INTERIM TECHNICAL REPORT:

EVALUATING CELL GRAZING VERSUS SET STOCKING - IMPACTS ON FARM PRODUCTIVITY AND ENVIRONMENTAL SUSTAINABILITY

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PREFACE

Innovative methods of pasture and animal management such as where animals are moved regularly to new pastures have been widely adopted by livestock farmers. One of the most productive of these methods is the TechnoGrazingTM system, developed in New Zealand by Harry Wier and marketed worldwide by Kiwitech International Limited.

TechnoGrazingTM is an innovative grazing infrastructure and pasture management method that strategically utilises a lane-based system based on GPS located posts to enable accurate pasture allocation and efficient livestock management. Whilst practitioners claim multiple benefits across economic and environmental spectrums often the evidence provided is anecdotal or unreliable due to the variability of different seasons and from farm to farm.

With local and national governments increasingly interested in livestock management for a range of environmental and social reasons a trend has emerged where stocking rate (number of animals on the farm) is seen as an appropriate tool for managing impact rather than how the animals are managed with regards to grazing and the wider production system. Precision Grazing Ltd are farm consultants specialising in livestock production, grazing management and grazing system design including the use of TechnoGrazingTM. To support their future business development and better inform their advice to clients, NGOs and the wider industry they identified it was important for a replicated and independent study to be undertaken.

In 2017 the opportunity to conduct an experiment came via an Agri-tech Cornwall initiative linking industry with academia. Successful application saw funding granted for a 3-year project at Rothamsted's North Wyke site, located in West Devon, and a fourth year was funded by Rothamsted Research. The project commenced in 2018, successfully navigating the challenges of the 2018 drought and COVID-19 pandemic, to be completed in 2022. This technical paper provides an update of the data collated during this period and proceeds with the submission of three scientific articles being completed for submission to peer-reviewed journals which will be accessible here once published. The project demonstrated the impact of grazing management on a range of outcomes as well as the importance of field scale, long-term research. In 2022, further funding was secured to enable the experiment to be continued and it is currently (as of 2024) in its seventh grazing season.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the contribution of industry partners who provided resources and knowledge to the project including Kiwitech International Limited, IceRobotics Ltd and Philip Warren & Son. Also, the contribution of Rothamsted Research staff including the research farm team and administrative support . Other researchers that contributed to the collection or analysis of data were Paulo de Meo Filho, Maite Fajardo, Charlie Morten and Deborah Beaumont. The photos included in this report were kindly provided by Dr. Sarah Morgan, unless otherwise stated.

This study was partially funded (2018-2021) by the European Regional Development Fund (ERDF) through the Agri-Tech Cornwall initiative, which is a 3 year £10m initiative to increase Research Development and Innovation in the Agri-tech sector across Cornwall and the Isles of Scilly led by Duchy College Rural Business School in partnership with the Universities of Exeter and Plymouth, Rothamsted Research and the Cornwall Development Company. Rothamsted Research receives strategic funding from the Biotechnological and Biological Sciences Research Council (BBSRC) of the United Kingdom. We acknowledge support from the Soil to Nutrition (BBS/E/C/000I0320) and Growing Health (BB/X010953/1) Institute Strategic Programmes funded by BBSRC.

NOTE FROM THE AUTHORS

Interpreting this paper: It is important to note that the outputs of weights and yields achieved in this experiment do not represent targets or limits of the two grazing methods. They are relevant only to the experimental site and dependent on the context in which they were applied (i.e. rainfall, elevation, latitude, soil type etc).

In order to apply to their own livestock management situation, the reader should instead focus on the difference between the methods, often presented as a % gain as this demonstrates the “potential” which awaits them if they were to change grazing management towards the tactics applied in the Cell Grazing method.

SUMMARY

This experiment compared two grazing methods, Cell Grazing (CG), using TechnoGrazingTM infrastructure where animals were moved every 1-2 days to new pasture with the area allocated varied to suit desired recovery periods, and Set Stocking (SS), where animals remained in the same area for the grazing season.

The study aimed to evaluate the impact of grazing management on various agricultural and environmental factors. Work took place over four years and involved six enclosures, with three replicates of each grazing method. Autumn-born dairy x beef steer calves arriving at ~6 months old were randomly allocated to groups and grazed for two consecutive seasons with the aim of finishing off grass by 24 months of age.

The experiment demonstrated that Cell Grazing had positive effects on soil carbon sequestration, pasture growth, and live weight production per hectare, particularly in the second cohort of animals. The results also highlighted the influence of animal genetics and grazing methods on animal performance and carcass quality.

KEY FINDINGS AND OBSERVATIONS INCLUDE:

SYSTEM PRODUCTIVITY

- Stocking rate increased in Cell Grazing due to higher pasture growth and flexibility in animal management.
- By Year 3 the Cell Grazing areas carried twice the stocking rate of the set stocked areas and achieved higher live weight production per hectare.
- On average the grazing season was three weeks longer for animals in the Cell Grazing plots compared to Set Stocking.

SOIL STRUCTURE AND HEALTH

- Soil carbon content increased in Cell Grazing enclosures and decreased in Set Stocking enclosures, suggesting higher carbon sequestration under the Cell Grazing method.
- Soil analysis revealed that in both methods, soil pH was maintained whilst phosphorus (P) and potassium (K) indices increased over the four-year period. Increases did not vary between grazing methods; therefore, despite greater LW take-off, the Cell Grazing paddocks maintained soil fertility.
- Soil compaction in the top 5 cm did not differ between the two methods despite Cell Grazing areas carrying twice the stocking rate and up to 40 times the stocking density.

ENVIRONMENT

- Nutrient leaching potential was similar between grazing methods despite the Cell Grazing method carrying up to twice the stocking rate suggesting that it is the management of the animals rather than the number of animals which has the greater influence.
- Cell Grazing increased the abundance of perennial ryegrass within the sward and maintained the levels of white clover. Set Stocking experienced changes in botanical composition, with an increasing abundance of volunteer weed grass species and weeds within the sward.
- Enteric methane emissions did not vary between the two grazing methods.

PASTURE GROWTH & UTILISATION

- Across the 4 years, DM production was on average 39% higher in the CG method; notably, in Year 4 the difference increased to 54% (11.5 t DM/ha vs 7.5 t DM/ha).
- Increased pasture growth was achieved due to short grazing duration followed by an appropriate rest period, which enabled the paddocks to maintain a higher Average Farm Cover (AFC).
- Cell Grazing plots consistently had a higher metabolizable energy (ME) content.
- Pasture utilisation increased over the 4-year period; Cell Grazing achieved 76% in years 3 and 4 compared to 63% for Set Stocking.

ANIMAL BEHAVIOUR & PERFORMANCE

- Set Stocked areas achieved higher individual animal Daily Liveweight Gain (DLWG) due to lower stocking rates providing the ability for animals to selectively graze.
- Cohort 1 cattle (Years 1 and 2) were “worked hard” in the Cell Grazing paddocks having to graze “non-selectively” which increased the composition of desirable pasture species but at expense of individual animal performance.
- Animals in the SS were more active (more steps and fewer lying bouts) than in the CG however animals in both methods had similar standing durations.
- For logistics, the slaughter date was the same for both treatments. Set Stocking animals graded fatter overall compared to Cell Grazing although all animals achieved “in spec” fat classes.

METHODOLOGY

EXPERIMENT DESIGN

A 12-ha field was divided into three experimental areas, each with two different grazing methods: Set Stocking (SS) and Cell Grazing (CG), thus proving 3 replicates of each grazing method. The SS paddocks were 1.5 ha in 2018 which was increased to 1.75 ha for 2019 onwards, while the CG paddocks were laid out using the TechnoGrazing methodology with the 1.0 ha plot divided into two 0.5 ha strips (lanes) each with 21 fence posts serving as markers to facilitate the creation of up to 42 x 0.024 ha cells. The entire field was ploughed and re-seeded in 2013 with perennial ryegrass and white clover, and was predominantly used for silage with occasional sheep or cattle grazing until the start of this experiment in 2018; at which point the sward still contained the sown species (perennial ryegrass and white clover) as well as a range of weed grasses and forbs.

FERTILISER

Inorganic fertiliser inputs were the same for both treatments applied uniformly to the study area as follows:

- 50 kg/ha/year of P in the form of triple superphosphate (applied all four years)
- 30 kg/ha/year of K in the form of muriate of potash (except for 2021).
- 100kgN/ha/year in the form of Nitram split across three applications (late spring, mid-summer and early Autumn) (Except for 2018).
- No herbicides or pesticides were applied.

ANIMALS & MANAGEMENT

Autumn-born dairy x beef steer calves were acquired in April 2018 (average weight 255 kg) and April 2020 (average weight 219 kg) to graze for two consecutive seasons and were randomly allocated to treatment groups which were balanced for live weight and breed type. At the end of their first grazing season (winter 2018 and winter 2020) the cattle were housed together and fed a diet consisting of grass silage, 2 kg sugar beet, 0.5 kg wheat distiller grains and 100 g minerals, targeting 0.8 kg DLWG. The following April they returned to the same grazing method and were taken through to finish on pasture.

GRAZING METHODOLOGY

SS enclosures were continuously grazed for the duration of the grazing season (April to October/ November) whereas CG enclosures were rotationally grazed with animals moving to a new cell every day. The daily allocated grazing area for the CG enclosures varied according to pasture growth rate. Target entry covers for CG plots were set at 3500 kg DM/ha (3.5 leaf stage) and grazing residuals at 1800 kg DM/ha (1.5 leaf stage) with the aim to maintain pasture quality whilst maximising leaf area for solar energy capture. In SS method animals were removed from a paddock when average pasture covers dropped below 2000 kg DM/ha or ground conditions deteriorated.

DATA COLLECTION

Throughout the study, animal weights were recorded at the start of the grazing season and then monthly through to the end of the grazing season. Pasture covers were recorded weekly using a rising plate meter and fresh pasture samples were collected fortnightly for lab analysis. Botanical composition was assessed at the beginning and end of each grazing season.

Soil samples were taken (to a depth of 10cm) annually in April for lab analysis. There was additional testing for soil compaction annually. Soil groundwater samples were collected monthly during the winter between grazing seasons (using porous ceramic suction cup lysimeters). Enteric methane emissions were measured at pasture during the summer and autumn of 2021. Weather data was obtained from a nearby Meteorological Office station.

A sub-sample of steers from each treatment were sent to slaughter to compare carcass conformation, fat class and meat quality (tenderness, fatty acids and minerals) via lab analysis.

SUMMARY

- Six enclosures were used for Set Stocked and Cell Grazing methods (3 of each treatment).
- Dairy x Beef Steer calves were split into groups and randomly allocated.
- Animal weights and pasture covers were regularly measured.
- Pasture and soil samples were analysed for various parameters.
- Botanical composition and meteorological data were recorded.
- Soil bulk density, carbon stock, and enteric methane emissions were studied.
- Soil compaction was assessed periodically.

RESULTS

WEATHER

Mean air temperature was 10.6 ± 4.61, 10.5 ± 3.77, 10.8 ± 3.52 and 9.7 ± 3.94 °C for 2018, 2019, 2020 and 2021. Total accumulated rainfall was 999, 988, 1132 and 1059 mm for each of the four years, while the rainfall recorded from April to October each year was 353, 485, 510 and 680 mm

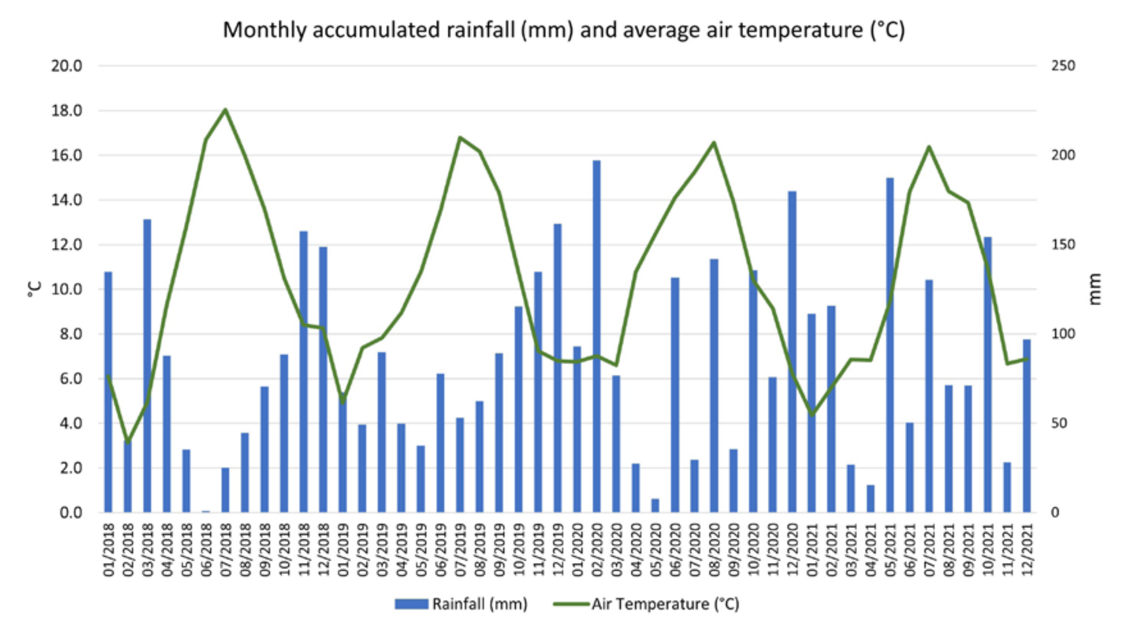

Figure 1. Monthly accumulated rainfall and average air temperature during the study period.

SOIL

Soil at North Wyke is Halstow clay which is poorly draining and therefore prone to water logging (Harrod and Hogan, 2008). Since it was re-seeded in 2013 the field had predominantly been cut for silage with occasional grazing by sheep and cattle. During the experiment soil pH varied in the tests from 5.9 to 6.4, no lime was applied and there was no significant difference between treatments (Figure 2). Phosphorous (P) content started at Index 1 but increased in both treatments to Index 1.5 (Figure 3). Potassium (K) also increased in both treatments from Index 1.5 to Index 2 (Figure 3).

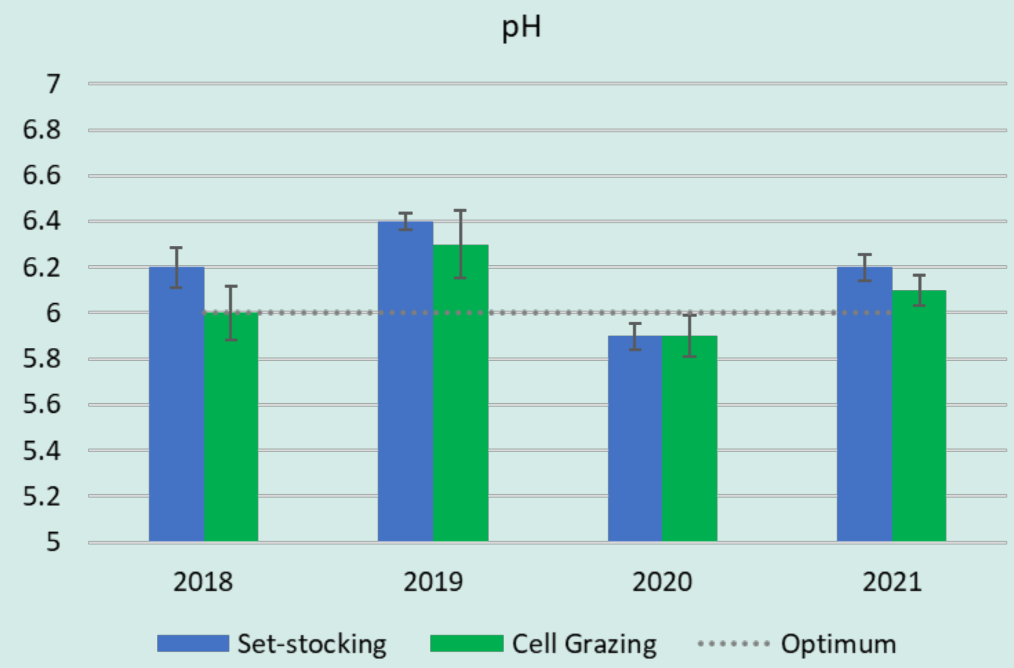

Figure 2. Soil pH of set-stocked and cell-grazed enclosures over a four-year study period.

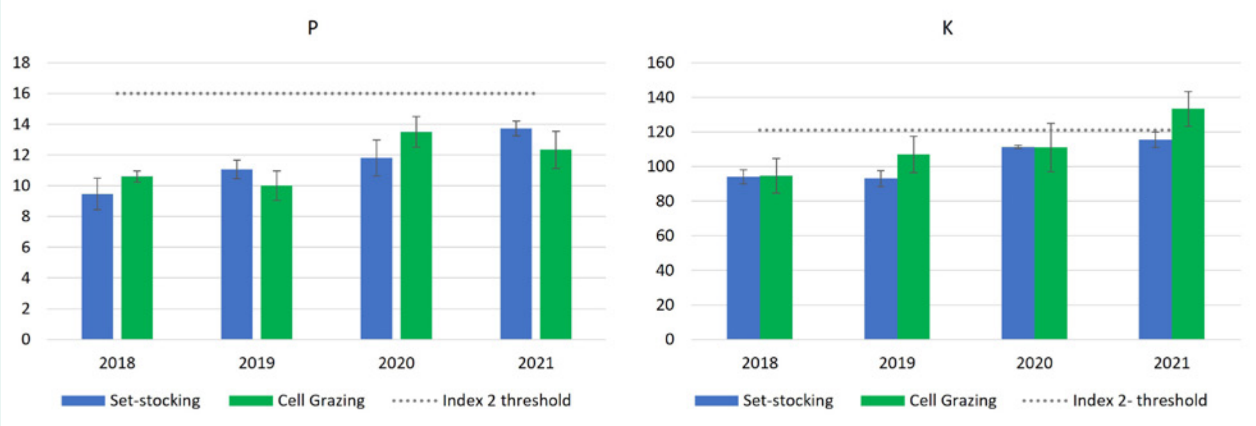

Figure 3. Soil P and K (mg/L) of set-stocked and cell-grazed enclosures over a four-year study period.

Organic Matter

For the first three years, there was a clear trend of increasing organic matter (OM) content in both grazing methods, particularly in the CG enclosures (Figure 4). However, in the fourth year, the soil OM decreased slightly in both methods, resulting in a net gain of around 1% OM over the four-year study period (from 8.4 to 9.3%).

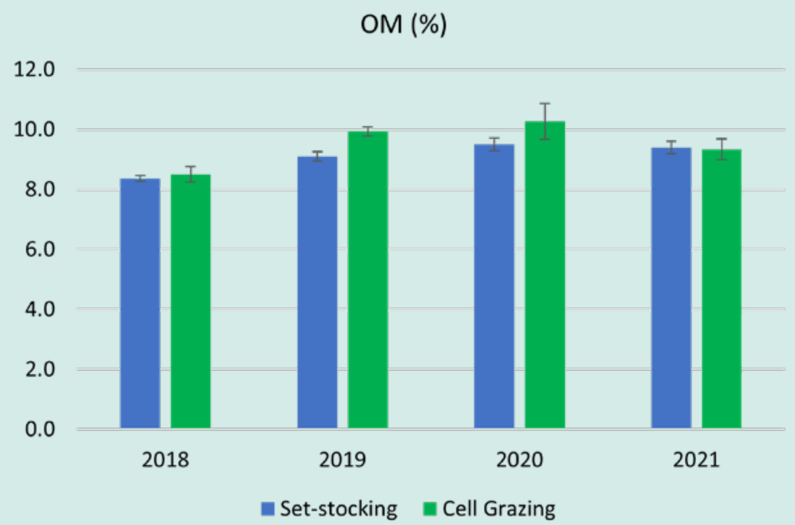

Figure 4. Soil organic matter (%) of set-stocked and cell-grazed enclosures over a four-year study period.

Soil Carbon

At the beginning of the experiment, carbon content was similar averaging 3.49 g/100 g (Figure 5). This equated to an average carbon stock of 24.5 t/ha (at a 10 cm depth, based on an average bulk density of 0.70 g/cm³ (as measured in 2021)). During the experiment, soil carbon peaked in 2020 for SS before declining, CG increased somewhat linearly year on year. By the end of the fourth grazing season, carbon content in the SS enclosures had decreased to 3.20 g/100 g, whereas in the CG enclosures, it had increased to 4.24 g/100 g.

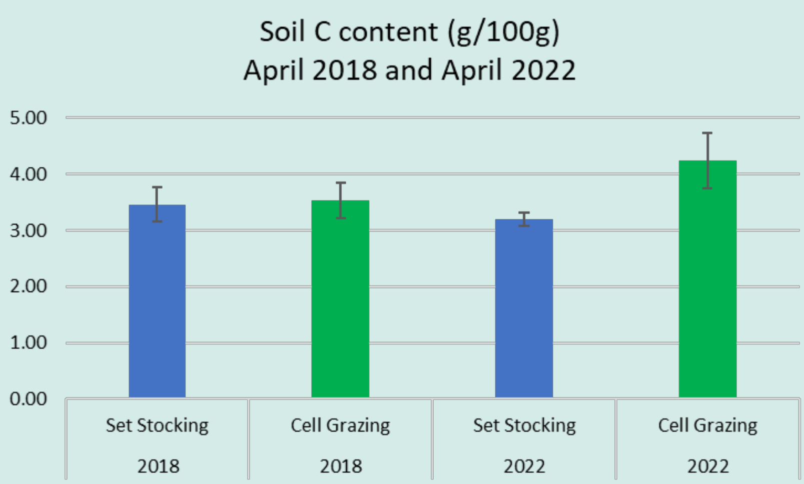

Figure 5. Soil carbon content changes during the experiment.

During the experiment there was a 5 t C/ha increase in the CG enclosures and a decrease of about 2 t C/ha of soil carbon in the SS enclosures (in the top 10 cm, Figure 6)). Therefore, over the 4-year period the rate of C sequestration for the CG method was 1.24 t C/ha/year, compared to -0.45 t C/ha/year for the SS.

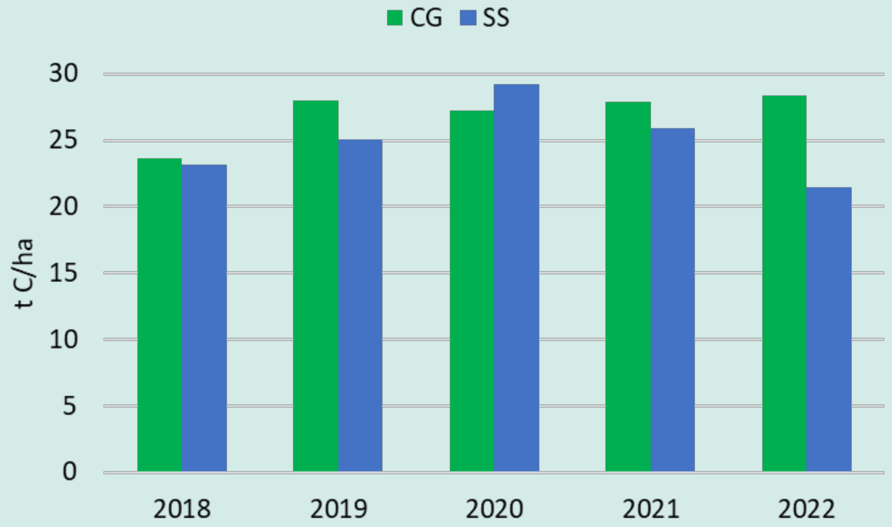

Figure 6. Changes in total soil carbon (tonnes per ha) as measured in the top 10cm.

Soil Structure

Soil compaction was assessed across all of the treatments using a penetrometer and results averaged by grazing method. This showed no difference in compaction in the first 5 cm of soil at the beginning of the second (April 2019) and end of the third (October 2020) grazing seasons. This was also confirmed by the bulk density measurement in April 2021, where the grazing methods both averaged 0.70 g/cm³.
This suggests that even though CG involves substantially higher stocking densities (up to 120,000 kg LW/ha), the rest periods between grazing events within the grazing season and over winter (between grazing seasons) allow the plants to grow deeper, more active root systems which enables the soil to recover/retain its original structure. Deeper in the soil profile, there seems to be no clear pattern of the effect of the grazing methods on resistance to penetration (Figure 7).

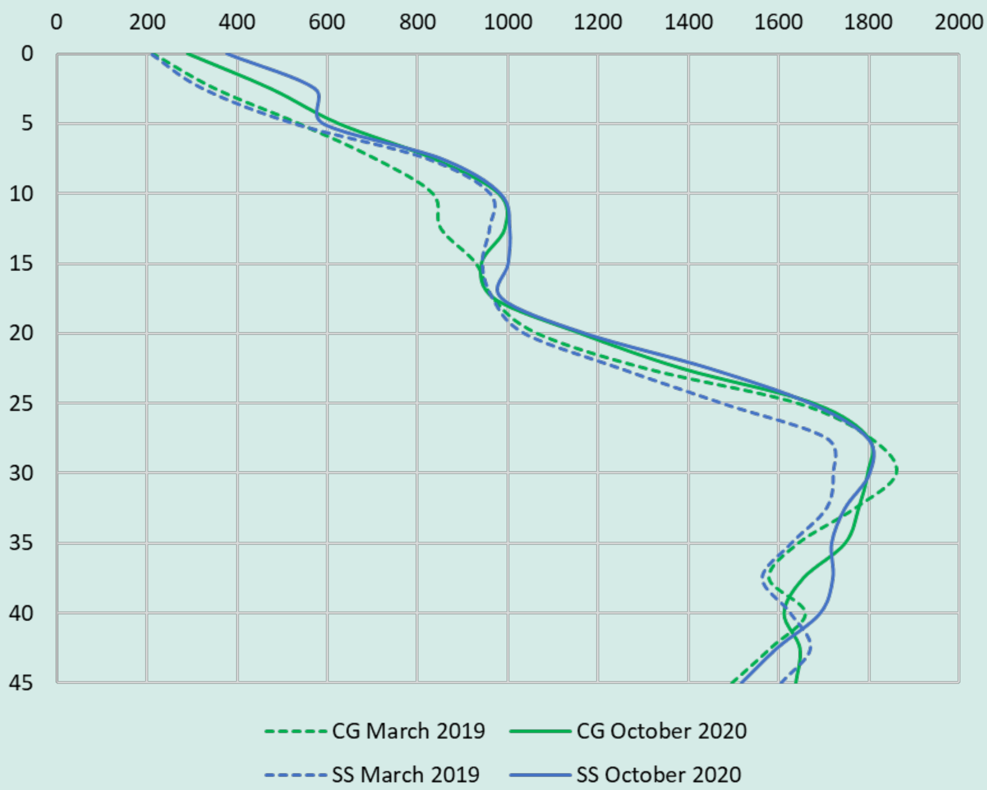

Figure 7. Resistance to penetration (Kpa) of soil (0-45 cm depth) of set-stocked and cell-grazed enclosures before the start of the second (2019) and at the end of the third (2020) grazing seasons.

Nutrient Leaching

The average total oxidised N (which equals NO3) was 0.059 mg/L over the four seasons assessed, while the total P was 23.2 mg/L, and the N in the form of ammonium (NH4-N) was 0.049 mg/L. The level of nutrients in the water runoff was similar between grazing methods despite the CG plots supporting, on average, a 145% high stocking rate (kg LW/ha) and grazing for 22 days longer. Therefore, the CG paddocks have lower leaching potential per kg LW produced.

Plant Species

After four grazing seasons, CG increased the area covered by perennial ryegrass and maintained a contribution of white clover both in spring and autumn (Figure 8). However, even though the SS started the fourth grazing season with an improved cover of perennial ryegrass (although lower than that of CG enclosures), by the end of the fourth grazing season, the cover was the lowest, with only 20%, and other grasses (e.g., Yorkshire fog) dominated the sward.

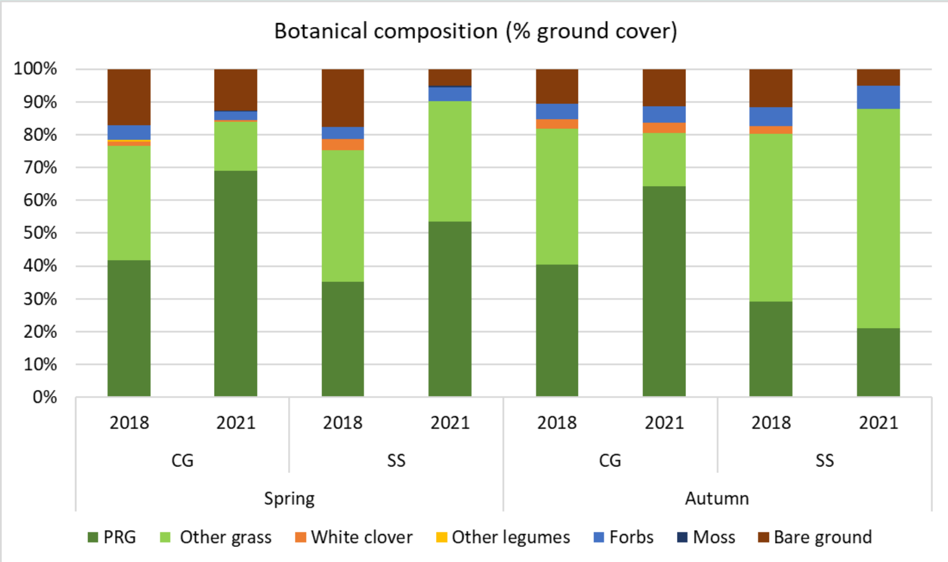

Figure 8. Botanical composition of set-stocked and cell-grazed enclosures before (spring) and after (autumn) the first (2018) and fourth (2021) grazing seasons.

The change in botanical composition over time, primarily driven by selective grazing of the set-stocked animals, is clearly shown in Figure 9.

Figure 9. Photograph taken in August 2021 from a fence dividing the set-stocking (left-hand side) and cell-grazing (right-hand side) enclosures.

Methane Emissions

Enteric methane emissions (EME) were assessed using the SF6 tracer gas technique (Figure 10) fitted to 12 animals from each treatment over two periods of 5 days - once during the summer (July) and again during the autumn (October) of 2021. There was no significant difference in the production of methane per animal per day between grazing methods (Table 1).

Figure 10. Steers fitted with equipment to measure enteric methane emissions (Photo: Dr Paulo de Meo Filho).

Table 1. Initial (ILW) and final (FLW) liveweights, Average Daily Gain (ADG) and enteric methane emissions (CH4) of 24 steers under Set Stocking or Cell Grazing methods during June (Summer) and September (Autumn).

	SUMMER		AUTUMN					
	SS	CG	SS	CG	SEM	TREAT	TIME	TREAT*TIME
ILW (kg)	509c	486d	610a	554b	10.0	0.0077	<0.0001	0.0002
FLW (kg)	610	554	658	593	9.2	<0.0001	<0.0001	0.0743
ADG (kg/day)	1.05	0.77	0.59	0.49	0.05	0.0009	<0.0001	0.0933
CH_4 (g/day)	201	199	230	217	7.9	0.3319	0.0056	0.4742
CH_4 (g/kg ADG)	201	281	430	485	34.1	0.0809	<0.0001	0.7471
CH_4 (g/kg LW)	0.37	0.38	0.36	0.37	0.02	0.4616	0.6427	0.8874

PASTURE

Pasture Quality

Pasture quality samples were taken fortnightly. For the CG enclosures samples were taken from the next day's grazing area and for SS the samples were taken at random across the area to be representative of what the animals were eating that day. On average the Dry Matter (DM) content of herbage was approximately 1 % higher in the SS method (Figure 11). Crude Protein content was variable between years with no clear trend when comparing grazing methods, averaging 13.7% (Figure 12). However, the metabolizable energy (ME) content was consistently higher in the cell grazing method, with average values of 11.2 and 11.0 MJ ME/kg DM for CG and SS, respectively (Figure 13). Note that 2018 in particular was impacted by a wet spring followed by a very dry summer period (see Figure 1).

Image: Rothamsted Research

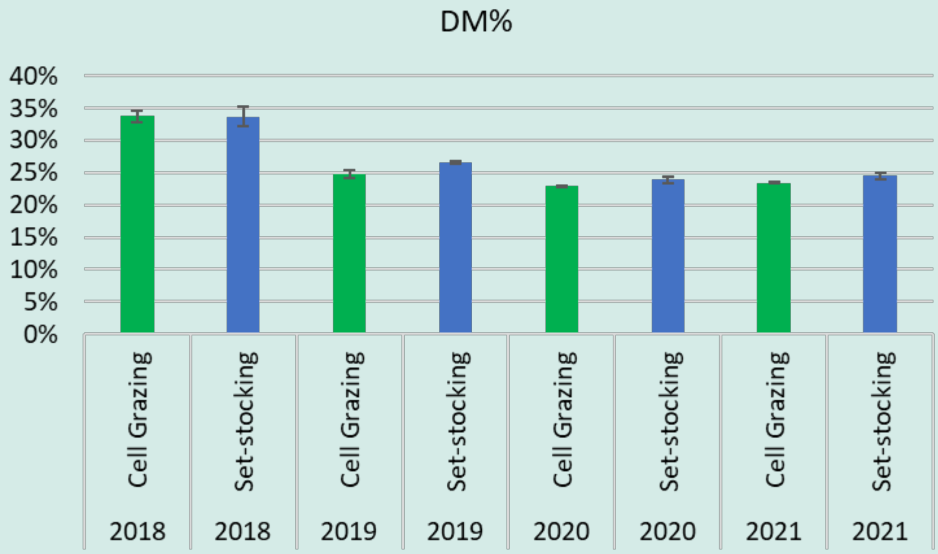

Figure 11. Dry matter content (%) of forage from set-stocked and cell-grazed enclosures over a four-year study period.

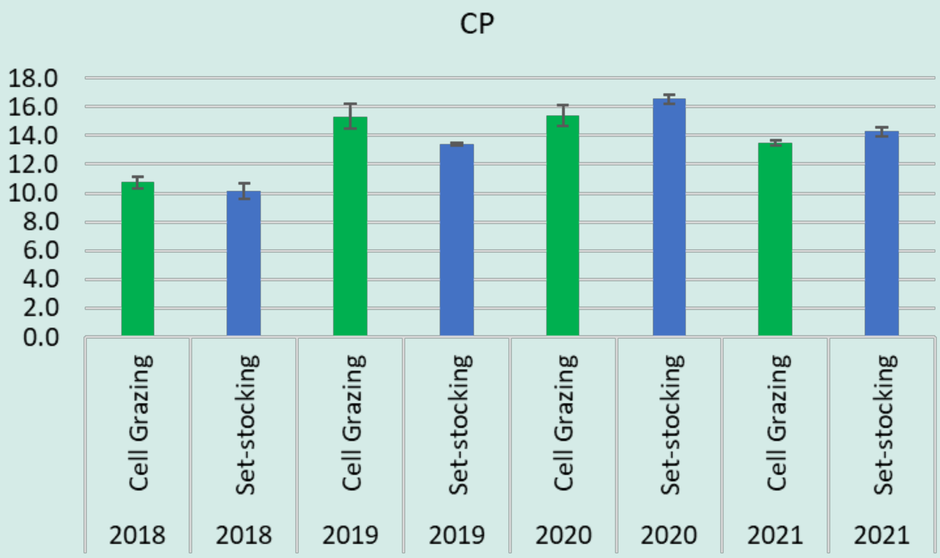

Figure 12. Crude protein content of forage from set-stocked and cell-grazed enclosures over a four-year study period.

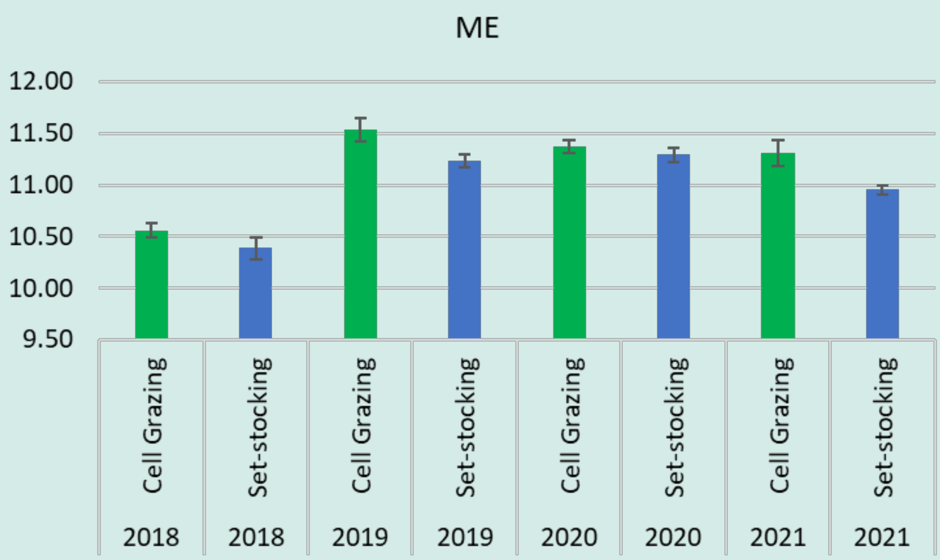

Figure 13. Metabolisable energy content (MJ/kg dry matter) of forage from set-stocked and cell-grazed enclosures over a 4-year experiment.

Pasture Quantity

Pasture covers varied during the grazing season and the overall Average Farm Cover (AFC) was similar between methods: CG at 2,798 kg DM/ha and SS at 2,672 kg DM/ha (Figure 14). The relatively high AFC meant that in the CG treatment Pre-Grazing covers ranged from 3200-3800 kg DM/ha.

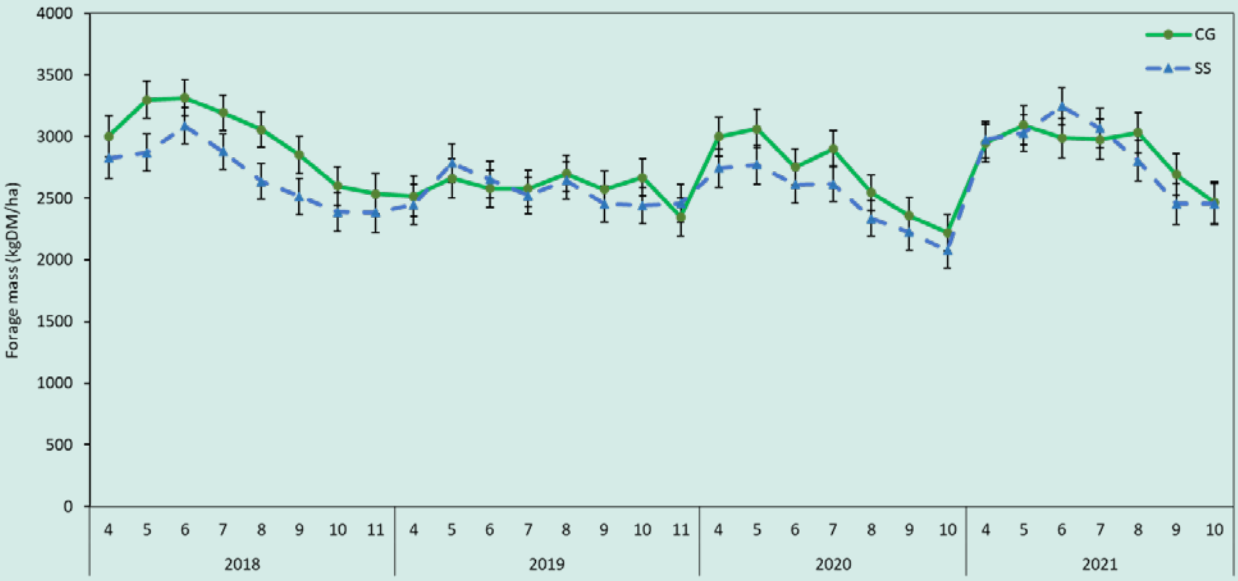

Figure 14. Herbage mass (kg DM/ha) of set-stocked and cell-grazed enclosures, measured with the rising plate meter, over a 4-year experiment.

As shown in Figure 15, the total pasture grown increased each year for the first 3 years under both grazing methods. However, the CG method achieved much greater yields reaching 11.8 t DM/ha before reducing slightly in Year 4 to 11.5 t DM/ha, whereas SS only reached 8.8 t DM/ha before reducing to 7. 5 t DM/ha in Year 4.

Across the 4 years DM production was on average 39% higher in the CG method. However, in Year 4 it was 54% higher (11.5 t DM/ha vs 7.5 t DM/ha). Pasture growth averaged 51 and 40 kg DM/ha per day for spring/summer and 5.8 and 4.1 kg DM/ha per day for winter for CG and SS, respectively, over the four years. Despite cattle being housed later on the CG systems they accumulated more pasture growth over winter allowing for an earlier turn-out in the spring.

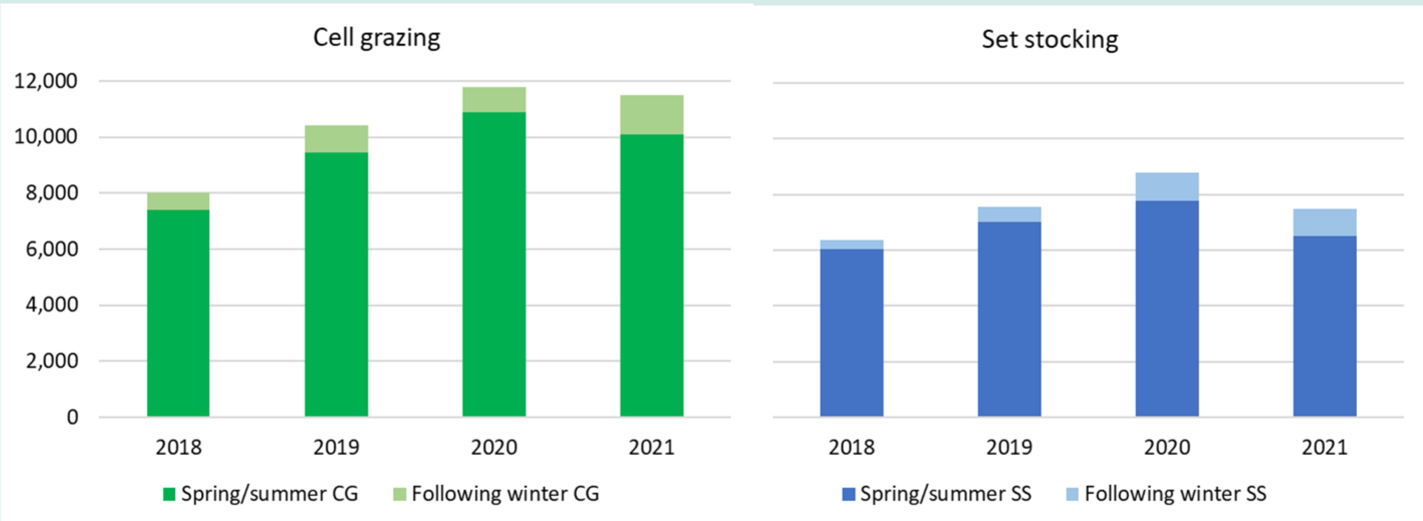

Figure 15. Estimated pasture dry matter production (kg DM/ha) per year (including spring-summer and winter seasons) of set-stocked and cell-grazed enclosures over a 4-year experiment.

ANIMAL PERFORMANCE

The dairy x beef steers in the first two years of the experiment (2018-2019) were a mixture of breeds, including both native and continental breeds from multiple farms. Arriving from the calf rearer where they had been fed a straw and concentrate ration to the grazing treatments presented a challenging transition. Coupled with low pasture quality (due to initial species composition), a very dry summer, followed by an extremely wet autumn resulted in a poor daily live weight gain (DLWG) of 0.34 and 0.47 kg/day for CG and SS, respectively (Figure 16). The CG animals were particularly affected as they were forced to "tidy up", especially during the dry period whereas the SS animals, at a lower stocking rate could graze selectively.

After housing in October, both groups of animals showed compensatory growth with the CG animals (on the same ration) catching up with the SS animals to reach 487 kg in April at turnout (average DLWG of 1.22 kg during the housed period). In the second grazing season, both groups averaged around 0.7 kg/day with 3 finished steers being selected from each enclosure (a total of 9 from each grazing method) for slaughter and subsequent carcass and meat analysis.

The second cohort of steers (2020-2021) were a consistent line of beef x dairy calves from a single farm. They arrived before the grazing season and were transitioned onto silage before being turned out onto the grazing treatments. Weather conditions were more normal and growth rates averaged 0.76 and 1.00 kg/day for CG and SS respectively. The CG group had a slightly higher average daily gain over winter (0.81 vs. 0.74 kg/day for CG and SS, respectively). In the spring, the SS steers were heavier than those in the CG method (516 vs. 486 kg liveweight, respectively) and maintained a higher DLWG of 0.81 kg compared to the CG cattle who averaged 0.65 kg.

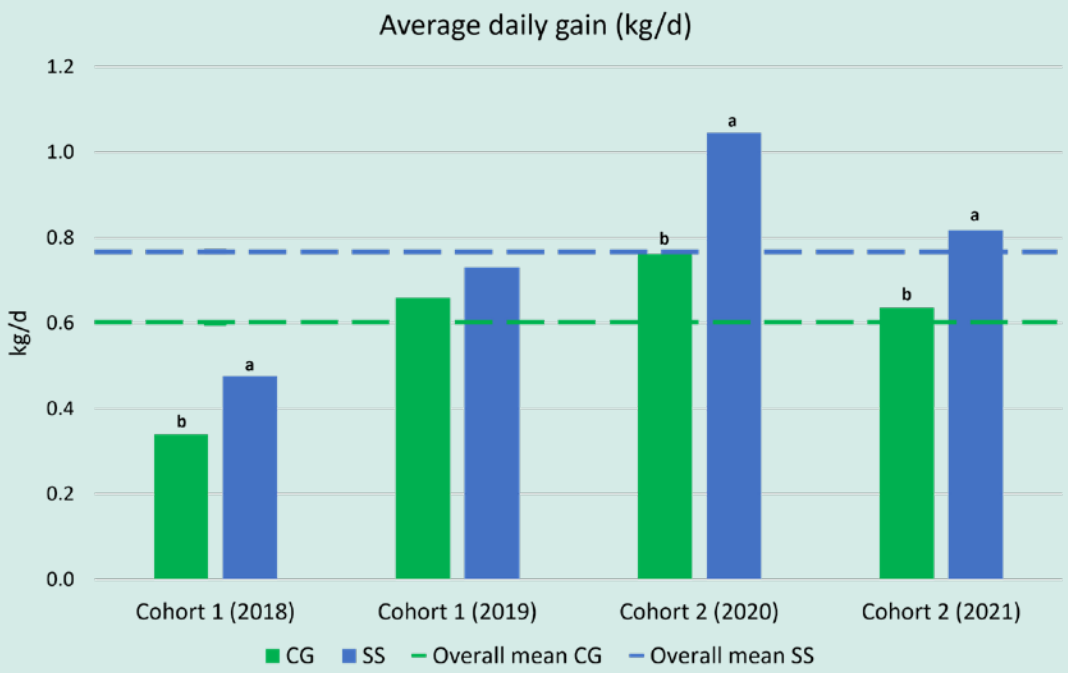

Figure 16. Average daily liveweight gain of dairy x beef steers under set-stocking or cell grazing methods over the four-year study period *(means with different letters differ statistically)*

Carcass

At the end of the grazing seasons in 2019 and 2021, nine steers were selected from each grazing treatment and were sent to the abattoir to assess their carcass quality and killing out percentage. The animals were selected based on liveweight and body condition score, aiming to achieve fat class 3. Slaughter date for these animals had to be fixed for both cohorts due to meat sampling requirements and provides a 'snapshot' in time of the animals' carcass development.

Age at slaughter was around 25-26 months for both years (Table 2). In both years, SS animals were heavier going to slaughter due to higher average DLWG compared to CG animals. Killing out percentage was very similar between grazing treatments for both years at around 51%, with SS being slightly lower in 2019 and CG slightly lower in 2021. Due to higher liveweights at slaughter and similar KO%, SS animals has higher dead weights of 350 and 333 kg in 2019 and 2021, respectively, compared to 339 and 319kg for CG animals. In 2019, the majority of those animals slaughtered from both treatments achieved the target fat class 3 (88% for SS, 67% for CG) at either O- or O+ conformation (Figure 17). In 2021, a higher proportion of animals achieved O+ conformation (due to their dams being more British-Friesian type dairy, rather than Holstein). Average fat class was similar to the 2019 animal but was more variable, with fat classes ranging from 1 through to 4H, which may be due in part to the cross breeds that were in cohort 2 (with the Hereford-cross animals tending to have the higher fat scores and the Fleckvieh-crosses being on the lower end).

	Cohort 1 (2018-2019)		Cohort 2 (2020-2021)	
	Cell Grazing (n=9)	Set Stocking (n=8)	Cell Grazing (n=9)	Set Stocking (n=9)
Age at Slaughter (m)	26	26	25	25
LiveWeight (kg)	692	723	630	637
DeadWeight (kg)	339	350	319	333
Kill Out %	49	48.4	50.7	52.3
Average conformation	O	O	O	O+
Average fat class	3L	3	3L	3
Estimated birth Weight (kg)	45	45	40	40
Lifetime DLWG (kg/d)	0.82	0.85	0.76	0.78

Table 2. Carcass weights and grades for cattle finished in 2019 (Cohort 1) and 2021 (Cohort 2).

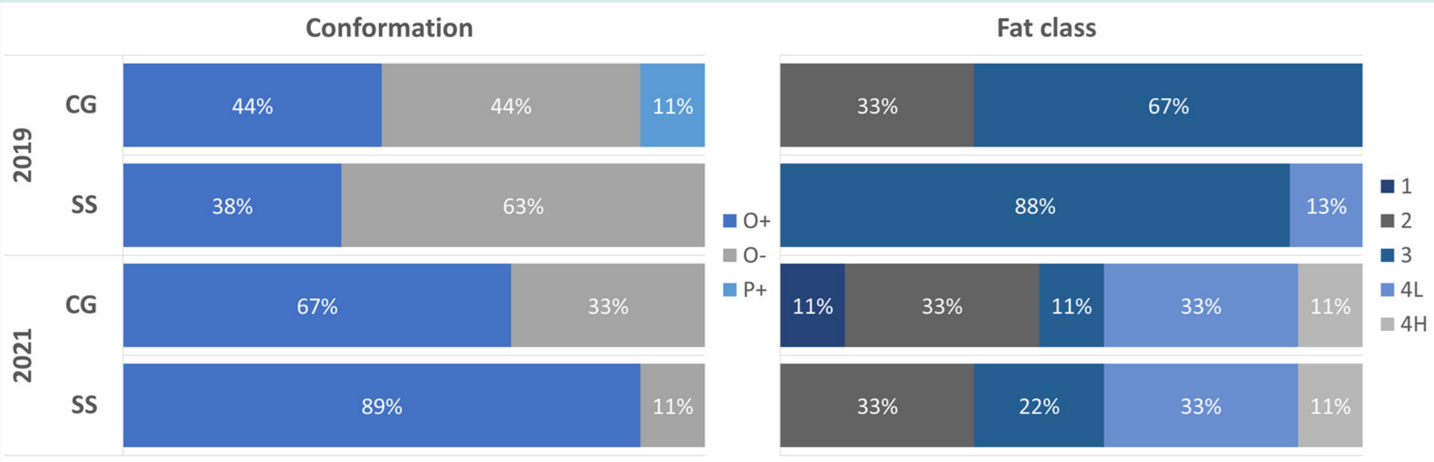

Figure 17. Carcass Conformation Grades and Fat Class scores for CG and SS Cohorts.

Animal Health and Behaviour

Faecal egg counts (FEC) were only performed ad hoc when lower than expected cattle growth rates were observed (e.g., October 2018) and the values observed were low on the few occasions that FECs were carried out. Blood minerals were taken in June and October 2018 and February and October 2019, and results showed a slight Iodine deficiency, therefore mineral lick buckets (salt based) were offered in 2020 and 2021 to correct for this.

Daily step count, as measured with IceCube pedometers (Ice Robotics Ltd., UK), for CG was lower than SS (927 vs 1644, respectively) (Morgan et al., 2021). Grazing management did not affect daily total standing time (average 682 min) but did affect number of lying bouts, with SS lower than CG (12 .0 vs 10.1, respectively) (Morgan et al., 2021).

SYSTEM PRODUCTIVITY

Stocking Rate

Stocking rate is a function of pasture grown, pasture utilised, pasture quality and animal feed conversion rate. As pasture grown under the SS method was fairly consistent, the stocking rate remained between 1300 and 1400 kg LW per ha throughout the years (Figure 18). The CG method increased pasture growth during the first 3 years, enabling an increase in stocking rate from 1800 to 3000 kg LW/ha. By Year 3 of the experiment, the CG was effectively carrying twice the number of animals per ha compared to the SS method - equivalent to doubling the size of a farm!

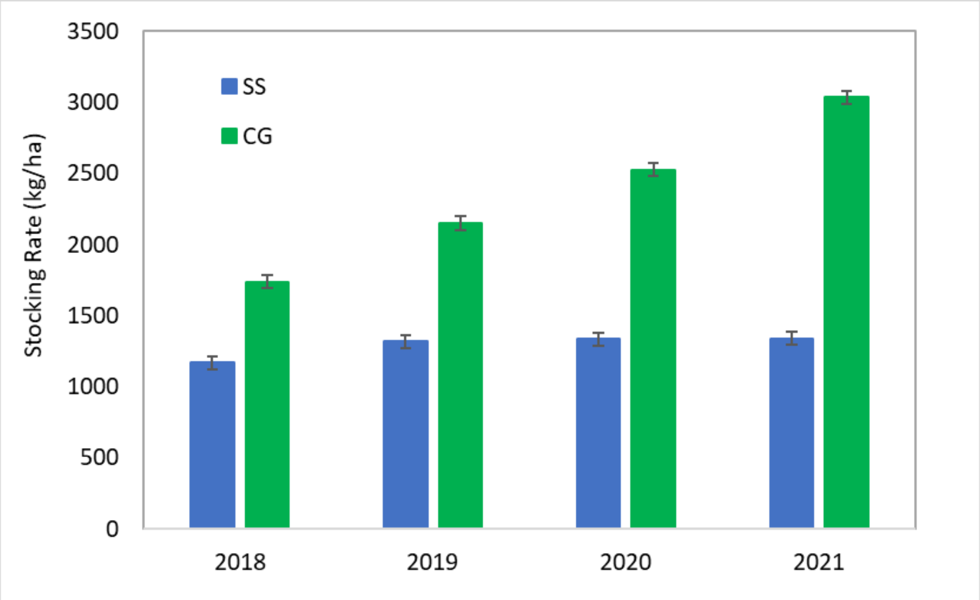

Figure 18. Stocking rate (kg LW/ha) of set-stocked and cell-grazed enclosures grazed with dairy x beef steers.

Days at Grass

Both SS and CG animals spent 161 days grazing (April to October) in 2018. In the following years this increased to an average of 176 days for SS, the CG groups achieved an average of 204 days, a difference of 28 days. It must be noted that other factors beyond that of grass availability and ground conditions limited days at grass, such as experimental soil sampling campaigns which meant the cattle had to be removed from the enclosures or TB testing. Nevertheless, these factors reduced the days at grass on a similar extent in both grazing methods.

Pasture Utilisation & Feed Efficiency

The CG increased pasture utilisation (amount of pasture eaten) during the experiment to 76% for Cohort 2 whereas the SS averaged 63% (Figure 19). To improve pasture utilisation a more flexible approach would need to be taken to pasture management allowing for animal demand to be varied at different times, for example by removing an area for silage or hay.

Feed efficiency varied during the study period (Figure 20). In Cohort 1 the CG efficiency was lower in Year 1 (2018) than SS due to their consumption of standing hay during the dry summer period. Feed efficiency increased in 2019 with the CG cattle being able to better manage pasture quality. Feed efficiency improved significantly in Cohort 2 due to the animal genetics being more suited to forage with both CG and SS achieving 9.4 and 9.3 kg DM/kg LW gain respectively in Y3 (2020). Feed efficiency was reduced in Y4 (2021) due to cattle reaching maturity and using a proportion of the energy consumed to lay down fat.

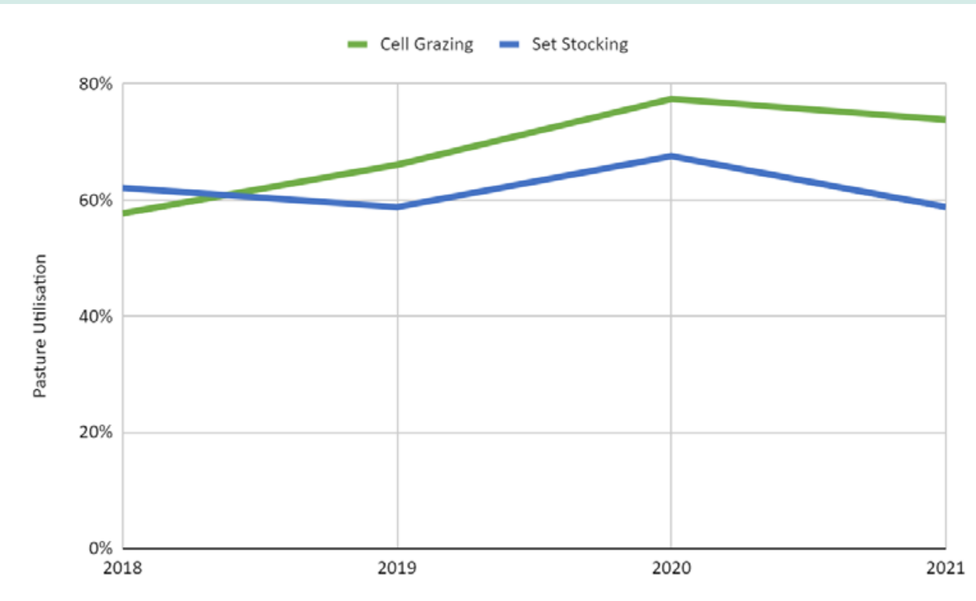

Figure 19. Percentage of utilisation (ratio between estimated forage dry matter intake and total forage production) of set-stocked and cell-grazed enclosures grazed with dairy x beef steer over a four-year experiment.

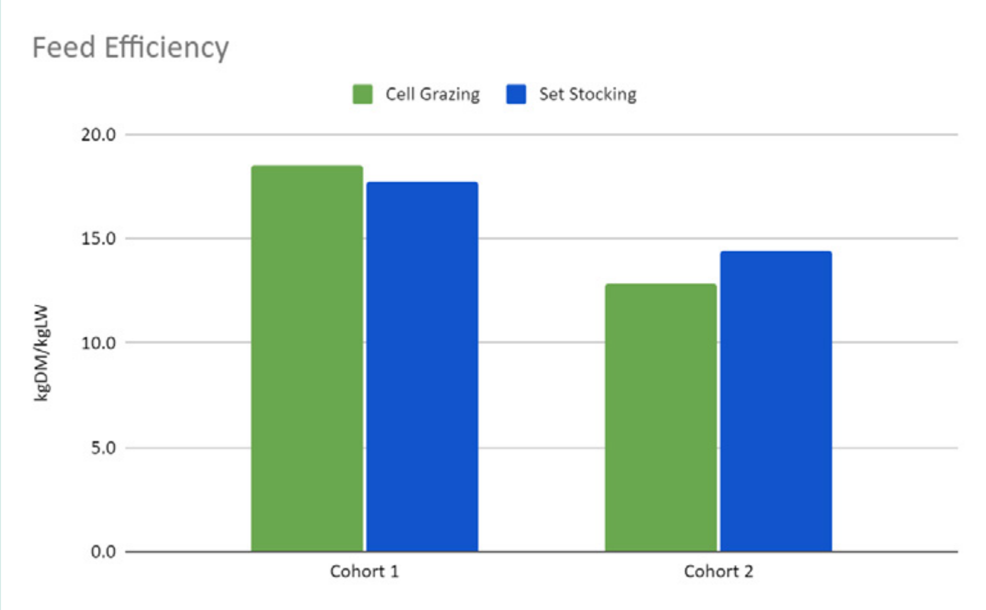

Figure 20. Average Feed Efficiency of each grazing method, lower the number the more efficient i.e. less feed required per kg of liveweight gain.

Live Weight Production

Production of live weight per hectare is relative to pasture grown, pasture utilised and feed efficiency. Both treatments produced around 350 kg LW/ha in 2018 (which was impacted by severe drought during the summer). By the end of 2019, due to increased pasture growth, the CG output had increased to 630 kg LW/ha compared to 377 kg LW/ha for the SS. In 2020, SS output more than doubled to 836 kg LW/ha enabled by a slight increase in pasture grown and the increased feed efficiency of the Cohort 2 cattle. CG output also increased due both to genetics and increased pasture growth to reach 1163 kg LW/ha. Output in 2021 was less for both treatments due in part to reduced feed efficiency of the older cattle (discussed above), with SS achieving 333 kg LW/ha and CG 617 kg LW/ha respectively (Figure 21).

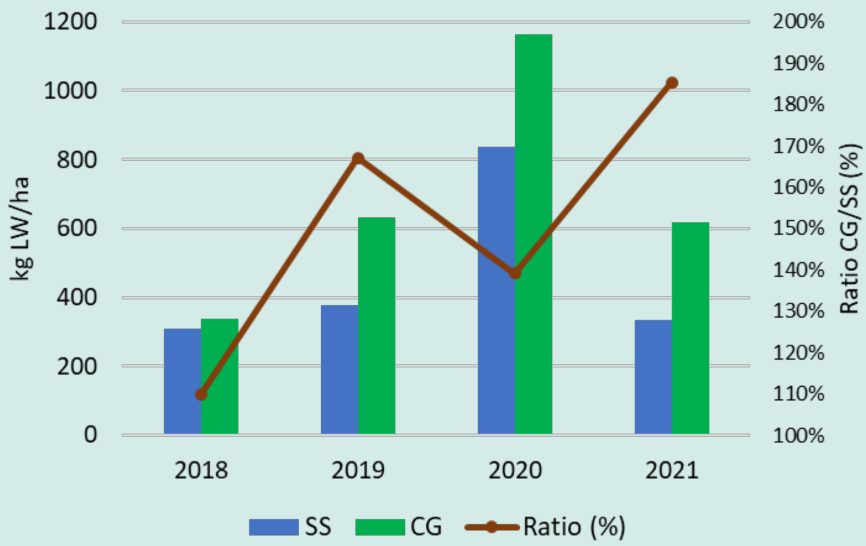

Figure 21. Average liveweight gain per ha for each grazing method. Influenced by pasture grown, pasture utilised and feed efficiency. Brown line shows % increase in output of CG relative to SS within each year, the average of the 4 years is 150%.

Considering Cohort 1 (2018-2019) and Cohort 2 (2020-2022) as separate production systems, the CG achieved a higher output of liveweight per ha averaging 483 and 890 kg LW/ha, respectively, compared to SS which averaged 367 and 585 kg LW/ha. Overall, the CG method achieved an 150% increase in LW/ha production compared to SS (Figure 22).

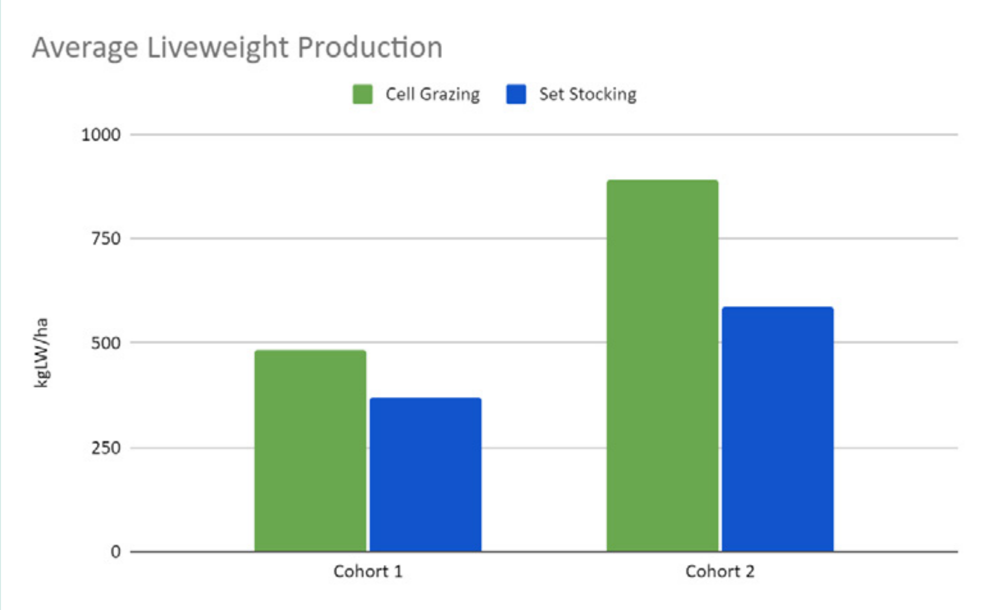

Figure 22. Average Liveweight Gain per ha for each grazing method comparing cohorts. Cohort 2 experienced increased pasture production and exhibited improved feed efficiency.

DISCUSSION

ENVIRONMENTAL FACTORS

- The period of severely dry weather in 2018 impacted summer pasture growth potential. In the CG plots, the Standing Hay method was used in 2018, where surplus pasture grown in May/June was left un-grazed then fed back in June/July during the dry period. Under the context of this experiment this positively improved metrics like "total days grazing", feed costs and potentially positively influenced pasture composition (i.e., self-seeding; however, it negatively impacted individual animal gain due to reduced quality of the Standing Hay pasture fed in that period.
- Soil pH remained relatively stable over the four years, and there was no significant difference between the SS and CG methods. Phosphorus (P) and Potassium (K) levels increased in both treatments despite the higher nutrient take-off of animal LW from the CG plots, indicating a potential improvement in soil nutrient cycling and therefore availability.
- The increase in soil organic matter (OM) was more pronounced in the CG enclosures for the first three years, resulting in a net gain of around 1% OM over the study period.
- CG enclosures showed a substantial increase in soil carbon content compared to a slight decrease overall in SS enclosures over the four-year study period. This suggests that CG is more effective in sequestering carbon and improving soil health. The reason for the fluctuation of soil carbon content (t C/ha) in the SS paddocks is unknown.
- Soil compaction, assessed using a penetrometer, showed no significant differences in the first 5 cm of soil depth between the two grazing methods, indicating that the higher stocking densities in CG did not negatively impact soil structure. Deeper in the soil profile, there was no clear pattern of the effect of grazing method on resistance to penetration. This suggests that CG, despite higher stocking densities, allows for soil recovery and maintains soil structure, possibly due to the inclusion of rest periods.
- The level of nutrients in the water runoff was similar between grazing methods, indicating a similar potential for nutrient loss per ha but a reduced leaching potential per kg LW produced in the CG plots. This is potentially due to nutrients both from the artificial fertiliser and directly from grazing livestock being cycled more efficiently by the plants due to their greater growth potential achieved through a "graze-rest-repeat" cycle and maintaining a greater AFC.

PLANT SPECIES

- CG increased the proportion of productive plants, notably perennial ryegrass, in the sward. In contrast, the SS method exhibited declining perennial ryegrass and white clover cover, with weed grasses and other grassland weeds dominating the sward by the end of the study period. This suggests that CG can help re-generate unproductive pastures as well as sustain sown/desirable plant species within a sward, potentially reducing the need to re-seed as often thus providing economic and environmental benefits.

ANIMAL PERFORMANCE

- The first cohort (2018-2019) presented challenges due to a mixture of continental type breeds which were less suited to utilising the native pasture and performing under the grazing management tactics (i.e., Standing Hay) used during challenging weather conditions of 2018. In the second cohort (2020-2021), the native cross animals showed improved growth rates.
- For meat sampling purposes slaughter dates had to be the same for both grazing management groups. Both methods achieved commercial carcass conformation (O- or better). The heavier carcasses weights and slightly better Fat Classes achieved by SS method is likely to be a function of the higher DWLG observed on that grazing method.
- Despite the slightly better nutritional composition of the CG pasture, the steers in the two stocking methods had similar levels of methane emissions (g/d) and emissions intensity (g/ kg LW).

SYSTEM PRODUCTIVITY

- CG significantly increased pasture growth and stocking rate during the first three years, effectively carrying twice the number of animals per hectare compared to SS by the third year.
- The longer grazing season for CG allowed for more grazing days and would potentially reduce the winter period and associated costs.
- CG achieved higher pasture utilisation rates compared to SS, especially with the second cohort of cattle. Feed efficiency varied across years but improved in the second cohort. The results indicated the influence of animal genetics and pasture quality on feed efficiency.
- On average CG produced 140% more liveweight per ha than SS over the study period.

CONCLUSION

In conclusion, this four-year experiment comparing Set Stocking and Cell Grazing methods has yielded valuable insights. The results show that CG is a more sustainable and productive grazing method than Set Stocking, and, as proven in this project, can be applied successfully on heavy clay soils. However, the study also highlighted the importance of managing the transition period of pasture and animals to the new system by considering suitable animal genetics, sward composition and management tactics prior to implementation.

Overall, the CG plots consistently outperformed the SS plots in terms of pasture quality and quantity. CG plots maintained higher metabolizable energy content in forage and achieved higher pasture growth, pasture utilisation and stocking rates resulting in significantly higher output per ha, thus providing a more efficient and productive system.

Despite higher stocking densities, CG plots achieved a lower nutrient leaching potential per unit of LW gain and similar soil compaction levels. Overall, the CG method had a positive impact on soil health. It led to an increase in soil organic matter and carbon content, contributing to carbon sequestration. Farmers adopting CG methods can potentially enhance their soil quality and contribute to climate change mitigation. Applying the method holistically could allow farmers to optimise production on the most suitable areas of the farm with positive impacts whilst employing complementary management options on other areas to provide an optimal balance of food production and environmental benefit.

OPTIONS FOR FURTHER RESEARCH:

1. Inorganic nutrient use: Stop the use of artificial fertilisers (Nitrogen, Phosphorus and Potassium) to reflect interest in reduction of carbon footprint and economic savings, and observe the impact on productivity, biodiversity and soil health.
2. Agroforestry: Integrate trees by planting them along the boundary and internal lane fences which make-up the CG plots and planting in-field trees within the SS plots to investigate impact on productivity, soil health, animal welfare and biodiversity.
3. Economic Viability: Investigate the economic aspects of adopting CG compared to SS considering impact on revenue, variable and fixed costs when applied as part of a whole farm approach.
4. Education: Consider education in theory and practical skills to implement systems on farm at scale including role of AI in supporting grazing management.
5. Wider Environmental Impact: Explore the broader environmental effects of CG, such as its impact on wildlife biodiversity and soil biology.

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Morgan, S., Lee, M., Rivero, MJ. (2021) Effect of contrasting grazing management methods on the behaviour and activity levels of dairy × beef steers at pasture. Animal - science proceedings 12, page 8, DOI 10.1016/j.anscip.2021.03.019.

KEY TERMS

Several metrics were calculated using the following methods:

- **Stocking Rate** was calculated as the sum of the estimated daily LW (kg) for each animal in each enclosure divided by the number of days of the grazing season (days) and the area (ha).
- **LW Production per Ha** was calculated as the sum of LW gained (kg) by all the animals that grazed each enclosure divided by the area (ha).
- **Dry Matter Intake** (DMI) was calculated using the equations proposed by the Agricultural Food and Research Council (AFRC, 1993) where ME requirements of growing animals (based on LW) and ME content of pasture are used for estimating DMI per animal and per ha.
- **Pasture Produced per Ha** was estimated by adding the estimated DMI/ha and the average Pasture mass per ha measured with a plate meter.
- **Pasture Growth Rate** during the grazing season was calculated as the estimated DM production divided by grazing days of each grazing season.
- **Pasture Growth Rate** during winter rest was calculated as the difference in herbage mass at the end of the grazing season and at the beginning of the following season divided by the number of days of the winter rest period.
- **Pasture Utilisation** was calculated as the estimated DMI divided by the estimated herbage DM production.
- **Feed Efficiency** was calculated as kg DM eaten per kg LW gained.


Image: Rothamsted Research


Image: Rothamsted Research