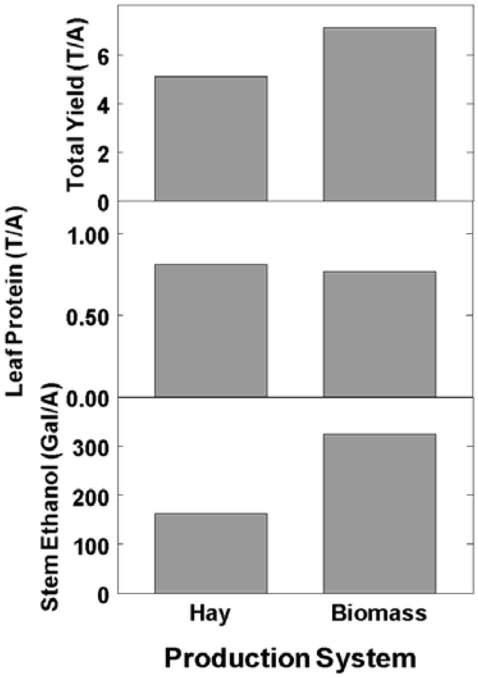
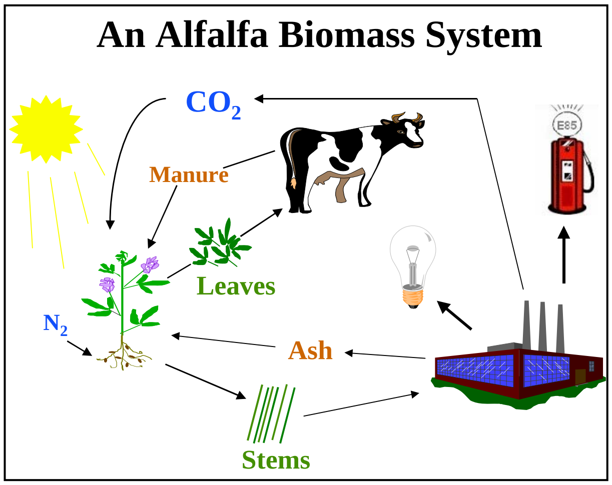
Alfalfa – A Sustainable Crop for Biomass Energy Production

The United States is experiencing an economic shock due to recent hikes in the price of oil and natural gas. For farmers, the prices of nitrogen fertilizer and fuel have risen to unprecedented levels, putting profits at risk. The President, Congress, industry, and the public are all calling for independence from imported oil. Ethanol produced from cellulosic biomass is a sustainable and achievable alternative to help fuel America's transportation system. At the same time, biomass crops must help support profitable agricultural systems, vital rural towns, and public demand for environmental protection.

Alfalfa has considerable potential as a feedstock for production of ethanol and other industrial materials because of its high biomass production, perennial nature, ability to provide its own nitrogen fertilizer, and valuable co-products. Unlike other major field crops like corn and soybeans, which are commonly refined for production of fuel and industrial materials, refining of alfalfa remains underdeveloped. Instead, alfalfa is primarily processed and used on-farm as livestock feed. Although alfalfa remains tied with wheat as the ***third most important field crop*** after corn and soybeans, declining dairy cow numbers and shifts in feeding practices have caused a reduction in alfalfa acreage over the last 25 years,. The end result has been an increase in continuous row cropping of corn and soybeans with little rotation to perennial forages. As a result, the risks of soil erosion, contamination of surface and ground water by nitrate and pesticides, and loss of valuable soil organic matter have increased. Growing more alfalfa for biofuel production would contribute to making the United States energy independent, improving our natural soil resource, reducing greenhouse gas emissions, and protecting water quality.



The USDA-Agricultural Research Service (ARS) is actively researching many potential biomass crops. The ARS Plant Science Research Unit (PSRU) in St. Paul, MN has been actively involved in alfalfa biomass energy research since 1993 in collaboration with the University of Minnesota. The PSRU has developed a ***biomass-type alfalfa*** that is taller and does not lodge at later maturity stages. These traits allow less frequent harvesting than conventional forage-type alfalfa, reducing harvest costs and protecting nesting birds in early summer. When biomass-type alfalfa is grown under a biomass management system with less dense seeding and only two harvests per year, compared with standard hay-type alfalfa production practices, ***total yield of alfalfa increases 42%***, leaf protein yield is equal, and ***potential ethanol yield from stems doubles.***



Alfalfa produces high net energy yield – that is, the energy required for production is far lower than the total energy contained in the crop. This is due, in part, to biological nitrogen fixation. Unlike corn and other grass crops, alfalfa can obtain nitrogen from the air. This saves the farmer money, but also represents a tremendous energy savings. Furthermore, alfalfa leaves enough plant-available nitrogen in the soil to meet the needs of the next crop of corn. In many cases, there is even enough nitrogen to satisfy one-half the need of the second crop of corn. Clearly, inclusion of alfalfa in rotation with corn increases the efficiency of energy production from corn.

To maximize energy yield, cellulosic biomass production and processing likely will need to be locally based. Recently, PSRU scientists analyzed the spatial distribution of net energy yield for soybeans, corn, and alfalfa in a prospective fuelshed, and the results demonstrate how net energy yield varies with soil type and decreases with distance from processing facilities. This approach has shown how biofuel facility planners can minimize costs and maximize energy production by contracting with nearby, high-producing farms. In addition to the many environmental benefits of growing a perennial legume, ***the efficiency of energy production by alfalfa is 2 to 3 times better than corn grain or soybeans***. Below are examples for specified biomass yields in fields located 15 miles from a processing facility.

Crop (yield)	Energy input	Delivered energy	Ratio of output:input
	Million BTU/acre		
Soybean (40 bu/a)	2.3	18.3	7.1
Corn grain (180 bu/a)	6.0	59.0	8.8
Corn stover (3.6 tons/a)	2.6	51.1	19.7
Alfalfa (6 tons/a)	3.0	78.2	***25.0***

In contrast to new crops and native perennials, production practices and machinery are well developed for alfalfa. There is agronomic expertise available in most states through the Extension service and private consultants.

Additionally, several value-added products can be produced from alfalfa leaves before conversion of the rest of the crop to fuel or energy. Examples are feed and food grade proteins, and nutriceuticals such as lutein. Scientists in the PSRU are working to produce ***bio-degradable plastic*** in alfalfa leaves. ARS scientists at the US Dairy Forage Research Center in Madison, WI are developing ***adhesives from alfalfa***.

Further research on alfalfa germplasm improvement, development of valuable co-products, and providing guidelines for the most environmentally beneficial deployment of alfalfa in cropping systems will strengthen the economic and environmental benefits to be gained from using alfalfa to provide the future energy needs of the United States. Because no single crop is adapted for growth on all agricultural landscapes, PSRU scientists collaborate with other ARS scientists and non-federal public and private sector scientists to investigate other potential biomass crops, including switchgrass and other perennial legumes and grasses, corn stover, and fast-growing trees.

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