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INCORPORATING COMPOSTING SHELTERS ON FARM: FINDINGS FROM RECENT FARMER CASE STUDIES

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Dairy farmer investment in composting shelters is being driven by a desire to tackle environmental challenges, improve animal welfare, and provide a more labour-efficient and satisfying farm working environment. This paper consolidates learnings from a recent composting shelter case study project, and interactions with farmers considering or already operating with the system.

Composting shelters are a unique animal housing structure in which cows spend a proportion of time under a covered structure where they lie on a deep (c. 600-800 mm), plant-based bedding material. Aerobic composting, aided by daily tilling and ventilation, mixes the bedding with urine and dung to create *in situ* composting. The heat generated from composting keeps the bedding warm and dry, allowing it to remain in place for one year or more before it is replaced and applied to land.

While the economics of composting shelters are proving sound for those operating the system, it is not typically financial performance that is driving investment. Interviews with existing composting shelter farmers throughout the country identified that it was the intangible, or harder-to-quantify benefits that were valued most highly by farmers and were the key motivators behind the initial investment.

For farms where the colder climate poses challenges for grass growth and wintering stock, composting shelters are being used as an alternative solution to intensive winter cropping, with stock generally wintered 24/7 within the shelter from dry off through to calving. The dry, warm environment within the shelter provides benefits to farm working conditions and animal wellbeing, while the stabilised climate provides significant winter feed savings typically in the order of 35-45%. A centralised location for farm activities also provides opportunity for reduced labour requirements.

Where shelters are incorporated in the system year-round, improvements to grazing management including the avoidance of pugging and over-grazing are possible through the implementation of a hybrid indoor-outdoor system. During the warmer months, the provision of shade alleviates the impact of heat stress on the cows, and where supplementary feed is used, the shelters can enable improved feed utilisation (*c.* 95%). For a South Waikato case study farm where the shelters were incorporated year-round, the improvements to the farm system were modelled to increase milk production by 14% (+57 kg MS/cow).

Significant reductions to nitrogen (N) loss are also possible by reducing time on pasture, with the same Waikato case study farm achieving a 45% reduction in N loss to water (51 kg N/ha/yr to 28 kg N/ha/yr) as modelled by OverseerFM (v6.4.3). In this system, time spent in the shelter by the cows averaged six hours per day throughout the year. In contrast, a farm in Canterbury using the shelters for wintering only (24/7 from 1 May to 15 August) was able to achieve an 18% reduction in N loss. The actual N reductions possible will be farm and system specific. It is not just determined by the specific hours and seasons of use of the shelter, but also other farm aspects (e.g. soil type, cropping, irrigation) which can impact on the potential of the shelters to reduce N loss.

Background
Limited published information within the New Zealand context is available to support farmers and rural professionals in the evaluation of composting shelters on farm. The purpose of this paper is to communicate the learnings from interactions with early-adopter farmers, present findings from a recent case study project (Durie and Woodford, 2022), and identify the areas for further research and development.

Insights and experiences from early-adopters
Interviews with six farmers throughout New Zealand (Waikato, Hawkes Bay, Canterbury, Otago and Southland) identified several key drivers in the decision to build that could be broadly categorised into wintering, environmental, staff and animal welfare. These motivators were not in isolation, and in most cases, it was a combination of these four drivers that led to the decision to build a composting shelter. While economic performance was important, it was these largely intangible benefits that were the focus.

Environmentally, many of the farmers felt their previous wintering systems (a mix of pasture and in-situ crop grazing) were unsustainable and felt that a change in their system was needed. Avoiding pugging, soil damage, meeting nitrogen (N) loss restrictions and improving the perception of New Zealand dairy farming were all linked to this, as was animal welfare. All the farmers saw the shelters as a way of providing a warm, dry environment where cows could be comfortably wintered and calve down out of the cold and any mud. In addition, the ability to use the shelters through the heat stress risk period was also seen as a key benefit, particularly for those in the North Island.

Creating a labour-efficient and low-stress farming business was also a key motivator. Farmers could see the ability to reduce winter workload and create a more pleasurable environment by having cows and feed in one central location out of the weather compared to previous systems which required setting up breaks, feeding out and shifting of multiple mobs on crop or grass.

On most farms, the shelters were being incorporated on farm in a year-round approach where cows would spend part of each day in the shelter. On farms where wintering posed a greater challenge and winter grass growth was limited, a greater tendency for 24/7 wintering in the shelters was evident. Feed systems varied across the farmers interviewed, with one shifting to a high input operation and another de-intensifying and shifting to a near self-contained, lower input, nil-cropping system with all milking and replacement stock kept on farm.

Across all the farms, there have been learnings along the way, including the new winter feed requirements. With cows now housed in a warm, dry environment requiring minimal walking, the winter feed requirements are considerably less with many farmers working on dry cow allocations of 8-9 kg DM/cow/day eaten.

New skills and knowledge of bedding management have also had to be learnt in relation to managing the *in-situ* composting process. Maximising the longevity of bedding is crucial to overall success and profitability of the system. Good management relies on frequent moisture and temperature assessments, and use of correct tilling techniques to aerate and drive the composting process. Having a dry product from the beginning is also crucial. There is no onesize-fits-all to bedding management, and there is still much to be learnt. The composting process is complex and impacted by climate, bedding material type, stocking rate, shelter design, tilling management and use of the shelter. Understanding the key factors for successful composting and being able to implement a system that provides longevity in bedding material will be a driving factor for profitability and overall success of the system.

Availability and price of bedding is a risk for those operating with the shelters, particularly as industries look to de-carbonise and make use of timber by-products. Sourcing or finding ways to grow alternative bedding materials will be of particular importance to the long-term viability of the system.

Physical, environmental and economic performance

Analysis of a proposed composting shelter operation on a South Waikato case study farm was completed using desktop analysis to understand the impacts to farm physical, environmental and economic performance (Durie and Woodford, 2022). Findings from farmer interviews were used to support the analysis and ground truth assumptions.

Physical farm system

Case study modelling was based on year-round incorporation of composting shelters on-farm. Stocking rate and imported feed in the composting shelter model remained unchanged from the status quo, though an improvement in pasture growth was assumed through the ability to avoid over-grazing and winter pasture damage. Feed eaten was modelled to increase by 6% resulting from the additional pasture and reduced wastage of supplements. This increase, combined with an improvement in feed conversion efficiency (12.0 kg DM/kg MS vs 12.8 kg DM/kg MS) and mitigation of heat stress, led to an overall 14% increase in modelled milk solids production (410 kg MS/cow to 467 kg MS/cow).

Environmental performance

OverseerFM was used to model the environmental performance of the farm business pre- and post-shelter. The South Waikato case study farm is located on well-drained pumice and allophanic soils. Total N loss in the status quo system was 51 kg N/ha/yr and reduced by 45% to 28 kg N/ha/yr following incorporation of the shelters. Of this, 87% of the reduction was directly attributed to reduced urinary N loss resulting from the reduced time on pasture. Over the whole season, cows spent an average of 6.6 hours per day in the shelter, varying from four hours through the peak milking period and late lactation, to five hours over the summer months, and then 18 hours per day during the winter dry period. Because the OverseerFM modelling was completed at the farm-level, the wider benefits achieved from reduction in N loss on the support property, where 230 cows were previously wintered, was not captured.

OverseerFM modelling has also been completed on a Canterbury farm located on poorly drained gley soils. The farm has incorporated composting shelters for use over the winter period only with cows housed in the shelter 24/7 from May to calving in mid-August. A smaller, but still significant reduction in N loss of 18% was achieved from this operation. If the farm increased the time cows spent in the shelter with an additional 10 hours per day over the high-risk autumn period in March and April, then total N loss could be reduced to 22% below the status quo.

Actual N loss able to be achieved from incorporation of shelters on-farm will therefore vary between farms based on soil type and frequency and season of shelter use. In addition, farm practices such as irrigation can also impact on the reductions able to be achieved. On the

Canterbury farm, it wasn't until the farm moved to a system of 'little-and-often' irrigation inputs that further significant reductions (extra 10%) were able to be achieved.

Composting shelters are currently not included as a structure type in OverseerFM, however 'work-arounds' are possible to estimate the impact to N loss. Greenhouse gases from the aerobic composting process within the shelter, however, cannot be estimated in OverseerFM currently. There is an expectation that there would be a reduction in methane emissions from effluent capture compared to other housing systems which typically use anaerobic storage. Reductions in nitrous oxide emissions are also expected through reduced urine patches on pasture and the aerobic nature of the composting. Further research is however required to quantify this, and particularly the impacts of bedding management on nitrous oxide emissions.

Economic performance

Economic modelling on the South Waikato case study farm was based on two core scenarios – the status quo system and the composting shelter scenario. The composting shelter scenario was then varied with four sub-scenarios developed based on structural design options and extent of concrete included.

Total capital costs ranged from $1.6 - $2.6 million, depending on materials used and extent of concrete included, with the structure itself comprising 46 – 66% of the overall project cost. It should be noted that the assumed capital costs were derived in 2022 when costs were rapidly rising, and many farmers now appear to be achieving similar builds at lower cost.

Assuming a $9.00/kg MS milk price, the composting shelter scenarios were able to deliver a 33% increase in per hectare operating surplus (EBITDA, earnings before interest, tax, depreciation and amortisation). Discounted cashflow analysis was used to assess the pre-tax performance of the each of the composting shelter models. Over a 50-year investment horizon, reflective of the longer-term Māori view held by the owners and the expected lifespan of the structure, the shelters were forecast to provide an internal rate of return (IRR) over the whole farm business of 6.8 – 7.4%, depending on specific capital decisions, and was above the 6.3% achieved under the status quo system. On a shorter 25-year investment horizon, the shelters were still able to outperform the status quo. The return on the composting shelter investment itself, based on the new capital expenditure and changes in net cash flows (marginal analysis), ranged from 8.4 – 12.4%.

Milk price has a significant impact on the performance of the composting shelter scenarios, with a 1.0 – 1.5% increase or decrease in the marginal return for each $1.00/kg MS change in the milk price. However, milk price would need to drop to $5.00/kg MS for the low capital cost structures or $7.00/kg MS for the high capital cost structures before the investment performed at a lower level than the status quo. While the investment was robust to changes in milk price, the returns from the whole farm business were highly dependent on the milk price (+/- 2.4 – 2.8% for every $1.00/kg MS change), with this situation being the case for both the status quo and the models incorporating composting shelter investments. Accordingly, the financial risks to the whole farm business were largely independent of the investment decision relating to the composting situation.

Where milk price remained unchanged, milk production, frequency of bedding turnover and cost of bedding were key factors impacting on the marginal performance of the shelter. For the case study farm, increased milk solids production was required for the investment to generate a return greater than the status quo. At a $9.00/kg MS milk price, the increase in production required to generate the same return as the status quo was an additional 31 – 43 kg MS/cow, depending on extent of capital costs. There will be situations where the operating cost structure can be significantly reduced by incorporating shelters, and therefore the additional milk production required will be lower. For instance, farms were significant off-farm winter grazing or winter cropping costs can be removed.

Consideration should be given to who will operate the system. Specific skills are needed to ensure a focus on management of the bedding and corrective action if intervention is needed. Similarly, the operating structure will impact on financial performance. The case study analysis was completed at the whole farm level, however where a herd-owning sharemilking structure, for instance, is implemented consideration should be given to how expenditure is split. With all of the capital expenditure typically paid for by the owner, and the benefits of milk production being split 50/50 under a sharemilker structure, the returns for the owner will be reduced. Splitting new expenditure such as the cost of bedding can help to share the financial benefits.

Conclusion and R&D needs

Composting shelters are already proving their worth as a transformational technology with many early-adopter farmers. Farmer interviews and case study analyses have identified the diverse benefits of composting shelter operations on the environment, animal welfare, farm and business performance, and farmer wellbeing.

Interest in the system will continue to grow as societal and regulatory pressures push farmers to consider alternative, lower-impact farming systems. Research is required both at the farmer level and at the industry level to ensure successful outcomes. Composting shelters require significant capital expenditure and this needs to be budgeted with care. Farmers considering the shelters should take care in ensuring sufficient personal research is undertaken before committing to a project to ensure that the design will be fit for the specific location and purpose.

Also, it needs to be recognised that developments are currently being farmer-led, without formal research and development programmes to guide the way. There is a particular need to focus on compost management and understanding the correct approaches to bedding and tilling management, and how this management can affect nitrous oxide emissions, animal health outcomes and overall profitability. As was discussed in a previous paper (Woodford *et al*., 2018), there is also a need to understand the effects of adding compost material back to land, at a range of carbon to nitrogen (C:N) ratios and on different soil types.

Inevitably, there is much more to be learned, but significant benefits are already evident.

References

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