Practical, Environmental and Financial Feasibility of using Woodchip bedding for livestock in the West of Scotland

March 2021

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Report produced by

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1. PROJECT TITLE/APPLICANT

1.1 **Project Title:** Practical, Environmental and Financial Feasibility of using Woodchip bedding for livestock in the West of Scotland

1.2 Overview of SAOS

Established in 1905, SAOS is Scotland's expert organisation on farmer co-ops and supply chain collaboration. It provides a range of specialist information, development and consultancy services aimed at shaping the future of farming and food in Scotland. Its purpose includes strengthening the profitability, competitiveness and sustainability of Scotland's farming, food and drink and rural economies through the promotion of co-operation and collaboration.

SAOS is a not-for-profit development organisation owned by its membership. As a membership organisation SAOS is committed to driving growth within agri and food co-operatives and stimulating collaboration within their supply chains.

Innovation and co-operation is at the heart of our objectives to achieve added value and production efficiency as is our proven role in smart project management and industry initiatives.

2. EXECUTIVE SUMMARY

Virgin woodchips and sawdust for livestock bedding were trialled on four farms in the West of Scotland during the winter of 2019/20. The trial focused on the practical and economic outcomes of using these materials and also the subsequent impact on returning the resultant farm-yard manure to land.

The project was undertaken by Fergus Younger (SAOS), Neil Donaldson (Argyll Small Woods Cooperative) and Audrey Litterick (Earthcare Technical). The project received funding support from the Scottish Government Knowledge Transfer and Innovation Fund.

Practical -The farmers in the trial found wood-based products to:

- be as easy to use as a straw equivalent.
- be equivalent in volume usage – 1 tonne straw/1 tonne wood-based product;
- require less labour to bed;
- be better at keeping livestock clean;
- have a noticeable positive difference on livestock foot health;
- be easier to spread as a FYM than a straw based equivalent;
- require additional time and resource to prepare the FYM properly.

Economic- The farmers in the trial found the wood-based products to:

- be cheaper than bought in straw;
- be more cost effective the more local the purchase or acquisition;
- be possible to create from homegrown resources;
- cause no problems with crops or soils when used as FYMs;
- be easy to acquire, though it should be noted that if there is significant increase in demand then this may not remain the case.

Soils - The analysis demonstrated that the wood based FYMs:

- are excellent sources of organic matter, as well as being good slow-release fertilisers.
- typically have a high C:N ratio and should always be tested prior to use, then crop N requirement calculated with care.
- are best stacked for at least a year prior to use and then turned at least twice, to minimise potential problems with N lock up.
- contain larger amounts of lignin than straw-based FYMs and this could help build soil organic matter faster in soils low in organic matter.

Environmental – The project demonstrated:

- Significant reductions in carbon emissions could be achieved by avoiding the road haulage associated with taking straw from the East to the West of Scotland.
- That there was potential to significantly improve the organic matter content and health of soils by using wood-based FYMs. Subsequently this could improve carbon sequestration in soils. However, further long-term soil testing would be required to prove this potential.

3. PROJECT DESCRIPTION

Background

During recent years it has become increasingly difficult for farmers to justify hauling straw as bedding material from East to West as the price of the straw increases and the demand for straw as a biomass crop increases. It is important that farmers investigate alternative systems, as keeping livestock in the west is an economically marginal activity and further price pressure could add further pressure to an already challenged sector. This project has taken account of the advice from the Agricultural Weather Advisory Panel and also the messages from the NFUS straw and fodder summit in 2018 and ongoing work on the issue. The project aimed to enable farmers to better cope with increasingly unpredictable weather systems and demonstrate a route to reducing costs through use of an alternative bedding material.

This Knowledge Transfer Innovation Fund (KTIF) project came about through an innovation development project supported by the Rural Innovation Support Service (RISS). The RISS project brought together four west coast farmers who were keen to explore the use of local timber to create woodchip and saw dust as alternatives to straw bedding material for livestock. The key driver for the farmers was initially economic: could wood-based bedding materials save the farmers money on buying in straw, as straw has trebled in price over the previous two years. The farmers, working along with the Scottish Agricultural Organisation Society (SAOS) and the Argyll Small Woods Cooperative (ASWC) carried out background research, visited farms using recycled wood fines, trialled chipping, explored the practicalities of extraction and sought scientific expertise into the use of wood-based farmyard manures (FYMs) on agricultural land.

SAOS and the ASWC also undertook a study tour in Wales where the use of woodchip and wood fines has been trialled successfully. A summary report is included in Appendix 1

The RISS project demonstrated to the farmers that there was value in carrying out a practical trial to explore best practice and hence provide guidance for farmers across Scotland. The assessment committee of the RISS programme made a key recommendation for the project to research previous work to avoid duplication. This work demonstrated that there had been no detailed practical work carried out on the use of virgin woodchip as bedding or on the impact of wood-based FYMs on soils. A summary of the previous work explored is included in Appendix 2.

ASWC have also looked at the potential for the cooperative to act as a supplier of woodchip to farmers. A report prepared by the Sylva foundation highlighted the opportunity. A copy of this section of the report is in Appendix 3.

The need for soil analysis

In recent years, the spikes in demand for and price of straw has created a situation whereby farmers are being forced to look for alternatives for bedding their livestock. Some farmers and woodchip brokers are giving little thought as to the potential short and long-term implications of using woodchip on the health and quality of the soils to which the materials will ultimately be applied. Some farmers are using virgin woodchips, whereas others are using waste woodchip and fines from a variety of sources.

Rarely has any testing been done to determine the amount and type of physical contaminants present, or to quantify the physical and chemical properties of wood-based bedding in order to determine its suitability for use on land. This is particularly worrying in the case of waste wood fines, some of which can be heavily contaminated with plastics, glass, metal, and potentially toxic elements (PTEs).

The Team

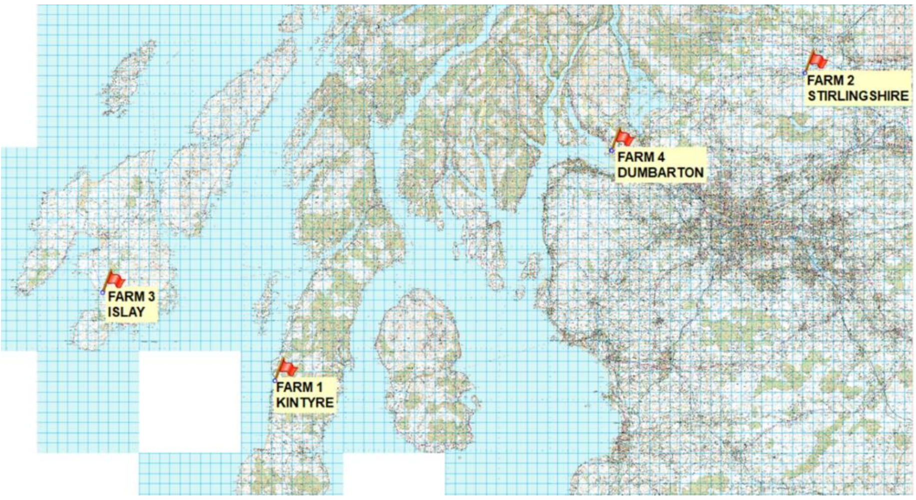
Together with the ASWC and SAOS, Audrey Litterick of Earthcare Technical joined the team to ensure a robust approach to evaluating the soils pre and post application of woodchip FYM.

The team conducted a wide range of tests on the chemical properties of the wood-based bedding material, including properties such as bulk density, dry matter, conductivity, potentially toxic elements, total nutrients, total carbon, and carbon to nitrogen ratio. It was important to characterise the bedding materials to ensure that they were likely to be safe for use with animals

The Project

The project secured funding from KTIF to look at the practice of using woodchips, wood fines and/or sawdust as animal bedding. With the aim to test the type of woodchips and fines being used in Scottish farming at present and to assess the economic, practical, and scientific realities to demonstrate the "how-to" approach that is necessary for farmers to uptake a new methodology.

The Trial Farms



Practical experimental trials were conducted on four farms located throughout the West of Scotland – as per map above. Due to the geographically peripheral nature of these farms on the west coast, their ability to access other alternative sources of bedding products is limited. Therefore, this study only compared the effectiveness of woodchip with straw, and not other types of bedding, such as paper, that may be available in more central locations.

The farms selected were all sheep and cattle enterprises that are typical to the West of Scotland. The four farms were selected either because they were already using some woodchip or sawdust as bedding or because the farmer had expressed an interest in the project. The secondary reasoning in selection was to get a good geographic split as demonstrated by the above map.

4. FINANCE

Total Original Grant approved: £35,482.00

A request was made at the end of the project for a variation to the conditions of grant awarded with respect to approved project under the KTIF programme.

The total claim remained the same as the original approved, there was a reallocation of budgets to address less travel and more project management time due to Covid Impacts.

Due to the COVID crisis, a contingency plan had to be adopted to ensure full and successful delivery of this project. As a result, and limited by the strict National COVID Guidelines, the team was unable to travel to the extent we anticipated at the outset of the project. This had a direct effect on the amount of time required to complete project outputs and impacted on the costs for the facilitation of the project. With this in mind we would like to request that the budget be re – allocated as follows PROJECT MANAGEMENT COSTS - £12,400 FEES FOR SPEAKERS - £22,353.45 T & S FOR SPEAKERS – £728.55

5. PROJECT AIMS/OBJECTIVES

Overall project aim: To determine the practical, environmental and financial feasibility of using virgin woodchip/sawdust as bedding for livestock in the West of Scotland

Objectives:

1. To determine whether the use of wood fines as bedding can improve competitiveness and profitability of beef suckler cow production by reducing input costs for wintering
2. To determine whether the use of wood fines as bedding can improve competitiveness and profitability of the sheep sector through reduced input costs for lambing and wintering.
3. To determine whether the use of wood fines for livestock bedding can produce an economic return from previously unproductive woodlands
4. To determine how farms can work together to access a chipping contractor to achieve economies of scale.
5. To build a community of farmers who are looking at alternative bedding systems
6. To build a community of small woodland owners who are looking for a market for low value timber
7. To increase economic activity in remote rural areas in order to help improve their sustainability and resilience.
8. To approximately quantify the reduction of GHG emissions from agriculture and the related land use sector through reduced haulage.
9. To determine whether there is increased sustainability in participating farms and whether there are improvements in soil fertility, water quality and biodiversity through the use of wood as a bedding material.

6. PROJECT OUTCOMES

6.1 How aims/objectives were achieved

1. *To determine whether the use of wood fines as bedding can improve competitiveness and profitability of beef suckler cow production by reducing input costs for wintering.*

The project identified that the use of wood fines was cost competitive as an equivalent to straw and that financial savings can be achieved in reducing input wintering costs.

2. *To determine whether the use of wood fines as bedding can improve competitiveness and profitability of the sheep sector through reduced input costs for lambing and wintering.*

The project identified that the use of wood fines was cost competitive as an equivalent to straw and that financial savings can be achieved in reducing costs during lambing and wintering. The trial farmers continue to use the product post the trial which is testament to the saving identified.

3. *To determine whether the use of wood fines for livestock bedding can produce an economic return from previously unproductive woodlands*

Only one farmer in the trial farmers undertook the production of wood chip from their own woodlands and only on a small scale, the farmer noted that to undertake a larger trial they would need to utilise the services of a chipping contractor which would likely increase cost.

4. *To determine how farms can work together to access a chipping contractor to achieve economies of scale.*

The farmers in this trial largely bought in their woodchip resource so we were unable to test how economies of scale for collective chipping of on farm woodland resources could work. However, the interest generated by the trial will likely stimulate a number of farmers to work together.

5. *To build a community of farmers who are looking at alternative bedding systems*

Throughout this project there have been a number of farmers who have followed up from the articles generated, short film and webinar to express an interest. NFUS will further circulate the final report and aid with further promotion of the practice.

6. *To build a community of small woodland owners who are looking for a market for low value timber.*

The project did not tackle this objective as not enough of the trial farms were utilising farm generated woodchip. However, the opportunity is now there to explore this element further through ASWC.

7. *To increase economic activity in remote rural areas in order to help improve their sustainability and resilience.*

Similarly, to objective 5 and 6 the project did not rely solely on locally produced chip and therefore was not solely generating economic benefits to the local areas.

8. *To approximately quantify the reduction of GHG emissions from agriculture and the related land use sector through reduced haulage.*

The project demonstrated that there was a reduction in straw haulage through the adoption of local woodchip as a livestock bedding resource, estimated to be approximately 2.9 kg CO_2 per litre of diesel fuel oil that was not used.

9. *To determine whether there is increased sustainability in participating farms and whether there are improvements in soil fertility, water quality and biodiversity through the use of wood as a bedding material.*

The anecdotal answer to this question is yes and that the sustainability gains could be significant. However due to the nature of soil life and the breakdown of woody material longer term soil analysis will be needed to determine a scientific answer. The anticipated outcome is that the use of wood based FYMs could accelerate the organic matter build of soils and subsequently their health and ability to sequester greater amounts of carbon.

6.2 Milestones

The four farms used locally produced chipped virgin wood (in one case, sawdust) as animal bedding (case studies are contained in the annex). The following methodology was followed:

- The woodchip bedding material and dung were tested prior to use as bedding.
- The mixed woodchip and dung FYMs were tested after stacking (and in some cases turning and/or covering) for 6 (and/or 12) months prior to being applied to land.
- The receiving soils were tested prior to applying the wood-based FYM and again 6 months after application.
- The impacts on the properties of the receiving soils were evaluated.
- The financial and practical impacts of using woodchip bedding were evaluated from each farm in a case study.
- The environmental/carbon impacts of using woodchip as a livestock bedding material were evaluated.
- A short film was made utilising two of the project farms to quickly summarise the practicalities of using woodchip for other farmers.
- Various press articles were produced on the project
- A closing webinar was held in March 2021 to summarise the project findings.

7. LESSONS LEARNED

7.1 Issues/Challenges

- Covid – limited the number of on farm meetings we could hold and the ability to revisit farms for testing as we were travelling across a large geographic area with ferries required.
- Time/weather – initial estimates of time to evaluate reapplied FYM and its impact on soils did not take account of poor weather delaying spreading and the subsequent knock on for time.

7.2 Impacts

- Covid did cause challenges, but we were able to over come them by using online approaches for meetings and by asking others to collect soil samples.
- Time and Weather – we should have anticipated this as poor weather and delays are not rare occurrences in Scotland.

8. COMMUNICATION & ENGAGEMENT

8.1 Detail throughout the project's lifetime

Together with the case studies (In Annex) produced in this report, the project also funded the production of a short film to highlight the potential of using woodchip as a bedding material. The film was produced by Strategy Story and included filming on farm in Kintyre and Islay. The short film can be viewed on SAOS website:

https://saos.coop/whats-new/news/woodchip-study-video

The hub for information on the project was provided by the page on the ASWC website:

https://www.argyllsmallwoods.coop/wood-chip-bedding-study/

Updates and articles on the project have been provided regularly in the SAOS newsletter, RISS newsletter, FAS and the NFUS farming leader and through other regional outlets. Links to some of these articles are provided below:

https://www.facebook.com/permalink.php?id=2196194607061078&story_fbid=5569951296352042

https://www.fas.scot/article/alternative-bedding-for-lambing/

https://www.innovativefarmers.org/news/2020/february/06/riss-two-years-of-farmer-led-innovation/

SAOS winter newsletter

https://saos.coop/assets/media/files/newsletters/SAOS%20Update%20Winter20_21.pdf

Due to Covid restrictions, the final project meeting was held as a webinar in March 2021. The webinar hosted 20 attendees who heard feedback from Duncan Macalister of Glenbarr farms on the practical use of sawdust as a bedding material on his farm. This was followed by a summary from SAOS on the practical and economic results of using woodchip on farm. However, the focus of the webinar was on a detailed presentation given by Earthcare Technical on the woodchip bedding, wood-based FYMs and their impact on soils during the project. A full recording of the webinar is available from ASWC.

9. KEY FINDINGS & RECOMMENDATIONS

Practical

All four farmers in the trial considered the woodchip or sawdust material to be easier to use than a straw equivalent for the following reasons:

Time

- The initial laydown of a 20-40 cm layer of woodchip material was easy to do with a loader bucket.
- The material lasted longer between each re-bedding and therefore required less daily labour to maintain.
- Buying in woodchip or sawdust was equivalent in time to buying in straw. One farm created their own material and in that case, the time involved was thought to be equivalent to that of producing home produced straw. However, no widely applicable conclusions could be drawn from this, as timber extraction time and costs are variable to each farm situation.
- Clearing sheds and courts of woodchip bedding after use was thought to be time equivalent to straw. However, a minimal increase in midden management time should be noted if the FYM is to be given an extra turn, as is recommended.
- Spreading of woodchip or sawdust-based FYM was found to be equivalent to spreading straw, but the materials often spread more evenly.

Health

- All farms noted that both sheep and cattle appeared to be cleaner on wood-based bedding materials as opposed to straw.
- Similarly, all farms noted that feet problems in livestock appeared to be less than with a straw equivalent; this was more prominent with sheep.
- Farmers noted that the atmosphere within housing was less dusty with the use of woodchip-based bedding compared with straw. This was regarded as beneficial in reducing pneumonia type issues in livestock. It was also likely to be beneficial to the farmers health.

Volume

- On farm experience indicated that 1 tonne of woodchip was roughly equivalent to 1 tonne of straw in terms of usage.

Economic

Summary feedback from the trial farms demonstrated that the wood-based material was 25-50% cheaper to buy in than the straw based equivalent. This buy in cost had the largest impact on the economics.

Distance

- The further the farm was from the main sources of straw (generally the further west it was) the less cost-effective straw became as haulage costs rose.
- Similarly, where woodchip or sawdust had to be hauled further, the cost differential to a straw equivalent lessened.

Sourcing

- In general, the more local the supply of wood-based bedding, the cheaper the cost to the farmer.

- One farmer chipped waste wood from their farm at 50% of the cost of bought in straw, but he noted that if they were to produce greater volumes of woodchip, they would need to bring in a contract chipper at additional cost.
- Creation of woodchip on a farm for use on that farm is likely to be cheaper than buying in woodchip product, but the costs of harvesting timber, extraction and chipping will vary from farm to farm.

Availability

- Current availability for farmers to buy in woodchip was not a constraint in this study. However, if demand was to increase significantly, this may put pressure on existing supply systems and may have an impact on price.

Fluctuations in supply of bedding materials

- One of the main drivers for this project had been the fluctuating and often poor availability of affordable straw for bedding. This is being driven by the effects of climate change, including extreme weather events that makes cereal harvests challenging.
- Woodchip availability and price is less dependent on the weather, but the demand for biomass is likely to continue to increase in future years. So, whilst the woodchip market is less volatile, the growing demand for it may result in gradual price increases.

Growing Crops and Grass with wood-based FYMs

- Typical application rates (from 10 to 40 t/ha) are likely to work best for practical reasons, though higher application rates are possible (depending on the total N content if land is in an NVZ).
- Standard dung spreaders or rear discharge spreaders would work well with the woodchip FYMs which tend to spread more evenly than straw-based FYMs.
- The FYMs were applied to the surface of grassland (Islay and Cardross) or surface applied and ploughed down (Kippen and Kintyre). Both application methods worked well for the farmers concerned.
- There was no evidence of N lock-up or other crop or soil problems
- This was a short project. Repeated applications and soil tests would be required over several years to determine the long-term benefits of applying the material.

Environmental and Soils

Environmental Impact

- The most obvious beneficial environmental impact was the reduction in haulage with fewer road miles travelled delivering woodchip bedding versus straw. Straw generally travelled further from east coast sources to the west.
- The carbon savings can be calculated as 2.9 kg CO_2 per litre of diesel fuel oil not used for haulage. Obviously for west coast farms this could generate a significant saving.
- In terms of production of woodchip versus straw, the fuel/diesel usage is broadly comparable, but it can vary if there more than typically challenging felling and extraction methods are needed for the wood.

The impact on soil organic matter (Straw FYM vs Woodchip FYM)

- This project showed that straw-based and wood-based FYMs are broadly similar in terms of their:
  - nutrient content
  - organic matter content.

  BUT… there is more woody material and therefore more lignin in the wood-based FYMs.

- Given that wood-based FYMs will contain more lignin than straw-based FYMs, their use may result in faster increases in soil organic matter (and therefore soil carbon) in low organic matter soils. The effect may be similar to that of green compost, which, when used regularly, results in a faster increase in soil organic matter than straw based FYM due to its high lignin content. More detailed long-term work would be needed to provide definitive proof.
- Wood-based FYMs will certainly provide useful quantities of organic matter when applied, which will help maintain and enhance soil organic matter content in all soils. They will therefore help to:

  ✓ Improve the structure and workability of soil;
  ✓ Increase soil water holding capacity, thus giving greater resilience of soils to dry weather;
  ✓ Increase water infiltration giving reduced flooding;
  ✓ Increase biological activity;
  ✓ Improve retention and turnover of nutrients.

Recommendations

The trial has demonstrated that there are clear practical and economic benefits for farmers in utilising virgin woodchip or sawdust as a bedding material for livestock. These materials were often easier to use, easier to spread and kept the livestock cleaner and healthier. If woodchip supplies and chipping services are available at competitive rates in local areas, then there is little reason for this approach not to be adopted more regularly. Some coordination of services and supplies may be necessary to encourage adoption

Wood based FYM needs to be treated carefully and turned or even composted properly to ensure the optimum benefits to soils and to ensure that there are no negative impacts due to N lock-up. The potential soil conditioning benefits of wood based FYMs to depleted soils in terms of boosting soil organic matter content are likely to be significant. However, further longer-term trial work is needed to establish the extent of likely soil organic matter/soil organic carbon gains.

10. CONCLUSION

- All farmers in this project found wood-based bedding products easy to use.
- All farmers in this project found the wood-based bedding to be cheaper than a straw equivalent.
- None of the farmers in this study observed any problems with crops or soils when using wood based FYMs.
- Wood-based FYMs were easy to make.
- Wood-based FYMs were excellent sources of organic matter, as well as being good slow-release fertilisers.
- Wood-based FYMs typically had high C:N ratios and should always be tested prior to use, then crop N requirement calculated with care.
- It is best to stack wood-based FYMs for at least a year prior to use and they should be turned at least twice, to minimise potential problems with N lock up.
- Wood-based FYMs will contain larger amounts of lignin than straw-based FYMs and this could help build soil organic matter faster in low OM soils.

11. ANNEXES

Case study 1 – Glenbarr farms

Farm name: Glenbarr farms

Farm Location: Glenbarr, Kintyre peninsula, Argyll and Bute

Farming system:

- 1000 ha farm.
- Breeder feeder of beef cattle.
- 140 breeding cows
- 700 breeding ewes

<u>Source and type of woodchip</u>

The bedding material used was fines/dust from green spruce, supplied in a walking floor lorry in 25 t loads. The farm has been using this material, which is supplied by a sawmill in Dumbarton, for 6 years.

<u>How is the sawdust used?</u>

The sawdust is used as bedding for breeding cows, young stock and sheep in late winter to early spring. It is brought into the shed with a tele handler, spread to a depth of 15 cm, then topped up as needed. The farm uses around 2 tele handler buckets of sawdust, three times a week (125 t/year in total). The farmyard manure (FYM) produced from the mixture of sawdust and dung is removed from the sheds at the end of the housing season and is stacked outdoors in field heaps for a period of around 7 months. It is then moved to new field heaps in the fields to which it will be applied and is typically applied in late March at 25 t/ha (10 t/acre). It is spread on different arable cropping fields across the farm every year.

<u>Properties of the sawdust FYM</u>

The sawdust was assessed by hand and tested by NRM laboratories to determine its physical and chemical properties. It was a lightweight, fine material which contained low concentrations of nitrogen (N), phosphate (P) and potash (K). It also contained a large amount of carbon (C) and a high C:N ratio (486:1), which would mean that it would tend to lock up N in the soil if applied alone. This high C content is typical of wood products such as woodchip and sawdust.

The sawdust-based FYM contained 2.9, 1.3 and 1.4 kg/fresh tonne of N, P and K respectively. These nutrient concentrations are lower than typical straw FYM. The C:N ratio was 32:1. This was higher than the ratio normally present in soils, so the material may have a tendency to lock up applied N in some soils. The FYM also contained small but useful amounts of Sulphur (S), magnesium (Mg) and the trace elements copper (Cu) and zinc (Zn). Concentrations of potentially toxic elements were low.

Defined practical, environmental and economic benefits

The sawdust was easy to spread, so saved time compared to rolling out large bales of straw. It had an anti-septic quality, so there were few foot problems with sheep and there were no naval issues with cattle. It kept cattle clean, so it was not necessary to clip their bellies.

The farm would use the same amount of straw as sawdust per year. Barley straw costs £155/t delivered to this area, whereas sawdust costs £74/t delivered. Sawdust bedding is therefore cheaper to use than straw bedding.

The sawdust FYM spread in a similar way to straw FYM but was easier to spread more evenly.

Soils report

The sawdust based FYM was removed from the sheds at the end of the housing season in 2019 and was stacked outdoors in a field heap in the same way as straw FYM would be for around 7 months. It was spread at approximately 25 t/ha on arable fields in March 2020, before being ploughed down prior to seedbed preparation for spring barley. When applied at 25 t/ha, the FYM supplied approximately 7 kg of crop-available N, 33 kg of phosphate and 35 kg of potash. The application also supplied 4.8 t/ha of organic matter.

It is not possible to determine changes in soil organic matter content or soil P, K or Mg status after a single application of sawdust based FYM. However, it was possible to confirm that the crop grew well, produced a good yield (yield in t/ha) and there were no visible issues with N lock-up, physiological disorders or crop pest and disease incidence. Similar results were obtained in past years where sawdust based FYM was used.

Conclusion

Sawdust is a superior to straw as a bedding material for this farm because it is cheaper than straw and because animals bedded on it suffer from fewer health issues. The FYM created from it is a useful soil amendment which will help to build and maintain soil organic matter content. It contains useful nutrient content, which should be fully accounted for when calculating fertiliser application rates.

Case study 2 – Old Leckie Farm

Farm name: Old Leckie Farm
Farm Location: Gargunnock, Stirling, FK8 3BN
Farming system: 128 ha farm of which 17 ha is woodland.

- 500 Llyen/Texel sheep, 750 lambs/annum
- 3 Tamworth X sows, 55 weaners/annum
- 1,200 Hyline free range hens, 370 000 eggs/annum
- Horticulture -1 acre potatoes and 1/8 acre salad leaves
- 60 Limousin X cattle – suckler herd, some finished. 55 calf/annum. 20 Bought in Highlanders for finishing

Source and type of woodchip

The bedding material used was mainly oak branches collected from field edge trees on the farm, mixed with softwood bark/dust from wood splitter. The wood was generally seasoned. The wood was shredded to a coarse chip (pieces up to around 6 cm in length).

How was the woodchip used?

The chip was brought into the shed with a tele handler, spread to a depth of 40 cm, then topped up as needed. It was used for bedding 5-10 cows and calves for around 8 weeks. It was removed from the shed at the end of February 2020 and was stacked, uncovered in a field for approximately 8 weeks. It was applied to land in April 2020 at approximately 75 t/ha prior to the land being ploughed and sown to spring barley.

Properties of the woodchip FYM

The woodchip was assessed by hand and tested by NRM laboratories to determine its physical and chemical properties. It was a lightweight, coarse chip which contained moderate concentrations of nitrogen (N) and low concentrations of phosphate (P) and potash (K). It also contained a large amount of carbon (C) and a high C:N ratio (91:1), which would mean that it would tend to lock up N in the soil if applied alone. This high C content is typical of wood products such as woodchip and sawdust.

The woodchip based FYM contained 4.9, 1.8 and 6.1 kg/fresh tonne of N, P and K respectively. These nutrient concentrations are slightly lower than typical strawy FYM. The C:N ratio was 24:1. This is higher than the ratio normally present in soils, so the material may have a tendency to lock up applied N in some soils. The FYM also contained small but useful amounts of Sulphur (S), magnesium (Mg) and the trace elements copper (Cu) and zinc (Zn). Concentrations of potentially toxic elements were low.

Defined practical, environmental and economic benefits

Compared to straw, the woodchip kept the cattle dry and clean as it was more absorbent. It was easier to manage than straw, as the chip could be topped up using a telehandler from outside the pen.

Overall, woodchip lasted longer than straw, it required fewer top-ups and the cattle appeared to have better foot health.

It was easy to produce small volumes of woodchip on farm, and it cost about £30/tonne for processing time. This was cheaper than imported straw which at the time would have cost £60/tonne. If larger volumes were needed, costs would increase as this would require bringing in an external contractor.

Soils report

The woodchip based FYM was removed from the sheds at the end of the housing season in February 2020 and was stacked outdoors in a field heap in the same way as straw FYM would be for around 8 weeks. It was spread at approximately 75 t/ha on to the surface of grass, prior to the land being ploughed down prior to seedbed preparation for spring barley. The barley crop was followed by a westerwolds ryegrass and clover mix sown into the stubble in the autumn of 2020. When applied at 75 t/ha, the FYM supplied approximately 37 kg of crop-available N, 135 kg of phosphate and 458 kg of potash. The application also supplied 15.8 t/ha of organic matter.

It is not possible to determine changes in soil organic matter content or soil P, K or Mg status after a single application of woodchip based FYM. However, it was possible to confirm that the crop grew well, produced a good yield (yield in t/ha) and there were no visible issues with N lock-up, physiological disorders or crop pest and disease incidence.

Conclusion

Woodchip was manufactured on the farm at no cost other than that of labour, machinery and fuel. The cost was estimated to be around £30/t which is considerably cheaper than imported straw, which would have been around £60/t in 2019.

The FYM created from the woodchip is a useful soil amendment which will help to build and maintain soil organic matter content. It contains useful nutrient content, which should be fully accounted for when calculating fertiliser application rates.

Woodchip bedding was a little easier to spread as a bedding material than straw and was easy to top up when in use - as material could be tipped into the pen utilising a telehandler from outside the pen.

Woodchip was superior to straw as a bedding material in that it lasted longer than straw and required fewer top-ups. It also appeared to be more absorbent and thus kept the cattle cleaner.

The farmer noted that it was easy to cheaply generate small amounts of woodchip on farm, but that to generate larger volumes from farm resources would require an external chipping contractor at additional cost.

Case Study 3 Coille Farm Islay

Farm name: Coille Farm
Farm location: Bruichladdich, Islay
Farming system:

- 322ha farm
- 400 sheep and 12 cattle
- Sheep: Blackface, Cheviots and Mules
- Sell some/store/fatten some
- Feed: draught and beet pulp
- Indoors: Start October 2018 – through the lambing – end April

Source and type of woodchip

This was the first time the farm had used chip, they sourced spruce chip from a local estate on Islay called Drumlossit. The timber was well seasoned before chipping into shed and the resultant chip had a low moisture content.

How the woodchip is used

The farm purchased 30 cube of product at a rate of £38/cube delivered. This product was used on the farm over a 5-month period in sheep housing.

One sheep pen had chip down for 2 months then removed whilst the other pen was topped up twice since over the 5-month period. The pends were top dressed as necessary with the chip being moved as necessary with a tractor/front end loader

During the five-month winter period 220 sheep used the chip bedding, this included a range of ewe lambs/store lambs/tups and during the lambing period.

The chip was removed with the tractor loader and stored on an outside concrete area and turned over every 2 months

Properties of the woodchip

The woodchip was a mixed grade material with some coarse fragments (pieces up to around 6 cm in length and some fines. There were no obvious physical contaminants present. It was very light in weight (297 kg/m^3) despite the sample tested being fairly moist. It had a pH of 4.6 and relatively low electrical conductivity, neither of which would cause problems when the material was mixed with animal manure.

The woodchip had an extremely high carbon: nitrogen (C:N) ratio (605:1), which indicates that it would cause significant N lock-up if applied to land as a fresh waste. N lock-up happens when any material with a high proportion of C relative to N is applied to soil.

Properties of the resultant sawdust - based farmyard manure

Once mixed with animal droppings, the resulting FYM was a useful material. It contained 3.7, 2.6 and 8.3 kg/fresh tonne of N, phosphate and potash respectively. These concentrations were slightly lower than those in "typical" cattle FYM, which 6.0, 3.2 and 8.0 kg/fresh tonne of N, phosphate and potash respectively (FAS, 2020).

The fact that the FYM contained these slightly lower nutrient concentrations was a reflection of the relatively low nutrient levels in the woodchip and the way in which the animals producing the dung were fed and that they were sheep at low numbers as opposed to cattle.

The FYM contained low concentrations of PTEs, none of which would cause any problems to the receiving soil.

Defined practical, environmental and economic benefits

The woodchip was easy to spread in the sheds, was easy to manage and kept the sheep dry and clean. The woodchip did not stick to the animals' feet, so there were few foot problems, the farmer had previously noted that sheep on straw would often get dung caps on their cloven hooves which could encourage foot rot and scad.

The farmer found the product good to use requiring less time and saw clear benefits for sheep foot health.

Soils report

This farm was the most extensive of the trial and was predominately well-established permanent pasture. Soil pH was only very slightly low prior to FYM application (the target pH for permanent grass in Scotland is 6.0) and no lime was required. Soil organic matter (SOM) content was very high indeed (at 19.5%). This high level is fairly common in long-term permanent pasture, particularly where the drainage is poor in some or all of the field. This SOM content is at least as high as natural top soils in this area.

Earthworm numbers were assessed as being "good" on the first visit. Microbial respiration was fairly low in the field, which indicated that the soil had relatively low microbial activity.

The results of soil tests conducted after application of the woodchip based FYM were similar to those conducted before it was applied and there was no evidence of any effects of applying the FYM, whether beneficial or deleterious. This was as expected, given that it typically takes a long time to see changes in soil properties such as nutrient status or organic matter content.

Conclusion

Woodchip was a superior to straw as a bedding material for this farm, because it was slightly cheaper than straw but mainly because the sheep bedded on it suffer from fewer health issues – particularly associated with foot problems.

The FYM created from it is likely a useful soil amendment which will help to build and maintain soil organic matter content.

The FYM based on woodchip was as useful as that based on straw in terms of its soil conditioning and fertiliser properties. The woodchip-based FYM used in this study contained slightly lower nutrient concentrations in comparison to typical values for straw-based FYM, but this is likely to be due mainly to the way in which the sheep were bedded at low densities on the chip and were fed, the numbers of animals bedded and the length of time they were housed for. Low nutrient levels in FYM are not a problem: it is simply important to test each FYM and understand nutrient concentrations in order to complete accurate field nutrient budgets.

Case study 4 – Lyleston farm, Dumbarton, Argyll and Bute

Farm name: Lyleston farm
Farm location: Cardross, Dumbarton, G82 5HA
Farming system:

- 81ha farm.
- 100 head suckler Aberdeen Angus cross.
- 200 sheep.
- Cows fed on silage and calves on cake.
- Cows indoors from November to March.
- Lambing indoors.
- Horses at livery all year round

Source and type of woodchip

The farm has been using woodchip for animal bedding for at least 20 years. They source the chip from three different tree surgeon companies, who deliver the chip free of charge to the farm. The chip is a mixture of hardwood/softwood and green material. The chip comes in a range of sizes and is stored outside in a bunker. It doesn't appear to matter if the material gets wet.

How the woodchip is used

The farm uses a mix of straw and woodchip in a similar way each year. Starting in November, a 150 mm layer of chip is laid with a tractor/front end loader, then topped up every week. The chip reaches around 1 m depth by the end of the winter. Horses are also kept on a bed of chip and straw in winter.

The farm buys straw in at £45/bale annually and uses about 14 tonnes of straw per year to supplement the chip. The farmer does not know how much chip is used each year.

The resultant FYM is stacked in field middens after use and is left outdoors, uncovered for a year before spreading. The manure is usually spread on well drained silage fields in March. Further detail on use of the woodchip FYM in 2020 is provided in the soils report below.

Properties of the woodchip

The woodchip was assessed by hand and tested by NRM laboratories to determine its physical and chemical properties. It was a lightweight, coarse chip (around 2 – 20 mm in size in the smallest dimension). It contained low concentrations of nitrogen (N), phosphate (P) and potash (K). It also contained a large amount of carbon (C) and a high C:N ratio (123:1), which would mean that it would tend to lock up N in the soil if applied alone. This high C content is typical of wood products such as woodchip and sawdust.

Properties of the resultant sawdust - based farmyard manure

The woodchip based FYM contained 3.8, 2.6 and 1.9 kg/fresh tonne of N, P and K respectively. These nutrient concentrations are lower than typical strawy cattle manures. The C:N ratio was 21:1. This is higher than the ratio normally present in soils, so the material may have a tendency to lock up applied N in some soils. The FYM also contained small but useful amounts of Sulphur (S) and magnesium (Mg). Concentrations of potentially toxic elements were low.

Defined practical, environmental and economic benefits

The woodchip was easy to spread in the sheds, was easy to manage and kept the animals dry and clean. The woodchip did not stick to the animals' feet, so there were few foot problems.

Although the farm did buy in some straw as usual, the fact that the chip was free greatly reduced the financial costs of keeping animals indoors over winter.

Soils report

The woodchip based FYM was removed from the sheds at the end of the housing season in spring 2019 and was stacked outdoors in a field heap in the same way as straw FYM would be for around 1 year. It was spread at approximately 25 t/ha to the surface of a silage field in April 2020. When applied at 25 t/ha, the FYM supplied approximately 7 kg of crop-available N, 33 kg of phosphate and 48 kg of potash. The application also supplied 7.5 t/ha of organic matter.

It was not possible to determine changes in soil organic matter content or soil P, K or Mg status after a single year. However, it was possible to confirm that the silage grew well, produced a good yield (yield in t/ha) and there were no visible issues with N lock-up, physiological disorders or crop pest and disease incidence. Similar results were obtained in past years where woodchip based FYM was used.

Conclusion

Woodchip was a superior to straw as a bedding material for this farm because it was cheaper than straw and because animals bedded on it suffer from fewer health issues. The FYM created from it is a useful soil amendment which will help to build and maintain soil organic matter content. It contains useful nutrient content, which should be fully accounted for when calculating fertiliser application rates.

Appendix 1 - Welsh visit report

1. Introduction

Argyll Small Woods Cooperative (ASWC) is a cooperative of small farm woodland and woodland owners and woodland contractors based in Argyll. The cooperative aims to encourage active management of small-scale woodlands through finding economically viable routes for small woodland timber and to develop forest skills.

Through Making Local Woods Work (MLWW) funding, ASWC is exploring options for generating income to support small woodland owners. One option being explored is the use of wood fines for cattle bedding.

In order to investigate the viability of this concept, ASWC is carrying out a feasibility study to explore the potential of converting low value farm woodland timber into wood fines for use as livestock winter bedding material.

As part of the research phase of the study ASWC organised a study tour (funded through MLWW) to visit two farms in South Wales who have been using wood fines as cattle bedding for over 10 years.

This note outlines the findings of the visit to the farms on the 30th October 2018.

2 The farms

The 2 farms visited are:

Farm 1 – Kemeys Farm, near Usk, Monmonthshire

1000 acre farm, with arable and 1100 cattle (420 dairy) and 850 ewes

Farm 2 – Wern Isaf Farm, Mid Glamorgan

450 acre farm with, arable, contracting, farm shop and around 200 cattle and 1000 wintering ewes.

3. Visit areas of interest

The visit looked at 3 areas of interest in relation to the use of wood fines for cattle bedding:

1. *Supply and cost of wood fines*
2. *Storage and handling of wood fines*
3. *Animal health and welfare*

4. The visits

Farm 1 has been using saw dust and wood fines for 15 years as bedding for 1100 cattle kept indoors throughout the year.

Farm 2 has been using wood fines for 10 years as bedding for around 200 cattle kept indoors in the winter.

Supply and cost of material

Farm 1 uses recycled wood sourced from a local mill at no cost as the mill is being paid to recycle and dispose of the wood. The farm uses around 2600t/annum. The farm uses the saw dust in cattle stalls and the fines in the loose housing. At the moment the material is readily available, but the farmer is interested in the effectiveness of using green wood fines.

Farm 2 uses recycled wood from a recycling centre. The material is delivered by lorry at a cost of £10/ton. The farm uses around 540 t/annum. Quality of supply varies depending on supplier.

Storage and handling of material

Both farms store the wood fines outside. Farm 1 stores the saw dust inside. It is important not to use saturated material.

Farm 1 keeps used wood fines and saw dust in a wood for a year before spreading on land pre-cultivation.

Farm 2 leaves the used wood fines for a year before ploughing it in. It is important not to spread the material too thick or deposit in the same area repeatedly.

Farm 2 sells some of the manure to local allotments.

The manure does not have any negative effect on the land.

Animal health and welfare

Both farmers felt that the wood fines keep their animals comfortable, dry, clean and healthy.

5. Study tour conclusion

Although the farms were using recycled wood fines, the tour confirmed the following in relation to the use of wood fines for cattle bedding:

- The material provides a cost-effective alternative to straw over a long period of time.
- If possible, the material should be stored under cover or blown into the sheds
- The size of the material enables the resultant used material to be used on the land after a year's composting, however it is important to apply sparingly, prior to crop growth and never in the same area repeatedly
- The wood fines provide a comfortable, clean and healthy bedding for cattle being kept indoors over long periods.
- Local supply of a low-cost material is crucial

The tour enabled us to gather practical information on the use of wood fine for cattle bedding. This will be used to inform the brief for the feasibility study.

Appendix 2 – Previous Research

1. Introduction

This paper contains the background research carried out to date on the use of wood fines for cattle bedding. This will be added to throughout the project and supplement findings from study tours and farm visits.

1. ADAS survey of woodchip corrals and stand off pads in England and Wales, 2005, Environment Agency

This study reviewed the construction, management and distribution for wintering livestock in England and Wales. Detail as follows:

- Looked at a total of 75 pads, mainly in the west of the country
- Two types of pads:
  - Corrals – unlined over freely drained soil
  - Stand off pads – lined and sealed with effluent collected
- Stocking density:
  - Standoff pads - 14m2/cow
  - Corrals – 16.5m2/cow
- Costs:
  - Stand off pads - £82/cow
  - Corrals - £130/cow
- Stand off pads worked well in terms of animal performance, drainage and management of effluent
- Suggest some removal of BOD, N and P in stand off pads
- The risk of contamination of water associated with corrals was unacceptably high
- There appears to be a considerable proportion of excretal N&P may be retained in woodchip
- There is a need for occasional removal of soiled chip
  - Recycled to land – need for grading and composting
- Great potential for future use – but need clear guidance on design, construction and management
- Chip size is of critical importance
  - Ave dimension of chip – 8cm x 10cm x 7cm
- There are problems if chip is too fine

2. CALU technical note, 2005

- Use of dry woodchip as an alternative for straw for cattle and sheep housed in sheds
- Based on 5 years experience of the Pont Bren farmers group
- Used hardwoods seasoned for 6m
- Chip size – 3cms
- Spread to a depth of 10cms, toped with 5cms chip every 7-10 days (sheep) and 2-3 days (cattle)
- Pleased with results compared with straw:
    - Less labour intensive – less handling
    - Stock remain clean
    - Low incidence of foot problems
    - Equivalent growth rate with straw
- Soiled woodchip composts rapidly at a high temperature
- Compost re used as bedding/growth medium for mushrooms and as a soil improver
- Canadian research shows chip retains considerable more Nitrogen than straw

3. HCC – Alternative bedding materials used for beef and sheep housing in Wales, 2010

The study looked at a variety of materials for cattle and sheep bedding.
The main questions relating to the type of material are:

- Will it keep animals dry and clean?
- Will it maintain a healthy environment?
- Will it provide a comfortable bed?
- Is it readily available?
- Is it cost effective?
- Is it easily stored?
- Can the resultant manure be composted?
- Can the manure be applied to land?
- What effect does manaure have on land and crop growth?

Other points raised:

- Chip can provide a good free draining bed for indoor sheep and cattle
- Chip needs to be less than 30% moisture content for maximum absorbancy
- Chip may be more expensive than straw – but can be used for numerous seasons
- Chip can offer many animal health and welfare benefits and has limited bacterial growth and dust
- Most soft or hardwoods can be used except Larch
- Woodchip/shavings are not waste, therefore no control regulations
- 10cm depth of chip is best, topped up with 5cm every 7 – 10 days
- Compost needs turned very 4 – 6 weeks

Appendix 3 - Sylva Report

1 CATTLE BEDDING USING WOOD CHIP - OPPORTUNITIES FOR ARGYLL

This is a sub paper to the main report into investigating opportunities for a wood hub in Argyll.

During the course of investigating opportunities to develop a hub in Argyll the issue of providing bedding for cattle arose. The problems are:

- Very little cereal crops are grown locally and therefore there is very little local straw available.
- Costs of transporting straw have gone up.
- The price of straw (ex-farm) has increased significantly over the last decade.
- Availability of straw has been a problem in recent years with some straw having to be imported from France!

Wood chips have been used as a replacement for straw in cattle bedding. The 'Woodchip for Livestock Bedding Project' ran from December 2005 until May 2008 in Wales to evaluate the potential of woodchip as an alternative bedding material to straw for use indoors with sheep and beef cattle[1]. It found that the health, welfare and cleanliness of the animals were of an equally high standard for animals housed on straw and woodchip.

1 https://www.dropbox.com/sh/m5jyy5y72bcmcen/AAAYBreYe4ENYP2hwG8KLV2Aa?dl=0

At the time of the study it found that purchasing pre-chipped wood at 2006/07 prices was not cost effective. Buying wood at the right price, chipping on farm and re-using for several seasons made woodchip financially viable.

Since 2008 big bale wheat straw prices from SE Scotland (nearest location figures provided by British Hay and Straw Merchants Association) have gone up by nearly 400% from £20 per tonnes to £78/tonne

However timber prices have also gone up. Forestry Commission statistics show that standing timber prices have risen 67% since 2008[2] although it should be noted that timber prices were historically low in the early to mid-2000's. How the changes in prices for straw and timber affects the overall viability of using woodchip for cattle bedding needs to be evaluated carefully.

2 https://www.forestry.gov.uk/forestry/infd-7m2djr

[3] https://www.argyll-bute.gov.uk/woodland

1.1 SWOT Analysis on using woodchip for cattle bedding in Argyll under the HWC model

1.1.1 Strengths

- There are many livestock farmers in Argyll
- Straw prices have gone up and availability is poor
- Argyll a long way from the large straw markets
- Argyll heavily wooded – 30% woodland cover[3]
- Makes use of existing facilities on farms and estates.
- Provides a new source of income for farms and estates that become Production Hubs.
- Hubs would benefit from having ready access to supply of bedding (therefore no delivery charge)

1.1.2 Weaknesses

- Suitable hubs in the right locations would need to be found.
- Requires farmers to change equipment and storage.
- Large distances and poor road network between farms could lead to high costs of chip.
- Timber prices have also gone up over the last decade. This needs to be factored into a new calculation about woodchip for bedding viability.

1.1.3 Opportunities

- Develop market for low grade timber for ASWC members.
- Develop an income stream for ASWC.
- Reduce reliance on imported straw.
- Increase resilience of Argyll livestock farmers.
- Integrated land use (farm and forestry coming together).

1.1.4 Threats

- Resistance to change.
- May need pump priming – cash up front to pay for infrastructure changes in early adopter farms.

Appendix 4 - Farm Soils Reports

Glenbarr Farms

Prepared by:

Audrey Litterick PhD, BSc Hons, MI Soil Sci, MBPR
Earthcare Technical Ltd.
Manor Farm
Chalton
Waterlooville
Hants PO8 0BG

Tel: 07785 796670
audrey@earthcaretechnical.co.uk

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Wood Chip

Background

This report forms part of a study which aimed to investigate the potential for using woodchip and sawdust products as alternatives to straw for livestock bedding. The key driver for the farmers was economic – with straw prices having trebled in some areas over the last 2 years.

Glenbarr Farms have been using spruce sawdust for 6 years for bedding cattle and sheep and have had only positive experiences of using it to date. It cost around £75/t in 2018, which compared favourably with straw (£160/t).

The study, coordinated by SAOS and managed by Argyll Small Woods Cooperative assessed the risks and benefits of using wood chip and/or sawdust as a bedding for cattle and sheep. Earthcare Technical evaluated the physical and chemical properties of the woodchip bedding materials, the farmyard manures from the farms and the soils before and after amendment with the wood-based dungs.

This short report defines the physical and chemical properties of the sawdust-based farmyard manure (FYM) which was applied to the test field at Glenbarr. It also defines the physical and chemical properties of the soil in the test field before and after the FYM was spread to arable land and discusses the economic and practical benefits and challenges of using sawdust as animal bedding.

Methods

The test field (Fort) was chosen by the farmer (Mr Duncan Macalister), who uses fresh spruce sawdust imported from Cardross, Dunbartonshire as animal bedding. There were no physical contaminants (e.g. nails or plastic fragments) in the material. The sawdust was placed in the shed in February 2018, was used for bedding fat lambs for 8 to 10 weeks. It was removed from the shed in August 2018 and was stacked, uncovered in a field for approximately 7 months in total (towards the end of this period, it was moved to the field where it was to be applied). It was applied to land in late March 2019 at approximately 25 t/ha prior to production of a spring barley crop.

The field was walked in order to select areas for soil sampling before amendment with the sawdust-based bedding. It was clear during inspections that the soil type differed slightly across the South and North halves of the field. It was therefore sampled twice in March 2019 and September 2020, with the South half of the field being sampled separately from the North half. The North "half" was slightly larger than the South "half" as per the original field boundaries. Each field was sampled by walking in a "W" pattern, during which time 32 sub-samples were taken using a spiral augur to 20 cm depth. Sub-samples were collected and mixed in a clean bucket and 500 g samples were sent to NRM laboratories for analysis for the following parameters:

- routine agricultural analysis ADAS methods (pH and extractable P [using Olsen P extractant], K and Mg [using ammonium nitrate extractant])
- routine agricultural analysis Scottish methods (extractable P, K and Mg using Modified Morgan's extractant)
- soil organic matter content (LOI)
- microbial respiration

- total potentially toxic elements (PTEs including cadmium [Cd], copper [Cu], chromium [Cr], mercury [Hg], lead [Pb], zinc [Zn] and nickel [Ni])

Soils were also tested by Earthcare Technical for microbial respiration (CO_2 evolution) using Solvita gel paddles. Results were read after incubating the sealed jars of soil at 24^{o}C for 24 hours (according to test instructions) using a digital plate reader. Two pits were also dug in each of the two halves of the field, to a depth of 30 cm. Soil structure was assessed using the VESS method (Ball *et al*., 2012) and the soil was sifted to determine earthworm numbers.

The sawdust was tested to determine its key chemical properties and to determine in particular its carbon (C) to nitrogen (N) ratio (a measure of the extent to which the N will be locked up when the material is applied to land) and the potentially toxic element (or heavy metal) content. It was tested for the following parameters:

- bulk density (the weight per unit volume)
- dry matter content (to determine how wet the dung is)
- pH (a measure of acidity/alkalinity)
- electrical conductivity (a measure of the saltiness/richness of the dung)
- total N, P, K, Mg, S (plant major and secondary nutrient content)
- total C, C:N ratio (a measure of the extent to which the N will be locked up when the material is applied to land)
- organic matter content
- ammonium and nitrate-N (the a mount of readily-available N in the dung)
- total PTE content (Cd, Cu, Cr, Hg, Pb, Zn and Ni)

The FYM was tested after stacking in the field for the same parameters as those listed above.

Results and discussion

Sawdust

The sawdust was stored in a covered shed prior to use. It was a fine grade material with no obvious physical contaminants present. It was very light in weight and the sample taken was moist, although it was probably much drier when delivered. It had a pH of 5.5 and low electrical conductivity, neither of which would cause problems when the material was mixed with animal manure (Table 2).

The sawdust had a high carbon : nitrogen (C:N) ratio, which indicates that it would cause considerable N lock-up if applied to land as a fresh waste. N lock-up happens when any material with a high proportion of C relative to N is applied to soil. It happens because soil micro-organisms need a certain amount of N in order to be able to grow, multiply and break down waste organic materials in soils. When N is lacking in the material(s) applied to land, then they seek out N from the soil reserves and they are much better at scavenging for N than plant roots are. The plants growing in soils to which high-C wastes have been applied therefore become N-deficient. Symptoms such as yellowing of leaves, poor growth and development are typical of plants growing in soils where N lock-up is occurring. This is one of the main reasons why it is important to stack and turn animal manures which contain a lot of straw or woody wastes for at least 6 months before applying them to land: the stacking and turning gives the microorganisms a chance to absorb the N present and break down the C-rich wastes so that the nutrients within them are more readily available to plants.

The sawdust contained a useful amount of organic matter, no readily available N (ammonium and nitrate-N) and relatively low plant nutrient concentrations. It contained very low concentrations of PTEs.

The sawdust-based FYM

Once mixed with animal droppings, the resulting manure was a good, though relatively low-nutrient material (Table 1).

Table 1. Summary of the properties of fresh, unused sawdust and sawdust-based dung, which had been stacked for approximately 6 months.

		Value	
Parameter	**Unit**	**Fresh sawdust**	**Sawdust dung**
Bulk density	g/l	214	720
Dry matter content	%	50.3	22.8
pH	pH unit	5.5	7.6
Electrical conductivity	µS/cm	41	333
C:N ratio	ratio	486:1	32:1
Organic matter content	% in fresh material	50	19
Ammonium-N	kg/fresh tonne	< 0.01	< 0.01
Nitrate-N	"	< 0.01	< 0.01
Total plant nutrients			
N	kg/fresh tonne	0.5	2.9
phosphate	"	0.1	1.3
potash	"	0.3	1.4
magnesium oxide	"	0.1	1.1
sulphur trioxide	"	0.2	1.1
Total PTE content			
Cd	mg/kg dry matter	< 0.1	0.154
Cu	"	1.47	26.5
Cu	kg/fresh tonne	-	0.01
Cr	mg/kg dry matter	< 2.0	5.27
Hg	"	< 1.0	< 0.1
Pb	"	< 1.0	5.72
Zn	"	6.86	161
Zn	kg/fresh tonne	-	0.04
Ni	"	< 1.0	4.72

It contained 2.9, 1.3 and 1.4 kg/fresh tonne of N, phosphate and potash respectively. These concentrations were lower than those in “typical” cattle manures, which 6.0, 3.2 and 8.0 kg/fresh tonne of N, phosphate and potash respectively (FAS, 2020). The fact that the manure contained relatively low nutrient concentrations was a reflection of the relatively low nutrient levels in the sawdust and the way in which the animals producing the dung were fed. It is neither a good thing, nor a bad thing. However, it is always worth knowing nutrient levels in FYM, so that the right decisions can be made in relation to nutrient budgeting for the fields to which it is applied.

The FYM contained low concentrations of PTEs, none of which would cause any problems to the receiving soil. It contained small but useful amounts of both copper and zinc, both of which are essential trace elements for crops and livestock. When applied at 25 t/ha, the FYM would add 0.25 kg/ha of Cu and 1 kg/ha of Zn to the soil.

Soil in the test field

The topsoil was a sandy loam in the Corby series. Soil test results are shown in Table 2.

Table 1. Summary of key agronomic soil properties in both parts of the field before and after spreading the sawdust-based FYM.

		South		North	
Parameter	**Unit**	**Before**	**After**	**Before**	**After**
pH (water)	pH unit	6.9	6.7	6.8	6.5
Lime requirement[1]	t/ha	0.0	0.0	0.0	0.0
Soil organic matter	%	5.3	4.9	7.4	6.8
Earthworm count[2]	mean no/ pit	7	6	4	5
Microbial respiration[3]	mg CO_2/gsoil/day	48	52	49	50
Soil structure (VESS)	Mean of two pits per area	2	2	2	2
Extractable nutrients (Scottish methods: Modified Morgan's extractant)					
Phosphorus, or P (status)	mg/l	8.3 (M-)	7.7 (M-)	6.6 (M-)	6.7 (M-)
Potassium, or K (status)	mg/l	125 (M-)	159 (M+)	133 (M-)	151 (M-)
Magnesium, or Mg (status)	mg/l	65 (M)	62 (M)	78 (M)	70 (M)
Extractable nutrients (ADAS methods: Olsen's P and ammonium nitrate extractant)					
Phosphorus, or P (index)	mg/l	37.8 (3)	36.4 (3)	31.2 (3)	35.2 (3)
Potassium, or K (index)	mg/l	135 (2-)	148 (2-)	132 (2-)	142 (2-)
Magnesium, or Mg (index)	mg/l	59 (2)	53 (2)	64.8 (2)	58.5 (2)

[1]Lime requirement refers to the no. of tonnes/ha of ground limestone required to bring the topsoil to target status for the crop in question (which in Scotland is 6.0 for grass and 6.5 for arable crops).
[2]Worm counts were based on excavation of four pits (20 x 20 x 30 cm depth) per field and sieving of soil to ensure all worms were counted. Worms were classified as 'absent' (0 per pit), 'poor' (1-5 per pit), 'good' (6 – 10 per pit) or 'very good' (>12 per pit). Score quoted is the average from all four pits.
[3]Microbial respiration was measured using Solvita® kits and the colour on the colourimetric paddles was measured using a plate meter. Results are an average of two tests per field.
[3]Soil structure was assessed using the Visual Assessment of Soil Structure Method (Ball *et al.*, 2012).

Soil pH was fine in both halves of the field prior to application of the FYM (the target pH for rotational grass and arable land in Scotland is 6.5) and no lime was required. Soil organic matter was 5.3% in the South and 6.8 in the North, which is fine, though slightly lower than natural topsoils in this area (which on average have an organic matter content of 7.1%). This slightly lower organic matter content suggests a soil which has been under frequent cultivation.

The Scottish soil test methods showed that P, K and Mg were all on target for arable cropping. This is ideal. P, K and Mg should simply be added in sufficient amounts to replace crop offtake in future.

The ADAS soil test methods, which are typically used in England and Wales, indicated that crop-available P was above target and that K and Mg were all on target for arable cropping. The English method (Olsen P) for testing P was developed for calcareous soils and is generally acknowledged by Scottish nutrient management specialists not to be the best method for non-calcareous Scottish soils. It is unlikely that soil P really is present at higher amounts than required, and this method has likely overestimated the amount of crop-available P present. None of the PTEs tested were present in the soil at concentrations which would cause problems for grazing livestock or arable cropping (Table 3).

The earthworm count was low, and indicative of a soil which has been cultivated regularly. Microbial respiration was also low in both halves of the field, which indicated a soil that had relatively low microbial activity. Soil structure in both parts of the field was allocated a “2” using the VESS method. This indicates that structure is reasonably good, but that some of the aggregates in the sample were fairly firm and there were some areas of compaction. A visual assessment of the field also showed

Table 3. Concentrations of potentially toxic elements (PTEs) in soil before amendment FYM.

		Value			
		South		North	
Total PTE	**Unit**	**Before**	**After**	**Before**	**After**
Cadmium (Cd)	mg/kg dry matter	0.32	0.34	0.32	0.24
Copper (Cu)	“	13.2	9.6	10.2	8.1
Chromium (Cr)	“	45.3	18.6	36.0	13.9
Mercury (Hg)	“	< 0.2	< 0.2	< 0.2	< 0.2
Lead (Pb)	“	14.3	13.6	19.8	14.6
Zinc (Zn)	“	52.7	37.3	50.0	29.6
Nickel (Ni)	“	10.1	< 10.0	< 10.0	< 10.0

that compaction was present in places, particularly in the areas which were slowest to dry out after rain, or where traffic was likely to be high on a regular basis.

Soil test results conducted after application of the sawdust-based FYM were very similar to those conducted before it was applied and there was no evidence of any effects of applying the FYM, whether beneficial or deleterious. This was as expected, given that it typically takes a long time to see changes in soil properties such as nutrient status or organic matter content. The results of this short project could only ever indicate the possibility of potential for fairly major benefits or problems, most likely with the crop grown rather than with the soil. There was a very slight drop in soil pH across both parts of the field, and a slight increase in soil K concentrations (from both types of soil K extraction), which may indicate that crop offtake of K was lower than the amount of K applied in fertiliser and FYM.

By applying the sawdust-based FYM at 25 t/ha, the farmer will be applying 4.8 t/ha of organic matter. Regular additions of organic matter are known to help develop and maintain soil health. Arable soils with adequate organic matter (SOM) levels are likely to have better structure, faster water infiltration, better water-holding capacity in dry periods, greater resilience to stress, higher numbers and diversity of soil organisms and ultimately higher yield potential than those with low SOM levels. Regular additions of organic matter will not necessarily result in a steady increase of soil organic matter content though, because several management practices, in particular regular cultivations will contribute to organic matter loss. Regular additions of organic matter are thought to be beneficial to most arable soils and this FYM will be an excellent source of organic matter as well as a useful source of nutrients. There is no evidence that the relatively high C:N ratio in it caused N lock-up in the following crop. Provided similar FYM handling procedures are followed in future, N lock-up is unlikely to be a problem in future. N lock-up would, however, be highly likely if the FYM were to be applied to soils straight out of the housing sheds, particularly if it was to be applied at higher rates, such as > 10 t/ha).

As expected, there is no evidence that the FYM will cause increases in soil PTE concentrations and will in fact add small but useful amounts of Cu and Zn.

Earthworm numbers were similar in the field before and after the trial. It is unlikely that earthworm numbers will substantially change with the use of sawdust-based FYM rather than straw-based FYM. Soil structure also remained in a similar condition after the trial and again it is unlikely to be affected by a change to sawdust-based FYM.

Spring barley crop

The spring barley crop performed as expected for the field. It was sown in March 2020, harvested in September 2020 and yielded around 6.6 t/ha, which is within the normal range for this field. It suffered from no obvious physiological disorders or pest and disease problems. There was no visible evidence of N lock-up following application of this relatively high C:N ratio FYM prior to cropping.

Conclusions

- Sawdust was available to Glenbarr Farms in slightly less than sufficient quantities and was therefore topped up by straw in small quantities. The sawdust proved to be a cheaper bedding material in 2018 and 2019 than straw. The price differential is likely to vary from year to year but in 2021 sawdust (at £75/t) is still half the price of straw (£150/t).
- Sawdust was easier to spread as a bedding material than straw and was easy to top up when in use.
- Sawdust was superior to straw as a bedding material in that sheep suffered from fewer foot problems and there were fewer naval issues in cattle.
- FYM based on sawdust was as useful that based on straw in terms of its soil conditioning and fertiliser properties. The sawdust-based FYM used in this study contained low nutrient concentrations in comparison to typical values for straw-based FYM, but this is likely to be due mainly to the way in which the animals bedded on the straw were fed, the numbers of animals bedded and the length of time they were housed for. Low nutrient levels in FYM are not a problem: it is simply important to test each FYM and understand nutrient concentrations in order to complete accurate field nutrient budgets.
- There was no evidence of N lock-up following application of the straw-based FYM to arable land. Providing sawdust-based FYMs are stacked and turned for 6 to 12 months and are applied at appropriate rates (usually around 10 to 30 t/ha) then

symptoms of N lockup in following crops are unlikely to be a problem, particularly when they are applied to healthy soils with an active microbial population.

- Considering the price, ease of handling, reduced animal health issues and acceptable quality of sawdust-based FYM, sawdust is an excellent choice of animal bedding material, which may often be cheaper and in practical terms also preferable to straw.

References

Ball, B., Guimares, R., Batey, T. & Munkholm, L. (2012) Visual evaluation of soil structure (https://www.sruc.ac.uk/info/120625/visual_evaluation_of_soil_structure).

FAS (2020) Optimising the application of bulky organic fertilisers. Technical Note TN 736. (https://www.fas.scot/downloads/technical-note-tn736-optimising-application-livestock-farmyard-manures-slurries/).

Audrey Litterick
Earthcare Technical
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Earthcare TECHNICAL

Old Leckie Farm

Prepared by:

Audrey Litterick PhD, BSc Hons, MI Soil Sci, MBPR
Earthcare Technical Ltd.
Manor Farm
Chalton
Waterlooville
Hants PO8 0BG

Tel: 07785 796670
audrey@earthcaretechnical.co.uk

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gov.scot

Wood Chip

Background

This report forms part of a study which aimed to investigate the potential for using woodchip and sawdust products as alternatives to straw for livestock bedding. The key driver for the farmers was economic – with straw prices having trebled in some areas over the last 2 years.

Old Leckie has not used woodchip bedding in the past and the farmer was keen to see how the material compared with the straw which he has used in the past.

The study coordinated by SAOS and managed by Argyll Small Woods Cooperative assessed the risks and benefits of using woodchip and/or sawdust as bedding materials for cattle and sheep. Earthcare Technical evaluated the physical and chemical properties of the woodchip bedding materials, the farmyard manures (FYMs) from the farms and the soils before and after amendment with the wood-based FYMs.

This short report defines the physical and chemical properties of the woodchip, which was manufactured from farm woodlands at Old Leckie and the properties of the resulting FYM, which was applied to the test field. It also defines the physical and chemical properties of the soil in the test field before and after the FYM was spread to a rotational grass field and discusses the economic and practical benefits and challenges of using farm-produced woodchip as animal bedding.

Methods

Woodchip bedding material was produced on the farm by shredding small branches and young trees which were cut during woodland management operations in the winter of 2018/19. Material was also generated as a by-product on farm from processing wood fuel for the farms 100 kw log boiler. The majority of the bedding material was therefore generated from well-seasoned wood. The wood was shredded to a coarse chip (pieces up to around 6 cm in length). It was placed in the housing in early January 2020 and was used for bedding cows and calves for around 8 weeks. It was removed from the shed at the end of February 2020 and was stacked, uncovered in a field for approximately 8 weeks. It was applied to land in April 2020 at approximately 75 t/ha prior to the land being ploughed and sown to spring barley. The farm was not in an NVZ; had it been, the application rate would have been limited to 50 t/ha. The barley was harvested in September 2020 and the stubble was sown with a westerwolds ryegrass and clover mix.

The test area within the field was sampled in March 2019 before the woodchip-based FYM was applied and again in December 2020 after the grass had established following the barley crop. The area was sampled by walking in a "W" pattern, during which time around 32 sub-samples were taken on each occasion, using a spiral augur to 20 cm depth. Sub-samples were collected and mixed in a clean bucket and 500 g samples were sent to NRM laboratories for analysis for the following parameters:

- routine agricultural analysis ADAS methods (pH and extractable P [using Olsen P extractant], K and Mg [using ammonium nitrate extractant])
- routine agricultural analysis Scottish methods (extractable P, K and Mg using Modified Morgan's extractant)
- soil organic matter content (LOI)
- microbial respiration

- total potentially toxic elements (PTEs including cadmium [Cd], copper [Cu], chromium [Cr], mercury [Hg], lead [Pb], zinc [Zn] and nickel [Ni])

Soils were also tested by Earthcare Technical for microbial respiration (CO_2 evolution) using Solvita gel paddles. Results were read after incubating the sealed jars of soil at 24^{o}C for 24 hours (according to test instructions) using a digital plate reader. The soil was also assessed for structure using the VESS method (Ball *et al.*, 2012) and earthworm numbers were counted in four test digs.

The woodchip was tested to determine its key chemical properties including its carbon (C) to nitrogen (N) ratio (a measure of the extent to which the N will be locked up when the material is applied to land) and the potentially toxic element (or heavy metal) content. It, and the woodchip FYM (following stacking) was tested for the following parameters:

- bulk density (the weight per unit volume)
- dry matter content (to determine how wet the dung is)
- pH (a measure of acidity/alkalinity)
- electrical conductivity (a measure of the saltiness/richness of the dung)
- total N, P, K, Mg, S (plant major and secondary nutrient content)
- total C and C:N ratio
- organic matter content
- ammonium and nitrate-N (the a mount of readily-available N in the dung)
- total PTE content (Cd, Cu, Cr, Hg, Pb, Zn and Ni)

Results and discussion

Woodchip

The woodchip was a mixed grade material with some coarse fragments (pieces up to around 6 cm in length and some fines. There were no obvious physical contaminants present. It was very light in weight and the sample tested was relatively dry. It had a pH of 5.4 and relatively low electrical conductivity, neither of which would cause problems when the material was mixed with animal manure (Table 1).

The woodchip had a fairly high carbon : nitrogen (C:N) ratio (91:1), which indicates that it would cause N lock-up if applied to land as a fresh waste. N lock-up happens when any material with a high proportion of C relative to N is applied to soil. It happens because soil micro-organisms need a certain amount of N in order to be able to grow, multiply and break down waste organic materials in soils. When N is lacking in the material(s) applied to land, then they seek out N from the soil reserves and they are much better at scavenging for N than plant roots are. The plants growing in soils to which high-C wastes have been applied therefore become N-deficient. Symptoms such as yellowing of leaves, poor growth and development are typical of plants growing in soils where N lock-up is occurring. This is one of the main reasons why it is important to stack and turn animal manures which contain a lot of straw or woody wastes for at least 6 months before applying them to land: the stacking and turning gives the microorganisms a chance to absorb the N present and break down the C-rich wastes so that the nutrients within them are more readily available to plants.

The woodchip contained a useful amount of organic matter and low concentrations of readily available N (ammonium and nitrate-N) and PTEs. It contained useful amounts of plant nutrients, particularly N and K.

The woodchip-based FYM

Once mixed with animal droppings, the resulting manure was a good, fairly nutrient-rich material (Table 1). It contained 4.9, 1.8 and 6.1 kg/fresh tonne of N, phosphate and potash respectively. These concentrations were slightly lower than those in “typical” cattle manures, which 6.0, 3.2 and 8.0 kg/fresh tonne of N, phosphate and potash respectively (FAS, 2020). The fact that the manure contained relatively low nutrient concentrations was a reflection of the relatively low nutrient levels

Table 1. Summary of the properties of fresh, unused woodchip and woodchip-based dung, which had been stacked for approximately 8 weeks after it was removed from the housing.

Parameter	Unit	Value	
		Fresh woodchip	**Woodchip dung**
Bulk density	g/l	202	502
Dry matter content	%	67.1	28.6
pH	pH unit	5.4	8.6
Electrical conductivity	µS/cm	810	1,860
C:N ratio	ratio	91:1	24:1
Organic matter content	% in fresh material	64	21
Ammonium-N	kg/fresh tonne	< 10	0.46
Nitrate-N	“	< 10	< 0.01
Total plant nutrients			
Nitrogen	kg/fresh tonne	3.6	4.9
Phosphate	“	0.9	1.8
Potash	“	2.2	6.1
Magnesium oxide	“	0.9	1.9
Sulphur trioxide	“	1.0	1.4
Total PTE content			
Cd	mg/kg dry matter	0.47	0.32
Cu	“	11.1	23.4
Cr	“	4.39	7.74
Hg	“	< 1.0	< 0.1
Pb	“	3.53	9.49
Zn	“	81.6	91.9
Ni	“	2.24	5.26

in the woodchip and the way in which the animals producing the dung were fed. It is neither a good thing, nor a bad thing. However, it is always worth knowing nutrient levels in FYM, so that the right decisions can be made in relation to nutrient budgeting for the fields to which it is applied.

The FYM contained low concentrations of PTEs, none of which would cause any problems to the receiving soil. It contained small but useful amounts of both copper and zinc, both of which are essential trace elements for crops and livestock. When applied at 75 t/ha, the FYM would add 0.75 kg/ha of Cu and 2.25 kg/ha of Zn to the soil.

Soil in the test field

The topsoil was a non-calcareous gley, with a silty clay loam texture in the Stirling series. Results from soil tests are shown in Table 2.

Table 2. Summary of key agronomic soil properties before and after applying woodchip FYM

Parameter	Unit	Byre's Park	
		Before FYM	**After FYM**
pH (water)	pH unit	6.0	6.1
Lime req't (rotational grass)[1]	t/ha	4	3
Soil organic matter	%	5.2	4.8
Earthworm numbers	Estimate[2]	good	excellent
Microbial respiration[3]	mg CO_2/gsoil/day	50	64
Soil structure (VESS)[4]	Mean of four test digs per area	1	1
Extractable nutrients (Scottish methods: Modified Morgan's extractant)			
Phosphorus, or P (status)	mg/l	2.8 (L)	2.7 (L)
Potassium, or K (status)	mg/l	68 (L)	63 (L)
Magnesium, or Mg (status)	mg/l	137 (M)	131 (M)
Extractable nutrients (ADAS methods: Olsen's P and ammonium nitrate extractant)			
Phosphorus, or P (index)	mg/l	17.0 (2)	17.5 (2)
Potassium, or K (index)	mg/l	67.7 (1)	63.1 (1)
Magnesium, or Mg (index)	mg/l	132 (3)	126 (3)

[1]Lime requirement refers to the no. of tonnes/ha of ground limestone required to bring the topsoil to target status for the crop in question (which in Scotland is 6.0 for grass and 6.5 for rotational grass and arable crops).
[2]Earthworm numbers were assessed in quick test digs (one full depth spadeful of soil) as being absent [no earthworms], poor [1 – 3 earthworms], good [4 – 10 earthworms] or excellent [> 10 earthworms]).
[3]Microbial respiration was measured using Solvita® kits and the colour on the colourimetric paddles was measured using a plate meter. Results were an average of two tests per field.
[4]Soil structure was assessed using the Visual Assessment of Soil Structure Method (Ball *et al.*, 2012).

Soil pH was slightly low in Byre's park prior to FYM application (the target pH for rotational grass in Scotland is 6.3). Lime was applied after ploughing at 5 t/ha. Woodchip FYM was then applied then the lime and woodchip were cultivated. Should lime be applied in future, it is probably best to use calcium-based liming products, and not magnesium-based ones. Soil organic matter (SOM) content was 5.2% in Byre's park, which is fine, and similar to the natural topsoils in this area (which on average have an organic matter content of around 5%). Earthworm numbers were assessed as being "good" on the first visit and the soil structure was good (as assessed using the VESS method). Microbial respiration was fairly low in the field, which indicated that the soil had relatively low microbial activity.

The Scottish soil test methods showed that crop-available P and K were both low (L) in Byre's Park, which is below the target of the lower half of moderate (M-) for crops including grass. The soil therefore needed both P and K. Crop available Mg was on target of moderate (M). The ADAS soil test methods, which are typically used in England and Wales, indicated that crop-available P and Mg were on target, and that K was below the target for arable cropping. The English method (Olsen P) for testing P was developed for calcareous soils and is not the best method for non-calcareous Scottish soils. It is unlikely that crop-available

P really is present at sufficient amounts and this method has likely overestimated the amount of crop-available P present.

None of the PTEs tested before FYM application were present in the soil at concentrations which would cause problems for grazing livestock or arable cropping (Table 3). Soil structural evaluations showed that soil structure was very good before the woodchip FYM was applied. This was typical of well-managed pasture soils.

Table 3. Concentrations of potentially toxic elements (PTEs) in soil before amendment with woodchip-based dung.

		Byre's Park	
Total PTE	**Unit**	**Before FYM**	**After FYM**
Cadmium (Cd)	mg/kg dry matter	< 0.1	0.17
Copper (Cu)	"	6.3	7.5
Chromium (Cr)	"	24.9	19.2
Mercury (Hg)	"	< 0.2	< 0.2
Lead (Pb)	"	36.5	22.1
Zinc (Zn)	"	51.6	44.2
Nickel (Ni)	"	11.9	13.3

The results of soil tests conducted after application of the woodchip-based FYM were very similar to those conducted before it was applied and there was no evidence of any effects of applying the FYM, whether beneficial or deleterious. This was as expected, given that it typically takes a long time to see changes in soil properties such as nutrient status or organic matter content. The results of this short project could only ever indicate the possibility of potential for fairly major benefits or problems, most likely with the crop grown rather than with the soil. Soil organic matter content was slightly lower when tested after FYM application, but this is more likely caused by natural variability between the soil samples rather than any real reduction in SOM content.

Soil structural evaluations again showed that soil structure was very good. There were high numbers of soft, small, well-formed aggregates and high earthworm numbers.

By applying the sawdust-based FYM at 75 t/ha (which is more than most farmers would apply in a single application), the farmer applied 15.8 t/ha of organic matter. Regular additions of organic matter are known to help develop and maintain soil health. Soils with adequate organic matter (SOM) levels are likely to have better structure, faster water infiltration, better water-holding capacity in dry periods, greater resilience to stress, higher numbers and diversity of soil organisms and ultimately higher yield potential than those with low SOM levels. Regular additions of organic matter will not necessarily result in a steady increase of SOM content though, because several management practices, in particular regular cultivations will contribute to organic matter loss. In practice, soils under any particular management regime will eventually achieve a stable equilibrium in terms of SOM content. Regular additions of organic matter are thought to be beneficial to most arable and rotational grass soils and this FYM will be an excellent source of organic matter as well as a useful source of nutrients.

There is no evidence that the relatively high C:N ratio in the woodchip-based FYM caused N lock-up in the following crop, despite the high application rate. This lack of N lock-up is indicative of a healthy soil with good potential to recycle nutrients. Provided similar FYM handling procedures are followed in future, N lock-up is unlikely to be a problem in future in this field, although for other fields and other farms, application rates of between 10 and 30 t/ha are recommended in order ot minimise the chance of N lock-up. N lock-up would be highly likely if woodchip FYM were to be applied to soils straight out of the housing sheds, particularly if it was to be applied at rates higher than 10 t/ha).

As expected, there was no evidence that the woodchip FYM caused increases in soil PTE concentrations. It added small but useful amounts of Cu and Zn. Differences between PTE concentrations in soil samples tested before and after FYM application are likely due to natural sampling variation rather than any real differences.

Conclusions

- Woodchip was manufactured on the farm at no cost other than that of labour, machinery and fuel. The cost was estimated to be around £30/t which is considerably cheaper than imported straw, which would have been around £60/t in 2019.
- Woodchip bedding was a little easier to spread as a bedding material than straw and was easy to top up when in use - as material could be tipped into the pen utilising a telehandler from outside the pen.
- Woodchip was superior to straw as a bedding material in that it lasted longer than straw and required fewer top-ups. It also appeared to be more absorbent and thus kept the cattle cleaner.
- The farmer noted that it was easy to cheaply generate small amounts of woodchip on farm, but that to generate larger volumes from farm resources would require an external chipping contractor at additional cost.
- FYM based on woodchip was as useful that based on straw in terms of its soil conditioning and fertiliser properties. The woodchip-based FYM used in this study contained slightly lower nutrient concentrations in comparison to typical values for straw-based FYM, but this is likely to be due mainly to the way in which the animals bedded on the straw were fed, the numbers of animals bedded and the length of time they were housed for. Low nutrient levels in FYM are not a problem: it is simply important to test each FYM and understand nutrient concentrations in order to complete accurate field nutrient budgets.
- There was no evidence of N lock-up following application of the woodchip-based FYM to arable land despite the relatively high C:N ratio in the material and the high application rate. It is recommended that woodchip-based FYMs are stacked and turned for 6 to 12 months and are applied at lower rates (usually around 10 to 30 t/ha) in order to minimise the chance of symptoms of N lockup in following crops.
- Considering the price, ease of handling, reduced animal health issues and acceptable quality of woodchip-based FYM, woodchip is an excellent choice of animal bedding material, which may often be cheaper and in practical terms also preferable to straw.

References

Ball, B., Guimares, R., Batey, T. & Munkholm, L. (2012) Visual evaluation of soil structure (https://www.sruc.ac.uk/info/120625/visual_evaluation_of_soil_structure).
FAS (2020) Optimising the application of bulky organic fertilisers. Technical Note TN 736. (https://www.fas.scot/downloads/technical-note-tn736-optimising-application-livestock-farmyard-manures-slurries/).

Audrey Litterick
Earthcare Technical
February 2021

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Coille Farm

Prepared by:

Audrey Litterick PhD, BSc Hons, MI Soil Sci, MBPR
Earthcare Technical Ltd.
Manor Farm
Chalton
Waterlooville
Hants PO8 0BG

Tel: 07785 796670
audrey@earthcaretechnical.co.uk

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Wood Chip

Background

This report forms part of a study which aimed to investigate the potential for using woodchip and sawdust products as alternatives to straw for livestock bedding. The key driver for the farmers was economic – with straw prices having trebled in some areas over the last 2 years.

Coille Farm has not used woodchip bedding in the past and was keen to see how the material compared with the straw which has been used previously.

The study, coordinated by SAOS and managed by Argyll Small Woods Cooperative, assessed the risks and benefits of using woodchip and/or sawdust as bedding materials for cattle and sheep. Earthcare Technical evaluated the physical and chemical properties of the woodchip bedding materials, the farmyard manures (FYMs) from the farms and the soils before and after amendment with the wood-based FYMs.

This short report defines the physical and chemical properties of the woodchip and the properties of the resulting FYM, which was applied to the test field. It also defines the physical and chemical properties of the soil in the test field before and after the FYM was spread to a permanent grass field and discusses the economic and practical benefits and challenges of using locally-produced woodchip as animal bedding.

Methods

Woodchip bedding material was produced by a local sawmill (on the island of Islay) from virgin softwood in 2018. The wood was shredded to a coarse chip (pieces up to a maximum of around 6 cm in length).The first batch of woodchip bedding was placed in the shed in September 2018, where it was used for bedding sheep during lambing and shearing for 35 weeks up to June 2019. It was removed from the shed in August 2019 and was stacked, uncovered in a field for approximately 16 months in total. It was surface-applied to a 2.5 ha permanent grass field in December 2020. The rate at which it was applied was not known, but it was likely to be approximately 20 to 30 t/ha. No crop was harvested from the field, which is used for permanent grazing. The field is typically grazed for approximately 10 months each year with between 30 and 50 sheep (mules) at any time. Sheep were returned to the land on this occasion shortly before the post FYM samples were taken in March 2021.

The field was sampled by walking in a “W” pattern both before and 3 months after the woodchip FYM was spread, during which time 32 sub-samples were taken using a spiral augur to 20 cm depth. Sub-samples were collected and mixed in a clean bucket and 500 g samples were sent to NRM laboratories for analysis for the following parameters:

- routine agricultural analysis ADAS methods (pH and extractable P [using Olsen P extractant], K and Mg [using ammonium nitrate extractant])
- routine agricultural analysis Scottish methods (extractable P, K and Mg using Modified Morgan’s extractant)
- soil organic matter content (LOI)
- microbial respiration
- total potentially toxic elements (PTEs including cadmium [Cd], copper [Cu], chromium [Cr], mercury [Hg], lead [Pb], zinc [Zn] and nickel [Ni])

Soils were also tested by Earthcare Technical for microbial respiration (CO_2 evolution) using Solvita gel paddles. Results were read after incubating the sealed jars of soil at 24ºC for 24 hours (according to test instructions) using a digital plate reader. Two pits were also dug in each of the two halves of the field, to a depth of 30 cm and the soil was sifted to determine earthworm numbers. Unfortunately it was not possible to get onto Islay to do earthworm counts and microbial respiration tests after the FYM was spread, due to Covid19 regulations. The farmer kindly obtained the required soil sample rather than Earthcare Technical staff.

The woodchip and woodchip-based FYM were tested to determine their key chemical properties and to determine in particular their carbon (C) to nitrogen (N) ratio (a measure of the extent to which the N will be locked up when the material is applied to land) and the potentially toxic element (or heavy metal) content. Materials were tested for the following parameters:

- bulk density (the weight per unit volume)
- dry matter content (to determine how wet the dung is)
- pH (a measure of acidity/alkalinity)
- electrical conductivity (a measure of the saltiness/richness of the dung)
- total N, P, K, Mg, S (plant major and secondary nutrient content)
- total C, C:N ratio (a measure of the extent to which the N will be locked up when the material is applied to land)
- organic matter content
- ammonium and nitrate-N (the a mount of readily-available N in the dung)
- total PTE content (Cd, Cu, Cr, Hg, Pb, Zn and Ni)

Results and discussion

The woodchip was a mixed grade material with some coarse fragments (pieces up to around 6 cm in length and some fines. There were no obvious physical contaminants present. It was very light in weight (297 kg/m^3) despite the sample tested being fairly moist. It had a pH of 4.6 and relatively low electrical conductivity, neither of which would cause problems when the material was mixed with animal manure (Table 1).

The woodchip had an extremely high carbon : nitrogen (C:N) ratio (605:1), which indicates that it would cause significant N lock-up if applied to land as a fresh waste. N lock-up happens when any material with a high proportion of C relative to N is applied to soil. It happens because soil micro-organisms need a certain amount of N in order to be able to grow, multiply and break down waste organic materials in soils. When N is lacking in the material(s) applied to land, then they seek out N from the soil reserves and they are much better at scavenging for N than plant roots are. The plants growing in soils to which high-C wastes have been applied therefore become N-deficient. Symptoms such as yellowing of leaves, poor growth and development are typical of plants growing in soils where N lock-up is occurring. This is one of the main reasons why it is important to stack and turn animal manures which contain a lot of straw or woody wastes for at least 6 months before applying them to land: the stacking and turning gives the microorganisms a chance to absorb the N present and break down the C-rich wastes so that the nutrients within them are more readily available to plants.

Table 1. Summary of the properties of fresh, unused woodchip and woodchip-based FYM, which had been stacked for approximately 6 months when it was tested.

Parameter	Unit	Value: Fresh woodchip	Value: Woodchip FYM
Bulk density	g/l	297	690
Dry matter content	%	49.4	37.5
pH	pH unit	4.6	8.7
Electrical conductivity	µS/cm	68	2571
C:N ratio	ratio	605:1	42:1
Organic matter content	% in fresh material	49	29
Ammonium-N	kg/fresh tonne	< 0.01	0.03
Nitrate-N	"	< 0.01	< 0.01
Total plant nutrients			
Nitrogen	kg/fresh tonne	0.4	3.7
Phosphate	"	0.1	2.6
Potash	"	0.3	8.3
Magnesium oxide	"	0.2	1.9
Sulphur trioxide	"	0.4	3.5
Total PTE content			
Cd	mg/kg dry matter	0.14	0.32
Cu	"	2.15	13.5
		-	0.01
Cr	"	2.41	7.98
Hg	"	< 1.0	< 0.1
Pb	"	1.17	3.93
Zn	"	17.1	114
		-	0.04
Ni	"	1.1	8.63

The woodchip contained a useful amount of organic matter and low concentrations of readily available N (ammonium and nitrate-N) and PTEs. It contained low amounts of plant nutrients, probably because the trees from which the woodchip was made had been grown on nutrient-poor soils.

The woodchip-based FYM

Once mixed with animal droppings, the resulting manure was a useful material (Table 1). It contained 3.7, 2.6 and 8.3 kg/fresh tonne of N, phosphate and potash respectively. These concentrations were slightly lower than those in “typical” cattle manures, which 6.0, 3.2 and 8.0 kg/fresh tonne of N, phosphate and potash respectively (FAS, 2020). The fact that the manure contained these slightly lower nutrient concentrations was a reflection of the relatively low nutrient levels in the woodchip and the way in which the animals producing the dung were fed. It is neither a good thing, nor a bad thing. However, it is always worth knowing nutrient levels in FYM, so that the right decisions can be made in relation to nutrient budgeting for the fields to which it is applied.

The FYM contained low concentrations of PTEs, none of which would cause any problems to the receiving soil.

Soil in the test field

The topsoil was a non-calcareous gley in the Torridon series. It had a sandy silt loam texture. Results from soil tests are shown in Table 2.

Table 2. Summary of key agronomic soil properties before and after applying woodchip FYM

		Road end field	
Parameter	**Unit**	**Before FYM**	**After FYM**
pH (water)	pH unit	5.9	7.0
Lime req't (rotational grass)[1]	t/ha	0.0	0.0
Soil organic matter	%	19.5	25.1
Earthworm numbers	Estimate[2]	good	-
Microbial respiration[3]	mg CO_2/gsoil/day	79	-
Soil structure (VESS)[4]	Mean of four test digs per area	1	-
Extractable nutrients (Scottish methods: Modified Morgan's extractant)			
Phosphorus, or P (status)	mg/l	3.0 (L)	1.9 (L)
Potassium, or K (status)	mg/l	181 (M+)	156 (M+)
Magnesium, or Mg (status)	mg/l	101 (M)	135 (M)
Extractable nutrients (ADAS methods: Olsen's P and ammonium nitrate extractant)			
Phosphorus, or P (index)	mg/l	19.0 (2)	15.8 (2)
Potassium, or K (index)	mg/l	189.0 (2+)	140 (2-)
Magnesium, or Mg (index)	mg/l	88 (2)	104 (3)

[1]Lime requirement refers to the no. of tonnes/ha of ground limestone required to bring the topsoil to target status for the crop in question (which in Scotland is 6.0 for grass and 6.5 for rotational grass and arable crops).
[2]Earthworm numbers were assessed in test digs (one full depth spadeful of soil) as being absent [no earthworms], poor [1 – 3 earthworms], good [4 – 10 earthworms] or excellent [> 10 earthworms]).
[3]Microbial respiration was measured using Solvita® kits and the colour on the colourimetric paddles was measured using a plate meter. Results were an average of two tests per field.
[4]Soil structure was assessed using the Visual Assessment of Soil Structure Method (Ball *et al.*, 2012).

Soil pH was only very slightly low prior to FYM application (the target pH for permanent grass in Scotland is 6.0) and no lime was required. Soil organic matter (SOM) content was very high indeed (at 19.5%). This high level is fairly common in long-term permanent pasture, particularly where the drainage is poor in some or all of the field. This SOM content is at least as high as natural topsoils in this area. (Typical soils in this series have SOM contents of around 9%, but according to the Scotland's Soils website (https://soils.environment.gov.scot/) this average is based on very few samples). Earthworm numbers were assessed as being "good" on the first visit. Microbial respiration was fairly low in the field, which indicated that the soil had relatively low microbial activity.

The Scottish soil test methods showed that crop-available P was low (the target is M-) for permanent grass. Crop-available K status was M+, which was slightly above the target (of M-). The soil therefore needed P to bring it up to the target index, plus some P and K to balance crop offtake. Crop available Mg was on target of moderate (M). The ADAS soil test methods, which are typically used in England and Wales, indicated that crop-available P and Mg were on target, and that K was below the target for arable cropping. The English method (Olsen P) for testing P was developed for calcareous soils and is not the best method for non-calcareous Scottish soils. It is unlikely that crop-available P really is present at sufficient amounts and this method has likely overestimated the amount of crop-available P present.

None of the PTEs tested before FYM application were present in the soil at concentrations which would cause problems for grazing livestock or arable cropping (Table 3). Soil structural evaluations using the VESS method showed that soil structure was very good before the woodchip FYM was applied (Ball *et al.*, 2012). This was typical of well-managed pasture soils.

Table 3. Concentrations of potentially toxic elements (PTEs) in soil before amendment with woodchip-based dung.

		Road end Field	
Total PTE	**Unit**	**Before FYM**	**After FYM**
Cadmium (Cd)	mg/kg dry matter	0.16	0.23
Copper (Cu)	"	14.5	12.4
Chromium (Cr)	"	20.9	29.3
Mercury (Hg)	"	< 0.2	< 0.2
Lead (Pb)	"	27.5	29.8
Zinc (Zn)	"	53.9	47.5
Nickel (Ni)	"	11.0	13.2

The results of soil tests conducted after application of the woodchip-based FYM were similar to those conducted before it was applied and there was no evidence of any effects of applying the FYM, whether beneficial or deleterious. This was as expected, given that it typically takes a long time to see changes in soil properties such as nutrient status or organic matter content. The results of this short project could only ever indicate the possibility of potential for fairly major benefits or problems, most likely with the crop grown rather than with the soil. Both soil pH and soil organic matter content were higher when tested after FYM application, but this is more likely caused by natural variability between the soil samples rather than any real changes in soil properties.

It was not possible to repeat the soil structural evaluations, the earthworm counts or the microbial respiration tests, because it was not possible to get onto Islay due to Covid19 regulations. However, the farmer did remark that earthworm numbers seemed very high in the field 3 months after application of the woodchip-based FYM.

By applying the woodchip-based FYM at 20 t/ha (a typical application rate), the farmer would have been applying 5.8 t/ha of organic matter. Regular additions of organic matter are known to help develop and maintain soil health. Soils with adequate organic matter (SOM) levels are likely to have better structure, faster water infiltration, better water-holding capacity in dry periods, greater resilience to stress, higher numbers and diversity of soil organisms and ultimately higher yield potential than those with low SOM levels. Regular additions of organic matter will not necessarily result in a steady increase of SOM content though, because several management practices, in particular regular cultivations will contribute to organic matter loss. In practice, soils under any particular management regime will eventually achieve a stable equilibrium in terms of SOM content. Regular additions of organic matter are thought to be beneficial to soils and this FYM will be an excellent source of organic matter as well as a useful source of nutrients.

There is no evidence that the relatively high C:N ratio in the woodchip-based FYM caused N lock-up in the following crop, despite the high application rate. This lack of N lock-up is indicative of a healthy soil with good potential to recycle nutrients. Provided similar FYM handling procedures are followed in future and similar amounts of material are applied, N lock-up is unlikely to be a problem in future in this field, although for other fields it is a possibility. It is always wise to apply lower rates of woody material such as woodchip-based FYM when they are applied on any field for the first time. N lock-up would be highly likely if woodchip FYM were to be applied to soils straight out of the housing sheds, particularly if it was to be applied at rates higher than 10 t/ha.

As expected, there was no evidence that the woodchip FYM caused increases in soil PTE concentrations.

Conclusions

- Woodchip was manufactured locally and was available at a cost of £38/t delivered. This was around the same price as imported straw during the year of the trial.
- Woodchip bedding was much easier to spread as a bedding material than straw and was easy to top up when in use - as material could be tipped into the pen utilising a telehandler from outside the pen.
- Woodchip was superior to straw as a bedding material in that it lasted longer than straw and required fewer top-ups. It also appeared to be more absorbent, stayed drier on the surface and thus kept the sheep cleaner, with significantly fewer foot problems.
- FYM based on woodchip was as useful that based on straw in terms of its soil conditioning and fertiliser properties. The woodchip-based FYM used in this study contained slightly lower nutrient concentrations in comparison to typical values for straw-based FYM, but this is likely to be due mainly to the way in which the animals bedded on the straw were fed, the numbers of animals bedded and the length of time they were housed for. Low nutrient levels in FYM are not a problem: it is simply important to test each FYM and understand nutrient concentrations in order to complete accurate field nutrient budgets.
- Woodchip FYM was considerably easier to spread than straw-based dung. It was easier on the spreader and spread more evenly.
- There was no evidence of N lock-up following application of the woodchip-based FYM to permanent pasture, despite the relatively high C:N ratio in the material. It is recommended that woodchip-based FYMs are stacked and turned for 6 to 12 months and are applied at lower rates (usually around 10 to 30 t/ha) in order to minimise the chance of symptoms of N lockup in following crops.
- Considering the price, ease of handling, reduced animal health issues and acceptable quality of woodchip-based FYM, woodchip was found to be an excellent choice of animal bedding material, which may often be cheaper and in practical terms also preferable to straw.
- The woodchip is available at short notice and no advance purchase is required as for straw, which is a big advantage.

References

Ball, B., Guimares, R., Batey, T. & Munkholm, L. (2012) Visual evaluation of soil structure (https://www.sruc.ac.uk/info/120625/visual_evaluation_of_soil_structure).

FAS (2020) Optimising the application of bulky organic fertilisers. Technical Note TN 736. (https://www.fas.scot/downloads/technical-note-tn736-optimising-application-livestock-farmyard-manures-slurries/).

Audrey Litterick
Earthcare Technical
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Lyleston Farm

Prepared by:

Audrey Litterick PhD, BSc Hons, MI Soil Sci, MBPR
Earthcare Technical Ltd.
Manor Farm
Chalton
Waterlooville
Hants PO8 0BG

Tel: 07785 796670
audrey@earthcaretechnical.co.uk

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Wood Chip

Background

This report forms part of a study which aimed to investigate the potential for using woodchip and sawdust products as alternatives to straw for livestock bedding. The key driver for the farmers was economic – with straw prices having trebled in some areas over the last 2 years.

Mr John Filshay has been using mixed shredded wood wastes at Lyleston Farm for 8 years for bedding cattle. He has had only positive experiences of using it to date. It is delivered free to the farm and is supplemented by straw if tonnages delivered are insufficient for bedding requirements.

The study, coordinated by SAOS and managed by Argyll Small Woods Cooperative assessed the risks and benefits of using woodchip and/or sawdust as a bedding for cattle and sheep. Earthcare Technical evaluated the physical and chemical properties of the woodchip bedding materials, the farmyard manures from the farms and the soils before and after amendment with the wood-based dungs.

This short report defines the physical and chemical properties of the woodchip-based farmyard manure (FYM) which was applied to the test field at Lyleston. It also defines the physical and chemical properties of the soil in the test field before and after the FYM was spread to arable land and discusses the economic and practical benefits and challenges of using sawdust as animal bedding.

Methods

The test field was chosen by the farmer (Mr John Filshay), who uses chipped mixed hard and softwood supplied as animal bedding. The woodchip was placed in the shed at the beginning of November 2018, where it was used to bed cattle over winter. Further woodchip was laid in a new shed in April where it was used for bedding sheep during lambing. The woodchip farmyard manure (FYM) was removed from the sheds at the end of May 2019 and was stacked, uncovered in a field for approximately 1 year. It was applied to the surface of silage grass in April 2020 at approximately 25 t/ha.

One field was chosen for testing before and after application of the woodchip-based FYM. It was a well-drained coastal silage field which had had woodchip-based FYM applied annually for around 8 years. It was sampled each time by walking in a "W" pattern, during which time 32 sub-samples were taken using a spiral augur to 20 cm depth. Sub-samples were collected and mixed in a clean bucket and 500 g samples were sent to NRM laboratories for analysis for the following parameters:

- routine agricultural analysis ADAS methods (pH and extractable P [using Olsen P extractant], K and Mg [using ammonium nitrate extractant])
- routine agricultural analysis Scottish methods (extractable P, K and Mg using Modified Morgan's extractant)
- soil organic matter content (LOI)
- microbial respiration
- total potentially toxic elements (PTEs including cadmium [Cd], copper [Cu], chromium [Cr], mercury [Hg], lead [Pb], zinc [Zn] and nickel [Ni])

Soils were also tested by Earthcare Technical for microbial respiration (CO_2 evolution) using Solvita gel paddles. Results were read after incubating the sealed jars of soil at 24ºC for 24 hours (according to test instructions) using a digital plate reader. Two pits were also dug in each field on the first occasion, to a depth of 30 cm and the soil was sifted to determine earthworm numbers.

The woodchip was tested to determine its key chemical properties and to determine in particular its carbon (C) to nitrogen (N) ratio (a measure of the extent to which the N will be locked up when the material is applied to land) and the potentially toxic element (or heavy metal) content. It was tested for the following parameters:

- bulk density (the weight per unit volume)
- dry matter content (to determine how wet the dung is)
- pH (a measure of acidity/alkalinity)
- electrical conductivity (a measure of the saltiness/richness of the dung)
- total N, P, K, Mg, S (plant major and secondary nutrient content)
- total C, C:N ratio (a measure of the extent to which the N will be locked up when the material is applied to land)
- organic matter content
- ammonium and nitrate-N (the a mount of readily-available N in the dung)
- total PTE content (Cd, Cu, Cr, Hg, Pb, Zn and Ni)

The woodchip-based FYM was tested after stacking in the field for the same parameters as those listed above.

Results and discussion

Woodchip

The woodchip was a coarse grade material with no obvious physical contaminants present. It was fairly light in weight and the sample taken was moist, and had some green, leafy material in it. It had a pH of 4.9 and low electrical conductivity, neither of which would cause problems when the material was mixed with animal manure (Table 1).

The woodchip had a high carbon : nitrogen (C:N) ratio, which indicates that it would cause considerable N lock-up if applied to land as a fresh waste. N lock-up happens when any material with a high proportion of C relative to N is applied to soil. It happens because soil micro-organisms need a certain amount of N in order to be able to grow, multiply and break down waste organic materials in soils. When N is lacking in the material(s) applied to land, then they seek out N from the soil reserves and they are much better at scavenging for N than plant roots are. The plants growing in soils to which high-C wastes have been applied therefore become N-deficient. Symptoms such as yellowing of leaves, poor growth and development are typical of plants growing in soils where N lock-up is occurring. This is one of the main reasons why it is important to stack and turn animal manures which contain a lot of straw or woody wastes for at least 6 months before applying them to land: the stacking and turning gives the microorganisms a chance to absorb the N present and break down the C-rich wastes so that the nutrients within them are more readily available to plants.

The woodchip contained a useful amount of organic matter, no readily available N (ammonium and nitrate-N) and relatively low plant nutrient concentrations. It contained very low concentrations of PTEs.

Table 1. Summary of the properties of fresh, unused woodchip and woodchip-based FYM, which had been stacked for approximately 6 months.

Parameter	**Unit**	**Value** **Fresh woodchip**	**Value** **Woodchip FYM**
Bulk density	g/l	326	1,030
Dry matter content	%	41.6	23.3
pH	pH unit	4.9	8.1
Electrical conductivity	µS/cm	447	464
C:N ratio	ratio	123:1	21:1
Organic matter content	% in fresh material	40	30
Ammonium-N	kg/fresh tonne	< 0.01	0.01
Nitrate-N	“	< 0.01	< 0.01
Total plant nutrients			
N	kg/fresh tonne	1.7	3.8
phosphate	“	0.6	2.6
potash	“	1.3	1.9
magnesium oxide	“	0.6	1.7
sulphur trioxide	“	0.5	1.8
Total PTE content			
Cd	mg/kg dry matter	0.19	0.35
Cu	“	3.26	22.1
Cu	kg/fresh tonne	-	0.01
Cr	mg/kg dry matter	< 2.0	14.7
Hg	“	< 1.0	< 0.1
Pb	“	2.2	25.0
Zn	“	42.5	147
Zn	kg/fresh tonne	-	0.03
Ni	“	1.45	12.5

Woodchip-based FYM

Once the woodchip was mixed with animal droppings and stacked, the resulting manure was a good, though relatively low-nutrient material. It contained 3.8, 2.6 and 1.9 kg/fresh tonne of N, phosphate and potash respectively. These concentrations are lower than those in “typical” cattle manures, which 6.0, 3.2 and 8.0 kg/fresh tonne of N, phosphate and potash respectively (SRUC, 2013). The fact that the FYM contains relatively low nutrient concentrations is a reflection of the relatively low nutrient levels in the woodchip and the way in which the animals producing the dung were fed. It is neither a good thing, nor a bad thing. It is simply worth knowing the nutrient levels in the dung, so that the right decisions can be made in relation to nutrient budgeting for the fields to which the dung is applied.

The dung contains low concentrations of PTEs, none of which will cause any problems to the receiving soil. It contains small but useful amounts of both copper and zinc, both of which are essential trace elements for crops and livestock. If applied at 25 t/ha, the farmer would be applying 0.25 kg/ha of Cu and 0.75 kg/ha of Zn.

The topsoil was a brown soil of the Carpow series. It was sandy loam in texture and shallow in places. Results from initial soil tests are shown in Table 2.

Table 2. Summary of key agronomic soil properties

Parameter	Unit	Silage field	
		Before woodchip FYM application	**After woodchip FYM application**
pH (water)	pH unit	6.3	6.2
Lime requirement[1]	t/ha	0.0	0.0
Soil organic matter	%	6.7	6.2
Earthworm count[2]	mean no/ pit	8	N/A
Microbial respiration[3]	mg CO_2/gsoil/day	53	57
Soil structure (VESS)[4]	Mean of two pits per area	2	2
Extractable nutrients (Scottish methods: Modified Morgan's extractant)			
Phosphorus, or P (status)	mg/l	7.3 (M-)	7.8 (M-)
Potassium, or K (status)	mg/l	78 (M-)	34 (VL)
Magnesium, or Mg (status)	mg/l	88 (M)	69 (M)
Extractable nutrients (ADAS methods: Olsen's P and ammonium nitrate extractant)			
Phosphorus, or P (index)	mg/l	39.0 (3)	48.0 (4)
Potassium, or K (index)	mg/l	78.9 (1)	34.8 (0)
Magnesium, or Mg (index)	mg/l	78.8 (2)	62.8 (2)

[1]Lime requirement refers to the no. of tonnes/ha of ground limestone required to bring the topsoil to target status for the crop in question (which in Scotland is 6.0 for grass and 6.5 for arable crops).
[2]Worm counts were based on excavation of four pits (20 x 20 x 30 cm depth) per field and sieving of soil to ensure all worms were counted. Worms were classified as 'absent' (0 per pit), 'poor' (1-5 per pit), 'good' (6 – 10 per pit) or 'very good' (>12 per pit). Score quoted is the average from all four pits. No worm counts were made on the second visit, since the field was full of frisky cattle and the farmer had to be present during soil sampling.
[3]Microbial respiration was measured using Solvita® kits and the colour on the colourimetric paddles was measured using a plate meter. Results are an average of two tests per field.
[4]Soil structure was assessed using the Visual Assessment of Soil Structure Method (Ball *et al.*, 2012).

Soil in the test field

Soil pH was fine in the silage field (the target pH for rotational grass in Scotland is 6.5) and no lime is required. Soil organic matter content was around 6 to 7% in the silage field (based on both sets of test results) which is slightly higher than natural topsoils in this area (which on average have an organic matter content of 5.5%). The slightly higher organic matter content reflects the fact that frequent organic matter returns have been made to the field in the past.

The earthworm count was low in the silage field, which reflects the fact that the soil has been cultivated from time to time. Unfortunately it was not possible to assess earthworm numbers after FYM application, since frisky cattle were present in the field and since the farmer had to be present for safety even during routine soil sampling. Microbial respiration was moderate on both test occasions in the silage field, indicating moderate microbial activity and suggesting a moderately healthy soil.

The Scottish soil test methods showed that soil P status was on target (at moderate, or M- and magnesium was on target (at moderate, or M) for rotational grass. This is ideal: P and Mg should simply be added in sufficient amounts to replace crop offtake in future. It is likely that very little synthetic P or Mg will ever be required where most of the P and Mg being removed in grazing is returned to the soil in the dung from grazing animals. Soil K status was much lower on the second sampling of this field, which may in part be natural sampling variation, but is also probably a result of the amount of silage which was removed since the previous sampling. The soil is now very low in crop-available K. Additional K fertiliser should be applied to address this shortage before further crops are taken from this field.

The ADAS soil test methods, which are typically used in England and Wales, indicated that crop-available P was above target in both fields both before and after application of the woodchip FYM. The English method (Olsen P) for testing P was developed for calcareous soils and is not the best method for non-calcareous Scottish soils. It is unlikely that soil P really is present at higher amounts than required, and this method has likely overestimated the amount of crop-available P present. The ADAS soil test methods showed that crop available Mg was on target but that crop available K was again well below target. This result again shows that additional K fertiliser should be applied to raise soil K concentrations.

Soil structure was allocated an average of “2” using the VESS method. This indicates that structure is reasonably good, but that some of the aggregates in the sample were fairly firm and there were some areas of compaction. A visual assessment of the field also showed that compaction was present in places, particularly in the headlands and around the gateway, where there were some areas where the VESS score was 3.

By applying the woodchip-based FYM at 25 t/ha, the farmer will be applying 7.5 t/ha of organic matter. Regular additions of organic matter are known to help develop and maintain soil health. Arable soils with adequate organic matter (SOM) levels are likely to have better structure, faster water infiltration, better water-holding capacity in dry periods, greater resilience to stress, higher numbers and diversity of soil organisms and ultimately higher yield potential than those with low SOM levels. Regular additions of organic matter will not necessarily result in a steady increase of soil organic matter content though, because several management practices, in particular regular cultivations will contribute to organic matter loss. Regular additions of organic matter are thought to be beneficial to most arable soils and this FYM will be an excellent source of organic matter as well as a useful source of nutrients. There is no evidence that the relatively high C:N ratio in it caused N lock-up in the following crop. Provided similar FYM handling procedures are followed in future, N lock-up is unlikely to be a problem. N lock-up would, however, be highly likely if the FYM were to be applied to soils straight out of the housing sheds, particularly if it was to be applied at higher rates, such as > 10 t/ha).

The woodchip-based FYM had a high C:N ratio (21:1) in comparison to typical strawy cattle manures, which typically have C:N ratios similar to those in field soils (around 9:1 to 12:1). This relatively high C:N ratio suggests that the woodchip-based FYM could cause N lock-up in some soils, particularly where high-carbon organic wastes have not been applied to the land in the recent past (which is not the case with this field). There were no symptoms of N lock up in the grass crop in the test field on this occasion, and given that woodchip-based FYM has been applied to this field on several occasions in the past without problems, N lockup is very unlikely to occur in future if the FYM is managed and applied to land in a similar way in future.

None of the PTEs tested were present in the soil at concentrations which would cause problems for grazing livestock or arable cropping either before or after application of woodchip FYM (Table 3). The differences in soil PTE concentrations between sampling dates appear to be quite large in some cases, but this can often happen as a result of natural variations between samples taken using the "W" method. Given that these PTE concentrations are low, this is not a problem and no further investigation is required.

Table 3. Concentrations of potentially toxic elements (PTEs) in soil before amendment with woodchip-based dung.

Total PTE	Unit	Silage field	
		Before woodchip FYM application	**After woodchip FYM application**
Cadmium (Cd)	mg/kg dry matter	0.15	0.19
Copper (Cu)	"	22.8	15.4
Chromium (Cr)	"	42.1	10.1
Mercury (Hg)	"	0.22	< 0.2
Lead (Pb)	"	89.5	68.8
Zinc (Zn)	"	70.0	34.4
Nickel (Ni)	"	< 10.0	< 10.0

Conclusions

- Waste woodchip was available for free, albeit in lower quantities than required for all the bedding needs on the farm. It was easier to spread as a bedding material than straw and was easy to top up when in use.
- Woodchip was superior to straw as a bedding material in that animals suffered from fewer foot problems.
- FYM based on woodchip was as useful that based on straw in terms of its soil conditioning and fertiliser properties. The woodchip-based FYM used in this study contained low nutrient concentrations in comparison to typical values for straw-based FYM, but this is likely to be due mainly to the way in which the animals were fed, the numbers of animals bedded and the length of time they were housed for. Low nutrient levels in FYM are not a problem: it is simply important to test each FYM and understand nutrient concentrations in order to complete accurate field nutrient budgets.
- There was no evidence of N lock-up following application of the woodchip-based FYM to arable land. Providing woodchip-based FYMs are stacked and turned for 6 to 12 months and are applied at appropriate rates (usually around 10 to 30 t/ha) then symptoms of N lockup in following crops are unlikely to be a problem, particularly when they are applied to healthy soils with an active microbial population.
- Considering the price, ease of handling, reduced animal health issues and acceptable quality of woodchip-based FYM, waste woodchip is an excellent choice of

animal bedding material, which may often be cheaper and in practical terms also preferable to straw.

References

Ball, B., Guimares, R., Batey, T. & Munkholm, L. (2012) Visual evaluation of soil structure (https://www.sruc.ac.uk/info/120625/visual_evaluation_of_soil_structure).

FAS (2020) Optimising the application of bulky organic fertilisers. Technical Note TN 736. (https://www.fas.scot/downloads/technical-note-tn736-optimising-application-livestock-farmyard-manures-slurries/).

Audrey Litterick
Earthcare Technical
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