

FORAGE CROP PRODUCTION

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Summary

The history of forage crops can be traced back to about 1300 BC when alfalfa was cultivated in Turkey. Relatively widespread use of forage crops, however, appeared

much later, around the beginning of the Christian era, when several species were cultivated in several areas of the world, mainly in the Mediterranean region of Europe. Little happened between the fifth and twelfth centuries, but the thirteenth to nineteenth centuries saw great advances in forage crops. They contributed to the development of mixed farming in the European agricultural revolution, and spread globally with the expansion of Europeans into other continents. The use of forage crops developed also with the rise of industrialized agriculture, which involved the use of new techniques and industrial inputs, the application of science and the rise of a forage seed industry.

The modern era dates from the beginning of the twentieth century. The development of forage crops has been dramatically accelerated by two main factors. The first is the enormous impact of modern science and technology. Progress in plant improvement has led to the development of many new cultivars and the dramatic growth of the seed industry, and thus to the global dispersion of many new forage plants. The second is the diversification in the value of forage crops in a changing society. On one hand, the value of forages as livestock feed has been continuously well recognized, with their production and utilization being strengthened by industrialized agriculture. On the other hand, many other uses of forage crops have been highlighted with the rise and growth of environmental issues. This emerging diversity of functions points to the future roles of forage crops in human existence and development.

1. Introduction

The domestication of our most important grazing animals—cattle, sheep and goats—is believed to have begun about 8000, 11 000 and 9000 years ago, respectively. The domestication of other important grazing animals, buffaloes, horses, asses and camels, is assumed to date from about 5000 years ago. Since these times, animals have played an important role in the existence and development of humans. They provide not only food (e.g. meat and milk) but also clothing (e.g. skin and wool), fertilizer (e.g. feces and urine), fuel (feces), and physical power as draft and packing. They serve as a source of family savings and economic security in the event of failure of food crops and natural calamities. They are a vital factor of human culture (e.g. exhibitions and shows, religion and ceremony, fighting, racing, pets and recreation, status symbol, and bride price and dowry). Currently (1999), the world carries 1323 million cattle, 1056 million sheep, 705 million goats, 163 million buffaloes, 61 million horses, 43 million asses, 19 million camels, 14 million mules, and 5 million other camelids (alpacas, llamas, guanacos and vicunas).

Grazing animals require forage as basal food. Therefore the most important aspect of the husbandry of grazing animals to humans is that we can obtain many diverse products from forage, which we cannot eat directly. Without the domestication of these animals, humans would not have been so prosperous in such an extensive area of the Earth. At the same time, the husbandry of grazing animals requires that humans make forage available to the animals. Forage crops have served as an important source of feed of domestic animals for a long period, although the history of their use is shorter than that of the use of native forages. Nearly 200 plant species have been known as forage crops.

The benefit of forage crops to humans, however, is not limited only to livestock production. They also contribute to food crop production and many other aspects of human life through the following: (a) soil conservation and amelioration; (b) landscape and wildlife conservation; (c) improvement and protection of the environment from pollution; (d) reclamation, revegetation and ecological repair of degraded land; (e) outdoor recreation and pleasure; (f) potential conversion of biomass to energy; (g) sources of fiber for the manufacture of paper and building materials; and (h) sources of extracts for high-quality proteins and medical and pharmaceutical products.

The aim of this chapter is to review the past and present use of forage crops and speculate about their future possibilities. Emphasis is placed on the impact of the evolution of society on the development of the crops, because of its outstanding importance as a driving force. Emphasis is also placed on the geographical movement of individual species, to highlight the involvement of many species of different origins and their dynamic dispersal throughout the world.

2. Early Recognition of the Importance of Forage

Since the first domestication of grazing animals in ancient times, forage has been a major concern of humans in the husbandry of animals. An early recognition of the importance of forage is found in the Old Testament. God is praised for his creation as: “You let the Earth produce grass for cattle, plants for our food” (Psalms 104:14). Moses, in the thirteenth century BC, promised the Children of Israel, as part of their inheritance if they obeyed the commandments of God, that “He will send rain at the right seasons, so you will have more than enough food, wine, and olive oil, and there will be plenty of grass for your cattle” (Deuteronomy 11:14-15). The want of grass was recognized as the symbol of misery: “Our cattle wander aimlessly, moaning for lack of pasture, and sheep are suffering” (Joel 1:18).

The early recognition of the importance of forage is also demonstrated by the early development of forage conservation. Forage is conserved as hay through drying or as silage through fermentation. The main objective of the conservation of forage is to preserve it at the optimum stage of growth for use during those seasons when the forage is unavailable. In Great Britain hay making and the scythe date from 750 BC. The historical development of silage dates back to 2000-1500 BC. Paintings found in Egypt, dating from the period about 1500-1000 BC, suggest that the ancient Egyptians were familiar with ensiling (the silage making process). Silos were found in the ruins of Carthage, which indicates that forage was ensiled there in about 1200 BC.

However, at this stage, and for many generations thereafter, there were no such things as forage crops. Forage plants occurring in grassland, rangeland and fallow land were an arbitrary gift of nature which humans could use but not increase by sowing and cultivating as crops. The domestic animals sought their food on those lands, or were fed byproducts of food crops (e.g. stubble, straw and hull) or cut forage from the naturally growing plants. Animals which needed high-quality feed, such as army horses, were supplemented with cereals (food crops) such as oats, barley and wheat.

Even in the time of ancient Greece, when cultivation of most of the temperate forage

crops used in modern agriculture was already well established, very few crops were cultivated primarily as food for animals. Although Theophrastus (c. 370-c. 287 BC) described widespread cultivation of crops such as turnip (*Brassica rapa* L.), lupines (*Lupinus* spp.) and vetches (*Vicia* spp.) in the Mediterranean basin, they were used for human food, green manure or medicine, rather than for forage. The beneficial effects of legumes on both the soil fertility and production of other crops were already appreciated in these ages, though it was not until the 1880s that it was realized that this was due to fixation of atmospheric nitrogen by associated root nodule bacteria.

The single outstanding exception is alfalfa (syn. lucerne) (*Medicago sativa* L.), which was the first forage crop to be domesticated and has been cultivated for over three millennia as the “Queen of the Forage Crops.” Hittite brick tablets (1400-1200 BC) discovered in Turkey indicate that animals were fed alfalfa all through the winter season and alfalfa was regarded as a highly nutritious animal feed. There is also historical evidence that testifies to the wide distribution of alfalfa in Media (NW Persia) in the 1st millennium BC. The name “alfalfa” can be traced to the old Iranian word meaning “horse fodder.”

The crop was brought to Greece by the invading Median armies in the fifth century BC. The literature describes that “Upon the defeat of Xerxes at Plataea in 479 BC and the withdrawal of the Median armies from Hellenic land, the Greeks beheld for the first time the thrifty patches of alfalfa which the invaders had established behind their lines for the sustenance of chariot horses, camels and domestic animals, and the plant was appropriately named ‘medic’ to denote its Median origin, and this subsequently became the ‘medica’ of Latin literature.” After its introduction, alfalfa soon gained some importance in Greek agriculture. Many writers, such as Aristophanes (c. 450 to c. 385 BC), Aristotle (384-322 BC), Theophrastus and others, either mentioned it or discussed it at length. For the next 200 or 300 years, however, no further references to alfalfa are found until the Roman era.

3. Early Use of Forage Crops

The widespread use of forage crops commenced around the beginning of the Christian era, because of the relatively broad use of forage crops in terms of both geographical distribution and number of plant species used. In the second century BC, the Romans acquired alfalfa from the Greek civilization, and this new crop thrived and quickly spread throughout Italy. During the period of the Roman Empire (27 BC-395 AD), the Roman farmer colonists eagerly established the crop in their newly acquired provinces. In the first century AD, alfalfa was grown in Andalusia in southern Spain and in the Lake Lucerne region of central Switzerland. Most authorities assume that the name “lucerne” comes from that Swiss lake region where the crop gained its popularity. At this time, alfalfa also reached southern France, and was probably making inroads into North Africa.

Roman agriculture had reached its peak by the first century AD. Works by several Roman writers mention several forage crops. For example, the culture and management of alfalfa is discussed in detail by Varro (116-27 BC), Pliny (23/24-79 AD) and Columella (in the first half of the first century AD). Varro suggested a rate of seeding

(about 38 kg ha⁻¹). Pliny recommended planting in a well-drained soil, the use of chalk (liming), and cutting at early flowering. Columella cautioned his readers to feed sparingly at first, lest bloating occur and the blood supply be greatly increased. He knew that alfalfa improves the soil, and had a high regard for its persistence and feed value. Besides alfalfa, crops such as turnip, lupines and vetches were discussed by Cato (234-149 BC) and Varro, and cowpea (*Vigna unguiculata* (L.) Walp. ssp. *unguiculata*) by Pliny and Columella. Columella described how the Gauls used turnips as feed for animals during the winter period. They also used rape (*Brassica napus* L.) for cattle feed. The use of turnip and rape may well have been the case also in Roman Britain. Red clover (*Trifolium pratense* L.), originating in Asia Minor and southeastern Europe, was cultivated in southern Europe in the third and fourth centuries AD. The legumes were cut and fed to animals as green forage or hay. Columella's writings also indicate that the Romans were well aware of the significance of proper hay curing. Because of their advanced knowledge about seeding, management, and hay-making practices of forage crops, the Romans are credited with being the fathers of forage culture.

The early use of forage crops is also seen in other parts of the world. Simultaneously with its arrival in Italy in the second century BC, alfalfa spread eastward into China, and in succeeding years, it became established throughout northern China as an important forage crop. By this time, sorghum (*Sorghum bicolor* (L.) Moench) had been used for forage in northern India. Some varieties of leucaena (*Leucaena leucocephala* (Lam.) de Wit.) is thought to have been spread widely throughout Central America by the Maya and Zapotec civilizations, though their use for fodder is doubtful.

Despite the use of forage crops in these times, their contribution to the husbandry of domestic grazing animals was still very limited. The animals were mostly dependent on naturally growing forages or byproducts of food crops. Reflecting this, for instance, in northern Europe the scarcity of winter feed resulting from the relatively short growing season of native forages limited the number of animals which could be maintained over the winter. Consequently, a large proportion of animals such as cattle and sheep were killed in the early autumn, thus providing processed and preserved (e.g. salted, smoked and dried) food for humans during the winter.

4. The Dark Ages

With the fall of the Roman Empire, and the advent of the Dark Ages, usage of forage crops declined drastically in Europe. For example, alfalfa virtually disappeared from Italy following the barbaric invasions in the fifth century. It was not until the Islamic ages that forage crops were rediscovered in southern Europe.

During the seventh and eighth centuries, the expansion of Islam sent its triumphant armies westward across Africa to the Atlantic, then northward across the Strait of Gibraltar, throughout Spain, and as far north as the Pyrenees. Alfalfa was possibly reintroduced into Spain via North Africa by the invading Moors in the beginning of the eighth century. The Spanish acceptance of the Arabic word "alfalfa" in preference to the Roman words, "medica" or "lucerne", gives credence to this route.

The crop was then reintroduced into Italy from Spain. Irrigated alfalfa fields formed a

distinctive part of Lombardy (northern Italy) farming as early as the twelfth century.

The recognition of the importance of forage crops by the Muslims is seen in agricultural writings in Spain during the eleventh and twelfth centuries. For example, Ibn al-Awwām, at the end of the twelfth century, highly valued alfalfa for its persistence and feed value, as the “Queen of the Forage Crops”. He also mentioned legumes such as lupines, vetches and red clover, but primarily as rotation crops that improve soil fertility.

In northern Europe, the role of forage crops in the animal husbandry remained unimportant, with few forage crops being grown. It is, however, thought that a wild type of alsike clover (*Trifolium hybridum* L.) was grown in Sweden as early as the tenth century.

Thus, there are only a few fragmentary pieces of information about forage crops in Europe between the fifth and twelfth centuries. There was negligible use of forage crops, but at the end of this period some crops began to recover their popularity in some regions in southern Europe.

5. The Great Progress

Between the thirteenth and nineteenth centuries, three big changes occurred with the development of forage crops.

5.1. The European Agricultural Revolution

The European agricultural revolution is usually thought to be an event originating in eighteenth-century England, but it has its precedents, both in England and on the Continent since the thirteenth century. Until this time, the major crops in northern Europe were cereals. They were cultivated mainly under the two-course system or the three-course system, both of which included a fallow phase of 12 to 18 months. Livestock depended mainly on native grassland. But as population grew between 1000 and 1300, grazing land was diminished through conversion into arable land. This, however, reduced the number of animals that could be kept, and so reduced the supply of manure, which in turn influenced cereal yields, which may have declined in the thirteenth century.

5.2. The Contribution of Forage Crops to the Development of Mixed Farming

The most significant early innovations took place in the Low Countries, first in Flanders and Brabant and later in Zeeland and Friesland. Two major systems were devised—the improved three-course system and the ley farming system. In the improved three-course system, the planting of forage crops replaced fallows. Vetches had been grown in Flanders by 1278. Turnip and red clover were grown in the fourteenth century. The ley farming system consisted of two years of cereals, one year of fallow followed by three to six years of forage crops; this had been known at Ghent by 1323. At first the ley was in grass, but later, red clover and to some degree white clover (*Trifolium repens* L.) were also used. The improved three-course system and the ley farming were common

practices in the Low Countries by the fifteenth and seventeenth centuries, respectively.

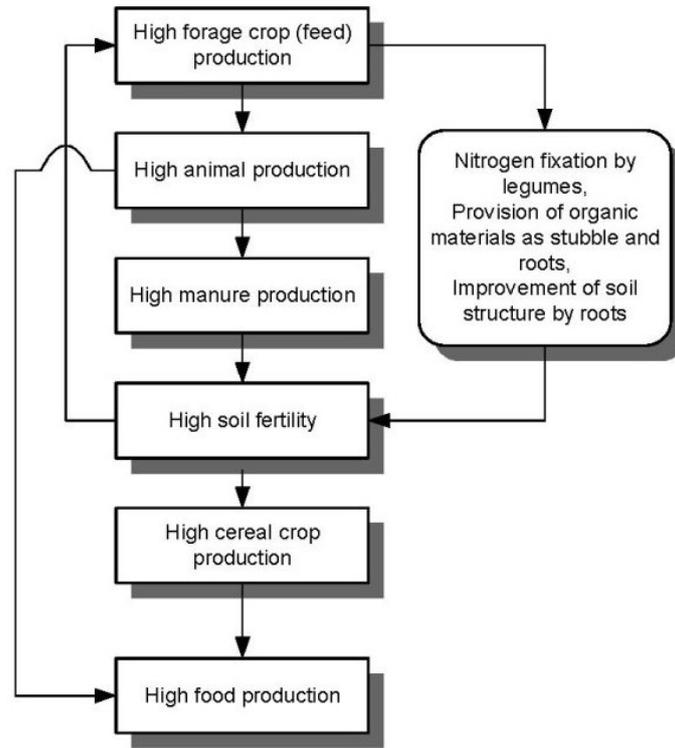


Figure 1. A diagrammatic representation of cereal-livestock integration through forage crops in mixed farming

In these new systems, the planting of forage crops not only provided the soil with a rest from cereals and improved the supply of livestock feed but also increased soil fertility through nitrogen fixation by legumes, provision of organic material such as stubble and roots, and improvement of soil physical structure by roots. This in turn resulted in the higher production of both cereals and forages (Figure 1). The higher forage production led to the higher production of animals and further to the higher supply of manure. The use of turnip and conserved forages increased the number of animals that could be maintained over the winter. In addition, when forages and roots were cut and stall-fed, the concentration of animal excreta in the stalls facilitated and increased the production of manure.

In the sixteenth and seventeenth centuries, the Low Countries were the Mecca for agriculturalists from all over Europe. The use of forage crops was rapidly adopted into England, where the alternate system of cereal crops and indigenous grasses had been long and widely practiced. Richard Weston, an Englishman, learned the use of turnip and clovers as rotation crops when he traveled in Flanders in 1644. An English writer, Walter Blith, dealt with clovers, sainfoin (*Onobrychis viciifolia* Scop.), alfalfa and turnip as new crops and recommended their culture in 1652. By the late seventeenth century turnip and clovers were grown in parts of southeastern England, and in the early eighteenth century the classic four-course system, i.e. a four-year rotation of wheat, turnip, barley and red clover, was established in Norfolk by Charles Townshend. This

English system was also able to increase both cereal and livestock production through the mechanisms described above (Figure 1). Furthermore, this system enabled the first whole-year stall-feeding of cattle.

Thus the mixed farming that integrates cereal production and livestock production was realized only with the use of forage crops. It originated in Flanders in the thirteenth century, matured in eighteenth-century England as the beginning of the European agricultural revolution, and thereafter spread to the rest of western Europe. The development and spread of mixed farming was enhanced also by the industrial revolution which increased the social requirements for agricultural products. It is said that the influence of red clover on civilization and European agriculture was greater than that of the potato and much greater than that of any other forage plant.

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Biographical Sketch

Masahiko Hirata was born in 1955 in Kobe, Japan. After completing a B.Sc. and a M.Sc. degree (agronomy) in the University of Tokyo, he started his scientific career as a Research Associate in the Faculty of Agriculture, Miyazaki University in 1982. He was conferred a Ph.D. degree (agronomy) from the University of Tokyo in 1989. He was promoted to Associate Professor in 1992 and Professor in 2003. His major field of research is Grassland Ecology, with particular interest in structural and functional aspects of grazing systems. He received the Research Encouragement Award (1989) and the Award of the Society (2000) from the Japanese Society of Grassland Science.