

Institute of Organic Training & Advice: Research Review:
The role and management of herbal pastures for animal health, productivity and product quality
(This Review was undertaken by IOTA under the PACA Res project OFO347, funded by Defra)

RESEARCH REVIEW: The role and management of herbal pastures for animal health, productivity and product quality

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1. Scope and Objectives of the Research Topic Review:

This review seeks to address the role and management of herbal pastures for animal health, productivity and product quality. It aims to do this by way of reviewing available Defra funded and other research and identifying key and relevant aspects.

In particular the target issues are:

- Impact on animal health and growth
- Mixtures/varieties
- Meat quality
- Production/yield; and
- Climate change issues.

There is however a clear variation in the number of papers focused on these various issues, with the majority of research being concerned with the impact on internal parasites and animal production performance primarily in sheep and deer.

There is however more recently some research coming out of New Zealand concerning climate change issues with respect to dairy cows.

This review highlights the key findings of individual papers, areas of knowledge and weakness along with opportunities for additional research.

In section 2 the key points (in terms of this review) from the relevant papers are identified and presented.

In section 3 the key advantages of mixed species pasture (MSP) and individual components are listed along with areas of weakness and opportunities for further research.

2. Summary of Research Projects and the Results

Deane, Joanne C; Warren, John; Findlay, Liz; Dagleish, Mark P; Cork, Susan C; Jackson, Frank and Keatinge, Ray (2002) The effect of *Cichorium intybus* and *Lotus corniculatus* on nematode burdens and production in grazed lambs. Paper presented at UK Organic Research 2002 Conference, Aberystwyth, 26-28 March 2002; Published in Powell, Jane and et al., , Eds. *Proceedings of the UK Organic Research 2002 Conference*, page pp. 89-92. Organic Centre Wales, Institute of Rural Studies, University of Wales Aberystwyth.

This paper is a reflection of the majority of UK based research around different herbs and their uses in organic production systems. That is its focus is on the role of herbs in combating the negative impact of internal parasites on animal growth/production.

In the case of this particular study the herbs evaluated are chicory (*Cichorium intybus*) and birdsfoot trefoil (*Lotus corniculatus*).

This study was designed to examine the hypothesis that chicory (*Cichorium intybus*) and *Lotus* sp. (*Lotus corniculatus*) have the potential to affect the naturally acquired nematode burden in grazed lambs.

The following are the key points from the paper relevant to this review.

- It was observed that the mean FECs (faecal egg counts) appear to be higher in lambs grazing Perennial ryegrass (PRG)/White Clover (WC) than those grazing chicory or Chicory (C)/*Lotus* (LC) with some evidence that these lambs also had lower weight gains than those grazing chicory or LC/C.
- Preliminary data from the small plot studies suggest that the number of *T. circumcincta* larvae harvested was greatest from the PRG/WC forage. This may be because the larvae have greater survival, increased development, or are better able to migrate up this herbage.
- Certainly, from the establishment and lamb performance data the use of chicory or *Lotus corniculatus* in a grazing regime may have some value as a tool to maintain satisfactory levels of production in organic lambs without reliance on anthelmintics as long as lamb condition and FEC are monitored.
- We have been able to establish and maintain Chicory for several seasons and it appears to be highly palatable for lambs. *Lotus* sp. is less easy to maintain from season to season (Marley & Lampkin, 2000).

Thamsborg, S.M.; Mejer, H.; Bandier, M. and Larsen, M. (2003) Influence of different forages on gastrointestinal nematode infections in grazing lambs. Paper presented at The 19th International Conference for the Advancement of Veterinary Parasitology: Old Dreams - New Visions: Veterinary Parasitology in the 21st Century, New Orleans, Louisiana, USA, 10.-14. August 2003; Published in Harrington, Kathleen Story, Eds. *Proceedings of the 19th International Conference of the World Association for the Advancement of Veterinary Parasitology, August 10th-14th 2003, New Orleans, Louisiana, USA, p. 189, page 189.**

- The study indicates a marked reduction in faecal egg counts when lambs graze sainfoin and a possible anti-parasitic effect of chicory on abomasal worms.

hamsborg, Stig (2001) Options for parasite control using tanniferous forages in livestock in Northern temperate areas. [oral] Presentation at *The 18th International Conference of the World*

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Association for the Advancement of Veterinary Parasitology: Promoting Advancement, Preserving Tradition, Stresa, Italy, 26.-30. August 2001.

- Leguminous forages with a relatively high level of condensed tannins (CT) (4-8 % of DM) fed to sheep may lead to lower faecal nematode egg counts and worm burdens.
- The legumes greater trefoil (*Lotus pedunculatus*), sulla (*Hedysarum coronarium*), sainfoin (*Onobrychus viciifolia*) and birdsfoot trefoil (*L. corniculatus*) are presently of major interest.
- In Denmark, nematode infected lambs grazing pure stands of sulla and sainfoin for 5 weeks have shown up to 50% reductions in egg counts compared to grazing clover.
- A Swedish study in lambs found no effect on worm counts of 15% (DM) birds-foot trefoil in the diet.
- Preliminary results have thus been promising but the following problems have to be addressed for a future, successful application of tanniferous forages in nematode control in Northern temperate areas:
 - Species better suited locally should be found. Sainfoin is not competitive in leys, and weeds dominate, particularly in organic farming without herbicidal use. Sulla, a Mediterranean plant, does not overwinter.
 - Efficacy relatively low. Knowledge of the mechanism of action may indicate ways of improving the efficacy. Selection of appropriate cultivars or growing conditions is needed.
 - The activity in cattle and goats needs to be investigated.
 - The forages need to be integrated in other systems of control, most likely repeated moves or biological control. The implementation is governed by the seasonality of the forages and the epidemiology of the infections.

Høgh-Jensen, Henning; Nielsen, Bea and Thamsborg, Stig Milan (2006) Productivity and quality, competition and facilitation of chicory in ryegrass/legume-based pastures under various nitrogen supply levels. *European Journal of Agronomy* 24.

Traditional perennial ryegrass-white clover mixtures have limitations in combined productivity and quality that herbs like chicory may alleviate. This study examined the consequences on productivity and quality as well as competition and facilitation after introducing chicory into various ryegrass-legume-based pastures in a field study over 3 consecutive growing seasons.

- A cultivar of chicory, suitable for grazing, in pure stand was found to out-yield a pure stand of ryegrass in terms of dry matter and nitrogen (N) accumulation but was found to yield similar to a mixture of chicory and ryegrass.
- It is concluded that chicory may improve the management of intensive dairy farms with a large N surplus because of the increase in productivity per unit area and N uptake efficiency and add significant improvements of the quality of the forage.
- The high content of zinc and copper in chicory may have a particular potential in free-range pig rearing systems as newly weaned piglets are deficient in zinc and copper (Carlson et al., 2004).
- The inclusion of chicory into perennial ryegrass/fodder leguminous grassland mixtures proved to be very beneficial in terms of productivity and N accumulation when evaluated over a 3- year period. The chicory was able to utilize sub-soil N which may provide a management tool to improve the environmental overload on dairy farms with a high N surplus (Halberg et al., 1995).
- Chicory was not found to co-exist well with neighbouring leguminous species. It transferred little N to associated species and under favourable soil N conditions it almost out-competed the white clover whereas lucerne was able to withstand the competition to some degree.
- In mixtures with ryegrass, chicory accumulated large amounts of calcium, potassium, sodium and zinc but significantly less magnesium and manganese irrespective of the N supply. In the case of sodium it was a short-term effect whereas calcium and possibly also sulphur, copper and zinc accumulation increased over time.

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Scharenberg, Anna; Arrigo, Yves; Gutzwiller, Andreas; Soliva, Carla; Perroud, Aurélie; Wyss, Ulrich; Kreuzer, Michael and Dohme, Frigga (2005) Akzeptanz von Futterpflanzen mit Vorkommen von kondensierten Tanninen bei Schafen und ihre Gehalte an nutzbarem Rohprotein [Palatability of plants containing condensed tannins by sheep and their content of utilizable crude protein]. Poster presented at 8. Wissenschaftstagung Ökologischer Landbau 2005 - Ende der Nische, Kassel, 1.-4. März 2005; Published in Heß, J and Rahmann, G, Eds. *Ende der Nische, Beiträge zur 8. Wissenschaftstagung Ökologischer Landbau.*

Plants with moderate contents of condensed tannins are assumed to have anthelmintic properties and to improve protein supply of ruminants by reducing its ruminal degradability. In this study, birdsfoot trefoil (*Lotus corniculatus*), chicory (*Cichorium intybus*) and sainfoin (*Onobrychis viciifolia*), (suitable to be grown in Central Europe), were tested for their suitability as feed for ruminants.

- Sainfoin proved to be the most promising forage plant since it was very well accepted by the sheep and presented the highest content of utilizable crude protein as determined in vitro.
- Only a few condensed tannins were detected in chicory.
- Further in vitro studies are required to confirm a better metabolic supply of protein for ruminants when fed sainfoin.

Younie, D. (2001) Organic grassland: the foundation stone of organic livestock farming, in Younie, D. and Wilkinson, J.M., Eds. *Organic livestock farming. Papers presented at conferences held at the Heriot-Watt University, Edinburgh and at the University of Reading, 9-10 February 2001, chapter 6, page pp. 75-102. Lincoln, UK: Chalcombe Publications.*

A number of herb species have deep tap roots and have the potential to explore deeper soil layers than conventional herbage species, and potentially make available an enhanced supply of nutrients (Swift *et al.*, 1990; Wilman and Derrick, 1994). This potential advantage of herbs has been demonstrated in practice, in the animal, by Younie *et al.* (1997), with weaned lambs grazing pure stands of chicory or perennial ryegrass.

Traditionally, organic farmers have often regarded secondary or indigenous grass species and forbs with approval, either in unsown pastures and field boundaries or sown in complex seed mixtures. Improved livestock nutrition and health are the reasons normally given. Herbs also tend to be more drought resistant than grasses and their tap root systems may also lead to a more open soil structure. Despite these potential advantages, forage herbs have been largely overlooked in practice, even in organic farming (Foster, 1988).

This is changing to some extent, at least in New Zealand and Australia, where breeding effort has led to the commercial release of varieties of chicory and ribwort (Moloney and Milne, 1993). Perhaps the main reason for the low level of use of forage herbs is their generally low contribution to sward biomass, largely resulting from low seed rates, poor establishment and persistence. This may be due, at least in part, to their inability to persist under intensive management regimes involving frequent utilisation by cutting and grazing regimes to which vigorously tillered grass species such as perennial ryegrass are ideally suited.

New thinking is also required in relation to the most appropriate companion species and mixtures for forage herbs. Umrani (1998) has shown that perennial ryegrass, with its vigorous, densely tillered growth habit, is a major competitor. It significantly reduced root length, root weight and shoot weight of individual herb plants. The upright and less well tillered growth habit of timothy is less competitive and, coupled with the N fixing ability of white clover, makes for a more suitable mixture, perhaps sown in strips or as separate swards, with the main bulk of the field sown to a ryegrass-based mixture. Of course the composition of mixtures needs to be designed with the proposed management regime in mind, and

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much work requires to be done to develop reliable and persistent herb-based mixtures for a range of organic management situations.

Heckendorn, Felix; Häring, Dieter Adrian; Maurer, Veronika; Langhans, Wolfgang and Hertzberg, Hubertus (2007) Effect of sainfoin (*Onobrychis viciifolia*) silage and hay against gastrointestinal nematodes in lambs. Paper presented at Zwischen Tradition und Globalisierung - 9. Wissenschaftstagung Ökologischer Landbau, Universität Hohenheim, Stuttgart, Deutschland, 20.-23.03.2007.

- Main finding is that by feeding sainfoin hay, the *H. contortus* burden was significantly reduced compared to the control group. The level of reduction was considerably higher than observed in previous studies using CT's. This suggested that sainfoin hay has a nematocidal effect towards *H. contortus*.
- Animals consuming sainfoin hay in this experiment exhibited higher daily weight gains compared to the controls. It is suggested that this finding is associated with the significantly lower *Haemonchus* worm burden observed in this group compared to the respective control group.
- In regions with moderate climatic conditions the production of soil dry sainfoin hay is problematic because the cut plant needs a short and hot drying phase in order not to lose the CT containing leaves in the drying process.
- As a feasible conservation alternative, ensiled sainfoin was therefore produced for this experiment.
- Although CT-contents were slightly lower in sainfoin silage than in hay, the anti-parasitic effect was largely maintained using this conservation procedure.
- However, no information on the stability of CT-molecules in ensiled tanniferous plants exists.
- Further studies using sainfoin silage must be performed, in order to determine its effect on other gastrointestinal nematodes (GIN) species and to evaluate the acceptance of the strategy among farmers.

Overall, conservation of tanniferous fodder plants offers exciting opportunities.

Keatinge, R (2004) Optimising the production and utilisation of forage for organic livestock (CTE0202). Report, Redesdale, ADAS Consulting Ltd. Defra Project OFO328.

One of the objectives of this project examined the likely effects of organic rations on animal health and product quality.

The point was made that there is much speculation on the role of herbs to supply minerals to organic livestock, but scientific research into individual herbs species, their mineral concentrations and their availability is limited. Chicory, sheep's sorrel, plantain, dandelion and *Lotus* species (trefoils) have all been investigated to some extent as sources of minerals in livestock diets. Whilst these herbs do have high mineral concentrations, their agronomic yield and persistency under UK climatic conditions is often unreliable.

- Studies in the UK, under organic farming conditions (Marley et al, 2003) found that lambs with naturally acquired helminth infections grazing birdsfoot trefoil (*Lotus corniculatus*) had fewer helminth parasites than sheep grazing ryegrass/white clover (*Lolium perenne/Trifolium repens*).
- Lambs grazing birdsfoot trefoil had a lower FEC on day 7 and fewer total adult helminths than those grazing the other forages on day 35.
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- Future use of these herbs within organic systems in the UK is likely to concentrate on their association with parasite control, particularly in sheep systems.

Hume, D T; Lyons, B and Hay, R.J.M (1995) Evaluation of 'Grasslands Puna' chicory (*Cichorium intybus* L.) in various grass mixtures under sheep grazing. *New Zealand Journal of Agricultural Research*, 1995, Vol. 38: 317-328

- The use of different grass species in a mixture with chicory will allow for a modification of the marked seasonal pattern of growth that occurs in chicory dominant pastures (winter dormant, summer highly active) and may increase total annual production.
- This may be best achieved through a companion grass species that not only has complementary seasonal growth to chicory but also a morphology that minimises the competition between the two species.
- Choice of pasture mixture should also consider the requirements of different animal production systems for quality and quantity of pasture throughout the year.

Li, G.D; Kemp, P.D and Hodgson J (1997). Herbage production and persistence of Puna chicory (*Cichorium intybus* L.) under grazing management over 4 years. *New Zealand Journal of Agricultural Research*, 1997, Vol. 40: 51-56

- Maintaining an adequate plant population is a prerequisite for high yields.
- However, a decrease in plant density under grazing management appears to be inevitable, although avoidance of hard grazing in late autumn lessens the decline in plant density (Li et al. 1997).
- Clark et al. (1990a) suggested the desirable proportion of leaf and stem under the best management should be 70% leaf and 30% stem.
- Leaves have a higher in vitro digestibility than stems (Clark et al. 1990b; Li et al. 1997). Therefore, in order to get high-quality feed, chicory should be grazed frequently enough (less than 4 weeks) to produce a high proportion of leaves, especially in late spring and early summer.
- However, if optimal grazing control is missed in spring, mechanical topping appears to be the only way to remove old stem stubble and control secondary and auxiliary stem development in summer.

Scales, G. H., Knight, T. L. and Saville, D. J. (1994). Effect of herbage species and feeding level on internal parasites and production performance of grazing lambs. *New Zealand Journal of Agricultural Research* 38: 237-247.

- In both years lambs grazing lucerne and chicory grew faster than lambs grazing grasses when offered the same allowance of green DM which is consistent with the findings of Nicol & McLean (1970) and Komolong et al. (1992).
- Mineral contents of chicory and lucerne were generally higher than those of the grasses.
- Chicory was higher in N, S, Ca, Na, K and Cu than grasses.
- Lambs grazing ryegrass in general grew more slowly than lambs grazing either cocksfoot or tall fescue.
- The parasitised lambs grazing chicory were daggy in spite of rapid liveweight gains.
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- Dag scores were poorly correlated with FEC or adult nematode populations indicating that drenching lambs on the basis of degree of dagginess is not likely to be an effective strategy to reduce internal parasitism.
- Dag scores were unrelated to carcass gain, higher dag scores being recorded in parasitized lambs grazing lucerne, chicory, and ryegrass.
- In Experiment 1, there was little effect of parasites on carcass gains of lambs fed high allowances which supports other findings that good nutrition may affect parasite populations (Steel et al. 1984) and their impact on production (Jagusch et al. 1980).
- However in Experiment 2, when the parasite challenge was greater, high feeding levels failed to offset the effect of parasitism on production.
- Chicory was the only forage in Experiment 2 where lamb carcass weight gains appeared relatively unaffected by parasites.
- Fewer larvae were recovered from chicory than grass swards suggesting conditions may have been less suitable for larvae development and migration.
- Moss & Vlassoff (1993) also observed reduced larvae counts on chicory.
- This may partially explain the lower FEC and adult nematode populations recovered in lambs grazing chicory, although the possibility of some dietary metabolic effect of chicory on host nematode populations and reproductions cannot be discounted.

In this research the reason for the reduced effect of parasites on lambs grazing chicory was not evident from the results. Chicory is low in tannin content, which has been shown to offer animals some protection from internal parasitism (Niezen et al. 1993b), but high in soluble carbohydrate and minerals which may enable the host to tolerate parasites. Whether chicory affords some anthelmintic property or rumen by-pass activity is open to speculation.

It is concluded that the use of chicory pastures will reduce the effects of parasitism in grazing lambs relative to either ryegrass, cocksfoot, or tall fescue but that the use of lucerne is more variable in its effect on parasitism.

Tzamaloukas, O; Athanasiadou, S; Kyriazakis, I; Huntley, J. F; and Jackson, F. (2005) The effect of chicory (*Cichorium intybus*) and sulla (*Hedysarum coronarium*) on larval development and mucosal cell responses of growing lambs challenged with *Teladorsagia circumcincta*. *Veterinary Parasitology* Volume 127, Issues 3-4, 28 February 2005, Pages 233-243

The aim of this study was to investigate the effects of grazing different bioactive forages on acquired immunity against *Teladorsagia circumcincta* infection. The development of immunity was assessed by following the response of trickle-infected lambs grazing chicory (*Cichorium intybus*; IC), sulla (*Hedysarum coronarium*; IS) or grass/clover (*Lolium perenne/Trifolium repens*; IGC), to a single challenge infection. Parasite-naïve lambs, grazing grass/clover, were also challenged with the single infection dose providing the uninfected control (UGC) group.

- Grazing treatment (chicory, sulla or grass/clover) significantly affected adult worm larval-stage recoveries of the trickle-infected lambs, with IGC group always carrying higher worm burdens than either IC or IS lambs.
- Suggested that the observed effects were due to an enhanced immune response.
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- The results suggest elevated immune responses against *T. circumcincta* infections in growing lambs grazing on either sulla or chicory compared to those grazing on grass/clover, probably due to differences in forage nutritional values.

Dunn R.M., Hopkins A., Buller H., Jones O., Morris C., Wood J.D., Whittington F. and Kirwan J. (2005) "Farm scale investigations of the links between pasture biodiversity and quality food production in the UK" *Presentation to the 13th Meeting of the FAO-CIHEAM Mountain Pastures Network (Quality Production and Quality of the Environment in the Mountain Pastures of an Enlarged Europe) September 15-17, 2005, Udine, Italy (to be published in FAO REUR technical series).*

This research project examines the relationships between biodiversity in pastures and the quality and value of foods produced from them.

It is notable, that following EU Regulation 2078/92, many agri-environmental schemes established in France were constituted around the production areas of distinctive food products such as cheeses, where the extensive grazing of species-rich and characteristic pastures ensures original and in some cases, highly sought-after products (Buller and Brives, 2000).

Examples of grasslands with diverse botanical species, which may affect meat quality characteristics, are salt marsh, limestone uplands, heather mountain pastures and acid heath-land.

There is some scientific but more anecdotal evidence that such pasture types introduce characteristics into meat and cheese, which improve various aspects of quality including flavour.

Three pasture types chosen; Salt-marsh, Heathland, and Moorland
One control farm of improved grassland.

- All groups of lambs had similar muscle fat contents (3%)
- Vitamin E levels were high in all lambs, particularly in those grazed on heather but all were higher than the control.
- Heather and moorland grazed lambs were higher in fatty acids.
- Moorland lambs had higher CLA levels.
- Flavour scores for all lambs were high, with meat from moorland and salt-marsh lamb scoring highest.
- Fat from lambs grazing semi-improved control pasture scored highest for abnormal odour and lowest in lamb flavour.
- This study shows that lambs grazing unimproved pasture produce meat that is of high quality and tastes good.

Daly, M.J., R.M. Hunter, G.N. Green, and L. Hunt (1996) A comparison of multi-species pasture with ryegrass-white clover pasture under dryland conditions. *Proc. N.Z. Grassl. Assoc.* 58:53–58.

- Multi-species pastures can be considered as a serious option for dryland pastoral farming.
- Results have shown that as a medium-term pasture, production is higher than for a standard ryegrass–white clover pasture.
- The long-term persistence of multi-species pasture has yet to be determined, and further monitoring of this trial will allow better assessment of their value as a permanent pasture.

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- Though this trial did not specifically measure pasture quality, the high legume component combined with a significant herb contribution in these multi-species pastures would suggest superior feed quality to a standard ryegrass– white clover pasture, which is likely to translate into better animal performance.
- The performance of the three MSP treatments was not markedly different; however the lucerne MSP performed consistently well, maintaining the highest legume content, and therefore warrants recommendation.
- Future work on multi-species pastures needs to address long-term persistency and animal performance measurements.

Moloney S.C. and Milne G.D. (1993). Establishment and management of Grasslands Puna chicory used as a specialist, high quality forage herb. *Proceedings of the New Zealand Grassland Association*, 55, 113-118.

- Puna has very good potential for finishing deer, sheep and cattle in both summer moist and dryland environments, with animal growth rates similar to that on pure legumes.
- For successful establishment, special consideration needs to be given to paddock selection, pre-plant weed control and seeding methods and depth.
- The major grazing management objective in spring is to ensure a high proportion of leaf relative to stem (i.e., 3: 1, or 70% leaf), rotation length and post-grazing residual height being the two critical factors.

Musgrave D.J. and Daly M.J (2004) Assessment of the performance of non-ryegrass pasture mixtures. *Proceedings of the New Zealand Grassland Association*, Volume 66.

Pasture productivity

- Reports have demonstrated the increased productivity that can be achieved by the use of non-ryegrass pastures or multi-species pastures (MSP) e.g. Judd *et al.* (1990), Ruz-Jerez *et al.* (1991), Johnson *et al.* (1994), Daly *et al.* (1996), Rollo *et al.* (1998).
- Generally these comparisons have shown increased spring and summer production compared to ryegrass, little difference over autumn and in some situations increased winter growth.

Animal productivity

- Including Pawera red clover in the pasture mix gave an increase in beef meat output of about 10% in a grazing trial (Cosgrove & Brougham 1988), an increase in milk production of 24% (Keogh & Thomson 1996) and a 24% increase in weaned lamb growth rate in the (Keogh & Thomson 1996).
- A grazing comparison of tall fescue and ryegrass pastures (Wright *et al.* 1985) showed that for lambs fed the same pasture allowance in early summer, carcass weight gains were not different between the pasture types and taking a previous silage cut made a significant impact on ryegrass liveweight gain, but had little effect on lamb liveweight gain on tall fescue pastures. However for ewes grazed on the same pastures from January to March the higher live weight at mating on the tall fescue based pastures, which resulted from better autumn growth rates (about 100g/hd/day difference during the trial period) gave an extra 11% and 20% lambs born/ewes mated on the tall fescue pastures in the two years of the trial.
- Similar results have come from comparisons with more complex mixtures with deer.
- Other studies have looked at the advantages from MSP on milk production, where on-farm studies have shown increases of around 16 – 23 % (Thom *et al.* 1998, 2002).

Animal health

- Having a range of species in a pasture is an accepted way to balance the mineral status of the diet i.e. tall fescue tends to have low sodium content, which can be a problem in simple mixtures, but is not in complex mixtures.

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- Including herbs, such as chicory or plantain in the pasture, is a particularly effective way of increasing the mineral content of the pasture (Crush & Evans 1990; Stewart 1996) which can give a useful improvement in animal performance (Scales *et al.* 1995).
- Scales *et al.* (1995) and Knight *et al.* (1996) have shown that lambs feeding on lucerne and chicory can have lower levels of internal parasites, which may have the potential to reduce the need for anthelmintics.

Weed infestation

- Ryegrass pastures are quite prone to invasion by weeds such as thistles, particularly after a dry autumn.
- Thistle numbers recorded in a grazing trial illustrate the potential for other pasture species to reduce weed invasion compared to ryegrass. The general pattern was that those species that best form a complete sward, with good cover of the sown species, such as tall fescue and cocksfoot, were best at preventing the invasion of both Nodding and Californian thistles.
- A further noteworthy observation was that the numbers of chicory plants were very low by the time the Californian thistle counts were taken in Year 7. Yet wherever chicory had been included in the original mixture, the number of Californian thistle plants was very low. Since most Californian thistle rhizome growth commonly occurs in the compacted zone just below the cultivation zone, it seems likely that the deep taproot of chicory may be breaking up compacted layers down the soil profile, and making conditions unfavourable for Californian thistle growth.

Fraser T.J. and Rowarth J.S. (1996) Legumes, herbs or grass for lamb performance? *Proceedings of the New Zealand Grassland Association, Volume 58.*

- Analysis of herbage harvested before grazing indicated that chicory and white clover had the highest digestibility and white clover, lotus and chicory had the highest protein content.
- Plantain stem had a very low digestibility and protein content, and in late summer and autumn stem made up 60% of the plantain on offer.
- Intake measured in year one was greatest on chicory and white clover and least on ryegrass and plantain plots.
- Lambs grew significantly faster on white clover and chicory plots than on ryegrass and plantain plots in each of the three years as indicated by liveweight gain, fasted liveweights at slaughter and carcass weights.

Fraser T.J., Scott S.M. and Rowarth J.S. (1996) Pasture species effects on carcass and meat quality. *Proceedings of the New Zealand Grassland Association, Volume 58.*

- Dressing-out percentage varied with year but was always lowest for ryegrass. Carcass analysis showed that white clover-fed lambs had the greatest muscle:bone, but also had the greatest fat:bone.
- Ryegrass-fed lambs had the smallest fat:bone, but also had the smallest muscle:bone. The relationship between the two ratios was positive, indicating that increased muscle is associated with increased fat.
- Lambs grazing white clover or lotus had significantly lower mean pH than those fed on plantain or ryegrass; the pH of lambs grazing chicory was intermediate between those of these two groups.
- Lambs fed on white clover had a significantly stronger sheep meat odour than lambs fed on ryegrass or plantain, but pasture type did not influence the intensity of the sheep meat flavour.
- Lambs fed on white clover or lotus also had a significantly higher foreign odour and foreign flavours than lambs fed on ryegrass, plantain or chicory.

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- As the possible effect of pH on odour and flavour had been taken into account in the tasting trial design, it can be concluded that although pasture type significantly affected the ultimate pH of lambs, pasture type had no significant effect on sheep meat flavour intensity.

Marley, C. L., Cook, R., Barrett, J., Keatinge, R. and Lampkin, N. H. (2006) The effects of birdsfoot trefoil (*Lotus corniculatus*) and chicory (*Cichorium intybus*) when compared with perennial ryegrass (*Lolium perenne*) on ovine gastrointestinal parasite development, survival and migration. *Veterinary Parasitology* 138: 280-290.

- When forages were compared on a dry matter basis, by day 16 there were 31% and 19% fewer larvae on birdsfoot trefoil and chicory than on ryegrass, respectively.
- In the second experiment, replicate 1 m² field plots of birdsfoot trefoil, chicory and ryegrass were sub-sampled on day 14, 21, 35 and 49 for larval counts following the application of sheep faeces containing 585,000 *Teladorsagia circumcincta* eggs to each plot on day 0. Results showed there were a minimum of 58% and 63% fewer infective stage parasitic larvae on birdsfoot trefoil and chicory, respectively, compared with ryegrass on day 14 and 35 when forages were compared on a forage dry matter, plot area sampled and leaf area basis.
- Overall, these results indicate that the number of infective stage larvae on birdsfoot trefoil and chicory pasture was reduced by the effect of their sward structure on the development/survival/migration of ovine parasitic nematodes.
- These effects may be one of the ways in which these forages may affect parasitic infections in grazing livestock.

Soil Association Technical Guides: Managing internal parasites in organic cattle and sheep.(2006)

- Trials in UK with tanniferous crops such as lotus have shown a reduction in parasite burden in weaned lambs;
- Current commercially available varieties in the UK tend not to compete well with weeds, are not very winter hardy and are sensitive to heavy grazing by sheep;
- Chicory has much better agronomic performance than lotus, promotes good lamb growth rates through its nutritional value and/or improved trace element status;
- Lambs grazing chicory have also been shown to have lower faecal egg output.

Turner, N. (1951). *Fertility Farming*. Faber; London.

- Herbal pastures of three to five years duration were regarded as meeting the author's requirements in terms of the provision of soil fertility and health giving animal nutrition.
- In cattle preference tests of 34-35 different herbs, the most favoured varieties were sheep's parsley, plantain and chicory. The next most favoured were burnet, kidney vetch, sainfoin and alsike.
- Turner identified a mixed herbal ley as essential for soil, crop and animal health, aeration of subsoil and transfer of minerals etc from subsoil to topsoil. He also noted that his change to 'Fertility Farming' made bloat a "thing of the past".

Stiefel, W and Popay, I. (1994) Comparing Mixed Herb leys with Ryegrass/White Clover Pastures for early Lamb Growth. In: 10th IFOAM Conference Lincoln University New Zealand. Conference Proceedings, 11-16 December 1994.

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- Mixed herb ley including 8 grasses, 5 legumes and 3 herbs (chicory, sheep's burnet and plantain) compared to ryegrass/white clover pasture.
- Lambs on an organic farm achieved superior growth rates on mixed herb pasture.
- Believed to be mainly due to better nutrition in Jan/Feb (summer) when chicory was a major component, but the mixed pasture may also have reduced parasite burdens by reducing the infective larvae numbers or by enhancing the lamb's natural resistance.

Fisher, G. E. J., Baker, L. J., Tiley G. E. D. (1996). Herbage production from swards containing a range of grass, forb and clover species and under extensive management. *Grass and Forage Science* Volume 51 Issue 1 Page 58-72.

- When sown singly with a standard grass mix the species that competed well with grasses and produced annual forb herbage yields greater than 20 t DM ha were black knapweed, oxeye daisy, ribwort plantain, burnet, birdsfoot trefoil, chicory, kidney vetch, red clover and white clover.
- When sown singly with a standard forb mix, grass species significantly affected the annual yield of total grass ($P < 0.001$) and forb herbage. The species that most suppressed the yield of forbs were common bent, Yorkshire fog and perennial ryegrass.
- Those that allowed for the highest yield of forbs were rough meadow grass, sweet vernal grass and crested dogstail.
- Averaged over the three harvest years, defoliation regime did not significantly affect herbage production, but the inclusion of white clover in mixtures increased the yield of grasses. The use of rosette-type forb blends increased forb yield, compared with erect-type blends.
- The effects of treatments on herbage N and mineral contents and yields were inconsistent. However, there was some evidence to support the view that the presence of forb species in swards can result in greater contents of minerals in herbage, compared with grass-only swards.

Wookey, B (1987). Rushall The Story of an Organic Farm.

- Barry Wookey had a mixture designed that best enabled the trace element requirements of livestock to be met.
- The recommended mixture included burnet, chicory, sheep's parsley as well as red fescue, timothy, perennial ryegrass, cocksfoot and white clover.

MINERAL CONTENT OF HERBS AND GRASSES

Species	P%	K%	Mg %	Cl%	Na %	Fe ppm	Mn ppm	Cu ppm	Co ppm
Yarrow	0.91	4.42	0.98	0.53	0.06	294	48.03	10.06	0.17
Burnett	0.62	2.22	1.82	0.15	0.07	249	31.02	8.00	0.18
Plantain	0.75	3.31	1.01	0.62	0.4	490	35.03	10.05	0.20
Chicory	1.11	5.51	1.07	0.92	0.37	469	57.05	12.05	0.20
Dandelion	0.3	3.59	0.47	2.21	0.64	619	48	18.02	0.13
Red Fescue	0.57	2.19	0.27	0.46	0.05	275	26.02	10.03	0.19
Meadow Fescue	0.58	2.47	0.44	0.66	0.2	250	29.02	9.05	0.16
Trefoil	0.79	2.77	1.27	0.56	0.18	383	43.04	7.03	0.20
Timothy	0.44	2.74	0.36	0.7	0.17	408	25.03	7.06	0.15

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Alsike	0.76	2.59	1.04	0.42	0.06	323	58.08	10.05	0.17
Perennial Ryegrass	0.59	2.38	0.35	0.51	0.19	252	21.06	8.05	0.15
Cocksfoot	0.59	2.78	0.36	0.31	0.17	200	45.05	10.00	0.14

Trace-element requirements of livestock (ppm of dm)

	Cattle	Pregnant Cattle	Sheep
Iron	30	30	30
Copper	10	10	10
Manganese	40	40	40
Cobalt	0.01	0.01	0.01
Iodine	0.12	0.08	0.08
Zinc	50	50	50

Rumball W., Keogh R.G., Lane G.E, Miller J.E, Claydon R.B., (1997) 'Grasslands Lancelot' plantain (*Plantago lanceolata* L.) *New Zealand Journal of Agricultural Research* Vol. 40: 373-377

- There was a significant 27% yield increase of plantain with less frequent grazing.
- Plantain was at least as palatable as white clover.
- In general terms it is higher than ryegrass and white clover for sodium and cobalt, similar to clover (but higher than ryegrass) for calcium, copper, and zinc; and slightly lower than both for potassium and manganese. Lancelot has levels of condensed tannins intermediate between those of chicory and *Lotus corniculatus*.
- Animals did not show it to give rapid weight gains or wool growth, but in each case the foliage was grazed at a very unpalatable growth stage. Robertson et al. (1995) reported very low palatability on foliage that was about 2-3 months old; and intake is known to be very low on such foliage. Fraser & Rowarth (1996) reported lamb growth rates on Lancelot as similar to high-endophyte Nui ryegrass (and less than for chicory, white clover, and lotus) but the feeding trials took place each year in summer/early autumn, when up to 60% of the plantain on offer was made up of stem, which had very low digestibility and protein content.
- Carcass composition was very similar to that from the other forages, when carcass size was taken into account (Fraser et al. 1996). As judged by taste panels, foreign odour and flavour, and sheep meat odour and flavour were similar for Lancelot, chicory, and ryegrass, and significantly less intense than those from lotus or clover.
- In mixtures with white clover, liveweight gains on a Lancelot-clover sward were greater than on mixtures of clover with ryegrass, with tall fescue, and with cocksfoot, though less than on clover with chicory. Sheep on the chicory gained 232 g/day in weight, those on plantain gained 183, and those on the grasses averaged 110 g/day.
- A diuretic property was indicated by the measurement of larger kidneys than would be expected from carcass size (Deaker et al. 1994a; Fraser et al. 1996).
- An anti-microbial property was suggested from experiments indicating inhibition of rumen flora activity though not permanent impairment of the rumen functions (Deaker et al. 1994b).
- There was also evidence of an anthelmintic property from laboratory assays which indicated a mild inhibitory activity towards the motility of third stage *Trichostrongylus colubriformis* larvae in Lancelot extracts. However, any anthelmintic activity in Lancelot plantain was not sufficiently strong to show an effect on internal parasites in the grazing trials of Robertson et al. (1995) and Knight et al. (1996).
- Reduced dagginess in plantain swards has been reported in some grazing trials (T. Fraser unpubl. data). Keogh (unpubl. report) has shown that earthworm numbers and biomass under pure plots

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of Lancelot plantain were over twice as high as those in ten other common pasture grasses and legumes, except for chicory and red clover.

Burke, J.L. Waghorn, G.C and Brookes, I.M. (2002) An evaluation of sulla (*Hedysarum coronarium*) with pasture, white clover and lucerne for lambs. *Proceedings of the New Zealand Society of Animal Production* 62: 152-156

Fifty-six weaned ram lambs were allocated to seven diets: pasture (80% ryegrass and 20% white clover), white clover, lucerne, sulla, and 50:50 mixtures (DM basis) of pasture:sulla, white clover:sulla and lucerne:sulla.

- Lambs fed sulla, white clover, white clover:sulla and lucerne:sulla had the most rapid daily gains (256-263 g/day) while lambs fed pasture gained 105 g/day, respectively.
- Lamb performance can be improved by feeding forage diets other than pasture alone. Sulla has the potential to supplement pasture, but greatest benefits were achieved when fed with white clover and with lucerne.
- Rumen parameters can be used to explain animal performance differences.

Moorhead, A.J.E.; Judson H.G. and Stewart, A.V. (2002) Liveweight gain of lambs grazing 'Ceres Tonic' plantain (*Plantago lanceolata*) or perennial ryegrass (*Lolium perenne*) *Proceedings of the New Zealand Society of Animal Production* 62: 171-173

Liveweight gain and trace element status of lambs grazing pure plantain (*Plantago lanceolata*) swards and high endophyte perennial ryegrass (*Lolium perenne*) pastures was evaluated for 85 days during summer (December - March) under irrigated conditions.

- Under rotational grazing management with frequent (28 day interval) grazing the immature seed head was readily removed from plantain. In contrast, under the same grazing management, ryegrass seed head was almost totally avoided by lambs. The difference in animal performance between this experiment and that of Fraser & Rowarth (1996) is probably due to (1) a cultivar effect based on the lower propensity of Ceres Tonic to produce aftermath seed heads than Grasslands Lancelot which was used in previous experiments and (2) the stem present was grazed at an earlier stage and therefore will have been more palatable (Stewart 1996).
- Although grazing intervals in this experiment were only up to a week shorter than those of Fraser & Rowarth (1996) palatability of reproductive stem appears to decrease rapidly approximately 25 days after seed head emergence (Moorhead, unpublished data). Older mature leaves and hardened stem of plantain are known to be much less palatable to stock than fresh leaf material (Ivins, 1952) but reproductive stem can be highly palatable if grazed before flowering while the reproductive stem is soft (Stewart, 1996).
- Liveweight gain was significantly higher for lambs grazing plantain (222 g/head /day) than ryegrass swards (135 g/head/day) when both were offered at an allowance of 2.5kg DM/head/day. Despite a lower stocking rate on plantain swards, lamb liveweight gain expressed on a per-hectare basis tended to be greater for the plantain treatment (6.0 kg/ha/day) than for the ryegrass treatment (5.1 kg /ha/day) although this did not reach statistical significance.
- Lambs grazing pure plantain swards had significantly higher liver copper and higher liver selenium concentrations but similar vitamin B₁₂ (concentration compared with ryegrass-fed lambs. These results indicate that well managed plantain is able to support relatively high rates of

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liveweight gain in lambs through summer and elevate liver copper and selenium concentrations and, therefore, could make a significant contribution to pastures in lamb finishing systems.

Woodward, S.L. Waghorn, G.C. Lassey, K.R. and Laboyrie, P.G. (2002) Does feeding sulla (*Hedysarum coronarium*) reduce methane emissions from dairy cows? *Proceedings of the New Zealand Society of Animal Production* 62: 227-230

An experiment conducted in late summer using Friesian and Jersey dairy cows investigated whether feeding sulla (*Hedysarum coronarium*), a condensed tannin (CT)-containing legume, reduced methane emissions without compromising milk solids production.

- Cows grazing sulla had higher intake and milk solids production than cows grazing perennial ryegrass pasture. Total daily methane emissions were similar. However, cows fed sulla produced less methane production per unit DMI and per unit milk solids yield than those fed ryegrass due to the higher nutritive value of sulla compared with the ryegrass, and possibly the presence of CT.
- The results of this study clearly indicate that CT-containing legumes, such as sulla, do effectively reduce methane emissions from dairy cows without compromising milk solids production.

Woodward, S.L. Waghorn, G.C. and Laboyrie, P.G. (2004). Condensed tannins in birdsfoot trefoil (*Lotus corniculatus*) reduce methane emissions from dairy cows. *Proceedings of the New Zealand Society of Animal Production* 64: 160-164

- Total methane production, was similar for the lotus and ryegrass cows, however, methane production per unit DMI was lower from cows fed lotus.
- The CT in lotus reduced methane production by 13% relative to lotus and was responsible for 66% of the difference between lotus and ryegrass.
- Cows fed lotus produced 32% less methane/kg milk solids compared to good quality ryegrass.
- This trial has clearly demonstrated that grazing dairy cows fed lotus increased milk production and reduced methane emissions per unit DMI or MS.
- The feasibility of feeding lotus as a methane mitigation option should now be assessed at a farm systems level to investigate effects on other greenhouse gases, productivity and profitability.
- These measurements will complement the partial life cycle analysis of Van der Nagel *et al.*, (2003) who showed the methane and carbon dioxide emissions associated with grain-based rations substantially exceeded those for pasture when expressed in terms of annual production.

Barry, T.N; Parkinson, T.J; Ramirez-Restrepo, C.A; McWilliam, E.L. and Lopez-Villalobos, N. (2004). Can mating ewes on condensed tannin-containing forages be used to reduce lamb mortality between birth and weaning? *Proceedings of the New Zealand Society of Animal Production* 64: 30-33

In a range of field experiments conducted in NZ over 12 years, grazing ruminants on *L. corniculatus* has been associated with increases in wool production (15%; Min *et al.*, 1998), milk production (20-40%; Wang *et al.*, 1996; Woodward *et al.*, 1999) and ovulation rate (20.30%; Min *et al.*, 1999, 2001), relative to control sheep grazed on perennial ryegrass / white clover pasture, with generally at least 50% of these increases due to the action of its CT. The increases in ovulation rate were associated

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with increases in plasma concentration of total essential amino acids (EAA) and branched chain amino acids (BCAA), with studies showing that most of this could be attributed to CT.

The legume *Lotus corniculatus* (Birdsfoot trefoil CV Grassland Goldie) was fed in two experiments and supplements of willow or poplar forage trees were given to ewes mated on low quality drought pasture in three experiments.

- Both *L. corniculatus* and the forage trees contained condensed tannins (CT) and in addition the crude protein content of the forage trees (166 g/kg DM) was much higher than that of drought pasture (122 g/kg DM).
- Mating on *L. corniculatus* and supplementing with forage trees consistently increased lambing percentage.
- Lamb mortality between birth and weaning was significantly reduced by mating on *L. corniculatus* in one experiment and by feeding forage trees during mating in one experiment. Similar trends of smaller magnitude were evident in the other experiments and did not attain statistical significance.
- In a systems approach conducted at Riverside farm in the Wairarapa, feeding *L. corniculatus* for 9 weeks during mating increased scanning and lambing percentages relative to control ewes mated on grass-based pastures as expected, but also substantially reduced post-natal lamb mortality.
- Feeding strategies which increase EAA absorption during mating therefore seem to consistently increase ovulation rate and lambing percentages and to reduce post-natal lamb mortality under some but not all conditions.

The mechanisms by which CT exerts its effects upon pre- and post-natal lamb survival remain to be elucidated. Nonetheless, given that the main nutritional effects of CT is to increase the availability of EAA, particularly BCAA, we postulate that its effects depend upon their creating a supply of amino acids that are better able than pasture-derived protein to support early embryonic development. This, in turn, might be expected to improve rates of development of the embryo/foetus and its placental attachments, with later, long-term consequences upon the foetus/neonate's carbohydrate and protein metabolism.

Additionally, where the period of ideal protein availability also spans the period of organogenesis and development of the haemopoietic and immune systems, it may also affect these. How long these effects of improved protein nutrition persist through the animals lives also remains unknown: longevity and/or survival studies would therefore be of considerable interest as well.

- Nevertheless, by whatever means the response to CT is effected, it is clear that it behaves as a permanent/long-term non-genetic response to the maternal environment that is present in the very early post-mating period of gestation (or, possibly, even in the period when final selection and maturation of the follicles that give rise to these embryos is taking place).

The challenge that is presented by the foregoing studies is, therefore, to identify the critical points at which improved protein nutrition affects the reproductive system (i.e. to affect lamb survival). Management and nutritional strategies can then be developed that include the use of CT-containing plants and also other methods of increasing the supply of EAA and BCAA to grazing ewes over the critical time period.

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Schreurs NM, Molan AL, Lopez-Villalobos N, Barry TN, McNabb WC (2002) Effect of grazing undrenched weaner deer on chicory or perennial ryegrass/white clover pasture on gastrointestinal nematode and lungworm viability. *Proceedings of the New Zealand Society of Animal Production* 62(), 143-144.

- Hoskin *et al.* (1999) found that undrenched weaner deer grazed on chicory did not have impaired growth rates and faecal egg counts were lower compared to similar animals grazed on perennial ryegrass/white clover pastures. This suggests that chicory has the potential to be used in farming systems to reduce the negative impact of internal parasites.
- Grazing forages containing high levels of condensed tannin have been shown to maintain productivity in parasitized sheep (Niezen *et al.*, 1995).
- Chicory has reduced the number of infective larvae found on the forage, this being attributed to plant morphology and sward structure (Moss and Vlassoff, 1993).
- Chicory also has a high feeding value, which is likely to improve the host's resistance to internal parasites.
- Condensed tannins are likely to be the secondary compounds responsible for the inhibitory effects on larvae in the rumen of deer while other secondary compounds are likely to take effect in the abomasum.
- It can be concluded that feeding chicory in a grazing system is a potential tool for controlling internal parasites in deer with reduced anthelmintic input.

Ramirez-Restrepo CA, Barry TN, Lopez-Villalobos N, Kemp PD, Pomroy WB, McNabb WC, Harvey TG, Shadbolt NM (2002). Use of *Lotus corniculatus* to increase sheep production under commercial dryland farming conditions without the use of anthelmintics. *Proceedings of the New Zealand Society of Animal Production* 62(), 177-178, 2002

Condensed tannins (CT) in *Lotus corniculatus* (Birdsfoot trefoil) reduce rumen protein degradability and increase essential amino acid absorption from the small intestine (Waghorn *et al.*, 1987). Separate feeding experiments with sheep have shown that CT in lotus increased wool production and milk secretion (Wang *et al.*, 1996a&b) and both ovulation rate during mating, and lambing percentage (Min *et al.*, 1999; Min *et al.*, 2001), all with no increase in voluntary feed intake (VFI).

- These results show that grazing on CT-containing *Lotus corniculatus* can be used to simultaneously increase wool and body growth, whilst at the same time minimizing FEC, dag formation and, hence, the requirement for anthelmintic drenching.
- Similar results were found when the experiment was repeated in the 2001 spring (Ramirez-Restrepo *et al.* unpublished).
- Under dryland farming conditions, use of *Lotus corniculatus* increased wool production and growth of lambs with reduced anthelmintic use, probably due to the effects of its condensed tannins in reducing rumen protein degradability and in controlling internal parasites, reducing costs for the farm and improving the quality of the final product in the market.

Other Research/Anecdotal Evidence

The copper status of deer was reported to be better when grazing chicory than when grazing ryegrass-based pastures (Grace *et al* 2003; Hoskin *et al* 2003). Chicory was found to have higher concentrations of copper and cobalt (Barry *et al* 2002).

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In ewes rearing twin lambs, Wang et al. (1996a) found that CT from *L. corniculatus* increased milk yield, protein and lactose percentage, reducing fat percentage. The higher protein percentage could be due, to an increase of amino acids (AA) and especially essential AA flows from the small intestine.

Mixed species pastures are said to have a calming effect on cattle and seemed able to carry stock longer than might otherwise be expected (Newman, J. pers com).

Chicory if cut or topped when mature needs to be rolled afterwards in order to prevent water entering the stems and rotting and killing the plant. This is less relevant in dry conditions but quite relevant to large areas of the UK (Dunne, F pers com).

Chicory can also be difficult to make into hay (M Measures pers comm.).

Sainfoin is said to lack competitiveness and yield in the UK climate and is alleged to be more appropriate for alkaline and dryland conditions (Mark Measures pers com).

Peter Desborough a pasture consultant in New Zealand describes plantain as highly palatable to all livestock, establishes rapidly, is very drought and pest tolerant and has a high mineral content.

In his experience cattle grazing chicory show excellent production as its forage is digested much more rapidly than normal pasture and this helps to account for high liveweight gains from chicory pasture and also helps animals to maintain good health (Desborough, P 2007).

3. Analysis and Conclusions

This review had identified a number of key findings which should have a direct impact on actual farm practice. There are also aspects that offer sufficient to justify further research and/or on-farm trialling.

There are also aspects where knowledge and practical experience need extending, identifying and description. The latter is needed in order to enable wider access to farmers for practical use.

Mixed Species Pasture (MSP)

Research indicates:

- Superior pasture yield vs. ryegrass and ryegrass/white clover;
- Improved feed quality;
- Reduced numbers of parasitic worms on pasture;
- Lower FEC's in lambs and deer;
- There are also an indication that they may have a positive impact on weed suppression/reduction;
- Animal production in terms of lamb growth and deer growth is superior to ryegrass/white clover pastures;
- Superior mineral content; and
- Improved performance in dryland, drought prone conditions.

Perennial ryegrass was found to be a species that most suppressed the yield of herbs.

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The advantages of MSP are clear from the research and are more specifically outlined below by way of a review of individual components. Their use within organic systems appears to have significant advantages.

The make up of whole mixtures and their management requires further research and clarification but will be entirely dependent on soil type, climate, livestock classes, and feed conservation.

There is more research on the animal production/performance impact of MSP in beef cattle to support the anecdotal evidence and in dairy cows to support the work done on individual components lotus and sulla (see below).

Chicory

One of the most widely researched herbs and the one with the clearest positive results.

- Lower larvae counts on pasture due to plant morphology and sward structure;
- Superior growth/production rates in deer and lambs;
- High yielding
- Reduced presence of parasitic worms in lambs and deer i.e. lower FEC's
- Suggested enhanced immune response in lambs, probably due to nutritional value
- Reduces the effects of parasitism in grazing lambs
- Greater carcass weight in lambs
- High mineral content e.g. zinc, copper and cobalt
- High protein content
- Deep rooting
- Possible negative impact on pasture weeds

Regular but not overgrazing is important in its management to ensure the appropriate leaf to stem ratio (70:30). The avoidance of hard grazing in the autumn is also recommended.

Chicory has great potential as a key component in organic pasture mixtures for finishing systems. Its positive impact on growth/production and reduced presence of parasitic worms are clear reasons for its inclusion in pastures for lambs, deer and possibly sheep milking (this would require further research).

There is some research and anecdotal/practical evidence which also supports its use in cattle finishing pasture systems and as mentioned above this is an area of future research opportunity along with its role in mixtures for dairy systems. The issue of milk taint from chicory may possibly be overcome through its inclusion in a diverse pasture mixture (MSP) the grazing of which by dairy cows may also deliver production, health and climate change issue benefits.

Sainfoin

A crop with enormous potential but without the volume of research that exists for chicory. The research that does exist is however clear and very positive.

- Reduction in FEC
- Possible anti-parasitic/nematocidal effect
- Palatable to sheep
- High content of utilisable crude protein
- High levels of CT's, also available as conserved forage
- Useful as a specialist crop for conservation or inclusion in specialist grazing mixes
- High daily weigh gains achieved

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There is more research required on Sainfoin to extend and support the existing work but its use in organic systems within specialist grazing and/or conservation mixtures is highly promising and its performance significant. It is sufficiently positive to justify on farm trialling at least, based on current evidence.

It could benefit by the development of superior competitiveness and persistence in a grazing situation as it said to be difficult to maintain.

Lotus

A high condensed tannin forage with good research behind it but there are some questions over its persistence/maintenance in the UK climate although this is not a consistently held view.

- Reduced parasitic worm counts on the forage due to effect of sward structure
- Reduced FECs in lambs and deer
- Good growth rate in lambs and deer
- Increased milk production (MS) in dairy cows but with lower methane per unit of milk solids
- Lower methane emissions from dairy cows per unit of DMI
- Increased ovulation rate in ewes, mainly attributed to CT
- Mating on lotus considerably increased lambing%
- Lamb mortality between birth and weaning significantly reduced
- Greater carcass weight in lambs and deer
- Possible negative impact on meat in terms of odour and flavour
- Allegedly struggles in a UK winter and less easy to maintain than chicory

It clearly has a role to play in organic MSP for its positive impact on growth rate and parasite reduction, in livestock rearing/finishing systems. Its significant impact on lambing performance and reduced mortality in lambs is strong evidence to support its use in sheep systems.

Its positive impact on lowering methane per unit of DMI and MS in dairy cow systems is also highly significant with the developing problem of global climate change and the seemingly disproportionate impact of agriculture.

The impact of odour and flavour are very unlikely to be material within a diverse sward.

The other negatives surrounding lotus, most particularly its persistence (or lack thereof) suggest greater work is required on its management and also its climatic limitations i.e. it may be fine in the south east but perhaps not west Wales. As with sainfoin, work is needed to advance persistence in a grazing situation. The issue of climate is relevant given that it has performed so well in eastern dryland systems in New Zealand.

Sulla

This is similar to lotus but perhaps even better adapted to a more Mediterranean style climate and therefore its ability to over winter in the UK must be highly questionable. It is grown in southern Italy in Europe and the research around sulla and its value is predominantly NZ based. That said it may be worth trialling in milder regions/climates.

- High condensed tannins
- Lower FEC's in lambs
- Suggested enhanced immune response in lambs, probably due to nutritional value
- Probable good nutritional value/higher feed value (vs. ryegrass/white clover)

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- Higher lamb liveweight gains (vs. r/wc)
- Greatest performance benefits when fed with other components such as lucerne and white clover
- Less methane per unit of DMI and MS in dairy cows
- Higher MS production for dairy cows vs. ryegrass
- Strong tap root
- Good conservation potential in the right climate

It is likely that advances in its persistence under UK climatic conditions would be required before it could be seriously considered. Its positive impacts are such however that it justifies further research under UK conditions.

Plantain

Plantain has a role in MSP on organic farms and is particularly recommended for drier, less fertile soils. As with chicory it requires regular but not overgrazing. The research supports the case for plantain having some medicinal qualities and suggests breeding pursues this strength and a greater ability to perform in fertile soils.

- Higher sodium and cobalt than ryegrass and white clover
- Higher calcium, copper and zinc than ryegrass (similar to white clover)
- Slightly lower K and Mn than ryegrass and white clover
- CT levels between that of chicory and lotus
- Low digestibility and protein content if predominantly older stem
- Palatability of stem reduces rapidly approximately 25 days after seed head emergence
- Lambs had higher liver copper and selenium concentrations but similar vitamin B12 vs. ryegrass fed lambs

There were some contradictory results in terms of palatability and animal performance which are probably due to i) different cultivars and ii) stem grazed earlier is more palatable, as was the case for the positive results.

Wild, diverse native pasture

This refers to salt marsh, heather uplands and moorland type pastures. The nutritive, health and meat quality parameters offered by these pastures is outstanding. This is a fact perhaps better recognised elsewhere and particularly in France, where products of such pastures (meat & cheese) tend to attract AOC status. The research gives weight to supporting the preservation and utilisation of such pastures and although it is beyond the scope of this review, marketing systems to support the conservation and utilisation of these bio-diverse pastures are well justified.

- Higher levels of healthy fatty acids
- Higher CLA levels
- Superior flavour scores
- Higher Vitamin E levels

Other

Herbs such as sheep's parsley, burnet and kidney vetch are mentioned in 'classic texts' such as Fertility Farming (Turner 1951). There is very little or no research base and evidence for their use.

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However seed merchants and researchers working with herbal pastures have been supportive of and suggest their unpublished trials were positive in terms of burnet and sheep's parsley's performance as components of MSP.

Kidney vetch is a legume usually regarded as a herb and is purported to be drought resistant, good on poor soils (less so on good soils) and highly palatable to stock. No research could be found into its impact on animal health, pasture performance or eating quality of meat from animals fed kidney vetch. There is clearly an opportunity for some research on this herb/legume along with burnet and sheep's parsley amongst others.

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