

BIOENERGY FEEDSTOCKS OF HIGH INTEREST

There is an extensive variety of plants that have been or are considered for bioenergy production. Only those that have garnered the most interest and have exhibited the most potential are described in the following listing.

Big Bluestem

Big Bluestem (*Andropogon gerardi*) is a dominant species of the North American tallgrass prairie. It has a high biomass production capacity and feedstock potential to produce ethanol or pelletize for direct combustion. It tolerates a wide variety of soil conditions, land types, and moisture. It does best in moist soils but can grow in sandy or droughty conditions. Big bluestem does not tolerate shade. As a late successional plant of the North America prairie ecosystem, it will regrow after fire. Big bluestem, along with other native grasses, is used in prairie restoration as well as to reclaim mined land or as a stabilizer in erosion control, forage for livestock, wildlife habitat, and landscaping.

Blue-Green Algae

Blue-green algae (*Cylindrospermopsis raciborskii*) is also known as cyanobacteria. It is a phylum of bacteria that obtains energy from photosynthesis. “Cyano” refers to its blue-green color. It is found in almost every terrestrial and aquatic habitat of the world. Some types of the bacteria grow in the fur of South American sloths, providing a type of camouflage for the animals. The extensive and highly visible blooms of the aquatic varieties can be toxic and pose human health risk under some circumstances. Researchers and industry have cultured genetically modified cyanobacteria which may be used in the biofuel industry. The pursuit of this organism for biofuels is a relatively recent development.

Canola

Canola is the North American name for a plant known in Europe as edible rapeseed (*Brassica napus*). The seed is used worldwide for oil (both cooking and biofuels). It is the most commonly used oilseed in Europe for production of biodiesel. In the U. S. most canola is used for cooking oil with a small portion going to biodiesel production. Canola will grow in most soils but requires rain to flower and produce full seed pods. For this reason most of the canola grown in the U. S. is of the winter variety. Many states grow canola, but North Dakota grows much of the canola produced in the U. S.

Duckweed

Duckweed (*Lemna minor*) is an aquatic plant that floats on or just below the surface of still or slow-moving fresh water. It is found worldwide and may be called water lentils or bayroot. Duckweed lacks both stems and leaves and is the smallest flowering plant. It can be spread by waterfowl or small mammals. Duckweed is being studied as a possible source of clean energy due its rapid growth and is considered a carbon neutral energy source. It also functions a

bioremediator, effectively filtering out contaminants. It can be an aggressive invasive in ponds, covering the surface of the water, depleting oxygen, and killing fish and other plants.

Energy Cane

Energy cane, a semi-tropical perennial grass that provides roughly double the fiber content of sugar cane, can be available as a feedstock from January through March – primarily in the southeastern United States. Energycane currently in development has been screened for delayed spring emergence and cold hardiness. It is derived from crosses between domestic sugarcane and a cold-hardy relative of sugarcane called *Saccharum spontaneum*, which improves cold-hardiness but reduces some of their sugar producing ability. As a result, most of the energycane is generally lower in sugar compared to sugarcane (10-11% for energycane vs. 12-14% for sugarcane) (see: <http://www.sungrant.org/NR/rdonlyres/897FF3CE-FFEC-4B88-B28F-27EB4ED2CDE0/3946/EnergycaneHighlights32014.pdf>).

Eucalyptus

Eucalyptus (*Eucalyptus cinerea*) is a tree or shrub native to Australia and some islands of the South Pacific. It is a member of the *myrtle* family. There are approximately 700 kinds of eucalyptus which grow in the tropical and temperate areas of the world. Most eucalyptus is not frost tolerant and requires a large amount of water. The plant is covered with oil glands and the oil is used as a natural disinfectant and can be harmful to some herbivores. Eucalyptus can grow in soils with elevated salt concentrations and is one of the fastest growing trees in the world. Both eucalyptus wood chips and oil are being considered by the bioenergy industry. The burning of eucalyptus in Europe is a concern as some eucalyptus oil is released in its smoke and can mix with pollutants which may reduce agricultural crop yields. In the wild, eucalyptus can be a fire hazard due to its oil and extensive foliage.

Giant Miscanthus

Giant miscanthus (*Miscanthus giganteus*) is a large perennial grass. It is a hybridization of *Miscanthus sinensis* and *Miscanthus sacchariflorus* which are native to Asia. It produces large, dense leaves and is used in Europe as a source of biomass either for direct combustion or conversion to a biofuel such as cellulosic ethanol. Miscanthus can be an attractive plant and varieties are often used in ornamental plantings which can become invasive. It exhibits greater photosynthetic efficiency and lower water requirements than some other plants but uses more water than corn. It grows well on barren land and without fertilization. Miscanthus propagates by rhizomes. It is being considered and studied widely for commercial uses such as in the plastic industry and as a bioenergy crop.

Giant Reed

Giant Reed (*Arundo donax*) has many names, such as Colorado River Reed, wild cane, Arundo, giant cane, and Spanish cane. It is native to eastern and southern Asia and probably parts of Africa and the southern Arabian Peninsula. It has adapted to the Mediterranean climate and is known to grow throughout the United States in a variety of soils and climates. Giant Reed is drought tolerant and durable but grows well in wet areas such as wetlands and along streams. It

produces a dense stand of foliage which aggressively competes with all other vegetation which causes it to be a fire hazard in parts of the United States. It is not eaten by insect herbivores or wildlife. Giant reed is considered invasive in parts of the United States and elsewhere around the world. The large biomass yield and ease of growth has added to industry interest in it for biomass production.

Hybrid Poplar

Hybrid poplar (*Populus*) is the result of genetic cross pollination between North American cottonwoods, aspens and European poplars. Hybrid poplar is hardy and grows six to ten times faster than similar trees. It thrives in most soils and climates and is drought, salt, and pollution tolerant which accounts for its popularity as an urban landscape tree. As such it is prone to ice damage and its roots are invasive. Hybrid poplar is grown commercially for plywood, paper making, peeler poles, and firewood. It does need consistent, frequent watering. Its rapid growth, large biomass production and adaptability to various soils and climate types create much interest in its use for bioenergy production (both for direct combustion and liquid fuel).

Indiangrass

Indiangrass (*Sorghastrum nutans*) is a perennial bunchgrass also known as yellow indiagrass and is native to North America. Indiangrass, along with big bluestem, switchgrass, and little bluestem is prominent in the Great Plains and the tallgrass prairie ecosystem found in the central and eastern United States and Canada. It adapts to a wide variety of soils and climates. Indiangrass is used for erosion control, livestock forage, restoration of native prairie areas, and wildlife habitat. It has no serious insect or disease problems. It is considered along with switchgrass and big bluestem as a regional bioenergy feedstock due to its high biomass yield and low production cost.

Jatropha

Jatropha (*Jatropha curcas*): Commonly called jatropha, this plant is native to Central America and is viewed as having potential in the production of biodiesel. Jatropha produces a golf-ball sized seed that is typically 27-40% oil. Once the seed is processed to produce biodiesel, the remaining material can be used as organic fertilizer. Jatropha likes well-drained soil but can grow on more marginally productive lands, prefers a temperature range of 68-85 F but can survive light frosts, and is drought tolerant. Efforts are underway to genetically alter jatropha to improve cold tolerance and extend the geographic range of production.

Princess Tree

Princess Tree (*Paulownia tomentosa*) may also be known as empress tree or foxglove tree. It is deciduous and native to central and western China. It tolerates drought, infertile and acid soils, and adapts to a variety of habitats. Its roots are far-reaching, deep and can produce sprouts. The princess tree is very fast growing and the stump can regrow. Most varieties are used as ornamentals but the wood, leaves and fine branches are being considered for biomass production. In Japan, the eastern U. S., and various other parts of the world the princess tree is considered an invasive due to its aggressive growth characteristics.

Reed Canarygrass

Reed canarygrass (*Phalaris arundinacea*) is a tall, perennial bunchgrass that grows in cool, humid climates of Europe, Asia, Northern Africa, and North America. It commonly forms dense stands along lakes and streams. Although it prefers wet conditions, it can become dormant during dry times and resume growing when plentiful moisture resumes. It grows well in poor soils and tolerates acid, moderate saline and alkaline conditions. Reed canarygrass is sometimes used to reclaim contaminated industrial sites. In Europe the grass is turned into bricks or pellets and used as a biofuel. The grass fiber is also used in the pulp and papermaking industries. Some types of canarygrass are grown as ornamentals, often called “ribbon grass.” Worldwide, reed canarygrass has been known to invade floodplains, riverside meadows and wetlands. Once established it is often considered an invasive weed and inhibits native vegetation and reduce biodiversity.

Sesame

Sesame (*Sesamum indicum*) is probably the oldest known oilseed in the world. It is thought to have originated in Asia or East Africa, but is now found in tropical, subtropical and southern temperate areas of the world. Sesame has an extensive root system and is known as a “survivor crop” since it is very drought tolerant. It adapts to a variety of soil types but prefers fertile, well-drained soils. The sesame seed has been used since ancient times for food, flavoring and cooking oil. It has one of the highest oil contents of all of the oilseeds and is considered as a possible biofuel source, especially in parts of Africa and Asia.

Sorghum

Biomass sorghum (*Sorghum bicolor*) is a type of sorghum developed as a biofuel feedstock. It has particularly dense foliage. Both biomass and sweet sorghum are used in the biofuel production industry. Approximately one-third of the sorghum grown in the United States is used for this purpose. Sorghum is native to the tropical and subtropical regions of the world and may be known as milo. It is naturally drought tolerant and can adapt to wet soil but not cold temperatures. It is an important food source for both animals and humans worldwide. Sorghum has a low nitrogen fertilizer requirement. When large amounts of sorghum are grown in an area, the crop can become stressed and more susceptible to pests. The rapid harvesting and storing of the ripe grain is crucial as it deteriorates quickly.

Switchgrass

Switchgrass (*Panicum virgatum*) is a native warm-season grass associated with prairie ecosystems. It is a perennial, warm-season bunchgrass native to North America and one of the dominant species on the Great Plains of North America. As a hardy, deep-rooted grass it is used for soil conservation, forage production, and game cover. It can also be used as an ornamental grass as well. Switchgrass is considered as a cellulosic biofuel feedstock due to its high biomass yield and low need of fertilizer. The cost of production is thought to be less than that of corn with a greater energy output. Switchgrass adapts to various weather conditions, soil types, and land conditions. It is drought and flood tolerant.

Willow

Willow (*Salix*) is a deciduous tree. There are over 400 species of Willow. Most prefer moist soils in the cold and temperate regions of the Northern Hemisphere. Willow roots spread widely and are large, tough and aggressive. The roots can produce new trees. Natural hybridization is not uncommon. The willow has medicinal, manufacturing, and various other uses. In Sweden the willow is used in the bioenergy industry and there is interest in production of short-rotation (typically 5 year or less harvest cycle) willow in the United States for biomass production. Most willows are grown for ornamental, shade, timber or erosion control. Willow plantings for erosion control in Australia are now regarded as invasive weeds.

[USDA Plants Database](#): All that is needed is the scientific or common name of the plant to search this database and retrieve information about growth and propagation characteristics as well as maps of geographic range in the U.S.

[Bioenergy Feedstocks at Low Risk for invasion in the USA: A White List Approach](#) – Published in Bioenergy Research in July 2014, this publication assessed 120 potential bioenergy feedstock taxa using weed risk assessment tools and generated a white list of 25 non-native taxa and 24 native taxa of low invasion risk in the continental USA. The list contains feedstocks that can be grown across various geographic regions in the USA and converted to a wide variety of fuel types. Although the white list is not exhaustive and will change over time as new plants are developed for bioenergy, the list and the methods used to create it should be immediately useful for breeders, regulators, and industry representatives as they seek to find common ground in selecting feedstocks.