ton/ha/yr and with 62% cellulose for this species he estimates it is possible to get as much as 40 ton/ha/yr of cellulose which is almost 4 times the best yields in eucalyptus plantations.

Dr Velez says the sugar (almost entirely fructose) content in some agave species is quite high reaching as much as one third of the weight of the stem and even leaves have some of it. *Agave tequilana* can produce 90 tons of stem per hectare per year which is capable of yielding 30 tons/ha/yr of sugars. And he is confident of reducing the gestation period from the present 10 years to barely 6 years by fertilizing it with Geomite, a mix of minerals, rhizomes and microorganisms that develop a symbiotic relationship with agave and biochar.

Growth characteristics of species are usually highly plastic in species and CAM plants are no exception. Generally the maximum growth potential of a locality is realized not by a native species but by an exotic. This is because the native vegetation are so functionally adapted to survival in the face of restrictive factors operating in the environment over the previous many centuries that even when some of the restrictive factors are no longer effective, or have become less severe over time, the plant adaptations to them that have matured genetically, continues to function in favor of bare survival. An exotic, on the other hand, is free of both the advantages and the restrictions of such adaptations and, given a new environment that offers more advantages and fewer restrictions, can have a relatively free run of its new locale. So, with intensive research programs it should be possible to find suitable agave species that perform excessively well in their new habitats.

Agave is relatively cheap to produce and easy to cultivate with one plant giving as many as one million new pups. Agave can be harvested round the year and both planting and harvesting can be comfortably mechanized. It should prove to be an excellent crop for bioethanol since it addresses two of the main concerns in using sugarcane, that of threatening food security by using fertile lands and consuming very high quantities of water.

And agave can also be used for carbon sequestration projects under CDM. Agave by itself would not constitute a tree crop and thus cannot provide the minimum crown cover of 10% (or the value chosen by the host country) by itself in order to create a forest over a non-forest land as required under CDM rules. But if the minimum required crown cover is created by planting an adequate number of some other suitable tree species in the agave plantation then the carbon sequestered in the agave plants will also be eligible for measurement as above ground dry biomass and thus provide handsome carbon credits.

In brief, agave could be an excellent CDM crop for bioethanol as well as for afforestation over poor quality lands with very limited access to water giving both permanent credits for bioenergy and the temporary credits of forestry for carbon sequestration. It causes no threat to food security and places no demand for the scarce water. It can be harvested annually after a short initial gestation period of establishment and yields many products that have existing markets and is thus well suited to eradication of poverty.

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References and further readings:-

Lal, R. 2001. Potential of Desertification Control to Sequester Carbon and Mitigate the Greenhouse Effect. Climatic Change. Vol 51(1)

Bautista-Cruz. A; R. Carrillo-González; M.R. Arnaud-Viñas; C. Robles and F. de León-González. 2007. Soil fertility properties on *Agave angustifolia* Haw. Plantations. Soil and Tillage Research.Vol. 96, Issues 1-2, pp. 342-349.

Pimienta-Barrios, E. and C. Robles-Murguia. 2001. Net CO_2 Uptake for *Agave tequilana* in a Warm and a Temperate Environment. Biotropica. Vol.33, Issue 2, pp. 312–318

Nobel. P. S. and T. L. Hartsock. 1986. Short-Term and Long-Term Responses of Crassulacean Acid Metabolism Plants to Elevated $C0_{2.}$ Plant Physiol. 82. pp. 604-606

Borland, A. M.; H. Griffiths; J. Hartwell; J. A.C. Smith. 2009. Exploiting the potential of plants with crassulacean acid metabolism for bioenergy production on marginal lands. Journal of Experimental Botany. Vol. 60. Issue 10. pp. 2879-2896