SAINFOIN — CURIOSITY OR CROP?

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ABSTRACT

Sainfoin *(Onobrychis viciifolia)* is a perennial forage legume that has been the subject of both scientific and farmer interest in New Zealand because of its non-bloating character. As there is limited local literature on and experience with sainfoin, this review of work overseas summarises some of the requirements for growing sainfoin and for realising its productive potential. Problems of identifying desirable plant attributes from available germplasm, and the possibilities of cultivar development for New Zealand conditions are discussed.

INTRODUCTION

Sainfoin species *(Onobrychis* spp.) have probably been part of native pastures in the eastern Mediterranean for as long as 6000 years (Hely and Offer, 1972). They have been actively utilised in the Transcaucasian Soviet Union for about 1000 years (Shain, 1959) and in the United Kingdom for about 400 years since its introduction from Europe (Bland, 1971). Despite this history it is regarded as a new plant in many areas of the world including New Zealand and it is not clear why the species, particularly *Onobrychis viciifolia,* has not become a more widespread crop. Possibilities such as lack of opportunity for accidental introduction (Hely and Offer, 1972), poor adaptation to the changing needs of agriculture (Hutchinson, 1965), inadequate evaluation of the basic requirements for plant growth and misleading visual estimates of the plant's worth due to its stemmy nature (Eslick, 1968) have all been suggested. In addition, the success of lucerne (Medicago sativa) as a summer active forage legume has probably led to some neglect of possible alternatives. However recently sainfoin appears to be receiving more attention.

In the northern United States and Western Canada, sainfoin is proving superior to lucerne for dryland sowings and it is also resistant to alfalfa weevil *(Hypera postica)* which is becoming an increasingly severe problem (Hanna *et al.*, 1972 Ditterline and Cooper, 1975). In Australia, the problems with aphid infestation of lucerne resulted in studies which indicated that sainfoin has resistance to a range of pests such as spotted alfalfa aphid *(Therioaphis trifolii* fm maculata), blue-green aphid *(Acythosiphon kondoi)* and lucerne flea *(Sminthurus viridis)* which are major pests of lucerne (Lance, 1980; St John-Sweeting, pers. comm.). In New Zealand, the interest in sainfoin has arisen because it is non-bloating due to the presence of condensed tannins in the plant tissue (Jones and Lyttleton, 1971; Reid and Clarke, 1974). An associated effect of the tannins is protection of the protein from rumen degradation and most studies indicate that this results in improved nitrogen utilisation by the animal (Thomson *et al.*, 1971; Ulyatt *et al.*, 1977; Ulyatt and Egan, 1979). Ulyatt *et al.* (1977) also point out that sainfoin has a very high voluntary intake, a factor which has a major influence on the feeding value of herbage species.

This review will attempt to provide some further insight into sainfoin as a plant, its agronomic requirements and its potential for development in New Zealand.

MORPHOLOGY

Sainfoin is a deep-rooted perennial that produces a number of stems from a crown. Leaves, borne on a long petiole, are imparipinnate with 5-14 pairs of leaflets and a terminal leaflet. The inflorescence is an erect raceme with 5-80 papilionaceous florets and the pods formed are single seeded, indehiscent and have marked reticulate ridges (Spedding and Diekmahns, 1972; Ditterline and Cooper, 1975). It has also been suggested that some older plants have the capacity for vegetative multiplication by means of short ascending underground stems that bear aerial stem buds at their tips (Badoux, 1965). Sainfoin falls broadly into two types — single cut with late flowering, (e.g. cvs. Eski, Melrose) and double or multi-cut with early flowering and a more even seasonal yield distribution (e.g. cvs. Remont, Fakir) (Cooper, 1972).

DISTRIBUTION

From its origins in the Near Eastern Centre e.g. Turkey, Iran, Trans-Caucasica (Vavilov, 1951) sainfoin has spread eastwards to mediterranean and central Europe and as a result has probably been cultivated in most European countries. However, active cultivation of sainfoin now seems limited to such places as Italy (Orsi, 1978), France (Hentgen and Desroches, 1978), Romania (Varga, 1968), the Soviet Union (Andreev, 1963), and more recently Canada and the United States (Hanna *et al.*, 1972; Ditterline and Cooper, 1975). In the United Kingdom, sainfoin survives as old isolated stands (Baker *et al.*, 1952; Evans, 1961) and is often regarded as a native species on chalk and limestone areas (Spedding and Diekmahns, 1972).

The main species grown would seem to be *Onobrychis viciifolia,* but *O. arenaria* (sand sainfoin) and *O. transcaucasica* (transcaucasus sainfoin) are important in the Soviet Union (Shain, 1959), while two Mediterranean species *O. caput-galli* and *O. crista-galli* are used in their native areas (Simmonds, 1976).

ENVIRONMENTAL REQUIREMENTS

It is difficult to accurately assess environmental requirements as the growth of a range of ecotypes (Sinskaya, 1958) and species (Chapman and Yuan, 1968) has been describ ed in most situations except the tropics. A further complication is that some of the more detailed studies have used either a limited range of cultivars (e.g. Koch *et al.*, 1972) or a limited range of environments (e.g. Evans, 1961).

Climate

As sainfoin occurs in a range of localities from Mediterranean regions with hot, dry summers to northern latitudes with severe winters, it is reasonable to assume that climatic requirements will vary considerably depending on the origin of the type or cultivar. This can be well illustrated by flowering time. Mediterranean material can flower in cooler, wet winters (St John-Sweeting, pers comm) while material of northern origins may require vernalization and long days to flower (Sheely, 1977). However the common factor is that sainfoin seems to be well adapted to drought in terms of both morphological features and time of maximum growth (Koch *et al.*, 1972). The adaptation of sainfoin to a short growing season is further illustrated by its ability to germinate and grow at low temperatures and thus withstand an early change to a hot, dry climate (Young *et al.*, 1972). Because of these characteristics United States workers (Ditterline and Cooper, 1975) recommend sainfoin for areas with a minimum rainfall of about 330mm.

Soils

Sainfoin is best adapted to free draining soils that have an alkaline pH and are high in lime (Spedding and Diekmahns, 1972). This requirement is not absolute as sainfoin has been successfully established in acid sand (pH6) (St John-Sweeting, pers. comm.), and was also grown in vermiculite using a nutrient solution of pH 6.2, without any apparent adverse effects (Smoliak *et al.*, 1972). However, some caution is needed as factors such as nutrient toxicity may occur at lower pH levels and Rorison (1965) suggested that it may be the toxic effects of aluminium that exclude sainfoin from some acid grasslands in the United Kingdom.

ESTABLISHMENT AND MANAGEMENT

Establishment

As there is a recent extensive review on the establishment and development of legume seedlings, including sainfoin (Cooper, 1977), only specific aspects will be mentioned here.

Firstly, the high seeding rates recommended for sainfoin may make establishment costs very dependant on seed price (Scott, 1979). Spedding and Diekmahns (1972) suggest 55-60 kg/ha for milled seed and 90-100 kg/ha for unmilled seed. However, with a seed weight (per 1000 seeds) of 13.2-16.8g in true seed and 18.2-23.6g in unmilled seed (Spedding and Diekmahns, 1972) the seeds are somewhat larger than many other commonly used pasture or forage legumes e.g. lucerne 2.15 g/1000 seeds (Gunn, 1972). The recommended lucerne seeding rates of about 10 kg/ha (Langer, 1973) are therefore very similar to sainfoin rates in terms of actual number of seeds sown. Unless it can be shown that the larger seeds of sainfoin enhance the chance of seedling survival or that improved cultural practices can reduce the seeding rates, the problem will only be overcome by using high seed yielding types so that costs can be minimised. One note of caution is that, despite its large seed size, sainfoin does not emerge well from deep sowings and so planting depth should be approximately 1-2 cm (Hanna *et al.*, 1972).

The next factor is whether the indehiscent pod should be removed prior to sowing as it has been shown to contain germination inhibitors (Carleton *et al.*, 1968; Smith, 1979). However as these have not shown any effects on field establishment (Carleton *et al.*, 1968) perhaps the best argument for removing the pod is that of Thomson (1952) who showed that the friction of milling reduces the number of hard seeds and also that shrivelled seed can be removed resulting in a more even seed sample. A further reason for removing the pod is due to its persistent nature which can result in cutting of the developing root and thus provide a site for disease infection (Sears, 1974 cited by Ditterline and Cooper, 1975). Even given these reasons for removing the pod, most seedings in the United States are made with the pod intact (Ditterline and Cooper, 1975) and so while it may be desirable to remove the pod it cannot be regarded as essential.

An important consideration at seeding is the use of an inoculum. As the sainfoin *Rhizobium* appears specific (Burton and Curley, 1968) it is essential that the seed is inoculated prior to sowing and that care is taken to ensure the use of viable strains. Even when this criterion is met, there are still problems with both lack of nodulation, and ineffective nitrogen fixation by apparently well nodulated plants (Ditterline and Cooper, 1975). However the problem is complicated as the symptoms may occur at any stage during growth, but do not always occur under cultivated conditions (Hanna *et al.*, 1972). Observations of nodule presence and function with sainfoin in its native habitat indicate a reasonable symbiotic relationship (Hely and Offer, 1972) which perhaps suggests that factors other than the strain of *Rhizobium* may be causal. A possibility is mineral nutrition but this will require further clarification as, apart from one study that showed root distortion from massive calcium accumulation (Ross and Delaney, 1977), the question of nutrient effects has not been examined in detail.

Finally there is the question of sowing time which will depend on the local circumstances. In cooler climates spring sowing will probably be most successful and also prevent some of the problems of early weed control as the plant will be able to grow rapidly as the temperatures increase (Ditterline and Cooper, 1975). However if summer conditions are particularly harsh as in Mediterranean climates, autumn sowing will have an advantage (St John-Sweeting, pers. comm.).

Weed Control

Despite the vigorous growth of young sainfoin plants they are often regarded as poor competitors with weeds (Bland, 1971; Ditterline and Cooper, 1975). The reason for this is not clear as sainfoin has a similar early growth rate to lucerne (Smoliak *et al.*, 1972; Fortune, unpubl.) which does not seem to suffer such a severe problem with early weed ingress. One possibility is that with sowing rates generally being about 35 kg/ha (Hanna *et al.*, 1972; Ditterline and Cooper, 1975) the plant populations are not sufficient to effectively smother the weeds. However, some of the taller types currently available may produce insufficient leaf area to shade weed seedlings even when high plant populations are present (Fortune, unpubl.).

Some care should be exercised with herbicides as being a relatively new crop, a limited number have been tested on a large scale in New Zealand. Currently such chemicals as trifluralin, 2,4-DB, MCPB and cyanizine appear reasonably safe (James and Atkinson, 1978) and no doubt others will become available with further testing. It is also possible that judicious grazing will also offer some degree of weed control as responses to grazing become better understood.

Fertiliser

Studies on fertiliser application suggest that sainfoin has a slightly lower demand for major elements such as potassium (Spedding and Diekmahns, 1972) and phosphate (Roath and Graham, 1968) than lucerne. However the nutrient demands of sainfoin require greater clarification and requirements are likely to increase if breeding and selection for higher yield are successful. Owing to the previously mentioned problems of poor nitrogen fixation ability, small amounts of nitrogen have often been applied but the responses have been varied (Meyer, 1975, Smoliak and Hanna, 1975). It is unfortunate that this problem has not been resolved as it places strong limitations on effective evaluation of sainfoin yield potential. One possibility that may add complications to nutrient requirements is when heavy applications of lime are used for pH modification. Other legumes such as lucerne (Sherrell and Toxopeus, 1978) and trigonella (Mϕlgaard and Hardman , 1980) can suffer moderate to severe boron deficiency under these circumstances. Many of the symptions associated with boron deficiency (Epstein, 1972) may have been observed in sainfoin and attributed to other factors e.g. altered nutrient uptake affecting root and shoot growth (Ross and Delaney, 1977). This example should highlight the need for further understanding of nutrient requirements.

Defoliation

As sainfoin is adapted to areas that limit growth to spring, mid-summer (Hanna *et al.*, 1972; Koch *et al.*, 1972) and as it has been used for haycutting with aftermath grazing (Spedding and Diekmahns, 1972), the crop has generally been cut at an advanced flowering stage. This practice has been successful in maximising yield as regrowth is often poor. Also any decline in quality as sainfoin matures is small (Baker *et al.*, 1952; Koch *et al.*, 1972) and even at advanced stages it does not appear prone to leaf loss (Carleton *et al.*, 1968). For the late flowering or single cut types, this timing also coincides reasonably well with the natural emergence and extension of any new basal shoots (Cooper and Watson, 1968).

Because of the trend towards late cutting, there has been little emphasis on other management possibilities which may be desirable in countries such as New Zealand where rainfall can be adequate for continuous summer growth and grazing is often used as well as conservation. To improve the options available a combination of improved regrowth in the later flowering types (Varga 1968; Carleton, 1968; Melton, 1977) and improved longevity in the early flowering or double-cut types that do have the potential for rapid regrowth (Chesneaux and Demarley, 1980) may be required. Even with these constraints it has been shown that the late flowering types can tolerate cyclical cutting (Thomson, 1951; Percival and McQueen, 1980) which can encourage regrowth and result in a more even distribution of yield through the season. However, despite the management used for the early flowering types which can produce yields of as much as 15 t D.M./ha/year (Chesneaux and Demarley, 1970), they suffer from rapid decline in yield and may only be useful for 2-3 years (Evans, 1961). Just why there is this apparent linkage between regrowth ability and longevity is not clear but may be related to the way in which assimilates are internally distributed and utilised. In the only study on this aspect, Cooper and Watson (1968) have shown that, for a late flowering type (cv. Eski), total available carbohydrates (T.A.C.) in the roots do not reach peak levels until seed maturity. Despite the limited nature of their study it does raise the possibility that regrowth will be effected by T.A.C. reserves and that frequent, severe cutting may result in a depletion of these reserves. Percival and McQueen (1980) have shown that for the relatively late flowering cultivar Melrose, a frequent cutting regime can result in both a decline in yield and plant numbers. Therefore until other cultivars are tested, caution would have to be exercised with early, frequent cutting. Further studies on the pattern of T.A.C. accumulation may prove to be valuable in determining either management strategies or in identifying types with better regrowth potential. Until some of these plant factors are resolved, it is likely that defoliation practices will have to be related to the growth stage of the plant and that flexibility may be introduced by choosing a range of early to later flowering types.

Mixtures

Mixtures make better utilisation of the area available by either providing a better quality material with a maximum yield or extending the period of time over which material is available for grazing or conservation. The possibility of combining sainfoin and lucerne to reduce bloat is a novel idea but the high palatability of sainfoin (Smoliak and Hanna, 1975) could necessitate some form of separation of the two species. Also with the relatively low yields of sainfoin in New Zealand, Scott (1979) has suggested that drenching is a more viable proposition for bloat control with lucerne. Grasses such as timothy (*Phleum pratense),* meadow fescue (*Festuca pratensis)* and perhaps cocksfoot (*Dactylis glomerata)* have shown promise in the United Kingdom (Spedding and Diekmahns, 1971). One mixture that has shown potential in the United States has been sainfoin and birdsfoot trefoil (*Lotus corniculatus)* where the mixture produced greater yields than either species grown alone (Cooper, 1973; 1979). Cooper (1973) attributes some of this gain to the growth patterns of the two species, with sainfoin being most active in the earlier part of the season and birdsfoot trefoil in mid-summer. Apart from these points of interest with mixtures they do add further complications to the question of management, and so at present effort may be better spent on understanding sainfoin in monoculture.

Seed Production

As high seeding rates seem to be important for successful establishment, seed costs for sainfoin can be a major expense so that seed production should be encouraged in New Zealand to ensure seed supply and stabilise prices. Low production resulting from poor seed set has been reported in France (Chesneaux and Demarley, 1970). The situation elsewhere suggests that, with reasonable management, the seed yield can be as much as 1400 kg/ha (Ditterline and Cooper, 1975). This results from a combination of both prolific flowering and high seed weight (Carleton and Weisner, 1968). The attraction of sainfoin to bees, means that it is a useful honey crop (Dubbs, 1968) as well as a seed crop.

Work will be needed to determine how best to handle seed crops under New Zealand conditions, but in general seed should be harvested at about 40% moisture as after this seed shedding can occur (Carleton *et al.*, 1967). Long term viability appears to be a problem with storage (Rogers, 1975), and germination tests on imported seeds would tend to support this (Fortune, unpubl.) but no doubt if demand increases this will receive more attention.

Pests and Diseases.

One of the main advantages of sainfoin is that it generally seems resistant to a number of pests that can attack other species, and in particular lucerne (Lance, 1980; St John-Sweeting, pers. comm.) Potential pests have been examined by Wallace (1968) and include some Sitona weevils which can attack the root system and the sainfoin bruchid *(Bruchidis unicolor)* which can cause extensive damage to the developing seed head.

The crown and root rot complex appears to be the main disease problem as it can cause a rapid decline in stand density, particularly under irrigation (Sears *et al.*, 1975). However this complex is not clearly understood as it was initially thought that *Fusarium solani* was the main organism involved (Sears *et al.,* 1975), but more recent studies suggest the causal organisms are bacteria (Gaudet *et al.,* 1980). In addition it is possible that other factors such as nutrient deficiencies could predispose the plant to infection. Despite these uncertainties there is potential for selection of disease resistant types (Auld *et al.,* 1977).

CONCLUSIONS

This review shows that one of the main problems in dealing with sainfoin is differentiating between inherent plant weaknesses and those resulting from a poor understanding of the plant. When it is considered that sainfoin's three main attributes herbage quality, drought resistance and pest resistance are the subject of breeding efforts in other herbage species (Howarth *et al.,* 1979; Ulyatt *et al.,* 1977; Lance, 1980),it is a realistic objective to exploit this resource. The present difficulty with evaluation is that material available in quantity from overseas has in general been developed for quite different climatic conditions to those in New Zealand. Even so it has been shown that yields of 10,800 kg DM/ha are possible from the Canadian cultivar Melrose (Percival and McQueen, 1980)and the use of this material has improved our understanding of sainfoin's field behaviour in New Zealand. It would seem likely on the basis of rapid improvement achieved elsewhere (Hanna *et al.,* 1970; Melton, 1977; St John-Sweeting, pers. comm.) that gains could be made in New Zealand with a co-ordinated effort to identify and overcome agronomic difficulties and also select for suitable types. A breeding programme now underway at Grasslands Division, DSIR will help in meeting these objectives.

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