Manifold green manures – Part I: Sainfoin and birdsfoot trefoil

Using diverse legume mixtures can simultaneously fulfil several functions in the rotation, such as building soil fertility, enhancing weed control, and supporting biodiversity. This was demonstrated by a research project called Legume LINK, which was led by the Organic Research Centre from 2008 to 2012. Modelling work in the project showed that a well-performing basic mix would be a combination of black medic, lucerne and red clover; including white clover as a fourth leguminous component would improve the resilience of the mix.

In addition, however, several more legume species are available that could enhance the multifunctionality of this basic mix. In this series of articles, we provide profiles of currently less frequently used legume species that could be included in fertility-building species mixes to make them more suited to specific soil, climate and management conditions. This first part gives information on sainfoin (*Onobrychis viciifolia*) and birdsfoot trefoil (*Lotus corniculatus*).

Sainfoin

Sainfoin is a perennial legume of South Central Asian origin, native to unimproved chalk grassland. It was introduced to Europe in the 15th century and has been cultivated widely as a forage crop throughout Europe, Asia and North America. Although it was widely grown in Britain in the 18th and 19th centuries, it has since dramatically declined in importance in comparison to other legumes such as lucerne. The name 'sainfoin' is of French origin, and means 'safe or healthy hay', referring to its historical usage to treat sick livestock. Sainfoin has relatively large seeds, and a long tap root which confers very good drought resistance, exceeding even that of lucerne. Pollination of sainfoin is mainly by bumble and other bees, and in temperate regions it flowers from June-August.

Sainfoin is known to thrive on alkaline soils, with good performance at a soil pH of 6.0 and above; accordingly, the Legume LINK study found a positive correlation between soil pH and sainfoin presence when the species was sown as part of a complex mixture on 34 farms across the UK. Sainfoin requires less warmth and is more winter hardy than lucerne. Establishment can be slow, but once established sainfoin can readily produce biomass in favourable conditions; in line with this, the Legume LINK project found that sainfoin regrowth after cutting was not significantly different from that of white clover.

Another relevant factor concerning establishment and general productivity is the sowing rate. While the seed rate in a sole crop of sainfoin is recommended as 140-180kg/ha, the typical rate for inclusion in a mixture is around 12kg/ha (http://sainfoin.eu/farming-sainfoin), but can be as much as 82kg/ha, when it is used as a main crop with companion grasses. However, due to the high species diversity of the mixture tested in this project, the seed rate of sainfoin used in the mix was much below this rate, with only 5kg/ha. This may explain why presence of sainfoin in the mixture was consistently lower than for example that of red clover and white clover. Thus, greater productivity of sainfoin in a less complex mix may require a higher seed rate than that used in our trials.

The recommended sowing time for sainfoin is spring to early summer, with later sowing time (late July/August) being regarded as too late for seedling establishment before winter. However, this observation is not confirmed by our study, as the six farms that did sow the mixture between July and October 2009 did not show reduced sainfoin cover in the following year (2010), when compared to the farms that sowed the mixture in spring.

Whilst sainfoin has a high capacity for growth as a sole crop, competition effects can impact on survival when it is grown as part of a mixture, particularly from grasses. Similar effects were observed in our trials where sainfoin was out-competed by stronger species over time: its presence decreased from year one to year three of the study.

In terms of productivity, sainfoin is often compared to lucerne, with sainfoin yields reported to reach about 70%-80% of lucerne yields. In contrast to these figures, the Legume LINK trials showed that in the first year sainfoin biomass was on average only 41% of the lucerne biomass. However the relative performance of the two species was highly variable between sites, with sainfoin outperforming lucerne at one site (Rothamsted, Herts), but reaching less than 10% of lucerne biomass at a site in Cornwall, which may partly be explained by differences in soil properties such as pH (see above).

Regarding persistence of sainfoin in the sward, sainfoin is considered to have high longevity; however, in the trials of the current study, sainfoin showed significant decrease in ground cover over the three-year trial period, when grown with other legumes and grasses in a complex mix.

The nitrogen fixation efficiency in sainfoin is relatively poor in comparison to lucerne, red clover, and white clover, mainly because of the lower overall biomass in sainfoin. Compared to lucerne, sainfoin has a lower Leaf Area Index and lower efficiency of using sunlight. Rhizobial inoculation of sainfoin is recommended.

When we looked at the plant residue profile of the species, the lignin content of sainfoin was significantly higher than for red and white clover. This may partly contribute to a relatively slower

decomposition rate in relation to clover species. In comparison to the other tested legumes, sainfoin had relatively high polyphenol content, being similar to red clover. In accordance with this finding, the literature indicates that sainfoin contains high levels and high diversity of phenolic compounds. These, especially in the form of condensed tannins, have implications for the forage value of sainfoin, as they result in the species' non-bloating nature, and increase protein absorption and palatability. Finally, phenolic compounds in sainfoin also confer antihelminthic properties. A feeding study found that both dried and ensiled sainfoin reduced established populations of parasitic nematodes in lambs.

In summary, sainfoin, thriving on alkaline soils, is a species with lower productivity than other legumes such as white clover, red clover or lucerne, but has other highly beneficial characteristics, as it is (relatively) drought resistant, is highly palatable, does not cause bloat, and has anti-parasitic properties when fed to livestock.

Birdsfoot trefoil

Birdsfoot trefoil is a native plant in Europe, growing on a vast area ranging from Northern Russia through to West Africa. It is pollinated by honey bees as well as bumble bees and has a long tap root, almost going as deep as lucerne, but shows a larger lateral root spread than lucerne.

The species is known for its relatively weak seedling emergence and slow establishment, and the experiments conducted in the Legume LINK project confirmed that birdsfoot trefoil was slow to establish, slower than many other legumes tested (such as crimson clover, lucerne, or red clover); interestingly, however, it was not significantly slower than white clover.

Regarding many productivity parameters, birdsfoot trefoil was not significantly different from white clover – seedling biomass and seedling relative growth rate, plant re-growth after cutting in first year, above ground biomass in the first summer, pre-incorporation biomass and pre-incorporation proportion of weed biomass. However, birdsfoot trefoil showed a substantially and significantly lower crop cover than white clover after the first winter. In comparison with other legume species, it was mid-range in terms of weed cover and weed biomass. During on-farm trials, birdsfoot trefoil decreased in frequency over time within a diverse species mixture, and showed a significantly lower presence on farms and in sampling quadrats than white clover, as well as a lower ground cover. Compared to the other Lotus species tested, large birdsfoot trefoil (*L. pedunculatus*), birdsfoot trefoil showed consistently higher productivity on all measured parameters. This is in line with results from some, but not all, reports in the literature, where in some cases large birdsfoot trefoil was shown to yield more than birdsfoot trefoil, depending on year, Lotus variety, and companion grass species.

Among the legumes, birdsfoot trefoil ranked highest in terms of root biomass. Regarding the plant residue profile, birdsfoot trefoil showed a significantly higher lignin content than the clover species tested, a similar polyphenol content as white clover, but a higher C:N ratio than white clover. Among the legume species tested, birdsfoot trefoil was only surpassed by large birdsfoot trefoil in terms of resistance to breakdown. The species was similar to white clover in terms of the amount of soil N pre- and post-incorporation and ranged in the upper third in terms of grain yield of following cereal, though there were no significant differences between birdsfoot trefoil and white clover in this respect.

Birdsfoot trefoil has a relatively wide tolerance regarding various environmental conditions and the present study supports this finding in that no significant regional differentiation was observed across the UK. While the literature describes birdsfoot trefoil as being adapted for acidic infertile soils, we observed a mildly positive correlation between the presence of birdsfoot trefoil on farms and soil pH, though only in the third year of the trials. Birdsfoot trefoil has been described as being more tolerant than white clover to soils of extreme pH values. The wide adaptation of birdsfoot trefoil also refers to its water requirements: while birdsfoot trefoil has been reported to be more drought-tolerant than large birdsfoot trefoil and lucerne, it is also better yielding than lucerne, white clover, red clover under poor drainage conditions, and it is more tolerant of flooding than lucerne. Birdsfoot trefoil is also quite tolerant of saline soils. However, the species requires high sunlight levels and is not shade-tolerant.

In the present study, birdsfoot trefoil was found to be reasonably tolerant to being cut to a low height, but less so than white clover. These results are in agreement with a study that found that white clover showed higher tolerance to grazing by beef cattle than birdsfoot trefoil. Just as sainfoin, birdsfoot trefoil is a non-bloating legume, containing condensed tannins; it has been reported to be highly acceptable to livestock, and controlled rotational grazing is therefore recommended.

In summary, birdsfoot trefoil is a legume species with moderate yield levels and it is relatively weak in the establishment phase. However, it provides good forage value as a non-bloating legume species, and high adaptability to relatively poor soil conditions, as well as slower breakdown after incorporation, which decreases the risk of nitrogen losses.

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