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ALFALFA INSIGHTS

VIRENXIA'S NEWSLETTER ON ALFALFA, THE QUEEN OF FORAGES

ALFALFA ENVIRONMENTAL IMPACT

A CROP WHICH HELPS THE ENVIRONMENT IN COUNTLESS WAYS

Alfalfa contributes to our society in countless ways that most people don't realize. It is not widely known that alfalfa plays an important role in preventing or alleviating several important environmental issues. This issue of Alfalfa Insights explains the very important role alfalfa has to play in the 'phyto-remediation' of environmental issues, due to its deep roots and its effective absorption of water and chemical compounds from the deep soil.

Alfalfa prevents Nitrate Leaching

Alfalfa, more than most other crop species, has the ability to intercept nitrates from the soil. Nitrates are considered by EPA to be a major water contamination problem. Sources of nitrate may be fertilizers, manures, industrial spills, or natural sources. Nitrate (NO3) is highly soluble, and moves with rainwater or irrigation water, and can contaminate groundwater, wells, streams, or estuaries. **Nitrates can cause health problems in humans and animals, and adversely affect ecosystems. These problems may be prevented or alleviated using alfalfa.** Alfalfa's ability to 'scrounge' nitrate is partially due to its ability to extract water. Alfalfa recovers most of the water in the root zone, and since most of the nitrate is dissolved in the soil water, the plant intercepts it. Secondly, alfalfa has an outstanding ability to absorb nitrate from the soil solution. Recent field research on a sandy soil in Minnesota showed that **alfalfa reduced the nitrate concentration of water flowing through the root zone from 25 to less than 1 part per million (ppm) nitrate-nitrogen, and from 50 to less than 5 ppm.** If concentrations in the soil are kept low by alfalfa, even large losses of water from the root zone will not contaminate groundwater aquifers.

Deep Roots Benefiting the Soil

A third key aspect of alfalfa's value in preventing contamination problems is deep-rootedness. In 1917, researchers reported that alfalfa roots were plentiful in the upper 6 feet of soil and penetrated to the water table at 15 feet on a sandy loam soil. More recent soil coring and isotope labeling experiments confirm the activity of alfalfa roots deep in the soil. **This deep vigorous root system prevents nitrates or other compounds from leaching.**

Protecting Estuaries & Surface Water

Reducing losses of nitrate in tile drainage water is extremely important for protection of surface water quality and the health of estuaries. In tile drained fields, both alfalfa and a grass/alfalfa mixture kept annual nitrate-N losses in tile drainage to less than 5 lb/acre.

Mitigating Accidental Chemical Spills

Because of alfalfa's high protein yield per acre, it is a valuable crop for cleaning up sites with too much available N. Alfalfa was used at derailment sites to remove excess spilled nitrate from the soil and groundwater. **At the ND spill site, total N removal in alfalfa over 3 years was 870 lb/acre, whereas corn and wheat removed only 330 lb/acre.**

Managing Water Tables

Alfalfa's high water absorption and deep roots also make it a valuable crop to manage water tables. In Australia, the federal research agency recommends using alfalfa in rotations with annual crops to help reduce water table levels. Alfalfa is also commonly used in the Delta region and Imperial Valley of California, as well as in locations in the US Northern Great Plains to **draw down high water tables and to limit saline seeps.** The specific hydrologic and chemical conditions at each site will determine whether alfalfa can be used for this purpose.

Removing Carcinogens from the Soil

The 'rhizosphere' of soil and organic compounds surrounding the root is very important environmentally. **There is good evidence that the organisms around alfalfa roots can efficiently degrade petroleum products and carcinogenic Polynuclear Aromatic Hydrocarbons (PAHs).** At one site, a standard alfalfa cultivar reduced PAH concentration by over 70%.

Uptake of Contaminants

If heavy metals are a problem in soils, Alfalfa may be able to absorb them, and – depending upon the concentration in the forage – the harvested forage can then be fed or incinerated. Alfalfa has been used to mitigate the 'Chromium 6' water contamination problem. Alfalfa has been used to mitigate Perchlorate contamination in water, a result of the manufacture of rocket fuel. Researchers have also begun to develop alfalfa that can absorb and breakdown Atrazine, a widely used herbicide sometimes found contaminating well water. A team of researchers have found a Pseudomonas bacterium that decomposes atrazine to harmless byproducts. After moving the bacteria's naturally occurring gene into alfalfa, they developed a plant that takes up 3 times as much Atrazine as normal alfalfa. They hope this alfalfa can play a role in preventing and cleaning up water contamination.

Recycling Organic Wastes

A wide range of organic waste products can be recycled using alfalfa. Many of these 'waste' products are, in fact, fertilizers, if used properly. Alfalfa is commonly used in many locations to **recycle dairy manures**.

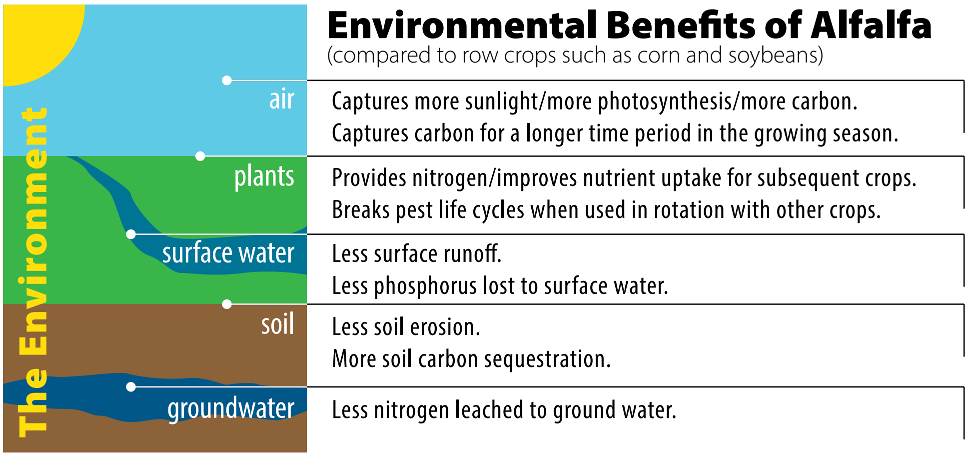
In other areas, alfalfa is used for **municipal waste recycling**. Although careful monitoring of heavy metals and biological compounds may be necessary, alfalfa can be used for the effective recycling of many different types of organic wastes.

Lowering Particulates in Air

Dust is a common hazard of farming and industry. Health professionals are concerned with PM10 particles since they are smaller than 10 microns and can lodge in the human lung, causing health problems. The federal EPA has developed guidelines to limit PM10 particles in air. Alfalfa contributes greatly to limiting particulates released into the air. Alfalfa releases only a small fraction of the particulates that are released from other agricultural and non-agricultural activities. **Furthermore, the vigorous canopy prevents movement of dust out of fields due to windstorms, and traps fugitive dust from other areas.**

CO^2 Sequestration

As a perennial crop, alfalfa fixes significant quantities of CO^2 through photosynthesis. A portion of this carbon is retained in the thick root structure and in the rhizosphere surrounding the root. An alfalfa crop helps to temporarily retain carbon, both in the plant biomass and the soil rhizosphere, potentially lessening the effects of global warming. **An alfalfa field naturally exchanges the CO^2 with oxygen, which freshens the surrounding atmosphere.**



Alfalfa Prevents Erosion

Although much of the current concern about the environmental effects of agriculture is focused on pesticides, soil erosion has always been a significant environmental hazard of agriculture. Soil erosion is a permanent loss of productive potential, since the most fertile soil layers erode, only to pollute streams and lakes with sediment. Alfalfa protects the soil from erosion in several key ways: by reducing the amount of cultivation, by holding the soil in place through extensive rooting, by providing a vigorous above-ground canopy, and by improving 'tilth' and water penetration.

Alfalfa 'Rhizosphere'

Alfalfa roots produce an excellent environment for growth of microorganisms immediately surrounding the root (the rhizosphere).
This flurry of biological activity is due to natural chemical exudates from roots, but also to the nitrogen and carbon in dead and dying roots and root nodules. **Microorganism populations are usually 10 to 100 times higher next to the root than in the bulk soil.** The alfalfa 'rhizosphere' is very important environmentally and is beneficial to the soil.

Improved Soil Tilth

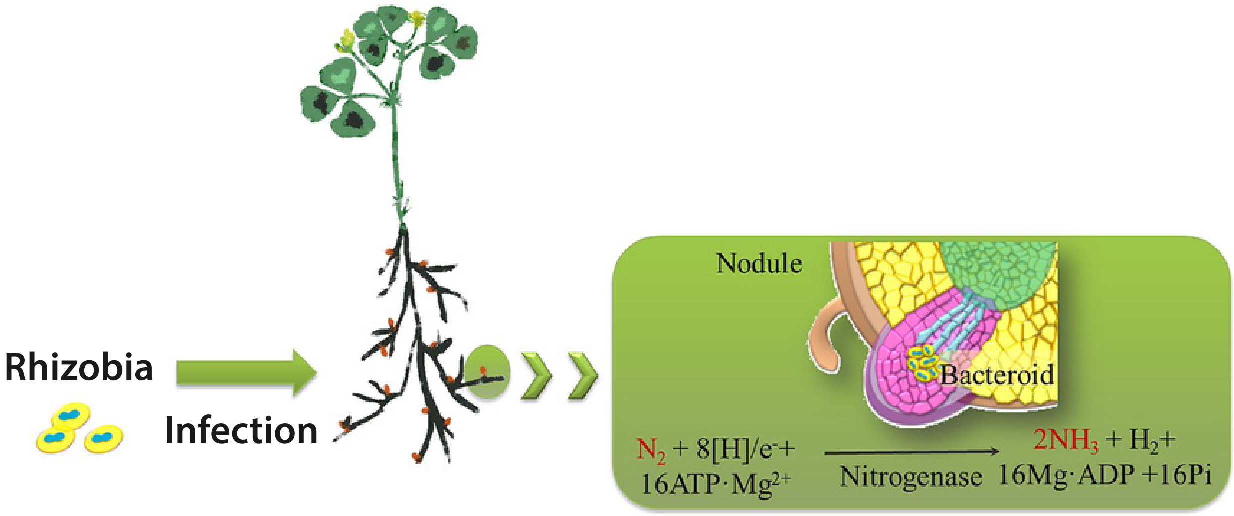
Organic acids produced in the rhizosphere improve the structure of the soil surrounding alfalfa roots. Soil particles aggregate, creating pore space for air and water movement.
The soil becomes 'crumbly' leaving many 'channels' – ideal for plant growth and water infiltration. Farmers the world over recognize the beneficial effect of alfalfa on the soil and the following crop. As Roman writer Columella wrote in 56 AD of alfalfa, "it dungs the land." This refers to not only the residual N from alfalfa, but also to soil tilth.

BIOLOGICAL NITROGEN FIXATION

ALFALFA ASSIMILATES ITS OWN NITROGEN REQUIREMENT

One of the key values of alfalfa is its ability to ‘fix’ nitrogen gas (N^2) from the air so that N is available for plant growth. Available N is very limited in the Earth’s crust and is frequently deficient in plants. Nitrogen is a basic building block for plant proteins, and for human protein nutrition. While cereal crops require millions of tons of N fertilizers per year, alfalfa requires essentially no N fertilizers for optimum growth. **Estimates for N^2 fixation in alfalfa range from 120 to 540 lbs of N per acre per year.**

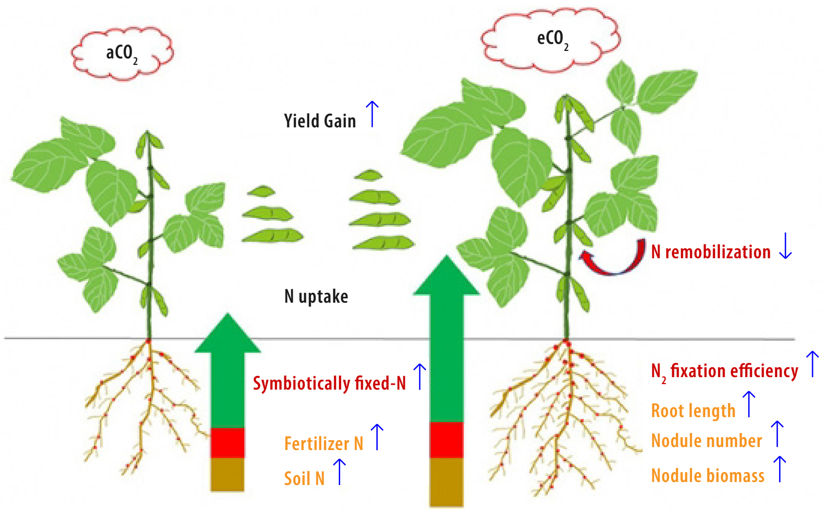
N^2 fixation is accomplished by symbiotic association with the bacteria Sinorhizobium meliloti, which lives in nodules in alfalfa roots. The US alfalfa crop fixes an estimated 2 – 2.5 million tons of N each year, which is used for protein production and plant growth.
The nitrogen fixation by alfalfa has several important environmental benefits, which are not broadly recognized.



Approximately 80% of the atmosphere is nitrogen gas (N^2). Unfortunately N^2 is unusable by most living organisms. Plants, animals, and micro-organisms can die of nitrogen deficiency, surrounded by N^2 they cannot use. All organisms use the ammonia (NH^3) form of nitrogen to manufacture amino acids, proteins, nucleic acids, and other nitrogen-containing components necessary for life. Biological nitrogen fixation is the process that changes inert N^2 to biologically useful NH^3.
This process is mediated in nature only by bacteria. Other plants benefit from nitrogen fixing bacteria when the bacteria die and release nitrogen to the environment, or when the bacteria live in close association with the plant. In legumes and a few other plants, the bacteria live in small growths on the roots called nodules. Within these nodules, nitrogen fixation is done by the bacteria, and the NH^3 produced is absorbed by the plant. Nitrogen fixation by legumes is a partnership between a bacterium and a plant.

Alfalfa provides N to subsequent crops

In addition to lessening the environmental costs of protein production from the crop itself, alfalfa contributes significant N to subsequent crops (e.g. wheat, corn). In most farm states the "N credit" for alfalfa ranges from 40-190 lbs N per acre. This is essentially free 'fertilizer' that can be utilized by the following crop. The exact amount available will depend upon alfalfa stand, soil type, and how much top growth is plowed down. In the US, assuming that about 20%, or 4.8 million acres of alfalfa are rotated to another crop each year (a conservative estimate), and using a conservative N credit of 50 lbs/acre to the subsequent crop, this amounts to 120,000 tons of N, or 146,000 tons of anhydrous ammonia equivalent potentially saved each year. **This is worth over 4 trillion BTUs of fossil fuel energy from natural gas, in addition to the amounts directly from alfalfa detailed above. The N^2 fixation of alfalfa is of tremendous environmental benefit each year.**



Greenhouse Gas Reduction and Climate Change Mitigation

It has been suggested that nitrogen fixed by legumes like alfalfa is much less susceptible to gaseous loss as nitrous oxide than fertilizer nitrogen. **This is critical because the global warming potential of nitrous oxide is 300 times that of carbon dioxide.**

There is evidence that alfalfa sequesters more carbon dioxide as soil carbon than annual row crops because of its longer photosynthetic season and deeper root system.

Alfalfa – Part of Sustainable Cropping Systems

Alfalfa performs a humble, unsung, yet vitally important role in cropping systems due to these characteristics. Some growers would continue to grow alfalfa solely for its rotational value and benefits to subsequent crops, even if the economic returns were marginal.

Alfalfa's N2 fixation, deep roots, protection and enhancement of the soil, relatively low pesticide load, and contributions to subsequent crops make it a highly valued component of sustainable agricultural systems.

Source: Publication of California Alfalfa and Forage Association

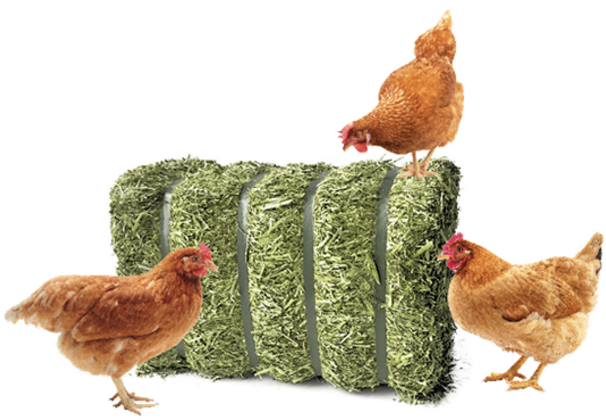
ALFALFA: INNOVATIONS

SILAGE AS ORGANIC FEED FOR LAYERS

German researchers have found the inclusion of chopped, extruded or pelleted silage in organic layer diets benefits the fatty acids composition, colour and cholesterol content of egg yolks. The researchers said including Alfalfa in the diets of laying hens is available practice because it contains high quality ingredients such as omega-3-fatty acids, pigments, vitamins, minerals and saponins. Furthermore roughage in the diets of poultry has been recognized to **improve the birds natural feeding behavior**, such as foraging, scratching and pecking and to **support healthy conditions for broiler and laying hens.**

440 hens divided into four groups were used in this study. The control group (A) received a complete feed mixture (CFM), while the silage groups (B,C and D) received a supplementary feed mixture (SFM). The SFM recipe was formulated based on an assumed ingestion of 20% silage in the diet. Eggs from hens fed with silage (B,C and D) contained 2.4 times more n-3 fatty acids than the control (A). Chopped, extruded and pelleted silage showed the same effect on the quality of eggs, but thermally treated silage (C and D) produced yolks with higher concentrations of SFA. Yolks from D exhibited the highest content of odd-numbered fatty acids, corresponding to the highest intake of silage. Hens fro group D consumed lowest amount of fat but the highest amount of silage, which corresponded to the lowest amount of cholesterol.

Alfalfa benefits the fatty acids composition, colour, and cholesterol content of egg yolks.



Source: Animal Feed Science & Technology, Germany

MARKET INSIGHTS

ALFALFA HAY

The USDA's National Ag Statistics Service began reporting prices for Premium and Supreme alfalfa hay with the latest monthly Ag Prices report, released March 28, 2019. The report actually lists hay prices in seven states, and an average for the top five: California, Idaho, New York, Texas and Wisconsin.

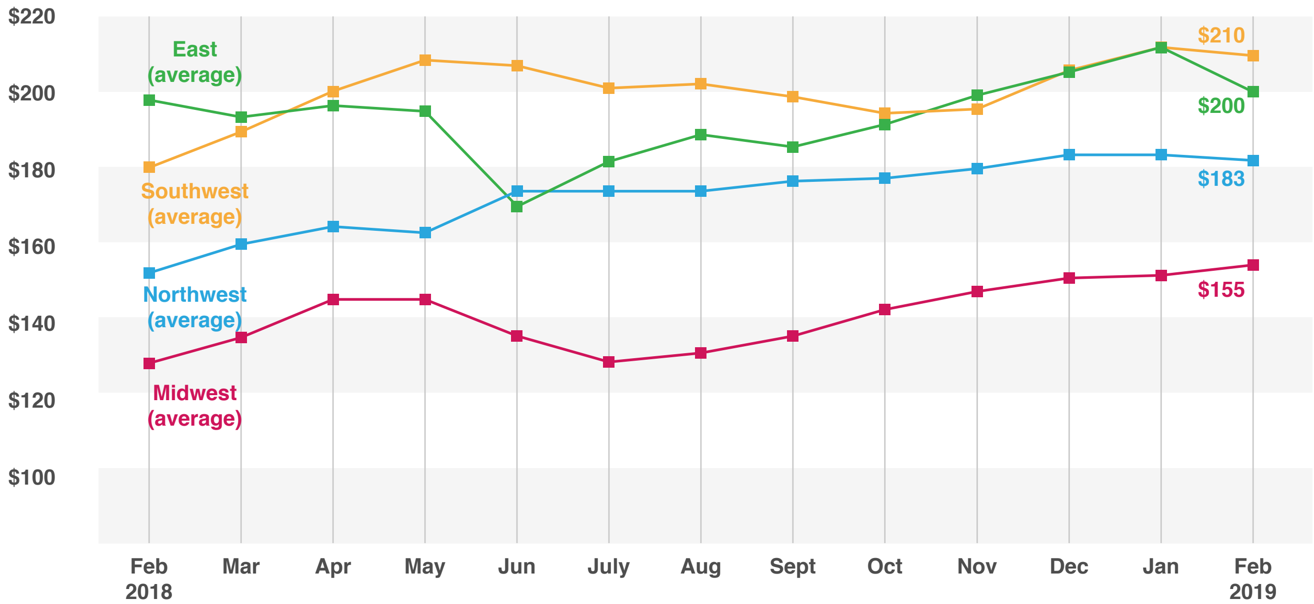
Table 1: Prices received for Premium and Supreme alfalfa hay in large dairy states (dollars per ton)

State	January 2019 (dollars per ton)	February 2019
California	245	240
Idaho	180	180
Michigan	180	175
Minnesota	198	232
New York	240	256
Pennsylvania	309	310
Texas	250	257
Wisconsin	227	248
Five-state Total[1]	221	225

[1]Five-state total represents a weighted (hay purchases) average price for the five largest milk-producing states (based on the pounds of milk produced during the previous month): California, Idaho, New York, Texas, and Wisconsin.

Source: USDA National Ag Statistics Service

Fig. 3: Alfalfa hay market trands (dollars per ton)



Alfalfa Hay market prices at a glance *(As of 14 May, 2019)*

Alfalfa hay prices reported to USDA from selected states.			
	Forage Quality Grade		
Location	Premium+	Good	Fair
	------$ per ton------		
California	210-270(d)	180-230	160-190
Colorado	N.A.	N.A.	N.A.
Idaho	160-170	140-160	100-130
Iowa	170-300	150-200	130-155
Kansas	170-270	160-175	100-165
Minnesota	170-320	150-285	140-245
Missouri	175-250	120-160	100-120
Montana	110-250	100-135	80-140
Nebraska	N.A.	110-165	140
New Mexico	200-300	185(d)-250(d)	N.A.
Oklahoma	200-210	N.A.	N.A.
Oregon	200-220	175	150
Pennsylvania	320-420	190-255	N.A.
South Dakota	160-210	130-190	123-165
Texas	265-360(d)	250	N.A.
Utah	130-200	80-145	60-90
Washington	180-260	175	N.A.
Wisconsin	318	220-285	185-215
Wyoming	200-215	130-165	N.A.

Source: USDA Hay market prices

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