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Alfalfa

After an 8,000-year journey, the "Queen of Forages" stands poised to enjoy renewed popularity

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Alfalfa holds the distinction of being the oldest forage crop for which we have a name, yet the etymology of the word is uncertain. It may have arisen from modifications of the Persian *aspo-asti* (horse fodder), the Arabic *al-fasfasa* or the Kashmiri *ashwa-bal* (both meaning horse power). Some have speculated that the name most commonly used in Europe, "lucerne," may derive from the Persian word *läjwärd* for lapis lazuli, the ultramarine blue mineral lazurite, in reference to the blue flowers of *Medicago sativa*—one of the two species, with *M. falcata*, known as alfalfa. Early French writers referred to it as *sain foin* (healthy hay), although this is now the common name of a different legume species. Today, alfalfa also is known as *medic*, named—according to the Greek geographer and historian Strabo, who called it *mhdich*—for the location of its origin, the ancient empire of Media. That root clearly persists in the Latin *medica*, the Italian *herba medica*, the Spanish *mielga*, the Old English *medick* and the scientific genus, *Medicago*.

What most of the proposed derivations for the word alfalfa have in common, however, is acknowledgement of the plant's merits. From the beginnings of Western Civilization, farmers have recognized that alfalfa provides excellent animal feed, improves the soil, increases yields of other crops and can be used as food or medication for people. Today, despite the widespread use of nitrogen-based fertilizers, alfalfa continues to play a vital role in agriculture, and the development of new uses for this ancient legume promises to ensure a bright future.

Alfalfa's Roots

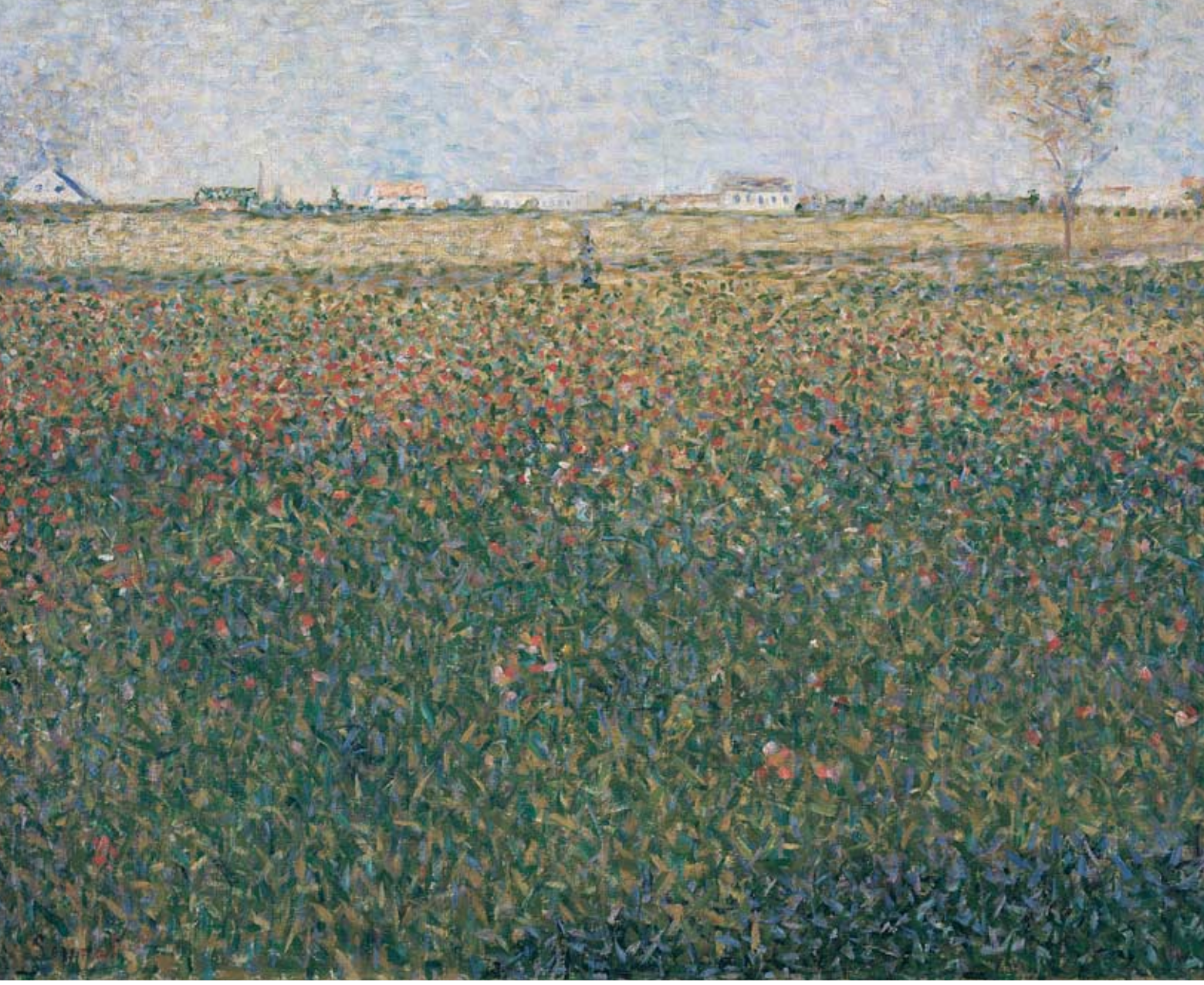
Alfalfa does turn up early in the written record, but its use actually predates recorded history. Although it is very difficult to identify specific plant species in ancient strata, charred seed of wild alfalfas have been identified in layers that date to about 6000 B.C. at Ali Kosh, in present-day southwestern Iran. And at Abu Hureyra, a very early agricultural community in Syria, charred remains of small-seeded legumes date from about 10,000 B.C. The Ali Kosh society evidently relied on a wide variety of wild plants and animals, and seeds of many grasses and legumes were collected.

Medicago falcata seed has been found at a fourth-millennium B.C. site in northwestern Pakistan and at third- and second-millennium B.C. sites in northern Afghanistan and Kashmir. In the later cases, both cultivated cereals and pulses (large-seeded legumes) also were present, indicating that alfalfa seed was either gathered or cultivated under irrigation for green fodder. Ethnobotanists speculate that small-seeded legume seed may have been used as a protein and fat supplement to the human diet (alfalfa seed contains about 10 percent oil and 40 percent protein on a dry-weight basis) or as flavorings, medicines or dyes.

On the other hand, the carbonized seed found at these sites may be the remains of plants or animal dung that were used as fuel. Seed of small-seeded legumes passes essentially unaltered through the digestive tract of ruminants. (Such seeds are referred to as "hard," because for physical reasons they do not absorb water and germinate when normal seeds do, providing a way for the plant to survive until environmental conditions improve.) Evidence of dung has not been found in many of these sites, and it also seems that collecting wild animal droppings for fuel would be too energy expensive. Both explanations (use as food for humans and for livestock) may apply, however, if livestock were kept. Recent analysis of milk residues in pottery shards and mortality patterns based on bone analysis have pushed back the estimated time of early livestock domestication.

Traveling with "Horse Power"

Like other crops, alfalfa traveled with trade and invading armies. The Hittites, known for



National Galleries of Scotland

Figure 1. Alfalfa not only holds the distinction of being the oldest named forage crop—dating to the 4th millennium B.C.—but also remains one of the most revered sources of nutrition for livestock. Beyond providing excellent animal feed, the perennial improves the soil, increases yields of other crops and can be used as food or medication for people. By 1800 alfalfa had spread to six of seven continents and was so widely grown in Europe that it is no surprise to find it in *The Alfalfa Field Near St. Denis*, by the French Neo-Impressionist painter Georges Seurat. Today alfalfa continues to play an important agricultural role, despite the advent of nitrogen-based fertilizers, and emerging new uses in environmental remediation, energy production and as an industrial feedstock promise to ensure its bright future.

their horse-drawn chariots, reigned in the Middle East from about 1400 to 1200 B.C. The oldest recorded reference to alfalfa is on one of their tablets, which says that animals were fed alfalfa during winter and that it was a nutritious feed. Later, alfalfa *(aspastu)* was included in the list of garden plants of Merodoch-Baladan, a contemporary of Ezekias, King of Judah (about 700 B.C.). Alfalfa's value to society at that time was evident by the high taxes levied on its cultivation by King Chosroes I during the mid-6th century.

Alfalfa made its way into Greece with the Median invasions under Darius in about 490 B.C. Theophrastus (4th century B.C.) reported that the Greeks first saw the green expanses of alfalfa after the Median armies withdrew. The invaders evidently had established alfalfa to sustain their horses, camels and other domestic livestock. Alfalfa was discussed or at least mentioned by several Greeks, including Aristophanes and Aristotle.

In the 2nd century B.C. the 4,000-mile Silk Road opened to China, allowing overland trade with countries to the west. Anxious to improve his military capability over the Hsiung Nu nomads, Emperor Wu-ti sent his general, Chang Ch'ien, into Central Asia to import Iranian horses. The best horses, those that "sweat blood when they perspire," were found in present-day Uzbekistan, and the astute Chang Ch'ien returned with both the horses

Figure 2. Alfalfa is actually a collective description for two species, *Medicago sativa* and *M. falcata*. The former is characterized by its blue flower and is often called lucerne in Europe, a word which may derive from the Persian for lapis lazuli, the ultramarine blue mineral lazurite. *M. falcata*'s flower is more likely to be white or yellow.

and the renowned horse fodder alfalfa. Several Chinese texts, beginning with T'ao Hung King in the 5th century A.D., refer to *mu su* both as a fodder and as a human food and medicine.

The Romans evidently held alfalfa in high esteem. In the chapter about fodder plants in his work *De Re Rustica,* Lucius Junius Moderatus Columella wrote:

> But, of all those that please us, the herb medic is the choicest, because, when it is once sown, it lasts ten years; and it can bear to be cut down four times, and sometimes also six times, in a year, because it dungs the land; and all emaciated cattle whatsoever grow fat with it, because it is a remedy for sick cattle; and a jugerum [about 29,000 square feet, or two-thirds of an acre] of it is abundantly sufficient for three horses the whole year.

In a footnote, the translators of this passage noted that Pliny the Elder had written that alfalfa would last 30 years; the contrast with Columella may well be due to differences in soils and climates. Pliny recommended selecting well-drained soil that either has good water-holding capacity or can be irrigated, liming the soil (to increase *p*H) and cutting at early flower—recommendations that are valid today.

As a valued fodder crop, alfalfa was probably distributed through the Roman empire during the first and second century A.D. Columella planted alfalfa in southern Spain in the first century. For the next several centuries, however, Europe entered hard times, and no record of alfalfa is known. The Moors probably brought it through North Africa, where it still grows near oases, and then into Spain when they invaded in 711. Alfalfa was well adapted to the soils and climate in much of the Iberian Peninsula and spread into surrounding countries. Still, there was no mention of alfalfa or other specific perennial forages in the widely printed and translated 13th-century *Boke of Husbandry,* by Walter of Henley.

The Renaissance saw a renewal of scientifically based agriculture. Italians apparently rediscovered alfalfa from the Spanish and Hungarians, and frequent references to *herba spagma* and *fieno d' Ungheria* can be found in agronomic literature of the time. Many references to alfalfa were made in the profusion of 16th-century texts about farming throughout northern and central Europe. William Turner wrote about medica in *A New Herball* (1562): "This herbe groweth nowhere in Englad [England] that ever I coulde se, savyng only in gardin. But I have sene it growyng wylde in Germany within a half myle of Wormes in the hygh way towarde Spyer." Turner described alfalfa as having a yellow flower, which suggests that this was *M. falcata,* rather than *M. sativa.* Camillo Tartello's *Ricordo d'agricoltura,* published in the late 16th and early 17th centuries in Italy, advised that four-crop rotation, including alfalfa and other legumes, replace the common use of fallow in the country. This idea evidently was based on Roman writings, rather than personal experience, and was not widely adopted.

The French author Olivier de Serres wrote in about 1600 that alfalfa was not well known in Italy or the adjacent Piedmont region but that it was widely grown in Spain and the southern part of France. He considered alfalfa to be one of the premier livestock feeds, as it was more palatable and productive than other forages. De Serres provided detailed information about which soils should be considered for alfalfa, good seeding and cultivation techniques, how animal manure should be applied, proper irrigation management, insect control, and harvest methods for forage and seed production. He strongly recommended cutting alfalfa as hay, instead of pasturing, because "this herb differs from the other common pastures in that it does not want to be eaten in place at all, nor to be trampled by the beasts: their teeth, breath, and tread are contrary to its nature." This rather winsome statement has been

discredited by the success enjoyed by Argentinean ranchers, whose cattle graze alfalfa on some 28,000 square miles of land.

Alfalfa Sets Sail

Seed was imported to Britain from France in 1650, according to John Donaldson, and in 1867, John Worlidge recommended alfalfa as a way to double forage production on British farms. Despite its productivity on some sites in northern Europe, however, alfalfa was not always a success. It was not included in the 1663 book about livestock fodder crops, *Thier Kräuter und Berg Buch,* by Johann Becher. Was the omission because of plant-disease problems, attempts to grow it on soil that was too wet or shallow, improper management or, perhaps, simple aesthetics? As late as 1911, Martin Sutton wrote, "But for its unsightliness Lucerne would be more frequently sown for permanent pastures than it is, a practice advocated by the late Sir J. B. Lawes. The plant develops so rapidly that it stands far above the surrounding herbage, and imparts a broken and irregular appearance to the meadow."

Alfalfa moved from the Old World to the New in the 16th century with Spanish and Portuguese explorers. George Stewart wrote in 1926: "When Cortez and Pizarro overran Mexico and Peru they left disease and desolation in the land. How it happened may not be ascertained, but when the conquests had run their courses the natives had alfalfa in lieu of their gold and of their monarchs." Another Spanish soldier, Cristobal Gago, apparently introduced alfalfa to Peru in 1535. Alfalfa remains an important forage crop in several Central and South American countries, including Peru, Chile and Brazil, and is found in special combinations of soil and climate in Ecuador, Guatemala and Mexico.

Not until the 18th century did alfalfa make its way over the Andean cordilleras and into Argentina. Yet its role was destined to be much larger there than in any other Central or South American country. With expansion and improvement of beef production in the late 1800s came the need for higher-quality pastures. Alfalfa is particularly well adapted to the climate and soils of the Pampas and has a particular advantage over native forages: Its deep roots can reach groundwater, which lies between 5 and 30 feet below the soil surface. Alfalfa rapidly became a crucial component of improved pastures in Argentina, expanding in area from about 250,000 acres in 1872 to about 3.7 million acres by 1900 and to 18 million acres today.

Elsewhere, alfalfa arrived in New Zealand by the early 1800s, although whether from Europe or Argentina is disputed, and settlers in Australia saw alfalfa about the same time. In the mid-1800s, alfalfa also made its way from France into South Africa, where it was used originally on ostrich ranches. It is now grown on about 750,000 acres there, and in 1988 some stands were reportedly more than 80 years old.

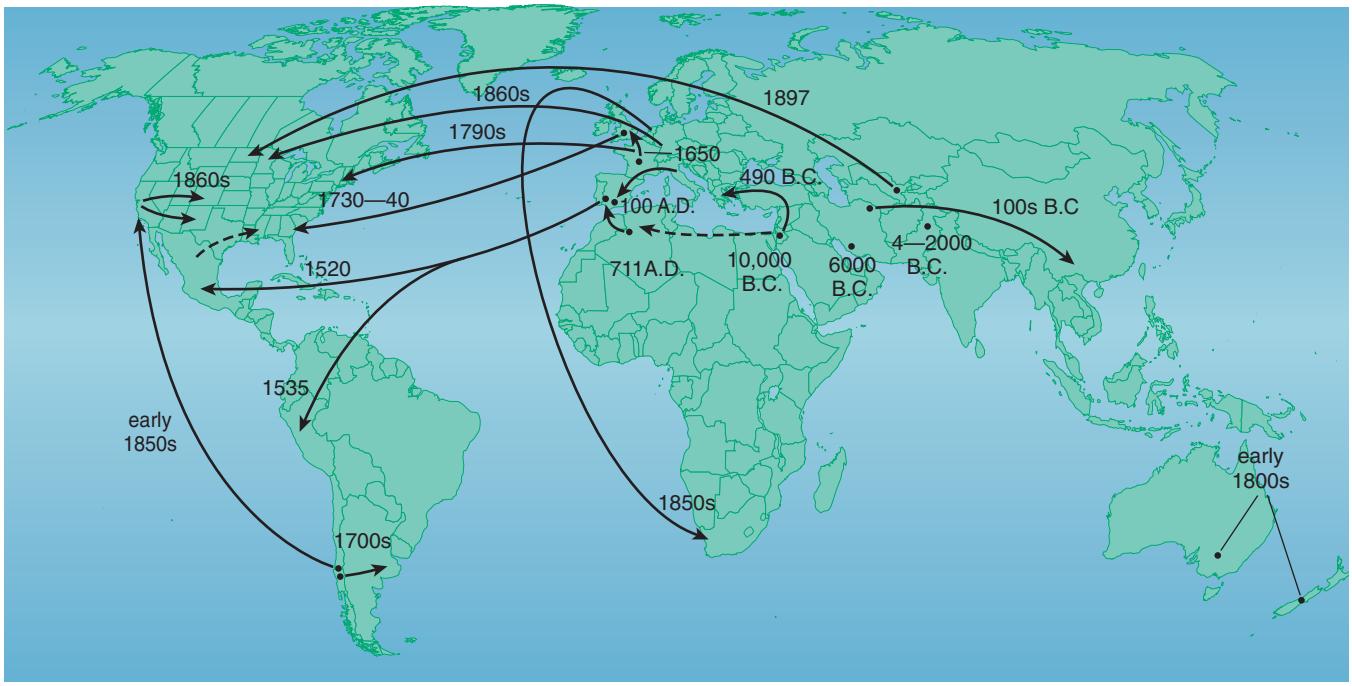


Figure 3. Over the millennia, when people moved, they carried alfalfa with them. The legume most likely originated in the Middle East and the steppes of Central Asia, and its first use by human beings may have been as early as the 10th millennium B.C. at Abu Hureyra in present-day Syria. By the 1st century B.C., it had spread to Greece and to China (by the Silk Road), and the Roman Columella planted alfalfa in southern Spain by 100 A.D. Alfalfa spreads it roots into the New World with the Conquistadors, jumped the Chilean cordillera into Argentina in the late 1700s and arrived in New Zealand and Australia around 1800. Still more importation took place when Niels Hansen brought winter-hardy varieties from Turkestan in 1897.

Alfalfa in the U.S.

English, French and German colonists in the U.S. were well aware of alfalfa's reputation as a forage crop and soil enhancer and were quick to make use of it. In 1735, a keg of seed was shipped for trials in the newly established garden run by the Trustees of the Colony of Georgia, who were seeking ways to become self-supporting. Alfalfa (and many other crops) did not grow well at the garden site, one half of which was "a poor bit of sand which, in the heat of summer, would have roasted an egg," and the other half a heavy clay slope that was wet at the base.

In neighboring South Carolina, Eliza Lucas, who at 16 had to oversee one of her family's plantations, enjoyed planting many non-native fruits, trees and crops at the encouragement of her father. "I own I love the vegitable world extremely," she commented. Eliza experimented with alfalfa as early as 1739 and wrote to her father in June 1741, "The Lucern is yet but dwinderling, but Mr. Hunt tells me 'tis always so here the first year." In 1742 she indicated that she "shall try deferent soils for the Lucern grass this year," but wrote nothing further about the crop in her letterbook.

George Washington ordered "a good deal" of alfalfa seed from a London company and seeded it in spring 1760 at Mount Vernon. Alfalfa seed was sold by various merchants, among them Colonel George Morgan, who experimented with several crop species on his farm in New Jersey. Jared Eliot, as respected in New England as Benjamin Franklin was in the middle colonies, was well known for his agricultural experimentation and encouraged broader use of alfalfa and other high-performing forages.

In France, alfalfa had regained some prominence during the mid-18th century because of improved correspondence between French and British agriculturalists. Several important French writers, including Duhamel du Monceau, Barthelemi Rocque and Henry Patullo, praised the crop, but Patullo wrote in the 1740s that French alfalfa hay usually was of poor quality because it was mowed too late. He recommended that it be mowed at early bloom for best color, fragrance and nutritive value. John Ball revised his recommendations in 1760, saying that "the very best hay of lucerne is that which is made by cutting it before it flowers"—a recommendation still used today for the highest quality alfalfa hay or silage. Duhamel gave detailed instructions for transplanting alfalfa into beds with three-foot-wide alleys, but most authors recommended seeding the crop directly.

In his 1775 book *American Husbandry,* J. Bew made copious suggestions for improvements in Colonial agriculture. He was particularly concerned about the lack of proper crop rotation:

> Relative to the grass, which should upon these principles be cultivated, the heat of the climate will make it necessary to have recourse to such plants as have a long tap root, because by rooting deep they will be more out of the power of the

G. Grace/FAO photo

Figure 4. Alfalfa does well in regions with relatively dry growing seasons—for example, as shown here in Albania—because its roots are able to penetrate deep into the soil. Stands in well-drained soils may extend their roots two or more meters per year and may last 30 years or longer.

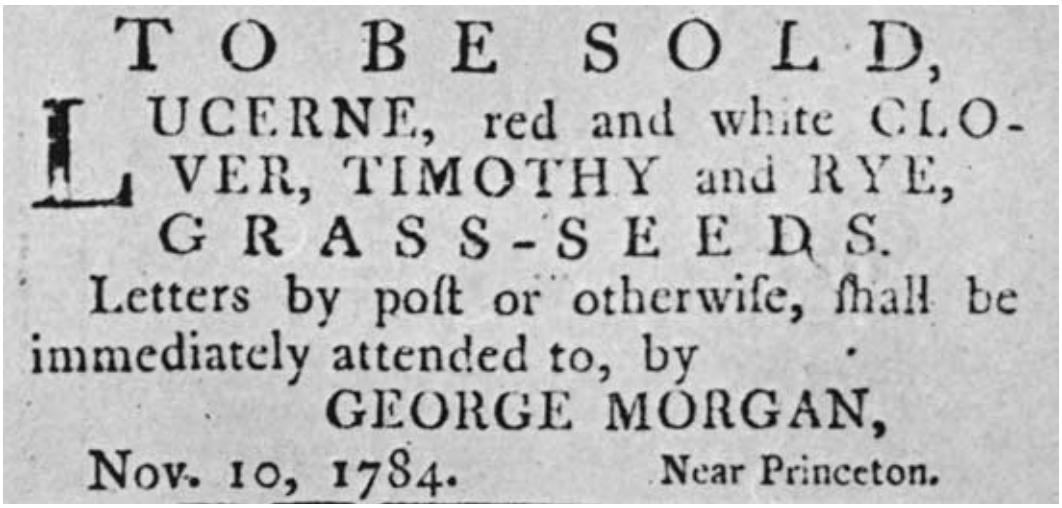

TO BE SOLD,
LUCERNE, red and white CLOVER, TIMOTHY and RYE,
GRASS-SEEDS.
Letters by poſt or otherwiſe, ſhall be immediately attended to, by
GEORGE MORGAN,
Nov. 10, 1784. Near Princeton.

Figure 5. Colonel George Morgan experimented with several crop species in the mid-1700s at his farm in New Jersey and was one of the many merchants who sold alfalfa (lucerne) to farmers such as George Washington. (Image believed to be from *The New Jersey Gazette*, November 15, 1784, reproduced in *The Development of Agriculture in New Jersey: 1640–1880*, by Carl Raymond Woodward.)

> sun: sainfoine and lucerne I should suppose would be found to be of singular utility, especially the latter; both these plants have been brought into the colder parts of Europe from very hot countries.… There can be no doubt therefore of their succeeding admirably on the dry tracts of land in the back parts of Carolina, and also in all the sandy hilly parts of the province. The culture would be attended with none of those inconveniences which have been found in England.…

In addition, he added, increased use of alfalfa would improve dung production by livestock, which would further enhance farm productivity.

Being familiar with French agriculture, Thomas Jefferson was initially quite enthusiastic about alfalfa. He grew it in 1793 and '94, but the types evidently were not well adapted to the conditions at Monticello, and in September 1795, Jefferson wrote Washington, "… I gave the Lucerne this last year a good coat of dung, & due tillage; yet it is such poor dwindling stuff that I have abandoned it.…" Washington responded, "Lucern has not succeeded better with me than with you, but I will give it another, and fairer trial before it is abandoned altogether."

Washington thought much of the problem had to do with either low seed viability or poor management. His letters in the mid-1790s to William Pearce, manager of Mount Vernon, included detailed instructions about seedbed preparation and planting time. In November 1799, Washington complained to the merchant, Clement Biddle, "Let me know at what price Clover seed Sells and whether *good* Lucerne seed can be had? Neither this kind of Seed, the white Clover, or Blue grass seeds with which your furnished me this Spring, was worth the freight; little or none of it came up."

Others in New York, Virginia and surrounding states conducted experiments and made recommendations on alfalfa management. Despite variable success with the crop at Hoboken, New Jersey, John Stevens maintained his enthusiasm: "Perhaps no one subject of rural economy will eventually prove of more importance to the American agriculturalist than the culture of lucerne."

In *The Practical Farmer* (1793), John Spurrier, "an old experienced farmer" who had moved from Great Britain to Delaware, echoed Columella: "It is the only plant in the world, whose hay is equal to the saintfoin for the fattening of cattle; but its virtues in that respect are very great. It is the sweetest grass in the world.… The soil to plant it on, must be either a hot gravel, or a very rich and dry land, that has not an under stratum of clay, and is not too near springs of water." It is likely that failures of unimproved alfalfa in much of the eastern U.S. were the result of wet conditions, plant diseases or low soil *p*H. Unfortunately, the early conclusions of people such as Jared Eliot in 1760, that alfalfa and other legumes required limestone (to raise soil *p*H) for good growth, did not gain general recognition for many decades. Others simply considered that alfalfa was not worth the effort. John Hare Powell wrote in 1827, "… Lucerne … requires more labour and accuracy of tillage than most farmers in this state have either the means or the disposition to apply."

Alfalfa entered the southern U.S. from Mexico in the early 19th century. D. L. Phares claimed that stands known to be over 35 years old were in good condition when he wrote *The Farmer's Book of Grasses and Other Forage Plants for The Southern United States* in 1881. By the 1860s, alfalfa was used in Mississippi to rebuild soil fertility after heavy cropping to cotton, corn, sweet potatoes and other crops.

Figure 6. Niels Hansen (seated, with white hat), a horticulturist at the South Dakota Agricultural Experiment Station, was appointed as the U.S. Department of Agriculture's first official plant explorer. In 1897 Hansen was sent, "at great expense," to eastern Europe and central Asia to collect seed of winterhardy, drought-resistant alfalfa. Of the 2,000 miles he traveled overland, 1,300 were spent in a *tarantass*, an unsprung wagon. The seed he brought back from Turkestan, along with that developed by Minnesota farmer Wendelin Grimm, were able to withstand the severe winters of the upper Midwest, making alfalfa a major crop in the region. (Photograph courtesy of *Farm & Home Research*, South Dakota State University.)

But it was in the dry, calcareous soils of the West that alfalfa first showed its true promise in the U.S. There the soil *p*H and drainage were perfectly suited to this crop. Alfalfa seed was imported to California from Chile during the Gold Rush in the early 1850s. W. E. Cameron sowed this seed in 1851 near Marysville in the Sacramento Valley, and by 1858 he had 270 acres of it. At the 1858 Annual Fair in Marysville, Cameron earned first place for the best bale of alfalfa hay, but James Simpson, of Yuba City, won both first and second places for the best fields of alfalfa. Another rancher in the area, Jerome C. Davis, reportedly had 1,200 acres seeded to alfalfa. This "Chilean clover" was well adapted to the climate and soils, and rapid expansion of alfalfa ensued in the semiarid West. It was growing in Colorado, Kansas and Minnesota by 1860s. Bulletin No. 1 of the State Agricultural College of Colorado stated in 1887 that "Alfalfa stands at the head of all clovers in nearly all respects. It needs no comment. Its feeding value and success as a hay crop is excelled by no other plant."

Alfalfa County, Oklahoma, and the town of Lucerne, California, are two places that reflect alfalfa's importance in the West. A third was "Box S," a struggling 1880s town in California's Mohave Desert. With a mean rainfall of only four inches, early European immigrants had a rough time eking out a living in the valley. But one settler, James Goulding, dug the first flowing well in the area and was successful growing alfalfa using irrigation. In recognition of the feat, the name of the town was changed to Lucerne Valley in 1916.

Early Selection and Plant Exploration

Farmers in the north central U.S. were not as happy with alfalfa as were their counterparts in the West. Cold winters took their toll on alfalfa fields, especially those planted with seed from South American sources. Within a few years of immigrating to the U.S. in 1857, Wendelin Grimm sowed alfalfa seed obtained from neighboring Swiss immigrants on his land in Carver County, Minnesota. This "ewiger Klee" (everlasting clover) was not completely winterhardy, and Grimm lost most of the plants over winter. Ever the optimist, however, Grimm collected seed from the surviving plants and sowed a small area the next year. He continued to collect seed each year, first using extra seed to expand his fields and as barter at the local store, and later selling seed to many neighbors as the crop gained local popularity.

By 1890, Carver County was the only county east of the Missouri River (with the exception of a few counties in New York) that reported at least 1,000 acres of alfalfa under cultivation. Even so, this success was not widely known. Alfalfa was not mentioned during a talk by a

southern Minnesota farmer about the feeding value of various crops at the 1885 Farmers' Institute at Shakopee, a few miles east of the Grimm farm. When asked why he omitted it, the speaker replied categorically that alfalfa could not be grown in Minnesota.

In 1900, two professors at the Minnesota Agricultural Experiment Station, Willet M. Hays and Andrew Boss, rode about 25 miles by horse and buggy from St. Paul to A. B. Lyman's farm near the Grimm homestead. The thriving alfalfa fields, likely sowed with Grimm seed, impressed Hays: "This is the beginning of alfalfa in Minnesota." In 1903, Hays, by then Assistant Secretary of Agriculture in Washington, D.C., named the variety "Grimm," and it became widely known as Hays worked to expand alfalfa acreage.

Other notable introductions of alfalfa occurred in the 1870s. Nathaniel Bethel brought seed from Alsace-Lorraine to Ontario, Canada, in 1871, and John Hahn imported "dreissig-Jahr Luzerne" (30-year alfalfa) to Wisconsin from Germany about 1875. All suffered declining stands as bacterial wilt disease spread.

Winterhardiness, disease resistance and drought resistance had been notable problems with the spread of alfalfa into the plains states from California. So important was the recurrent loss of alfalfa stands to U.S. agriculture that in June 1897 the Secretary of the U.S. Department of Agriculture (USDA), James Wilson, appointed professor Niels Hansen, a horticulturist at the South Dakota Agricultural Experiment Station, as the USDA's first official agricultural explorer. Hansen was sent, "at great expense," to eastern Europe and central Asia to collect seed of winterhardy, drought-resistant alfalfa. His report read:

> Along the Volga River, at the dry-region experiment stations of Eastern European Russia, I found this plant doing well, and when I got to the desert and semi-desert regions of Turcomania, Bokara, and the Semiretchinsk provinces of Russian Turkestan, all east of the Caspian Sea, I made careful study of the plant. Here were camels by the thousand, and clouds of dust often so thick that a wet sponge was found to be essential for relative comfort and breathing. I was so pleased with what I had seen of this plant that I did not stop until fully 18,000 pounds of seed was secured, chiefly from the cotton-growing sections among the Sarts or native Mohammedans.
>
> The main reason for making the overland journey of over 2,000 miles (1,300 by wagon, 700 by sleigh) from Tashkent, the capital of Russian Turkestan, to Omsk, in Siberia, via Kuldja [now Yining], in Western China, was to trace this plant to its northern limits, which we found to be nearly Kopal, in Siberia (latitude 45°10′, longitude 79°10′ east of Greenwich).

M. falcata also had been collected at several sites near Kopal by the Russian physical geographer, Petr Petrovich Semenov, in 1856 and '57. He wrote that *medunka (M. falcata)* was one of the predominant plants of the steppe near Lake Issyk-kul'. But Semenov's purpose was to survey plants and minerals, not collect seed, as Hansen did.

Seed from Turkestan provided the first important impact of Hansen's collections. In 1900, he wrote:

> The unusually severe winter of 1898–99 killed off probably half of the alfalfa in Nebraska, Colorado, Wyoming, and many fields in the central prairie states to the eastward were badly damaged, but the Turkestan alfalfa grown in the states mentioned was not affected. At the experiment station at Brookings, S.D., with a minimum temperature last winter of forty degrees below zero, with the ground bare, the common alfalfa was killed, while this variety from the heart of Asia came through unharmed.

This surprising but welcome news encouraged further exploration.

On two succeeding trips, Hansen returned with seed of *M. falcata*, a very winterhardy, drought-tolerant alfalfa from Siberia. Falcatas derive their species name from their sickle-shaped (falcate) seed pods. As mentioned earlier, they typically have yellow flowers, in contrast to the

Figure 7. Alfalfa was popular enough in the upper Midwest to generate a pageant in its honor. Written in 1926 by Laurence F. Graber, Chairman of the Department of Agronomy at the University of Wisconsin and known as Mister Alfalfa, "The Coronation of Queen Alfalfa" featured the monarch and a group of attendants, offering lime, inoculation, a firm seed bed and other characteristics that would ensure her welfare. (Photograph from *Mister Alfalfa,* by Laurence Frederick Graber.)

Figure 8. Among its other duties in environmental remediation, alfalfa has been used to clean up a fertilizer spill caused by a train derailment in North Dakota. A special variety was developed to absorb nitrogen only from the soil, rather than the air. Here JoAnn Lamb (a plant geneticist with the USDA's Agricultural Research Service), LeeAnn Thomas (with the Canadian Pacific Railroad) and the author inspect a strip of this variety that has become chlorotic (yellow), indicating that it has absorbed the nitrogen from the soil. The surrounding alfalfa is a normal variety that absorbs nitrogen from the air and soil. (Photograph courtesy of Bruce Fritz.)

blues and purples of *M. sativa*. This yellow-flowered alfalfa did not come into widespread cultivation in northern Europe until the second quarter of the 19th century. It appears that the hardy alfalfas from northern and central Europe, such as the population used to produce Grimm, were natural hybrids of *M. sativa* and *M. falcata*.

Alfalfa breeding projects were started in several north-central states in the early 1900s. New plant introductions were made, notably "Ladak" from Kashmir, which had improved winterhardiness and better resistance to some bacterial diseases. Droughts during the decade of 1927–36 caused devastating failures of many crops, but alfalfa persisted and helped some livestock farmers weather those tough times. No wonder the Queen of Forages was celebrated.

As disease resistance, insect resistance and tolerance to cold and drought were developed in agronomically superior lines, and as appropriate crop management strategies were devised, alfalfa acreage expanded rapidly. About 2 million acres were grown in the U.S. in 1899, most of which was in the West. Thirty years later, acreage had grown sixfold, and 30 percent was then in northern and eastern states. About 30 million acres of alfalfa were grown in the U.S. by 1950, 42 percent of it in the Upper Midwest.

Alfalfa into the Future

Now, at the beginning of the third millennium A.D., alfalfa continues to be a major forage crop, with about 22 million acres grown each year in the U.S. and 80 million acres worldwide. Although nitrogen fertilizer and pest-control technologies have reduced the need for crop rotations that include perennial legumes, alfalfa continues to improve our soil and remains a premier livestock feed. We are also discovering brand new uses for alfalfa.

Alfalfa helps protect surface and groundwater quality by acting as a great sponge for excess nitrate and water. It does duty as a wastewater recycler and has gone to work cleaning up fertilizer spills, such as the site of a train derailment in North Dakota. A new alfalfa has been developed that fixes nitrogen only from the soil, not from the atmosphere, to increase its effectiveness as a nitrate absorber and provide a visual clue (yellowing) when the job is finished. Likewise, new varieties are being developed with rapid root growth (even normal varieties grow one to two meters per year and continue to extend each year), to quickly capture nutrients, water and contaminants far below the soil annual crops explore.

Residues of atrazine, the herbicide widely used on corn, are long lived in the soil and are now found in many rural wells. Normal alfalfa is killed by atrazine, but university and ARS scientists at the University of Minnesota have produced plants that are able to absorb and break down the herbicide. Alfalfa can also help remediate other contaminants, such as carcinogenic polyaromatic hydrocarbons and petroleum compounds, because alfalfa roots provide an ideal environment for microorganisms that decompose these organic compounds. 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.

Alfalfa can also be better used as a food source for people. Despite recent problems with processing, alfalfa-sprout production has grown remarkably in the past three decades and now accounts for about 7 percent of the total U.S. alfalfa-seed supply. Alfalfa sprouts have high antioxidant activity and phytoestrogen concentration, which may be important in preventing osteoporosis, cancer, heart disease and menopausal symptoms. 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. New techniques allow extraction of noncolored neutral-tasting protein from alfalfa leaves, which can be whipped into a foam that resembles meringue. A French cooperative, France-Luzerne, currently processes and markets more than 30 products from alfalfa foliage.

Because of its high protein content, alfalfa likely will play a leading role in future "pharming," producing important chemicals for industrial and pharmaceutical use. One new alfalfa already produces phytase, the enzyme that improves phosphorus availability in monogastric animals, such as swine and poultry. This product should reduce feed costs for poultry producers by $20 million per year, and surface-water quality problems caused by phosphorus should be lessened as a result. Another important compound found in alfalfa protein is xanthophyll, a carotenoid used by the poultry industry to give egg yolks and poultry skin a golden color, and that contains lutein, recommended to reduce the risk of macular degeneration in people. Also of interest to poultry operations, a research team at Alabama State University, Montgomery, is working to develop transgenic alfalfa that expresses an oral poultry vaccine against infectious bursar disease.

Alfalfa fiber, especially abundant in the stems, can be used to make paper, or, using the appropriate enzymes, it can be broken down and fermented to yield ethanol or lactic acid, a feedstock for biodegradable plastics. Likewise, the stems can be gasified and burned to produce electricity, saving the rest of the plant for feed or food protein. In contrast to switchgrass and hybrid poplar trees, alfalfa needs no nitrogen fertilizer. Its ash also contains very few hazardous compounds and can be used as a fertilizer and lime source.

These are only a few of the potential new roles for alfalfa. We've come a long way with alfalfa over the past 8,000 years, but it seems we are just beginning to learn how versatile and beneficial this crop can be.

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