EDITORIAL

Halophytic biofuels revisited

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> “At present, more than 40% of Earth is arid or semi-arid, almost 98% of its water is not potable and over 800 million ha is already salt affected…”

Bilquees Gul[1], Zainul Abideen[1], Raziuddin Ansari[1] & M Ajmal Khan*[2]

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Energy availability is central to improvements in economy and agriculture. Fossil fuels, due to their abundance and high density, have been the primary source of energy; but these resources are finite and may last for only the next 50–100 years [1]. Developing technologies that help to recover oil and gas from deposits previously considered expensive or too difficult to access has enabled fuel production to exceed estimates, and has allowed access to new types of reserves, for example, methane from methane hydrate deposits discovered undersea near Japan and the Arctic East Siberian Sea [2], but these may only delay the eventuality. In any case, the use of these fossil fuels will result in releasing GHGs causing climate change and questioning sustainable development. For practical purposes, the limiting factor on fossil fuel use may, hence, not be their exhaustion, but that of the Earth’s capacity to withstand the consequences of fossil fuel combustion.

Energy from plant biomass for producing a number of biofuels, including ethanol and biodiesel, has been suggested to be a sustainable and a better alternative to the fossil energy sources. There has been a long ongoing debate on the effects of using food crops for biofuel production, with both sides having arguments in their support. Those against it fear reduced supply of food for human consumption and increases in food cost, while others argue that the problem is not of food shortage but its distribution – there has been excess production at certain places and shortage at others even before biofuels were introduced [3].

Threat of salinization

Resources and supplies of every kind, including those of food, fuel and fiber, are coming under growing pressure to meet the demand of 7 billion people and an increasing population [4]. It may be noteworthy that vast areas of good agricultural lands are either saline or are under threat of desertification, due to over exploitation of natural resources [5]. At present, more than 40% of Earth is arid or semi-arid, almost 98% of its water is not potable [6], and over 800 million ha is already salt affected [101], with secondary salinization happening at many places due to faulty irrigation practices. This may have more hazardous consequences than the competition between food and fuel crops for the limited resources of arable land and good quality water.

[1] Institute of Sustainable Halophyte Utilization, University of Karachi, Karachi, Pakistan
[2] Shell Professorial Chair in Sustainable Development, College of Arts & Science, Qatar University, Doha, Qatar
*Author for correspondence: Tel.: +974 4403 4952; Fax: +974 4403 4931; E-mail: ajmal.khan@qu.edu.qa

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Available options

Salinity and plant growth are, however, not inimical. Halophytes are the plants of saline environments found in abundance on vast areas of saline soils present worldwide and require saline or brackish water for growth. Seas and water bodies containing salty water cover almost 80% of the Earth's surface and large quantities of underground saline water are also present. The realization of the looming danger of reduced crop yields due to salinity, for which there appears no solution at least in the near future, has increased interest in halophyte culture to meet the demands of mankind. Use of halophytes as a sole source or supplement to animal fodder is common in many countries of the world [7], while their use on a commercial scale to make turf has also been reported [8]. There has been a recent surge in exploring the potential of halophytes use as medicine [9], edible oil [10], for phytoremediation of wastewater [11], and in biofuel production including both cellulosic conversion to bioethanol and conversion of oil to biodiesel [4].

Progress & precautions

Biomass production from halophytes in saline-sodic or sodic soils, using brackish or saline water for irrigation, demands further investigation. We have identified several halophytic plant species with the potential for biofuel feedstocks [4]. They can be grown on moderately to highly saline, agriculturally marginal, degraded (eroded), disturbed, polluted soils, which may have additional benefits of soil carbon sequestration, and enhance soil quality and the ecosystem. Increase in the terrestrial carbon pool is, however, a slow process and improvement in soil quality may be gradual. Furthermore, these plants have never been grown systematically in field trials for optimizing cultural practices such as method of planting, spacing between plants and rows, harvesting intervals, fertilizer requirements, insect pests management and so on under diverse natural conditions. This may consequently require the joint input of soil scientists, agronomists, ecologists, physiologists and entomologists. At some stage, breeders/molecular biologists may have to be involved for incorporating desirable changes in the plant makeup for say higher yields, desirable lignocellulose contents and so on.

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Halophytes that accumulate salt (accumulators, mostly *Chenopods*) are generally unsuitable as biofuel crop, and therefore salt-excluding plants (generally grasses) that do not take up excess salt are preferred. Salt excluders, on the other hand, are associated with increases in soil salinity because they restrict entry of salts at the root surface. Under these conditions, a combination of both a salt excluder, which may be fed to animals, and a salt accumulator, which is grown side by side in the same plot but is separately harvested, may provide a viable solution [7].

Marine algae

The use of algal biomass as a biodiesel feedstock has recently attracted global attention. The most significant advantage of algae is their fast growth and, potentially, their 10–15 times higher oil production per ha than conventional crops such as palm, rapeseed and *Jatropha* [12]. They are nonfood resources and do not necessarily need arable land and freshwater for growth, as will be the case if suitable marine algae are utilized. A recent study has shown better lipid contents in *Chlorella* sp. in the presence of sodium chloride and acetate than without them [13]. Theoretically, this approach promises many advantages but several bottlenecks will have to be overcome for producing biodiesel from algal oil commercially. Scarcity of ecological information on algae strains, effect of weather changes and of exposure to biological agents in the atmosphere, and effect of varying sunlight intensity in outdoor cultures on yield and oil content has to be monitored through more scientific assessment on important indigenous algal strains [14].

Selecting crops for saline environments

Several factors need to be taken into consideration, such as those stated below:

- The first step is the formation of an extended gene pool, which is a crucial starting point due to the variability of edaphic conditions and the consequent multiplicity of plant traits required to best fit them;
- Selection, hybridization and breeding to be conducted in the field, under specific pedoclimatic conditions for domesticating wild species and developing economically useful crops with higher salinity thresholds;
- The effort should not be restricted to conventional breeding techniques but should also include the more advanced, recently developed bioengineering solutions; that is, marker-aided selection and the development of transgenic plants for inducing desirable traits;
- Several practices can be combined into systems that function satisfactorily depending upon the economic, climatic, social and hydrogeological situation. Thus, management measures should not be considered in isolation but should be developed in an integrated manner to optimize water use, minimize drainage and increase crop yields within limits of the physical and social environment.

Economic & social considerations

The agricultural utilization of saline lands has generally been overlooked, in the belief that it would not be profitable. However, saline land and brackish water can be used to produce nonconventional cash crops like biofuels from halophytes. This way saline resources considered waste are being used as an income generating source, but also result in environmental benefits such as soil protection against water and wind erosion, biodiversity enhancement, creation of friendly habitats for wildlife and protection of atmosphere quality through mitigation of GHGs. Some additional carbon from that captured during photosynthesis may be released during biofuel production if mechanical methods are used, but through enzymatic digestion this can be minimized to make it almost carbon neutral, which means that on burning, only the CO_2 fixed during photosynthesis is released into the atmosphere, while leaving a portion of biomass unharvested in the field, it may even be possible to become 'carbon negative' through a net gain in carbon fixed during the process.

Adopted on a large scale and with careful planning; that is, ensuring proper management of land and water resources, avoiding the introduction of invasive species, mitigating environmental degradation, avoiding loss of biodiversity through mapping areas of high conservation value and so on, biofuels could help to reduce poverty in the developing world, through stabilizing oil prices and opening new employment opportunities.

The attribution of even an approximate financial value to such benefits as stated above is difficult. In the long run, it may give the biosaline agriculture the right to claim support to the limited income from direct farming. Growing halophytic energy crops and achieving significant product without putting any more pressure on limited, good-quality land and water resources would contribute to mitigate social strains and litigations, inside and outside national boundaries. Through such possible pathways, agriculture can abandon its present uncomfortable position of environmental polluter to assume instead that of the environment defender.

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