SOLID participatory research from UK: Performance of Diverse Swards on Commercial Dairy Farms

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Summary

The use of herbal leys and mixed swards became rare in the UK even from the late fifties mainly due to the rise of the commercialisation in agriculture but, the practice survived with a few enthusiasts, mainly in organic systems, or as part of specific habitat management schemes. Nowadays there is a renewed interest and farmers are seeking more information about how to manage diverse swards and how to best exploit their potential for milk production on dairy farms. This is because mixed lays can have benefits both for the pasture and animal productivity but also for the environment. Recent evidence shows that legume-based leys can maximise pasture productivity and other ecosystem services while functional diverse plant species can be optimised and fine-tuned to farm-specific needs. Diverse swards have increased above-ground biomass and greater stability of biomass production compared to monocultures while productivity increases over time. In addition, they have greater resilience to adverse weather, climate and management conditions. The aim of this case study was to determine the establishment and the productivity of diverse swards compared with ryegrass-white clover on commercial dairy farms and to determine how the evolution of the species mix varies with grazing conditions and soil type.

Four farms participated in this project and agreed to establish a diverse sward leyson their farms with the aim to compare its productivity with the standard leys (i.e. grass-clover) that the farmer normally uses. In three farms experimental swards were established by the farmer's usual methods in spring 2013, while swards in Farm 4 were established in 2007 (the farmer re-seeds the sward every 2-3 years with the mix shown in Table 1). The content of the seed mixtures was discussed with the participating farmers and they were designed and prepared in discussion with seed suppliers and with input of a livestock consultant. On two farms one mix was designed for light, drought-prone land and one for heavier land. Both seed mixtures contained a range of grasses, legumes and herbs, designed for grazing and robustness.

The farmers committed to a research protocol that defined how and when the botanical assessments and pasture productivity data collection should be done. Assessments and data collection on one farm were carried out by the ORC researcher. However, contrary to our expectations three farmers did not succeed in carrying out the full assessments and the research outcomes in this study depend on the data collected form one farm only.

The fact that the farmers did not succeed in carrying out the assessments highlights the importance of their involvement for the successful completion of participatory studies. Nevertheless, the results collected from one farm only show that although pasture productivity of the diverse sward lay was slightly lower than that in the grass-clover lay, the total productivity remained relatively high suggesting that diverse pastures can serve as a viable alternative to conventional pastures.

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1 Aims and Research question

The aim of this a study was to assess the establishment and the productivity of diverse swards compared with ryegrass-white clover mixtures on commercial dairy farms and to determine how the evolution of the species mix varies with grazing conditions and soil type.

2 Background

2.1 Farmers' Background

There is a growing number of organic or low-input conventional farmers who are interested in increasing the diversity of swards grazed by their cows.

At the beginning of this participatory study (i.e. autumn 2012), a group of farmers met and discussed what do they expect of their grazing pastures. According to their expectations a grazing pasture should have the following key properties:

- Herbage production must promote high milk yield of good quality (fat, protein) and should be of about 12 t of DM per ha.
- Herbage production throughout the year at an affordable cost.
- Should promote drought and flood resistance.
- Palatability, persistence and longevity.
- Promote animal health and welfare (no bloat, anthelmintic properties, minerals).
- Enhancing soil fertility and ease of conservation.

Diverse swards were considered likely to provide several of these attributes since including a wide variety of species in the sward can increase soil resilience to drought and flooding while mixed lays provide forage of quality to the cow with wide range of nutrients. Mixed swards are also characterised by high resilience towards varying physical conditions and cope better with on less fertile soils (low organic matter) while mixing species with different properties allows for better weed control.

This is because mixed lays can have benefits both for the pasture and animal productivity but also for the environment. For example, some farmers by introducing a wider variety of legumes to grazed pastures aim to increase N-fixing potential of the pasture which is essential for fertility building in addition to other benefits that come from the high protein content of the sward. Most of the mixed leys used on-farms also include herbs which are a good source for minerals (Pirhofer-Walzl et al., 2013) while other plants have medicinal properties. For example, chicory and sainfoin are known to have anthelmintic properties and can help to reduce drug-use for internal parasitic control at a farm level (Li et al, 2005) and species with high tannin content can enhance the rumen by-pass protein intake in ruminants.

Some farmers express concerns associated with grazing legumes related to bloat. The main preventive measures are to keep the diet as constant as possible and in this respect, high quality diverse swards can be part of the solution. Organic farmers report that spreading salt on the pasture reduces the risk of bloating in legume-rich pastures. Anecdotal evidence from a farmer in the group also suggested that allowing the plants to flower before they are grazed has reduced the risk of bloat.

This study aimed to compare the establishment and productivity of a diverse sward and a ryegrass/clover sward under similar conditions on three farms collecting data for two years with the contribution of the participating farmers. More specifically the study aimed to carry out assessments of a diverse mixture including legumes, herbs and grasses, under grazing on different farms and compare them with that of the grass/clover lay. Monitoring of the abundance of the sown species at the different farms aimed to determine how different plant species in a mixed lay establish over time in different grazing and environmental conditions. Assessments were also carried out regularly by the ORC researcher on one farm which already uses diverse swards for grazing of young stock (heifers and steers).

2.2 Research Background

Over the last fifty years or more, with the drive for high levels of production, the use of herbal leys and mixed swards became rare in the UK, surviving with a few enthusiasts, mainly in organic systems, or as part of specific habitat management schemes (Foster, 1988). Nowadays there is a renewed interest and farmers are seeking more information about how to manage diverse swards and how to best exploit their potential for milk production in dairy farms.

It has been shown that legumes and herbs (i.e. red clover, white clover and chicory) compared with grasses can provide considerable higher amounts of minerals per kg DM of grazed forage (Lindstrom et al, 2013) which is particularly important for the pasture-fed cow in organic or low-input dairy farms. The same study also showed that the micronutrient status of the soil, and variety within plant species has a minor effect on the mineral content of legumes and herbs, but the pH of the soil can affect mineral concentration in the herbage, particularly of Mn and Mo. In digestibility trials with sheep, Andueza et al (2013) have found that swards rich in forbs are of higher digestibility in early season compared to swards rich in grasses, indicating nutritional advantages of mixed swards. The study of Seither et al (2012) showed that diverse swards generally produce herbages of higher nutritive value than grass dominated swards.

In the UK, information about the performance of diverse swards and the benefits of mixing species comes from the recent “LEGLINK” project (completed in 2013). This project aimed to determine the ease of establishment of mixed legume species and their efficiency of production over time in different areas in the UK. The project involved replicated field experiments in multiple locations across the UK and trials tested the performance of 12 legume and 4 grass species that were sown in monocultures or as a mixture; in addition, the study mixture was compared to farmer-chosen ley mixtures. It was concluded that species-rich legume-based leys can maximise pasture productivity and other ecosystem services while functional diverse plant species can be optimised and fine-tuned to farm-specific needs. More specifically, the project revealed evidence that diverse swards have increased above-ground biomass and greater stability of biomass production compared to monocultures while productivity increases over time. In addition, they have greater resilience to adverse weather, climate and management conditions.

According to the LEGLINK project (Döring et al 2012), mixes with high agronomic productivity contain both Lucerne and White Clover while the overall performance improves by including a third or fourth legume species. The three best multifunctional mixtures all contained Black medic, Lucerne and Red clover. Some species such as meadow pea, winter vetch, large birdsfoot trefoil showed low performance almost on every occasion; however, these species can perform better under other

climatic conditions as other European studies have shown. White clover consistently performed well in terms of yield and persistence and its creeping habit makes it the best legume adapted to grazing. Red clover is generally more productive than white clover, but, less persistent and less tolerant to high grazing pressure than white clover (Smetham, 1973; Cormack, 1996). Due to its long roots, red clover is regarded as drought tolerant (Knight et al, 2008). Lucerne also produces high quality feed, when dried or ensiled, although it is not commonly grazed. The LEGLINK project showed that Lucerne is a high yielding species but not significantly higher than red or white clover. At some sites, Lucerne appeared to be relatively intolerant to being cut short, suggesting intolerance to grazing. Nevertheless, some farmers claim that they have managed their stock to grazed it successfully. In addition, Lucerne offers benefits in terms of drought tolerance and is known to require well drained soil, so it can replace vetch in heavy soils. In terms of grass species, ryegrass is recommended for high yield while Festulolium, which is a cross between a Fescue and Lolium (Perennial or Italian Ryegrass), provides a combination of high quality forage with good winter hardiness, persistence and stress tolerance.

Sweet clover seed performs best when inoculated with rhizobium bacterial. In the LEGLINK project it did not perform particularly well without inoculation. It is deep rooted, so would contribute to mining nutrients; factors making it less suitable for grazing are the risk of bloat, a bitter taste due to coumarin content, and the fact contains an anti-coagulant produced from the coumarin which can cause a bleeding disease. Sainfoin is attractive as a non-bloating legume, but does not survive well in competition from grasses.

The herb species commonly included in grazed leys are largely chosen for either their deep rooting nature and hence their ability to reach minerals from deep in the soil, or for palatability and possible medicinal properties. The most common are chicory, ribwort plantain or “ribgrass”, sheep’s parsley, burnett and achillea. The following notes are taken from Turner (1974): «*Burnett is highly palatable, deep rooting and has tonic properties. Plantain is also palatable, and contains a very high concentration of minerals. Achillea has high protein and tonic properties. Chicory can root up to ten feet deep, so is the ultimate collector of minerals from deep in the soil. It has remarkable powers of recovery after grazing in dry conditions. Sheep’s parsley is included for its medicinal value, being high in minerals and in the compound “apiol” which is effective for treating kidney and bladder complaints*».

3 Methodology and data collection

3.1 Location of the Farms

Four farms participated in this project; Farms 1 and 2 are located in Berkshire, Farm 3 is located in Devon and the fourth farm is located in the Cotswolds, near Gloucestershire, UK.

3.2 The seed mixtures used

The content of the seed mixtures was discussed with the participating farmers and based on the literature reviewed were designed and prepared in discussion with seed suppliers and with input of a livestock consultant from the Farm Consultancy Group, UK and a livestock researcher from the ORC.

Table 1: *Composition of the seed mixes used in the participating farms.*

Species	Variety	Farms 1 & 3*		Farm 2	Farm 4
		Mix 1	Mix 2		
Grasses		% by weight			
Cocksfoot *(Dactylis glomerata)*		10.0			7.8
Creeping red fescue *(Festuca rubra)*					5.4
Crested dogstail *(Cynosurus cristatus)*					1.6
Festulolium *(Festulolium loliaceum)*	Perun, organic	12.5	22.5		
Foxtrot *(Pennisetum alopecuroides)*	Pastour, organic	20.0	20.0		
Italian ryegrass *(Lolium multiflorum)*					7.8
Meadow fescue *(Phleum pratense)*					7.0
Meadow fescue *(Phleum pratense)*	Rossa			7.0	
Perennial ryegrass *(Lolium perenne)*	AberAvon, organic			20.0	
Perennial ryegrass *(Lolium perenne)*	AberDart, organic			15.0	
Perennial ryegrass *(Lolium perenne)*	Aston Princes, organic			30.0	
Perennial ryegrass *(Lolium perenne)*					7.8
Meadow grass *(Poa pratensis)*					1.6
Tall fescue *(Festuca pratensis)*					3.9
Timothy *(Festuca arundinacea)*					5.4
Timothy *(Festuca arundinacea)*	Dolina	7.5	7.5		
Timothy *(Festuca arundinacea)*	Presto			8.0	
Yellow oatgrass *(Trisetum flavescens)*					1.6
Legumes		% by weight			
Alsike clover *(Trifolium hybridum)*					1.6
Sanfoin *(Onobrychis viciifolia)*					20.2
Sweet clover *(Melilotus officinalis)*					5.4
Birdsfoot trefoil *(Lotus corniculatus)*					2.3
Lucerne *(Medicago sativa)*		5.0			
Red clover *(Trifolium pratense)*					2.3
Red clover *(Trifolium pratense)*	Maro	12.5	17.5		
Vetch *(Vicia orobus)*	Early English organic	15.0	15.0		
White clover *(Trifolium repens)*					2.3
White clover *(Trifolium repens)*	AberConcord			5.0	
White clover *(Trifolium repens)*	Avoca medium leafed	2.5	2.5		
White clover *(Trifolium repens)*	Barblanca			10.0	
White clover *(Trifolium repens)*	Riesling large leafed	5.0	5.0		
Herbs		% by weight			
Burnet *(Sanguisorba minor)*		2.5	2.5	1.1	6.2
Chicory *(Cichorium intybus)*		2.0	2.0	2.0	5.4
Ribgrass *(Plantago lanceolata)*	Ribwort	2.5	2.5		
Ribgrass *(Plantago lanceolata)*	Tonic			1.4	
Ribgrass *(Plantago lanceolata)*	ribwort plantain				0.8
Sheeps Parsley *(Petroselenium Crispum)*		2.5	2.5		2.3
Yarrow *(Achillea millefolium)*		0.5	0.5	0.5	1.6

* In farms 1 and 3 the same seed mixes were used; Mix 1 for light, drought-prone land and Mix 2 for heavier land. In farms 2 and 4 only one seed mix was used.

For Farms 1 &3 two different seed mixtures were formulated. One mix was designed for light, drought-prone land and one for heavier land. Both seed mixtures contained a range of grasses, legumes and herbs, designed for grazing and robustness. A detailed overview of the seed mixtures used in each farm is given in Table 1. Grass species included ryegrass, (for yield) cocksfoot (for the light land mix due its drought tolerance), Timothy (winter hardy and better adapted to heavier land) and Festulolium. Legumes included were red and white clover, lucerne, vetch, sainfoin and sweet clover. The control mix on each farm was the mixture that the farmer would normally use.

Control and experimental swards were established in three farms (Farms 1 2 and 3) by the farmer's usual methods in spring 2013, while swards in Farm 4 were established in 2007 (the farmer re-seeds the sward every 2-3 years with the mix shown in Table 1). On all farms the "control" mix was established in equivalent conditions in terms of date, soil type, site location and establishment methods. In every farm the area used to establish the diverse swards was large enough to hold one day's grazing by the dairy herd.

3.3 Data collection and sampling

Assessments and data collection in Farm 4 were carried out by the ORC researcher while collection of the data in the remaining farms (i.e. Farms 1, 2 and 3) was relied on farmer's input, meaning that the farmer was the sole responsible to carry out the assessments, to collect samples and provide all the data needed according to a mutually agreed research protocol. Preliminary assessments regarding the establishment of the plant species in each treatment were meant to be carried out by the farmers in 2013 (late summer – autumn). In 2014 three assessments with regards to herbage production, pasture productivity and determination of sward composition were agreed to be performed from April to September and each farmer was asked to keep records of the following data.

3.3.1 Percentage cover of sown mix and botanical assessment

The percentage cover of sown mix in addition to the percentage of weeds stubble-crop and bare ground was agreed to be estimated by the by the DAFOR scale using a one-square meter quadrat. Briefly, the DAFOR scale is used to assess terrestrial vegetation coverage. DAFOR It is a useful tool that visually assesses the abundance of any species on a semi-quantitative or as in this case qualitative level with D = Dominant; A = Abundant, F = Frequent, O = Occasional, R = Rare. The farmers were provided with recording sheets that included all the seed species used for the establishment of the diverse swards in their farms and were asked to record the relative abundance of each species they find in the one-square meter quadrat. In cases were species seems intermediate between two categories the farmers were asked to choose the lower category (e.g between occasional or frequent, to choose occasional). For each assessment, the farmers were asked to perform the procedure at least three times per plot (i.e. the replicates per plot). The DAFOR classes have no strict definition so personal interpretation is required when applying this scale (Sutherland1996).

Picture 1. *Assessing percentage cover according to DAFOR scale and forage productivity using a one-square meter quadrat.*

3.3.2 Estimation of forage DM

The square-metre quadrat method was also used to determine the productivity of the diverse swards and control pastures. Briefly, a one-square-metre quadrat was placed randomly three times across the plot and all the vegetation within the quadrat area was cut to approximately 5 cm height; the cut herbage from each quadrat was collected in separate bags and fresh weight was recorded. DM content of the herbage both in the diverse sward and control plots were determined, allowing the calculation of the total DM productivity of the field. On Farm 4 additional herbage samples were analysed by wet chemistry for metabolisable energy (ME) and Crude Protein (CP) content.

3.3.3 Monitoring of farm records and additional calculations

At the end of the monitoring period in year 2014 each farmer was asked to provide data and information regarding milk production and composition, grazing records (i.e. area and livestock numbers grazed daily) as well as supplementary feeding records regarding forage and concentrate supplementation, amounts and periods fed.

3.4 Time Scale

The project initiated in 2013 with the establishment of the experimental pastures while in farm visits in late 2013 and early 2014 the farmers were trained on how to carry out the assessments themselves. Systematic data collection lasted from March to September 2014.

4 Results and Discussion

Contrary to our expectations and despite the fact that farmers were initially keen on participating, providing their land and time for the purposes of this study, none of the farmers succeeded in carrying out the assessments. One farmer notified us in early 2014 that he wishes to withdraw for the study due to time limitation. As a result, this report will present only the pasture productivity and herbage composition data collected by the ORC researcher in Farm 4.

The productivity of the diverse sward during the monitoring period (i.e. May to September 2014) averaged 10.5 tonnes per hectare. Herbage composition and monthly productivity of the diverse swards grazed by young stock (i.e. dairy bulls and heifers) from April to September are shown in Figure 1a. Preliminary data collection also showed a similar productivity for the same season in 2013.

Herbage production reached a peak performance in June (i.e. 3.3 tonnes DM per ha) while the composition of the herbage fluctuated from month to month as shown in Figure 1a. Clover production accounted for about 46% while grass production accounted for 34% of the total herbage production. The productivity of other legumes and "broad leaves" represented 14% of the total production and senescent material was about 6% of the total production. Preliminary data collected in 2013 indicated a similar productivity of the diverse sward (data not shown).

Forage samples collected at farm visits were analysed for chemical composition. The diverse sward had an average of 15.7% DM, 9.7 MJ of ME and 21% of CP indicating a good quality forage. The average ME content was marginal as normal values for this type of forage are 11 to 13 MJ of ME per kg DM, but CP content was high and NDF within the expected levels.

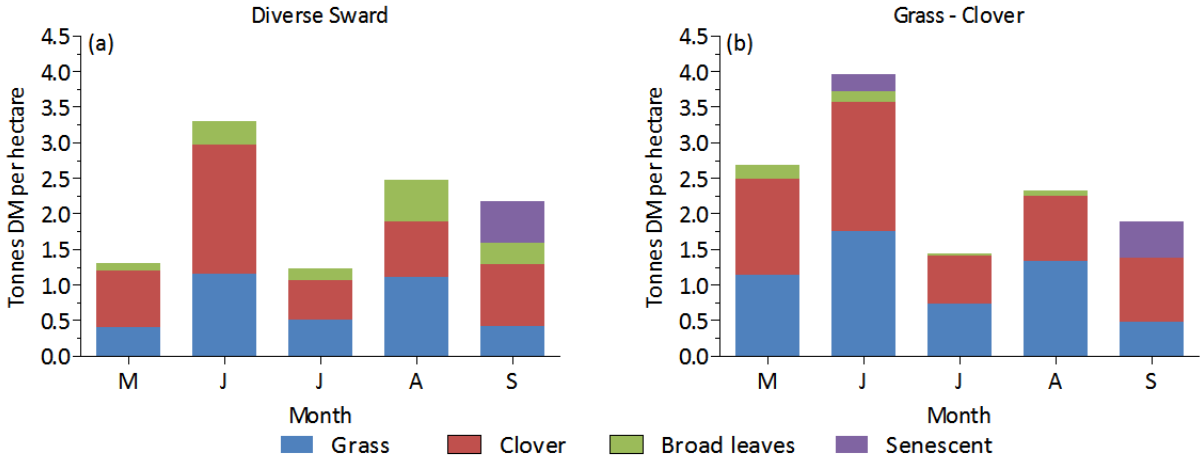

Figure 1. *Monthly pasture productivity (tonnes of DM per hectare) and herbage composition of diverse swards (panel a) and grass-clover (panel b).*

Herbage production of grass-clover ley during the monitoring period (i.e. May to September 2014) was better than those of diverse swards and averaged 12.3 tonnes per hectare. As expected, composition was dominated by grass and clover which accounted for about 44% and 46% respectively, while the productivity of other legumes and "broad leaves" represented just 4% of the total production (Figure 1b); as in the diverse swards, senescent material was about 6% of the total production. The grass-clover lay had an average of 17.2% DM, 10 MJ of ME and 21.5% of CP indicating a good quality forage.

5 Conclusions/Recommendations

In view of the limited data collected we cannot draw strong conclusions from this study. Nevertheless, the results collected from one farm only show that although pasture productivity of the diverse sward lay was slightly lower than that in the grass-clover lay, the total productivity remained relatively high suggesting that diverse pastures can serve as a viable alternative to conventional pastures. The fact that three farmers did not succeed in carrying out the assessments as proposed by the research protocol highlight the importance of farmers' involvement for the successful completion of participatory studies. On-farm research implies an increased level of farmer's involvement as the farmer is directly involved in carrying out part or all of the management operations, data collection in the trial.

Future research in this area should focus on gathering more information and evaluating the economics of diverse swards vs standard mixtures. The suitability of mixtures, species or varieties to different soil types but also the impact of diverse leys on soil fertility (nutrients, carbon, structure, water) is of particular importance. The feed value of diverse leys as forage for the dairy cow merits further investigation in terms of milk production, livestock performance and animal health.

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