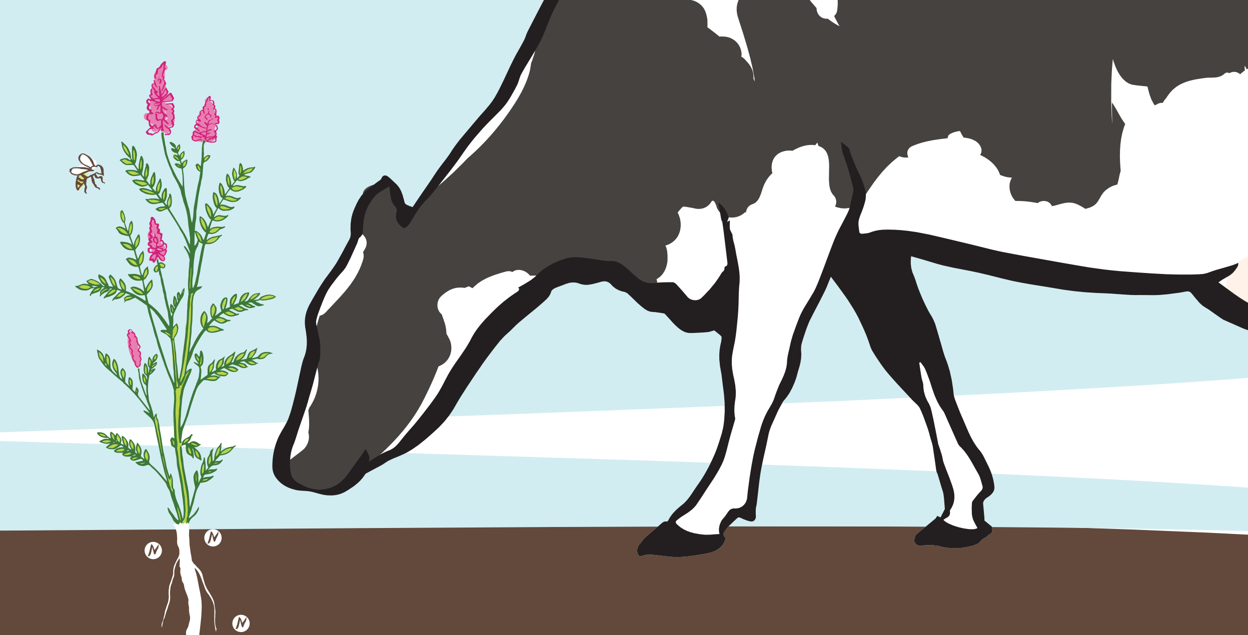


SAINFOIN

Surprising Science Behind a Forgotten Forage

By Marina Mora Ortiz & Dr Lydia Smith
Edited by Ian Wilkinson & Fiona Mountain

COTSWOLD Grass Seeds DIRECT

First Hand- Interview with Henry Edmunds

Sainfoin Farmer, Hampshire, UK

When did you first hear about sainfoin and why did you decide to grow it? Could you give a brief history of how you became a successful sainfoin grower?

Sainfoin is a family business. It has been growing on my farm for five generations, since 1730. I remember working with it when I was a child and even then I noticed that it was the most productive plant that could be grown on poor chalk soils.

More recently, and partly because this is an organic farm, I have also become very interested in farm biodiversity and pollinators in particular. There has been some research conducted here on the farm, which has shown that sainfoin is also one of the most supportive plants for wildlife on the farm, especially for pollinators.

One of the big questions about sainfoin seems to be how to find a balance between the investment in inputs and the potential yields. Sainfoin establishment can be challenging. What would you recommend, based on your own experience?

Sainfoin is so persistent under natural (low input) conditions, which makes it especially suitable for organic farming. I have around 200 acres dedicated to sainfoin and I have some sainfoin fields that have been growing as a continuous stand, without reseeding, for over twelve years.

I operate a rotational system on my farm. After sainfoin has been ploughed in and has improved the soil fertility, I grow three or four annual crops over five years. The first rotation is usually oats or barley followed by a forage crop like vetch. During this time I will maintain sainfoin growing simultaneously in other areas of the farm, so when I want to re-drill sainfoin, I can use my own seed. I normally grow around twenty acres of land for seed production per annum, harvesting a seed crop from plants that are in the fourth year of growth.

To establish a new field of sainfoin, I like to sow it with barley, under-sowed with the sainfoin. The barley is drilled first and then sainfoin and grass seeds. It is very important to grow grass seeds as companion crops with the sainfoin, since it increases the final yield by at least 50% and also stops weeds from invading the bottom area of the crop. The best mixture for my farm is about five kilograms of meadow fescue with about half a kilogram of Timothy grass, with 25 kilograms per acre of sainfoin seed.

Which variety of sainfoin are you growing, and what is the main purpose of your production (e.g. silage, hay…)?

My family has been using Cholderton-Hampshire-Common since 1895. We make silage and hay but we also graze our cattle and sheep in the sainfoin fields. We don't sell it because we need it all to feed our own animals.

Do you know which types of farmers or breeders are interested in feeding their animals with sainfoin?

There are not many farmers currently growing sainfoin or feeding their animals with this forage crop, but the farmers who are interested in using sainfoin use it mainly for sheep, which is the traditional usage. However I also use it for my dairy cows which really like it. If they have the option to choose between lucerne and sainfoin, they will always choose sainfoin and the milk yields always go up.

Did you experience any difficulty in the past when growing sainfoin and how did you solve it? What made you persist in trying to overcome this issue?

I've not had any real problems. Sainfoin is very reliable. It adjusts very well to poor soils and is resistant to most common pests and diseases.

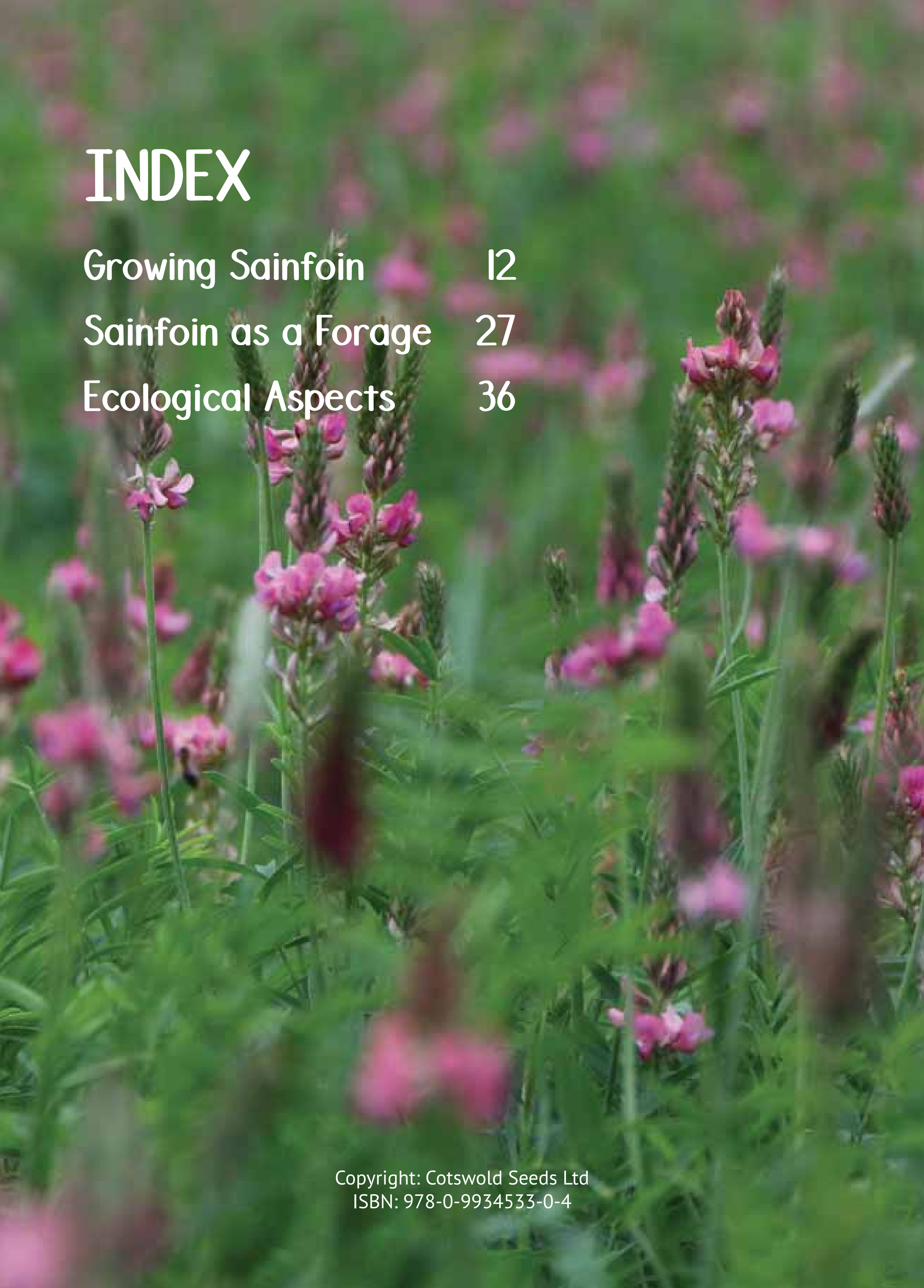
What research into sainfoin is currently most important to you?

There are a lot of really important things to do. We have to look at sustainability, because farming is becoming too intensive with too great a dependence on expensive inputs. Sainfoin does not need fertilisers. Secondly, it is a brilliant plant for insects, and therefore very important to support bee populations. Thirdly, we need to look at the way in which sainfoin helps to build up soil organic matter, trapping carbon dioxide (CO_2) from the atmosphere and putting it into the soil. We need to know how many kilograms per hectare sainfoin can add to the soil.

It also helps to reduce CO_2 in the atmosphere, sequestrating CO_2 on a big scale, but again actual amounts have not yet been quantified and research needs to be done to determine rates and to demonstrate that sainfoin is a very competitive crop compared to other crop choices and can therefore help the country meet the target set by the Paris agreement.

Would you recommend sainfoin to other farmers in Europe and why?

Of course; it is a brilliant crop. It does not cost anything and is productive on really poor land. In addition, it helps sustainability, is wonderful for livestock such as cattle and sheep which love it. Lucerne can give bigger yields, but sainfoin comes out earlier in the year (around March) than lucerne (June). Furthermore, it is not all about yields; the quality is also important and sainfoin is much more competitive in this respect.



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Introducing Sainfoin

This guide is the culmination of a four year, EU funded research project, LegumePlus, to investigate the benefits of growing sainfoin and other bioactive forage legumes to improve protein utilisation in ruminant livestock farming, combat parasitic nematodes and aid nitrogen fixation.

Since 1980, politicians have promoted agricultural intensification through legislation under the European Union's Common Agricultural Policy (CAP) in order to cope with the increasing demand for food by an expanding population. The accessibility and attractive price of inorganic nitrogen (N) fertilisers, in conjunction with low energy prices during the second part of the 20th century has resulted in a decline in the use of legumes in Europe since the 1950s. This has contributed to certain negative impacts, including an increase in greenhouse gas emissions, a reduction in diversity of species cultivated and a strong dependence by Europe on imports of rich-in-protein grain legumes from third world countries to support livestock production. Legumes offer great potential to address these issues by:

i) Providing residual fertility due to nitrogen fixing activity in root nodules by rhizobia

ii) The ability to adapt to aspects of climate change (for instance rising temperature - sainfoin is very drought tolerant partly thanks to its deep taproot)

iii) A high nutritional value as a forage or fodder crop due to a whole-crop profile rich in proteins

Additionally, when drilled in grassland-based mixtures, legumes improve the forage yield and the value of the final herbage. Some legume species also contain secondary bioactive metabolites such as condensed tannins (CT) and polyphenol oxidase (PPO) which represent an extra advantage for farmers due to their benefits for livestock.

Sainfoin, is a re-emerging leguminous forage crop that contains condensed tannins. It is traditionally grown as a long term perennial ley across Europe, Asia and North America, where it is used primarily for livestock feed. Another benefit is that it is resistant to most common pests and diseases.

Over the last decade there has been a resurgence in interest in sainfoin due to its beneficial nutraceutical, anti-bloating and anti-parasitic activity, which represents a clear advantage for livestock farmers. Unfortunately, limited selective breeding, problems associated with dormancy, poor competitive ability against weeds and often low yields during the establishment year, deter growers from choosing sainfoin, favouring alternatives such as clover or lucerne (Medicago sativa) which respond much better to inputs.

Sainfoin has benefited from little genetic or agronomic improvement since the 1950s. The objective of this grower's manual is to provide farmers with agronomic strategies for sainfoin cultivation that could promote the use of this forage crop. This manual has also considered methods for improving establishment and yields, which are the most challenging issues for farming sainfoin. This guide represents the first practical approach for sainfoin cultivation focused on building a bridge between the latest advances in science and the growers community.

Common Names

The Latin name of sainfoin is Onobrychis viciifolia, which derives from the Greek, ónos (ὄνος, "donkey") and brýkein ("to eat avariciously"). It is believed that this name makes reference to the plants' beneficial attributes in animal nutrition that has been known since ancient times.

Sainfoin has many common names, "sainfoin" being the most popular in English. It means "healthy/holy hay".

The term Luzerne is used in many languages to refer to plants of the genus Medicago, especially Medicago sativa (lucerne), and the traditional use of this denomination for sainfoin can generate some confusion. It is also called "holy grass" due its beneficial properties, "French grass" or "Cock's head" in English, or "crête de coq" in French. It is called "pipirigallo" in Spanish, meaning cockscomb, which relates to the shape of spiny husk of the seed. "Foin de Bourgogne", "Fenasse", "Bourgogne" or "Herbe éternelle" are other names.

Sainfoin has other denominations that come from the Provençal name esparceto. Some examples are "esparceta" in Spanish, "esparsette" in Danish, "esparcette" in Dutch, "sparceta" in Polish, or "Эспарцет" (espartset) in Russian.

For a grower, it is important to be aware of the different common names that sainfoin can take in order to avoid confusion between generic sainfoin and specific varieties when importing or buying seeds.

History

Sainfoin originally comes from South Central Asia and the most probable date at which it was introduced into Europe is the fifteenth century, when it was extensively cultivated. It was subsequently introduced to North America at some point in the following century but the exact date is uncertain.

Traditionally, sainfoin was a common indigenous species in Asia Minor, particularly in Turkey, the districts of the Caucasus and the Caspian fringes. Sainfoin was originally cultivated by Arabian peoples and was then introduced to Greece and Italy. Cultivations in France have been documented sometime between the late 14th and 15th century; in England from the 17th century and in North Italy and Switzerland during the 18th. Its cultivation was noted for the first time in Spain between 1799 and 1822, referred to as "pipirigallo", one of the common names of sainfoin in this country. Sainfoin was cropped in the 17th and 18th centuries after which it was introduced to North America in between 19th and early 20th. The presence of sainfoin in England from the 18th century onwards has been documented on calcareous soils in the south and southeast, East Anglia, north to the Humber and west to the river Severn. There is also a history of crops in the Vale of Glamorgan.

Sainfoin was strongly linked with limestone and chalk land.

We can follow its history across the UK through descriptions in different documents and books. 'The English Improver Improved' (1652) indicates that many thousands of acres in England were used for sainfoin production due to its importance in animal nutrition. It is also mentioned in Jethro Tull's 'Horse Hoeing Husbandry' (1731) and well documented in 'General View of the Agriculture of Oxfordshire' by Arthur Young (1809). Traditionally, it was sown mixed with a companion species; usually a non-invasive grass, such as meadow fescue Festuca pratensis or Timothy Phleum pretense. This strategy enabled farmers to suppress weed invasion, which is one of the biggest challenges in the cultivation of sainfoin, especially during the establishment period.

The decline of sainfoin in Britain started in the 1920s, and increased significantly as large scale reduction in long term leys were ploughed during the 1939-1945 war period. This loss of popularity was partially associated with a decrease in the cultivation of land for sheep production in favour of the cultivation of ryegrasses. Furthermore, the decline was also attributable to the decline in the use of horses as they were replaced by tractors.

To quantify this decline, it was recorded that about 150 tonnes of sainfoin seeds were sold every year in the late 1950s; sufficient for circa 2400 hectares. Sales dropped to 150 hectares in the 1970's and seed for only 50 hectares were sold in the 1980's.

Nowadays, sainfoin is still an important crop in parts of Asia, especially Turkey and Iran. There is also some cultivation in North America and parts of continental Europe, mainly Italy, Spain and the UK. Changes in the CAP (Common Agricultural Policy) along with the resurgence of interest in sainfoin due to its beneficial properties could start to draw a new picture and sainfoin cultivation may begin to recover in the near future.

Botanical Description

Sainfoin is a perennial forage legume crop with epigeal germination, which indicates that the cotyledons are pushed above ground during germination and form the first seed leaves. Growth of sainfoin depends on seed reserves during the first seven days. After that the energy synthesis through photosynthesis in the cotyledon leaves play an important role in the development and expansion of the first true leaves.

The general habit of the plant is an erect or suberect structure; however there are also many accessions with a more prostrate or rosette habit. The morphological plasticity of sainfoin adds to difficulties in characterising the species, but this malleability is important to its ability to withstand cold stress during the winter and early spring months.

Sainfoin has a characteristic long and strong taproot responsible for its drought tolerance.

It is quite branched, and multiple thin lateral roots constitute the root system.

As the plant develops in the spring, many hollow stems grow from basal buds and form a branched crown. Plants are between 20 and 100 cm tall, depending on variety, with most being about 70-90 cm tall. Sainfoin normally has between 16 and 18 stems per plant with a variable thickness of 3-9 mm. The colour is generally green and occasionally includes some red pigmentation; significant variability has been observed in the green colour of the different accessions.

Stems have pinnate leaves in a variable number between 6 and 14. These leaves are compounded by oblong leaflets, normally with between 10 and 28 per leaf. The number of leaves per plant varies according to variety.

Inflorescences are dense with 10-80 flowers and peduncle between 12 and 20 cm; inflorescences are developed on axillary tillers.

The corolla of the flowers is pinkish, this base colour has high diversity from white to purple and they show darker linear patterns of greater intensity than the primary colour.

Sainfoin generally takes from May to October to complete the flowering period from green flower buds to dry seed in UK field conditions. During this period it is a valuable resource for pollinators due to the high quality of its nectar, quantity and long term availability.

Flowers generate kidney-shaped seeds within a brown pod, the size of which varies between 2.5 and 7 mm long, 2 to 3.5 wide and 1.5 to 2 mm thick. The maturity of the fruit at the time of harvesting is the major factor that will determine the final colour of the seed. Weight of unmilled and milled seeds is between 15 g/1000 seed for the former and 24 g/1000 for the latter. The dispersion of the fruit is by animals, facilitated by the spines that cover the pod.

Sainfoin Varieties

Sainfoin has been traditionally divided in two types, 'Giant sainfoin' or 'Two-cuts' and 'Common sainfoin' or 'Single-cut'.

They have different characteristics (see table below) and the main differences in their morphology are that the 'common type' has more stems per plant. Conversely, the 'giant type' has longer stems, more internodes per stem and more leaflets per leaf. The 'giant type' is normally recommended for fertile lands while the 'common type' is used in less fertile, marginal land or high altitude sites.

	Giant Sainfoin	Common Sainfoin
Synonym	Two-Cuts	Single Cut
Origin	*Onobrychis sativa* var. *bifera* Hort	*Onobrychis sativa* var. *communis*
Geographical Origin	Middle East	Central Europe
Growth Habit	Erect habit during year of sowing	Slightly prostrate during year of sowing
Re-growth	Will re-flower after being cut. Can be cut more than once per year	Slow and vegitative. Can be cut once per year. Often doesn't produce flowers during the establishment year
Survival	Up to 3 years	Between 7 and 10 years

Ambra, Vala and Zeus *from Italy;*
Perly *from Switzerland,*
Emyr *from Hungary;*
Fakir *from France;*
Višňovský *from Czech Republic;*
Cotswold-Common and Cholderton-Hampshire-Common *in UK.*

Most of the varieties available now were developed in the 1970s and they are an intermediate type, in between 'giant' and 'common' sainfoin. Some of the most popular varieties are often described as a landrace or of landrace origin, which have been maintained by enthusiastic and supportive farmers.

In other areas, such as Canada and New Zealand, we will find varieties such as Nova and Eski.

Varieties of interest

Several universities and research institutes have been working together to understand and improve this crop (including The University of Reading (UK), Technical University of Munich (Germany), Wageningen University (The Netherlands), INRA Toulouse (France), the University of Copenhagen and NIAB (UK)). It is important to remember that sainfoin is heterogeneous, being an out-breeding species and there have been slight shifts in the agronomic characteristics of some varieties when maintained at different sites. Nevertheless, the list provided below summarises the main benefits and attributes associated with the most common sainfoin varieties. In the future, it will be necessary to develop varieties of sainfoin that are more competitive.

	Agronomic Interest	Tannins & Others	Nitrogen Content	Low Methane Emissions	Anthelmintic Properties
Cotswold Common	+	+			
Ambra		+			–
Sombourne		+			–
Taja	+		–	+	
Buciansky				+	
Simpro		–	+	+	–
Camaras			–	+	–
Biovalari				+	+
Cholderton-Hampshire Common	+	+	+		
Nova		–		+	–
Korunga				+	
CPI 63763					+
CPI 63767					+
Miatiletka		+		–	
Giant					
Rees					
CPI 63810/273784		+		–	+
Premier		+	+		
274		+		+	
Visnovsky	+				


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Climate, Habitat and Soil

The sainfoin habitat is very broad; it can grow well in a broad range of climatic and soil types found in Asia, Europe, North America, New Zealand and Australia.

In the Mediterranean basin, sainfoin grows well in sub-humid climates and is compatible with semi-arid ones. It is known that sainfoin grows well in Portugal, Spain and pre-Pyrenees, where it is tolerant to high mountain climates as well as to moderately warm and dry conditions. Its optimum is 600 m above sea level, although it can grow between 100 and 2500 m. Indeed, in a survey developed in Spain of 40 farmer producers of sainfoin seeds, 90% of the farms were located in altitudes of between 600-1474 m.

Soil and water needs

Sainfoin grows well in areas that are dry and drained or irrigated, but it grows very poorly on waterlogged land.

In the absence of irrigation, annual rainfall should be at least of 330 mm.

> In the UK, sainfoin has always been linked to calcareous chalky or limestone soils. Sainfoin establishes well in alkaline and neutral soils with pH above 6. Poor establishment is obtained on clay soil at pH 6 with failures on alluvial sand at/or below pH 5.

In Spain it is traditionally linked to neutral or slightly alkaline brown-earth soils. It is incompatible with acidic, poor draining soils such as podzols, greysolic acid brown, grey forest and oxisols.

In general, sainfoin prefers deep free-draining soils that are not compacted. Sainfoin does not need particularly good soil fertility if the requirement for lime and water are satisfied. It is well known that sainfoin can provide better results than red or white clover and lucerne when soil is poor, especially on limestone soils and cold areas.

Temperature

It has been traditionally accepted that periods of high temperature adversely affect sainfoin and subsequent yields, especially following defoliation, since the transpiration through the leaves is not as high as in other legumes such as lucerne, where the leaves have a bigger area.

Although sainfoin has been traditionally considered as intolerant to high temperatures, there is some preliminary evidence that shows it can grow at temperatures above 32°C in Spain and Greece.

There are very few studies into sainfoin frost tolerance; it is not believed to be especially sensitive to low temperatures; and young seedlings of sainfoin are more cold tolerant than other legumes (e.g. clover species and lucerne). Reports from Saskatchewan, in central Canada where temperatures with snow cover regularly fall to -40°C, imply that it is extremely cold tolerant.

Drought Tolerance

Sainfoin is often discussed as a crop that will gain importance in future, when the frequency and severity of drought periods will increase as predicted by climate change models. Thus, the drought resistance of sainfoin was tested and compared to other forage plant species in Zurich, Switzerland.

Drought stress was simulated with shelters (see picture) that excluded all the rain for 18 weeks. The absolute wilting point, at which it becomes impossible for the plant to get any water, was reached at 40 cm soil depth after approximately 12 weeks. Thus, for the last 1.5 months of the rain exclusion period the plants experienced a very strong drought stress

Photo: Rain out shelter used to simulate drought stress by excluding all the rain during a period of 18 weeks.

where very little water was available and only from deep soil below about 40 cm. The yield of these drought stressed plants was compared with non-sheltered plants growing in rain fed control plots.

The forage species sown for comparison with sainfoin were: lucerne (Medicago sativa), chicory (Cichorium intybus), red clover (Trifolium pratense), white clover (Trifolium repens), perennial ryegrass (Lolium perenne), meadow fescue (Festuca pratensis) and cocksfoot (Dactylis glomerata).

The experiment lasted for two years. In the first year the conditions in the rainfed control plots were moderately watered, yet not too wet. In the second year, the non-sheltered plants had ample rain. The results for four of the most common cultivars available on the European seed markets are shown here and compared with the other seven forage plant species tested.

Forage Species (Cultivar)	Yield change under drought 2013 (%)	Yield change under drought 2014 (%)
Sainfoin (Perly)	-20	5
Sainfoin (Visnovski)	-34	162
Sainfoin (Taja)	-56	-16
Sainfoin (Esparsette)	-66	100
Red clover (Elanus)	-32	-41
White clover (Bombus)	-31	-79
Lucerne (Sanditi)	-45	18
Chicory (Puna II)	-55	-64
Cocksfoot (Accord)	-90	-96
Meadow fescue (Pradel)	-74	-97
Perenial ryegrass (Lacerta)	-64	-86

What these results show, is that sainfoin generally performed well under drought with average loss over all four cultivars of 44% in 2013 and average yield gain of 63% in the wet year 2014 (Table 1). The biomass losses of Perly and Visnovsky in particular, were smaller than even for lucerne (which is known for extreme drought tolerance) with 45% losses in 2013 and an 18% gain in 2014.
Within sainfoin, important differences between the cultivars were detected. Taja and Esparsette were less drought tolerant than Perly and Visnovsky, although they were still as drought tolerant as chicory.

In the wet year 2014, the sainfoin cultivars and lucerne actually performed better under drought, although the extent of drought was again substantial. The exception was the sainfoin cultivar Taja, which is conversely more tolerant to wet conditions than other varieties.

Perly was a very stable cultivar, with the lowest losses of all cultivars in the very dry year 2013, but still coping well with the wet conditions in 2014 and having high yields in both years (yields not shown here).

The forage grasses generally performed very poorly under these severe drought conditions and decreased their yield to almost zero.

An experiment was also conducted to evaluate what the best management strategy would be during a drought period. Two management options were compared: firstly, plants were cut in the middle of the drought period and secondly, plants were left uncut throughout the whole drought period. The data presented in the table are for plants which were cut in the middle of the drought period.

Preliminary results show that sainfoin plants which were not cut throughout the drought period barely lost yield due to drought. In contrast, all other forage species, except lucerne, suffered from drought even without the cut in the middle of the drought period.

These preliminary results show that for sainfoin, the stress caused by cutting during a drought should be avoided.

If the drought persists for long, it could even be an option to allow sainfoin to flower and form seeds in order to rejuvenate a stand. Seed production was almost unimpaired by drought and the quality of the seeds even improved compared to the rainfed control. This was because under wet conditions, sainfoin is subject to pre-harvest sprouting.

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Sowing Sainfoin

In the warm Mediterranean basin, sainfoin is normally drilled either in autumn or at the beginning of spring. Conversely, in colder areas like the UK it is recommended to drill sainfoin between April and July when the soil temperature is warm and humid enough to facilitate a quick germination. Sainfoin has an extended optimum temperature range for germination, but it is normally advised to drill it between 10-20°C and never below 5°C. Early sowing can improve the development of the plants thanks to the early development of the vegetative plant and roots, and yields in the first year.

The seeds can be drilled either milled or unmilled, although it is not fully agreed which is the best option. Use of unmilled seed could provide staggered germination and thus cushion potential weather disturbances. The use of big and mature seeds is advisable, since it increases establishment success giving stronger plants, with more nodules and higher rates of nitrogen fixation.

In order to establish a population of 70-150 plants/m2 in the first year, seed rates of 40-50 kg/ha milled seed, (or 80-120 kg/ha unmilled) are recommended. These should be sown at a depth of between 1 and 2cm in the UK and Canada; but in China a depth of 4 to 5 cm is recommend. These variations in planting depth are attributed to differences in the soil texture and moisture at the different sites, so it is always important to follow the recommendation of the specific country. Sainfoin appears to germinate well at a range of sowing depths between 1-5 cm.

Inoculation and Nitrogen Fixation

Sainfoin, along with other leguminous species, is able to establish symbiotic relationships with bacteria from the family Rhizobiaceae and with mycorrhizal fungi.

The symbiosis with Rhizobiaceae is sited in specialised root nodules, which in sainfoin can exhibit a range of morphologies. In these nodules bacteria reduce atmospheric nitrogen to ammonia. Sainfoin uses this ammonia to synthesise amino acids that will produce its proteins.

The Rhizobia benefit from carbohydrates produced from photosynthesis in sainfoin. The inoculation of sainfoin with rhizobium sp. can be developed using strains isolated from related legumes such as sweetvetch (Hedysarum), bastard senna (Coronilla) or prairie clover (Dalea) or from healthy nodules on sainfoin. Isolation of Rhizobia from more cold tolerant legumes such as alpine milkvetch (Astragalus alpinus), Oxytropis madelliana and Oxytropis arctobia, led to an improvement in nitrogen fixation during cold conditions.

Mycorrhizal symbiosis is different and takes place between sainfoin roots and fungi. The fungus supplies sainfoin with phosphate and other nutrients from the soil, and also promotes plant resistance to pathological infections. The plant provides the fungus with carbon.

Sainfoin has been noted to have a high nodular activity and weight of nodules compared with other legumes. This is attributed to a higher demand of energy. Sainfoin leaf area is smaller than lucerne, which means that its photosynthesis is slightly less efficient. Moreover, nitrogen fixation in sainfoin nodules can be inadequate in some situations, and nitrogen deficiency symptoms can be frequently observed. Nowadays there are commercial inoculums for sainfoin, which should be applied as a seed dressing before drilling. It has been noted that the best combination should include both Rhizobiaceae and mycorrhizal fungi, which can be applied as a granular inoculum for application during drilling. Nevertheless, research in this area is still at an early stage and nearly all seed is sown untreated.

It has been observed that in optimum conditions, the nitrogen fixation rate of sainfoin has been estimated between 130 and 160 kg/ha and for lucerne between 140 and 160 kg/ha. This resulted in an improvement of yields of 17% and 25% respectively.

Fertiliser requirements

Fertiliser requirements for sainfoin vary.

It is traditionally believed that sainfoin does not require fertilisers, however, a small amount of N when sowing can be advantageous, since sainfoin takes quite a long time to develop its nodules in the first place. In general, studies showed that use of very low levels of inorganic N amendments stimulated nitrogen fixation in sainfoin, but high doses inhibited fixation rates. It is also important to consider the original N content of the soil in order to adjust the dosages.

In a comparative study, total N, P and K extracted from the soil by lucerne and sainfoin were evaluated. It was concluded that sainfoin needs more N and P than lucerne, and that lucerne needs more K and Ca than sainfoin. Studies referring to the needs of sainfoin in terms of P and K are not fully conclusive yet.

Weed Control

Weed invasion in newly planted sainfoin fields leads to poor establishment, especially with broad leaf species such as cleavers, common groundsel, goosefoot, red dead nettle, and chickweed.

Problems during establishment are the major issue in sainfoin fields, followed by low yields during the first year. These two main issues are closely related. One major reason for sainfoin's poor competitive ability against weeds, compared to lucerne, is its more diffuse canopy structure during the first four months of growth. With this reduced leaf cover, the competition against weeds is disadvantaged. Timely sowing in warm soils can be advantageous as sainfoin grows vigourously in these conditions.

However, it is very important to identify and establish a good weed control plan. The principal options to control weeds are herbicide and companion strategies.

Herbicides

Since early establishment is a critical step in sainfoin production, pre-emergence treatments are an important approach to address weed control. Some of the herbicides suggested to cover this period are Pendimethalin (455 g/l), Metazachlor (500 g/l) and Prosulfocarb (800 g/l). Efforts to control weeds in sainfoin have shown that post-emergence control of dandelion, a type of weed that can seriously compromise sainfoin yields, can be achieved with Metribuzin [4-amino-6-tert-butyl-3-methylsulfanyl-1,2,4-triazin-5-one] (1.0 kg ha-1), leading to yields being improved by up to 28%.

This approach can be combined with a reduced set of potential herbicides, including Bentazone [3-Isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide] and Imazethapyr [5-ethyl-2-[(RS)-4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl]nicotinic acid]. It was also observed that inclusion of an adjuvant (Tween 80 or ammonium sulphate) efficiently controlled weed invasion in newly planted fields. Imazethapyr (75g

Spray Timing	Active ingredient	Dosage
Pre-em	Pendimethalin	455 g/l
Pre-em	Metazachlor	500 g/l
Pre-em	Prosulfucarb	800 g/l
Post-em	Metribuzin	1.0 kg ha^{-1}
Post-em	Bentazone(*) (+ adjuvant)	1440g a.i.ha^{-1}
Post-em	Imazethapyr (+ adjuvant)	75g a.i.ha^{-1}
Post-em	Chlorsulfuron	0.01 kg ha^{-1}
Post-em	Hexazione	2.0 kg ha $^{-1}$
Post-em	Terbacil	1.0 kg ha $^{-1}$

*Can reduce yields

a.i.ha-1) was preferred, since, unlike Bentazone (1440g a.i.ha-1), it did not reduce sainfoin biomass. Carbetamide [(R)-1-(ethylcarbamoyl) ethylcarbanilate] has been tried for maintenance during the winter, and MCPA [a.i. 4-(4-Chloro-2-methyl-phenoxy) acetic acid] and MCPB [a.i. 4-(4-Chloro-2-methyl-phenoxy) butyric acid] was used for the control of broad leaved weeds during the spring. Chlorsulfuron (0.01kg ha-1) has been shown to successfully control broadleaf weeds.

In one study, yield was increased by 20% using Hexazione [3-Cyclohexyl-6-dimethylamino-1-methyl-1,3,5-triazine-2,4-dion] (2.0 kg ha-1) and Terbacil (3-tert-butyl-5-chloro-6-methyluracil) (1.0 kg ha-1) treatments.

In the USA, the natural tolerance to Glyphosate (2.5% glyphosate (4 lb/gal as siopropylamine salta) at 10 gal/acre + ammonium sulphate at 12 lb/100 gal) was the basis for attempted control using post-emergence multiple applications of low dosage Glyphosate (N-(phosphonomethyl) glycine). We did NOT find this to be effective in the UK due to crop toxicity.

Companions

Weed control can also be addressed through the use of companion crops; traditionally mixtures containing grasses Timothy and meadow fescue or under-sowing with spring barley have been favoured.

Co-cultivation with a second leguminous species, birdsfoot trefoil, has also been considered. Strategies to produce sainfoin combined with other beneficial crops have also been tried.

Chicory has been considered an interesting alternative due to its anti-parasitic properties. Recent studies have shown that it can grow together with sainfoin during short periods, so it could be used in rotations, but we found that at the rates drilled it started to suppress sainfoin growth during the third year and so should probably be either controlled or reduced in the initial seed mix.

In general, the diffuse and heterogeneous canopy of sainfoin makes it difficult to find companions that do not suppress the main crop. The development of new sainfoin varieties is crucial in order to define a good match between cultivar and companion crop species.

Pests & Diseases

Traditionally sainfoin has been considered free from most common pest and disease problems compared with other legumes. This has been attributed to the presence of several secondary metabolites within the foliage, including tannins, which are well known for their capacity to defend the plant against attacks by insects, molluscs, fungi and bacteria.

Besides, it has also been suggested that the low levels of soil invertebrates in some marginal areas where sainfoin is cultivated, together with the small area of sainfoin cultivation, could also help to minimise the spread of pests to new cropping areas.
Some minor damage through insects has been noted however. Lucerne

curculio (Sitona scissifrons) is a weevil that can attack sainfoin; its larvae eat the roots in the field, which are then more prone to pathogen invasions. Around June the larvae become adults, which then eat the edge of the leaves, producing characteristic indentations along the edges. It can cause significant damage to seedlings, but produces minor losses in the adult.

Other insects of minor relevance are larvae of a clear-wing moth (Sesia chalcidiformis) which feeds on sainfoin roots; and larvae of garden (Loxostege similalis) and sugar beet webworm (L. sticticalis) that feed on leaves. Lucerne butterfly (Colias eurytheme), and dark clouded yellow or common clouded yellow (C. edusa) and pale clouded yellow (C. hyale) have been also reported to feed on sainfoin leaves. Beetles (such as Phytonomus farinosus and Hypera trilineata) have also caused problems with sainfoin. The potato leaf hopper (Empoasca fabae) can be a damaging pest, although it is localised only in very specific areas in Europe. Lygus (Lygus elisus, Lygus hesperus and Adelphocoris lineolatus) attack sainfoin, feeding on buds, flowers and seeds, but the final damage does not have severe consequences.

Midges (Contarinia onobrychidis) can be a serious pest in some areas of Europe, including England; galls develop in the flower heads and affected flowers produce non-viable seeds; this will therefore impact on seed crops. In Europe sainfoin seed chalcid (Eurytoma onobrychidis), Perrisia onobrychidis, Pear-shaped pea weevil (Apion pisi), Odontothrips intermedius, alfala snout beetle (Otiorhynchus ligustici) and Meligites erythropus also damage seed production. In the US Bruchidius unicolor and Bruchophagous spp. damage sainfoin seeds. Predation and damage from nematodes is negligible, with minor damage due to Meloidogyne spp. and Ditylenchus dipasaci reported in the US. Similarly sainfoin is rarely damaged by diseases; only Fusarium has been found to have an economic impact on the crop. If infected by Fusarium a crown and root rot affects the longevity of the crop, especially winter survival. Fursarium solani is the most common type in sainfoin and symptoms are seen as a dry brown rot of the inner tissues of the tap root. Fusarium oxysporum has also been found infecting sainfoin in England, characterised by dead patches in the field. Turkish accessions were the most sensitive and Spanish accessions were more resistant to the combined natural infection with Fusarium solani and Fusarium oxysporum.

Rot (Sclerotina trifoliorum) has been described in the UK, causing crown stems and root rot. The fungus overwinters in the soil from one season to the next. The best possible control is through rotation with a non-susceptible crop such as a cereal. Verticillium alboatrum has been reported in the UK and Germany. It is also a disease transmitted by the soil that causes what is commonly known as verticillium wilt.

Anthracnose (Ascochyta fabae) affects sainfoin producing lesions in leaves and stems. The former present initial symptoms that are dark brown circles, slightly sunken with a very well defined border. The centre is clearer than the borders and is where the pycnidia is developed. The latter presented elongated damage, darker than the lesions in the leaves. This disease has been reported in Turkey and Iran under different conditions. A similar species, Aschochyta onobrychidis, has been also reported to occur in sainfoin, generating similar symptoms with leaf and stem spots similar to Ascochyta fabae.

Stemphylium sp. caused black stems and characteristic pepper spots in leaves. Uromyces onobrychidis caused rust, Botrytis cinerea produced chocolate spots in leaves and Erysiphe polygoni originated powdery mildew. It has been reported in Spain, coinciding with warm temperatures and humidity, produced by the irrigation system that actively growing plants were able to withstand the attacks, whereas flowering plants were more susceptible. Finally, Ramularia onobrychidis, Septoria orobina and Phoma sp. have been reported to cause leaf spots of different characteristics in sainfoin.

Seed Production

Every sainfoin flower has the biological capacity to produce a seed, but on average only 55% of these will successfully produce a viable seed.

Sainfoin can produce between 5 and 40 tillers, each one with between 3 and 5 inflorescences. Inflorescences in sainfoin are composed of 5 to 80 flowers. The variety of sainfoin chosen as well as the environment will have an impact on the final seed production. Honey bees (Apis mellifera) and leafcutting bees (Megachile rotundata) are the recommended pollinators to assist in sainfoin seed production. Assisted pollination in sainfoin is considered to be more successful than in lucerne due to the more elongated morphology of the flower.

In order to improve the seed production yield, it is recommended to acquire from two to three colonies of honey bees per hectare. Wild colonies of several species of bumble bees and solitary bees are also good pollinators. The flowering period of sainfoin takes between 2 and 3 weeks. To optimise seed yields it is important to swath the seeds when these contain 40% or less moisture. They should be dried in the windrow before threshing them. It is possible to obtain between 500 and 900kg of clean seeds per hectare, although there was a record of up to 1100 kg ha-1 from Canada. After harvesting, it is recommended to leave the seeds unmilled if they are going to be stored, since it has been noticed that they can maintain their viability for longer.

There are several factors that can impact on final yield of crops grown for seed production. The best yields will be obtained when the flowers are cross-pollinated. Size will increase when seeds per head of the plant decrease. Plant density is another factor that has an impact on seed production, with production dropping in line with higher competition due to distance between plants. In dry areas, such as Italy, the seed production improves with irrigation.

Sainfoin Technical Summary

What type of soil is most suitable for sainfoin?

Sainfoin is very well adapted to poor lands; it grows very well in chalk, limestone and sandy soils. It is resistant to drought but it does not tolerate flooded periods very well.

How to establish sainfoin?

It is recommended to drill between 65 and 100 kg of unmilled seeds per hectare at 1-2 cm depth. The recommended row spacing is between 50 and 60 cm. It is desirable to achieve a population of 70-150 plants/m2 during the establishment year.

What can I do to prevent weed invasion?

It is very important to have a good weed control plan. Weeds in sainfoin fields can be controlled either using companions or herbicides. Sainfoin can be sown with barley (in a reduced density) and Timothy and meadow fescue grasses.

Some herbicides recommended during the pre-establishment are Pendimethalin (455 g/l), Metazachlor (500 g/l) and Prosulfocarb (800 g/l). Metribuzin (1.0 kg ha-1) and Imazethapyr (75g a.i.ha-1) are useful during post-emergence. Chlorsulfuron (0.01 kg ha-1) has been shown to successfully control broadleaf weeds.

Fertiliser and inoculation

A low amount of nitrogen is recommended during the first spring. After this time sainfoin should not need any more nitrogen. It is recommended to add Potash at 50-60 kilos per hectare and to inoculate sainfoin with both rhizobiaceae and mycorrhiza.

Production systems

It is recommended to harvest sainfoin between the beginning of flowering and mid flowering. After this point, the natural defoliation will reduce yields. The rate of regrowth will depend on the variety and this will in turn determine how many cuts can be taken per year. Most of the varieties accept between one and three cuts per year. Sainfoin fields are traditionally used for grazing during autumn. Sainfoin can produce between 5.17 t/ha ad 13.58 t/ha during the first year (records from England).

Seed production

In order to improve the seed production yield it is recommended to acquire from two to three colonies of honey bees per hectare. To optimize seed yields it is important to swath the seeds when these contain 40% or less moisture. They should be dried in the windrow before threshing them; it is possible to obtain between 500 and 900 kg of clean seeds per hectare. It is recommended to store the seeds in the unmilled form to optimize its viability.

SAINFOIN AS A FORAGE

The Fascinating Mysteries of Plant Tannins

Sainfoin and a few other forage legumes contain a select group of benign chemicals called 'tannins'. We come across these natural plant compounds in many nuts, fruits and some grains. Most importantly, we actually know them quite well for their slightly astringent or sometimes bitter taste in beer, wine, fruit juices and green tea (unripe sloes and cider apples are an extreme example of astringent tannins!).

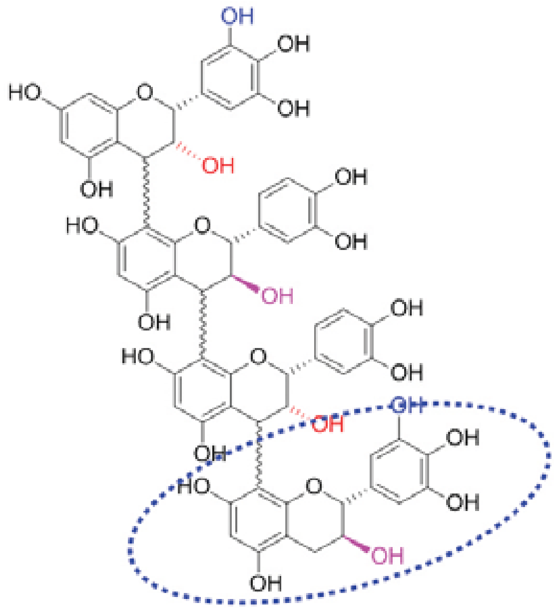

Fig 1

Research has been conducted into many different tannin types in order to exploit them for their benefits, which are described in the rest of this manual. Of particular interest is their potential for deworming of animals, for preventing painful bloat in ruminants, for wasting less of the proteins in plants and for reducing greenhouse gas emissions (nitrous oxide and methane) from ruminants. Recent interest has also focussed on their potential to improve the nutritional value of milk and meat from ruminants that have been fed with tannin-containing legumes.

Why eat tannins?

We are told that we should eat '5 portions of fruits or vegetables a day'. The reason for this is that tannins are antioxidant polyphenols, which are good for us – and for livestock.

What are tannins?

Tannins are quite complex structures, but can be understood better when considering them as consisting of many small pieces (called flavanols) stuck together, like Lego blocks. The colours in Figure 1 highlight some of the differences between the Lego blocks. The benzene rings on the right (= hexagonal rings like the cells of a beehive) have either 2 or 3 OH groups (e.g. blue OH). The red and pink OH groups can either point behind the page or stick out above the page. Therefore, this particular tannin has 4 different Lego blocks and one of them is indicated by an ellipse.

Another way of looking at these flavanol blocks is in comparison to sheep. There are many different types of sheep, just as there are flavanol blocks.

Sheep are fond of walking in rows – and tannins have a similar habit in plants, where they can occur as short chains (with just a few flavanol blocks stuck together) or as much longer tannins that have hundreds of flavanol blocks.

Plants function as intriguing chemists. They can synthesise these complex compounds naturally, which no chemist can do. And just as there are different sheep breeds, different plant species grow all sorts of different tannin mixtures, where tannins have more or less OH groups (=antioxidant properties) and are longer or shorter (=better or worse dewormers).

> We are fascinated by the beneficial effects that the different tannin types have on animal nutrition and health. By unravelling which particular tannin mixtures are best for controlling parasitic worms, for improving the digestion of dietary proteins and for reducing greenhouse gas emissions, we hope to develop new sainfoin varieties with optimum tannin compositions.

Prof. Irene Mueller-Harvey - University of Reading, UK

Why Feed Sainfoin to Ruminants?
A Forage of a Good Feeding Value

Compared to lucerne, sainfoin has a similar cell wall concentration but a greater water-soluble carbohydrates concentration, leading to a better energy/nitrogen balance.

As a legume species, sainfoin is rich in protein. Although the protein concentration is lower in sainfoin than in lucerne, they are better utilised by the ruminant due to its lower proportion of soluble N.

Indeed, the proportion of soluble N is low in sainfoin because condensed tannins contained in the plant are able to bind protein, protecting them from rapid degradation and solubilisation in the rumen.
Like other forage species, the nutritive value of sainfoin hay is lower than fresh forage due to the loss of leaves during hay making, but sainfoin is preserved well in silage as the condensed tannins also protect protein from proteolysis in the silo.

Its high sugar concentration also helps to bring about rapid and intense lactic acid fermentation.

Although some tannins can be antinutritional factors, the tannins in sainfoin do not impact negatively on digestibility, which is similar to lucerne or clover, and the high sugar concentration in sainfoin increases its palatability. The studies conducted in the last decade, which aimed to better understand how condensed tannins interact with the nitrogen metabolism in ruminants, indicate that the decrease of protein degradation in the rumen is not really counterbalanced by an increase of protein digestion in the intestine (though this could be a Swiss/French variety effect).

Although the non-degraded N flow to the duodenum is increased, results indicate that condensed tannins could result in a decrease in intestinal digestibility due to an incomplete dissociation of the tannin-protein complexes or a re-formation of these complexes when the pH increases beyond the abomasum. This means that the protein retention by the animal is not improved by condensed tannins, but a clear decrease in urinary N losses can be observed, providing an environmental benefit.

Greenhouse Gas Emissions

Our livestock sector is an important contributor to greenhouse gas emissions. With an estimated amount of 7.1 gigatonnes of carbon dioxide-equivalents, the sector accounts for 14.5% of all the human-induced emissions. Typical greenhouse gases involved are methane, nitrous oxide and carbon dioxide, with methane being the most important one responsible for about 44% of the sector's emissions. Most of this methane originates from enteric fermentation resulting from the breakdown of feeds by the microbes residing in the forestomach (rumen) of ruminants (beef and dairy cows and sheep).

In the rumen a complex microbial community of bacteria and protozoa degrade the ingested feed into nutrients that can be absorbed and used by the ruminant. A side effect of this process is that hydrogen is being formed. The hydrogen, however, is detrimental to the microbes themselves and therefore needs to be removed from the rumen. In our domesticated ruminant animals this is resolved by a special group of microbes, the Archaea or methanogens, that transform the toxic hydrogen into non-toxic methane.

A number of studies have shown that tannins can affect ruminal methane formation, however, the efficacy of the tannins depends on the plant source and the type. Recent studies have shown that the condensed tannins present in sainfoin can reduce methane production.

Feeding trials with dairy cows in the Netherlands showed that a partial replacement of grass silage by sainfoin silage resulted in a 5% increase of dietary intake, a 10% increase in milk production and a 12% reduction in methane emission per kg produced milk.

These results indicate that sainfoin has the potential to be used as a dietary strategy to reduce enteric methane emission by ruminants.

Milk and Meat Quality

Usually, milk and meat from ruminants have a more saturated fatty acid (SFA) profile than meat from monogastrics. The main reason is that most dietary unsaturated fatty acids are transformed into saturated fatty acids by rumen microbes. However, polyunsaturated fatty acids (PUFA) are not only essential nutrients for humans but, in the case of omega-3-fatty acids such as linolenic acid, are also considered to be beneficial for human health.

For many years, a variety of approaches have been tried in order to increase the content of PUFA in milk and meat of ruminants. Increasing the intake of dietary PUFA is one possibility since by increasing their intake the amount of PUFA passing unchanged through the rumen increases as well. One simple way to increase the dietary linolenic acid intake is to feed ruminants linseed. Likewise, herbage based diets, which are also rich in linolenic acid, are more beneficial in this respect than a total mixed ration based on maize silage. Another way to change the fatty acid composition in milk, dairy products and meat is the direct manipulation of digestive processes in the rumen so that less PUFA are altered by rumen microbes. Condensed tannins occurring in sainfoin and birdsfoot trefoil may have this potential because they can bind to other nutrients and protect them from digestion in the rumen or directly affect the activity of rumen microbes.

Feeding trials carried out at Agroscope, Institute for Livestock Sciences, in Switzerland, showed that the content of linolenic acid in milk and cheese was increased when instead of lucerne pellets sainfoin pellets were added to a dairy cow diet. Furthermore, feeding solely sainfoin silage compared to lucerne silage caused a marked increase in the linolenic acid and total omega-3-fatty acid content in lamb meat.

Another positive effect of condensed tannin-containing legumes on lamb meat quality might be the reduction of pastoral flavour which occurs when sheep graze pasture. The compounds causing pastoral flavour are the 2 rather bad smelling compounds indole and skatole. They are produced in the rumen from the amino acid tryptophan. As condensed tannins can protect protein from degradation, the production of indole and skatole might be decreased. In this respect, a feeding trial at Agroscope provided promising results. The content of skatole in lamb meat was significantly decreased when sainfoin silage was fed compared to lucerne silage. Also from a sensory perspective, panellists detected less "sheepy" flavour in meat from lambs fed sainfoin.

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Prof. Wilbert Pellikaan - Wageningen University, The Netherlands
Dr. Frigga Dohme-Meier - Head of Research Group, Agroscope, Institute of Livestock Sciences, Posieux, Switzerland
Dr. Giuseppe Bee - Head of Research Group, Agroscope, Institute of Livestock Sciences, Posieux, Switzerland

Sainfoin as a Natural Wormer

Worms or gastrointestinal nematodes, in small ruminants and cattle can cause disease and lead to production and economic losses (e.g. poor growth rates, drop in milk yield) if not controlled. Farmers have been using different families of synthetic anthelmintics or drenches (wormers) for many years to prevent this. These commercial drugs are generally highly efficient, cheap and user-friendly and their application is therefore widespread in intensive farming. However, this has resulted in the emergence of drug-resistant nematodes over the past decades in sheep and goats and also, to a lesser extent, in cattle.
Moreover, the trend towards low input and organic farming products has significantly expanded to address the increased wish of consumers' demands for minimal synthetic drug inputs to reduce the risk of residues in food and limit the impact on the environment. Therefore, for more than 10 years, research has focused on the exploration (or rediscovery) of alternative solutions to control parasite infections in sheep, goats and cattle breeding.


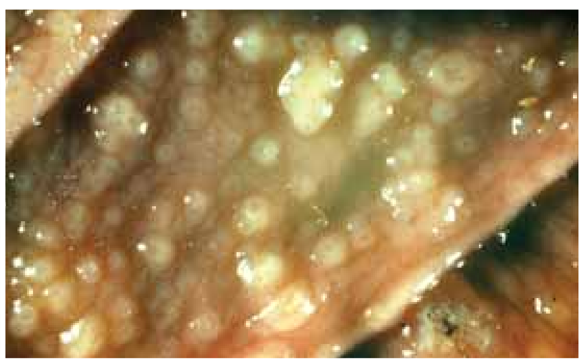

Photo 1: A calf severely affected by worms has developed swelling under the jaw ("bottle jaw").
Photo 2: Numerous white nodules in the stomach (abomasum) due to developing worms.

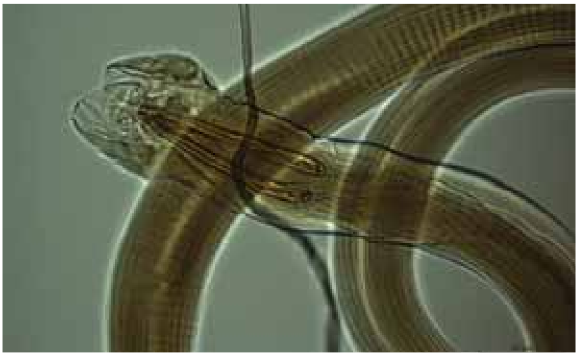

Photo 3: The worm (Ostertagia/Teladorsagia) responsible for the lesions illustrated in photo 2.
Photo 4: Haemonchus worms in sheep. This species is blood sucking which explains its red colour.

The general objective nowadays is to achieve an integrated control by combining several solutions. These include providing good pasture, avoiding overstocking, moving livestock to undergrazed pastures in the same season (e.g. after cutting for silage in the spring) and mixed grazing of cattle and sheep.

Sainfoin as a forage represents a promising option for a more natural way to control worms. It is a tannin-containing legume with antiparasitic properties. Sainfoin has been the main subject of studies in two successive EU projects “Healthy Hay” and “LegumePlus”.

However, some other plants can also be described as bioactive forages in relation with tannin content (e.g. birdfoot trefoil or with other natural compounds which are not tannins e.g. chicory.)

How does it work against parasitic worms?

In sheep and goats the results of a wide range of in vitro studies designed to measure the anthelmintic effect on parasitic nematodes were promising. Since then, many studies have been performed in sheep and goats in order to confirm these laboratory results. A smaller number of studies have confirmed the results in cattle. The consumption of sainfoin can affect the main species present in either the abomasum or in the small intestine of sheep, goats and cattle.

This is because the consumption of sainfoin, as an example of a tannin-containing legume, disturbs the biology of three main stages of the parasite life cycle: the eggs, the infective larvae and the adult worms.

The effects are a reduction of parasitic egg excretion (due to either a lower fertility of female worms or fewer worm numbers), a lower development of the eggs to larvae, or a lower establishment of the infective larvae in the animals.

To summarise, good grazing management and the feeding of bioactive forages like sainfoin contribute to lower the contamination of pasture and the risk of animal infection.

In cattle in the late part of the grazing season, pastured calves may get heavy infections with the stomach worm, Ostertagia, characterised by diarrhoea, lack of appetite and retarded growth. In these animals, weight gains can be reduced by up to 315 g/day on average. Adult cattle are more resistant to the worms; however, the production can also be impaired without showing clinical signs e.g. reduced milk production by 0.5 – 1.0 l/day per cow.

Dried sainfoin pellets were fed to young calves for 6 weeks following infection, which reduced the number of Ostertagia stomach worms by more than 50%. It is recommended to feed it ad libitum with another roughage sources and supplemented with minerals if necessary. Other bioactive crops with documented effects against Ostertagia include chicory (Cichorium intybus).

Sainfoin and other tannin containing forages can be exploited in different forms. All forms including grazing, silage, hay and pelleting have shown anti-parasitic properties in studies with sheep and goats.

Conserved forms (hay, silage and pellets) are attractive because they facilitate storage, and allow the measurements of tannins before use and feed standardisation.

Feeding trials with sainfoin pellets have reported promising results with the reduction of infection with the very pathogenic species Haemonchus contortus, a reduction in faecal egg counts and a better blood packed cell volume. In the digestive tract of ruminants, tannins may cause physical damage to the worms reducing their survival and egg-laying capacity. This may improve the immunity (natural resistance) of the animals against the worms.

However, the plant composition in terms of tannin content can vary considerably and depends on variety, environmental conditions and processing.

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Elodie Gaudin - PhD Student, INRA, ENVT Parasitology, Toulouse, France
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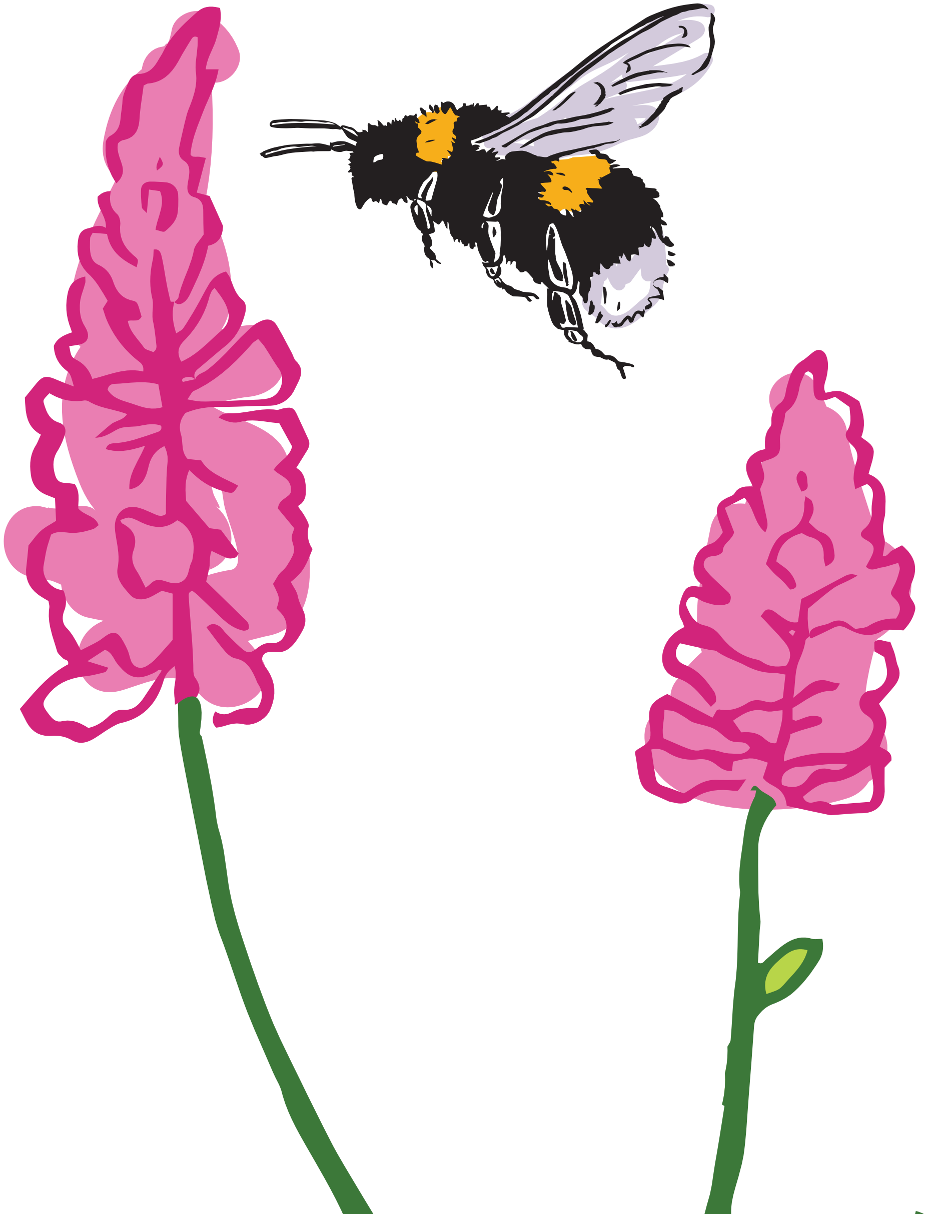
ECOLOGICAL ASPECTS



Sainfoin as a Resource for Pollinators

Decline in both wild and managed pollinators has been the cause of considerable and increasing concern in the UK, and more widely in Europe, the USA and Asia. A single definitive cause has not been identified, but the consensus among many beekeepers is that several factors are involved, with bee nutrition and habitat loss being one of the most important. Trends towards crop monoculture in many areas may have contributed to the problem, because pollen derived from a single source can compromise nutrition and health.

> Sainfoin flowers are a rich source of pollen and nectar, reported to attract ten times more bees than clover species; and this nectar is secreted exceptionally freely.

Sainfoin is considered to be one of the highest yielding 'honey' plants. The pollen is also of high quality, with one of the highest oil contents of all UK flowering plants. Sainfoin provides this resource for both managed and indigenous pollinator insect species, including solitary and bumble bees (Apis, Bombus and Osmia). It is probably the sole pollen source for Osmia avosetta bees in Turkey.

> In an ongoing USDA funded project, sainfoin was found to be one of the best sources of both pollen and nectar. According to beekeepers; 'when sainfoin flowers, it is so appealing to honeybees that they will often ignore all other nectar sources to forage on it'.

In the UK, sainfoin starts flowering in May and continues up to October. If cultivated as a crop and cut, this will encourage 2–3 flowering periods, and thus provides a good source of pollen and nectar for over-wintering bees. Syngenta research led to a recommendation for general sowing of sainfoin to enable bees to lay down food reserves for the winter.

Different authors do not agree on the optimal requirement for pollinators; it has been suggested that two to three colonies of honey bees per hectare is required (approximately one colony per acre) near the field. But others calculated that two to three colonies per acre would provide five or six visits to every sainfoin flower. This would appear to be low, thus more colonies may be required.

In recognition of the need for this type of resource the concept of 'bee-pastures', specialized pastures designed specifically for honey bees (and other pollinators), is gathering momentum. The USDA-ARS Pollinating Insects Biology, Management, and Systematics Research Unit, has been developing this theme to define the most desirable and beneficial forage for honey bees. They note that flight is costly in terms of energy and time, so bees will minimise flying distances if quality pollen and nectar sources are available near to a hive or nest. If necessary, honey bees will search the surrounding 4,000 ha.

In the UK, it has been estimated that sainfoin yields up to 400 kg/ha of honey per annum. In the USA, the production per hive has been measured at in the region of 200lbs honey per annum. Sainfoin honey is light gold in colour with a very distinct, delicate flavour. Beekeepers with access to fields of sainfoin are said to be 'truly privileged' and 'honey made from sainfoin is of the finest quality'.

Dr. Lydia Smith - Head of Innovation Farm, NIAB, Cambridge, UK

The structure of the flower is suitable for most nectar collecting insects and sainfoin provides bees with abundant pollen and nectar. The pink flowers grow on tall erect spikes; flowering begins at the bottom of the spike taking between two or three weeks to reach the tip. Each plant bears multiple spikes so that at any one time many flowers are open on the same plant (which means that bees don't have to expend a lot of energy while foraging).

Overall sainfoin has a relatively long flowering period and can potentially provide resources over the summer. Because of this it is often recommended as a useful component in Countryside Stewardship nectar and pollen mixes. Cutting will delay flowering and it is possible to extend the flowering period for bees by cutting part of the field or margin, so that there is more than one pulse of flowers.

As long ago as 1947 American beekeepers noted that, given the choice, honeybees will collect pollen from sainfoin over other legume species such as lucerne and clovers. Furthermore the nectar has a relatively high sugar content that results in excellent, clear and abundant honey, making it an attractive plant for beekeepers.
Recent concern for bumblebees and other wild bees in the UK has homed in on the lack of flowers available in the countryside. Including sainfoin in leys and field margins will provide good resources for wild bees, helping to conserve and increase their populations.

As sainfoin was imported by farmers in the 17th century, it has been suggested that it is not a native plant but it is interesting to note that sainfoin is associated with one particular rare solitary bee Melitta dimidiata, which is confined to Salisbury plain, and only collects pollen from sainfoin. This has been used as an argument to suggest that sainfoin is native to the UK.

In addition to bees, butterflies and moths will also feed on the nectar and including sainfoin in wildflower mixes will encourage them. However, little is known about the use of sainfoin as a larval food plant although it has been shown that green hairstreak butterfly caterpillars feed on it, as do the caterpillars of some moths, including the beautifully named latticed heath, yellow belle, and sainfoin piercer.

Natural enemies of crop pests have been shown to be abundant in sainfoin fields, which is a good sign of a healthy insect community. Sainfoin is a relatively tall plant and many varieties grow over a metre in height. This structure is likely to encourage the buildup of crop pest's natural enemies, as they are known to increase with structural diversity. Confirming this, recent work has shown that sainfoin leys supported high numbers of beneficial insects such as ladybird larvae, spiders and parasitoid flies and wasps. Other wildlife that depend on insects as a food source will benefit from the rich insect life that sainfoin encourages. Insects that are known to be part of the farmland bird diet such as myrid bugs, sawfly larvae and a variety of beetles have all been recorded in sainfoin leys. In general sainfoin is an excellent all round plant for wildlife on farmland.

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Introduction

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Sainfoin as a Forage

Why Feed Sainfoin To Ruminants

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Ecological Aspects

Sainfoin as a Resource for Pollinators

Sainfoin for Wildlife

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Biological Records Centre Database of Insects and their food plants http://www.brc.ac.uk/dbif/ (accessed 02/10/2015)

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Further information is available at **http://legumeplus.eu**

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