

Irrigated Alfalfa Management for Mediterranean and Desert Zones



Alfalfa for Industrial and Other Uses

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Alfalfa growers throughout the world appreciate the high yielding, high quality characteristics of their crop and its value to the farm enterprise. Alfalfa is recognized as a high quality feed with tremendous versatility. It can be harvested and fed as greenchop, hay, cubes, haylage, or silage, or it can be grazed. It is also used for human consumption and as a nutritional supplement. The potential exists for alfalfa to be used for industrial purposes, providing farmers with new high-value products and adding to their profit margin. Exploitation of these potential food, feed, and industrial products will expand markets for alfalfa. To accomplish this goal, there is a need to develop new technologies to convert alfalfa into important value-added goods such as biodegradable plastics, high-quality animal feeds, improved textiles, pharmaceutical ingredients, and enzymes.

Although biotechnology will provide many of the new products for industrial utilization, there are opportunities for utilization of conventional alfalfa to produce value-added goods. Alfalfa has many advantages over other agronomic crops as a source of new value-added products. With its long growing season and 3- to 5-year stand life, it has great production potential. Its nitrogen-fixing capabilities make alfalfa superior to other crops in that it does not require supplemental nitrogen fertilizer.

This is an advantage because it reduces the need for increased utilization of fossil fuels to supply fertilizer to produce biomass. In addition, varieties are adapted to production areas throughout the world, and host plant resistance affords significant pest control, limiting the need for pesticides. Combined, these characteristics make alfalfa a highly sustainable and desirable crop for industrial and other uses that will result in both environmental and economic benefits.

Alfalfa produces more protein per acre than any other crop and is known for its ability to improve soil condition, thus providing value to crops following in the rotation. There is also

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evidence that alfalfa helps protect surface and groundwater quality by acting as a sponge for excess nitrates and water. A new alfalfa variety has been developed that fixes nitrogen only from the soil, not from the atmosphere, to increase its effectiveness in absorbing nitrates. It also provides a visual clue (yellowing of the foliage) to indicate when soil nitrogen is depleted. New alfalfa varieties have been used to clean up fertilizer spills and

residues of atrazine, a corn herbicide. Alfalfa tissue immobilized on silica beads has also been used to filter heavy metals, such as cadmium, chromium, copper, nickel, zinc, and lead from water.



Fractionation

Processing alfalfa to obtain value-added products often includes fractionation. There are three different fractionation methods: dry fractionation, wet fractionation, and fractionation by passage of the plant material through the digestive system of ruminant animals.

Dry fractionation is the process of separating the plant into leaf and stem fractions.

Alfalfa leaf meal can effectively replace some of the alfalfa hay, soybean meal, and/or protein supplement in animal rations.

Wet fractionation is the separation of freshly cut herbage into juice and fiber fractions, each of which can be converted into valuable products. The fiber fraction can be used to make paper, or if exposed to appropriate enzymes, the fiber can be converted to sugars, which, in turn, are fermented to industrial chemicals or fuels such as lactic acid or ethanol. Biodegradable plastic can be made from the lactic acid. Products produced from the juice fraction include: food- and feed-grade protein concentrates, industrially valuable enzymes, pigments, antioxidants, and nutraceuticals. *Nutraceutical* is a term that combines “nutrition” and “pharmaceutical” and refers to foods claiming to have a medicinal effect on human health. Such foods are also called *functional foods*.

Passage of the plant material through the digestive system of ruminant animals leaves a high fiber residue. The fiber from alfalfa manure has yielded construction pressboard and water filters capable of removing heavy metals from contaminated water.



Biofuels

Biofuels include ethanol, biodiesel, and other hydrocarbons achieved either through a fermentation or gasification process using biomass. The US Department of Energy reports an annual need for one billion tons of biomass to produce enough biofuel to replace 30 percent of current U.S. petroleum consumption. Perennial crops, including forage crops and trees, account for approximately 377 million tons of that annual production. The primary criteria for any biofuel crop are high yields achieved with low input costs in an environmentally friendly manner. In the past, the focus for biomass production was on poplar trees (*Populus* spp.) but more attention is currently being paid to perennial grasses. Switchgrass (*Panicum virgatum* L.) is one of the main perennial biomass species being evaluated as a dedicated energy crop for cellulosic ethanol production. Other high yielding forages like bermudagrass (*Cynodon* spp.),

tall fescue (*Festuca* spp.), red and white clover (*Trifolium pratense* L. and *T. repens* L.), and alfalfa are also good candidates, but comparisons need to be made in terms of production economics and yield of ethanol and biofuel co-products, not simply total tons of biomass per acre. Ethanol produced from any feedstock (corn grain, switchgrass, wheat straw, etc.) is all chemically identical, but cellulosic feed stocks are far better than grain in producing ethanol. They are estimated to produce approximately five times more energy than corn grain and have a broader range of adaptability to poorer soils and regions that cannot support corn production. In order for alfalfa to be competitive as a biomass source, dividing the harvested product into components, such as leaves and stems, and using the leaves as a protein supplement while the stems are used for biofuel production improve the economics for alfalfa. If co-products such as pharmaceuticals are simultaneously extracted from the leaf material, this allows the economics of using alfalfa as a biofuel crop to work even better. An advantage over other crop options is that alfalfa doesn't need a source of nitrogen fertilizer and its ash can be used as a fertilizer and lime source. In addition, another major, short-term advantage is its ability to be used as a rotation crop to supply nitrogen to a subsequent corn crop.

Alfalfa for Electricity Generation

Increasing environmental sensitivity has led to greater consideration of renewable resources as an alternative to fossil fuels. It is widely believed that fossil fuel emissions harm the environment and contribute to global warming. A feasibility study in Minnesota, conducted by the Northern States Power Company and the University of Minnesota, with support from the U.S. Department of Energy and USDA, analyzed the potential of using alfalfa as an environmentally, and economically sustainable, renewable source of energy for the production of electricity.

It was estimated that the program would utilize approximately 750,000 tons (680,250 megagrams) of alfalfa each year. The system

separated alfalfa hay into leaf and stem fractions. Leaves were used as a protein feed supplement while the stems were gasified to generate 75 megawatts of electric power. Current low energy costs in this country have limited the use of alfalfa stems to generate electricity from gasification, but the ability to produce a high value co-product may make this approach more economically feasible in the future.

Alfalfa for Protein Production

Potential exists to take advantage of the high quantity and quality of protein in alfalfa. The objective is to extract protein and sell it as a purified product while feeding the extracted leaves and stems to cattle. The extract is 55 percent protein, has a good balance of fat and trace minerals, and is high in xanthophyll content. The amino acid balance is very good for nonruminants and is used for poultry rations to provide protein. Chickens require high xanthophyll in the ration for good skin color and yellow egg yolks (Fig. 19.1). This product is less expensive as a xanthophyll source than the marigold extracts currently used. Protein extract from alfalfa has also been used as a human protein source in Mexico and France.

FIGURE 19.1

Alfalfa extract is high in xanthophylls and is an economically favorable alternative to include in poultry rations for good skin color and yellow egg yolks.



The green alfalfa fiber residue which remains after protein extraction qualifies as a high quality dairy alfalfa feed containing 17 percent protein since the alfalfa is harvested at the bud stage. The product is dried to 10–20 percent moisture and stored in a warehouse to preserve quality.

Alfalfa for Human Consumption

Alfalfa sprouts have been used for human consumption for decades (Fig. 19.2). They are most often used in salads and on sandwiches. Alfalfa sprouts have a high antioxidant activity and phytoestrogen concentration, which may be important in preventing diseases in humans. Alfalfa leaves are a good source of protein and vitamins A, E, and K, and they contain four times as much vitamin C as citrus juice.

Growing Pharmaceuticals

Another potential use of alfalfa is to produce pharmaceuticals. As an example, at the University of Wisconsin, genes have been transferred into alfalfa that allow it to make insulin. Alfalfa could be grown and after the insulin is extracted, the residue could be fed to cattle. This strategy would provide an economic incentive to those growing the crop and encourage increased alfalfa acreage. As mentioned above, alfalfa is also a good source of phytoestrogens, which could also be extracted as a pharmaceutical co-product.

Novel Compounds

Alfalfa could be developed to produce phytase, cellulase, antibodies, or edible vaccines.

Alfalfa could be developed to produce phytase, cellulase, antibodies, or edible vaccines. The enzyme phytase improves phosphorus availability in monogastric animals, such as swine and poultry. Phytase, from

FIGURE 19.2

Alfalfa sprouts are a common addition to salads and sandwiches where their antioxidant activity and phytoestrogens may contribute to disease prevention in humans.



transgenic alfalfa, has already been tested in rations and has the potential to reduce feed costs for producers while at the same time reducing water quality problems caused by phosphorus. It can be fed as leaf meal or as juice dried on ground corn, and the manure has less than half the phosphorus levels of manure from chicks fed inorganic phosphorus supplements.

Researchers in Ontario, Canada, have developed a vaccine against shipping fever, a disease of cattle that occurs when the stress of movement weakens their immune system and they develop viral and then opportunistic bacterial infections. A bacterium that resides in the tonsils is the major cause of the disease. Researchers have genetically modified alfalfa to produce antigens against the bacterium. They plan to feed the alfalfa to calves to see if they will develop immunity to the disease.

Research is also underway to develop alfalfa that produces granules that can be extracted to produce a biodegradable plastic. Such a product would not use petroleum as a base and would not pollute as non-degradable plastic does.



Conclusions

The value of alfalfa is not limited to the cash value of the crop. Production of value-added products can more than double the value of the crop while creating jobs and stimulating the economy in rural areas.



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