Adding Biofuels to the Invasive Species Fire?


The U.S. renewable energy initiative has new impetus to the identification of biofuel crops as sources of energy. However, an earlier presidential directive, Executive Order 13112, attempts to protect the United States from invasive species, unless benefits clearly outweigh potential harms. The policies may conflict because traits deemed ideal in a bioenergy crop are also commonly found among invasive species (see figure).

Biofuel crops may have economic benefits, but studies of concomitant environmental risks of movement into novel habitats are seldom conducted. Although anecdotal claims of “low risk” for some species may be valid, many purportedly beneficial introduced species have had long-term economic and environmental costs owing to their invasiveness. For example, Sorghum halepense is an introduced forage grass that became an invasive weed in 16 of the 48 U.S. states in which it occurs. Even the most conservative estimate of competitive losses for cotton and soybean crops in three states is in excess of $30 million annually.

Several grasses and woody species have been evaluated for biofuel production, with perennial rhizomatous grasses showing the most economic promise. Arundo donax (giant reed; native to Asia) and Phalaris arundinacea (reed canary grass; native to temperate Europe, Asia, and North America) are two C₄ grasses being considered as biofuel species that are invasive in some U.S. ecosystems. The former threatens riparian areas and alters fire cycles; the latter invades wetlands and affects wildlife habitat.

The hybrid grass Miscanthus × giganteus (native to Asia) and Panicum virgatum (switchgrass; native to central and eastern United States) are C₄ grasses being considered in Europe and the United States. Several Miscanthus species are invasive or have invasive potential; in particular, the parent species of M. × giganteus, Miscanthus × giganteus, is an allopolyploid that does not produce viable seed and reproduces vegetatively. However, allopolyploidy does not guarantee continued sterility and vegetative propagation is often associated with invasiveness. Several other traits that make Miscanthus potentially valuable as a crop could enhance invasiveness (ability to resprout from belowground tissue and rapid photosynthetic mechanisms, and rapid growth rates).

The U.S. native, P. virgatum, shares many traits with Miscanthus and can also produce seeds, which may give P. virgatum even greater invasive potential. Furthermore, plants native in one region can become invasive when established elsewhere. Escape from competitors and natural enemies may help explain the weediness of P. virgatum outside its endemic range.

Internationally, there has been little success in eradicating or even controlling an invading grass. Herbicides are used to control invasive grasses on croplands, but they are too expensive to use on rangelands, national parks, and reserves. Development of the most economical tool, biological control with a specific natural enemy, has been avoided because of the perceived risk of its expanding its host range to include commercial grasses, such as wheat, corn, barley, or rice.

Balancing costs and benefits of species introductions is a key contemporary challenge. Introducing some plant species as biofuel sources may be safe, but safety must be established by agronomic and ecological analyses. Such analyses are already mandatory for biological control agents and transgenic plants. Experts must assess ecological risks before introducing biofuel crops, to ensure that we do not add biofuels to the already raging invasive species fire.

References and Notes


14. Minnesota Department of Natural Resources; www.dnr.state.mn.us/invasives/terrestrialplants/grasses/amur silvergrass.html.


19. A bibliography is provided as supporting online material.

Supporting Online Material

www.sciencemag.org/cgi/content/full/313/5794/1742/DC1

10.1126/science.1129313

C. photosynthesis

Long canopy duration

Perennial

No known pests or diseases

Rapid growth in spring

(to outcompete weeds)

Sterility

Partitions nutrients to belowground components in the fall

High water-use efficiency

Ideal ecological traits of biomass energy crops

Miscanthus potentially valuable as a crop could enhance invasiveness (ability to resprout from below ground, efficient photosynthetic mechanisms, and rapid growth rates).

miscanthus giganteus

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