A comparison of a Spread-a-Bale and a Kidd 450 straw spreaders on bedding characteristics in a loose housed system for dairy heifers

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Table of Contents

List of Figures

List Tables

1: Introduction

Straw is commonly used for bedding cattle on dairy farms. Spreading straw manually is time consuming and there are health and safety implications of spreading dusty straw and being in the shed with large and boisterous cattle. The condition of the bed in loose housing systems is important as it can influence cattle cleanliness, disease and the overall wellbeing of the animals. Tucker *et al.* (2009) found evidence that bedding depth is key for cow comfort, playing an important role in preventing the development, severity and prevalence of leg injuries. Deep straw provide greater isulation for animals than an insulated floor without bedding Inglis and Robertson (1953) and reduces heat loss through conduction. In addition, deep beds help the animal to avoid drafts with beds that are deep, dry and not too dense allowing nesting behaviour compared with dense, wet and sparse beds Lago *et al.*(2006).

The objective of this study was to investigate the effects of using one of two straw spreaders (the Spread-a-Bale and the Kidd 450 turbine straw chopper) on the quality characterisitcs of the bed. These two machines are expected to produce a different quality of bed, although this is also dependant on the bale quality. The Spread-a-Bale is designed to spread straw with rotating blades which maintain straw length, and to leave a fluffy bed, well suited to nesting as the straw is left longer. In comparison the Kidd 450 first chops the straw with a knifed auger before sending the straw through a spout via a flywheel which blows the straw into the bed, leaving the straw shorter. This could lead to a reduction in bedding quality and nesting ability.

2: Methodology

2.1 Aims

The aims of the project were to investigate whether the type of straw spreader used to bed-up growing dairy heifers affects bedding characteristics and run time of the machine used to power the straw spreader.

2.1.1 Null hypothesis

There is no effect of the straw spreader on bedding characteristics or the run time of the machine used to run the spreader.

2.2 Study Design

The study was run in Spring 2022. Four straw-bedded pens within the heifer rearing shed at Harper Adams Dairy unit were used for the study. The pens were bedded with fresh straw three times a week on a Monday, Wednesday and Friday at 10am. They were mucked out every 3 weeks.

The two straw spreaders used were:

Treatment 1: a Spread-a-Bale Midi

Treatment 2. a Kidd turbine chopper blower.

The machines were used to spread straw in two of the pens over a three-week period. After three weeks the pens were mucked out and the treatments were swapped, so each pen was bedded using both machines over the 6 week study period. This was to reduce any environmental impact or impact of the age and weight of the heifers in these pens. At the beginning of the trial the pens were mucked out and the first spread of straw was done with the farm's current spreader. This approach was also taken in the middle of the trial when the pens were mucked out for the second time and re-bedded with the farm's straw spreader.

2.2 The straw spreaders

2.2.1 Spread-a-Bale Midi

The midi Spread-a-Bale used in this trial had both front and side mounting brackets which fitted to the farm's Manitou telehandler. The machine is powered by the telehandlers auxiliary hydraulics to run the belt and beater system using 55

litres/minute of oil flow. The side mounts allowed versatility but also meant that during the trial, both machines could spread from the feed passage, rather than running over the bedded area. This machine uses a belt floor to push the bales into two beaters with blades that spread the straw across a width of 6 to 9 meter and 6 to 9 meters in front of the machine (see Figure 2.1).

Figure 2. 1: Spread-a-bale internal beater and floor (Source: Authors own)

2.2.2 Kidd 450 chopper

A Kidd 450 straw chopper (Figure 2.2) was the second spreader used in this trial for the comparison against the Spread-a-Bale. This machine was PTO driven and powered by a John Deere (JD) 6170r, which is a larger tractor than necessary but it was the only tractor available for the trial. The JD 6170r is 170 horsepower (hp) and 140 hp at the PTO. This machine feeds the straw through a beater which then feeds the straw into the flywheel powered by the PTO, it is then blown up the spout and blown into the pen. It has a high and low gear for different operations and in high can blow straw up to 25 meters.

Figure 2. 2: Kidd *450 internal beater and flywheel* *(Source: Willcocks, 2022)*

2.3 Heifer pens

Holstein Friesian heifers (n= 72) were split over four pens. There were 18 heifers in each of the pens. Each pen housed heifers of a different age groups meaning that the average total weights of cattle in a pen were also different. The pens were labelled one to four (see Figure 3) with Pen 1 containing heifers aged 10 months with the average weight of 315Kg, Pen 2 animals were 9 months with an average weight of 258Kg. Pen 3 animals were 7 months old with and average weight of 185Kg and Pen 4 contained animals aged 4 months with an average weight of 124Kg. These four different age groups were used as the Harper Adams University heifer shed rears replacements for the all year round calving dairy unit. Each pen was 10m x 8m which gave a total of 80 m^2 and allowed 4.4m^2 per heifer. Total weight of heifers in the pen was calculated and divided by the 80 m^2 for each pen to give a kg liveweight/m^2. Pen 1 had a total of 70.88kg /m^2, Pen 2 58.05 kg/ m^2, Pen 3 41.63 kg/m^2, Pen 4 27.9 kg/m^2.

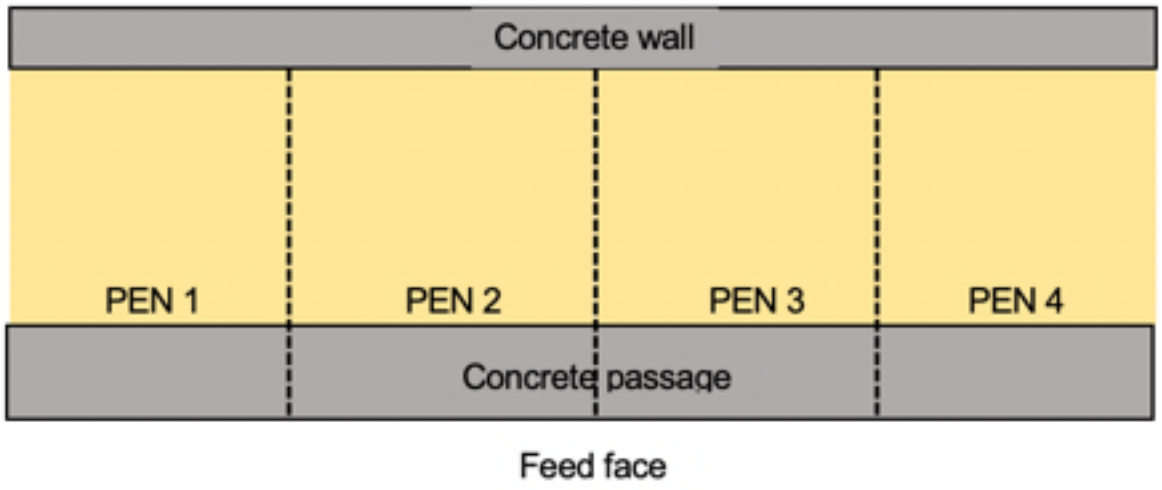


Figure 2. 4: *Trial pen design with concrete passage uses by each machine.* Dotted lines represent gates

2.4 Measurements

During the operation both machines, cattle were shut onto the beds and the Manitou with spread-a-bale and the JD with the Kidd chopper drove down the feed passage firing the straw into the pens over the cattle. Any down time was also recorded between the two machines and reason for down times was noted.

2.4.1 Bales used

During the trial the number of bales used for each machine were recorded, all

bales used were 120cm x 90cm 6 string wheat straw bales. Bales were stored in a shed, so all the straw used was dry pre-spreading. The straw was taken from the stack and places at the loading site as both machines were loaded in the same place. The bales were not weighed but an average weight of 450kg is assumed for the standard wheat 120cm x90cm (Keythorpe, undated). This was then used to assume the weight of straw used by each machine for bedding the pens. Assumed bale weight used by each machine was recorded and then used for the data analysis.

2.4.2 Nesting score

The beds were then assessed in the morning before spreading and after spreading to assess bed quality produced by each machine. The nesting score for each pen was assessed both pre-spreading and post-spreading. The pre-spreading depth was used to determine the bedding longevity between both machines. And the post-spreading measurement was used to determine the bedding quality produced by each machine.

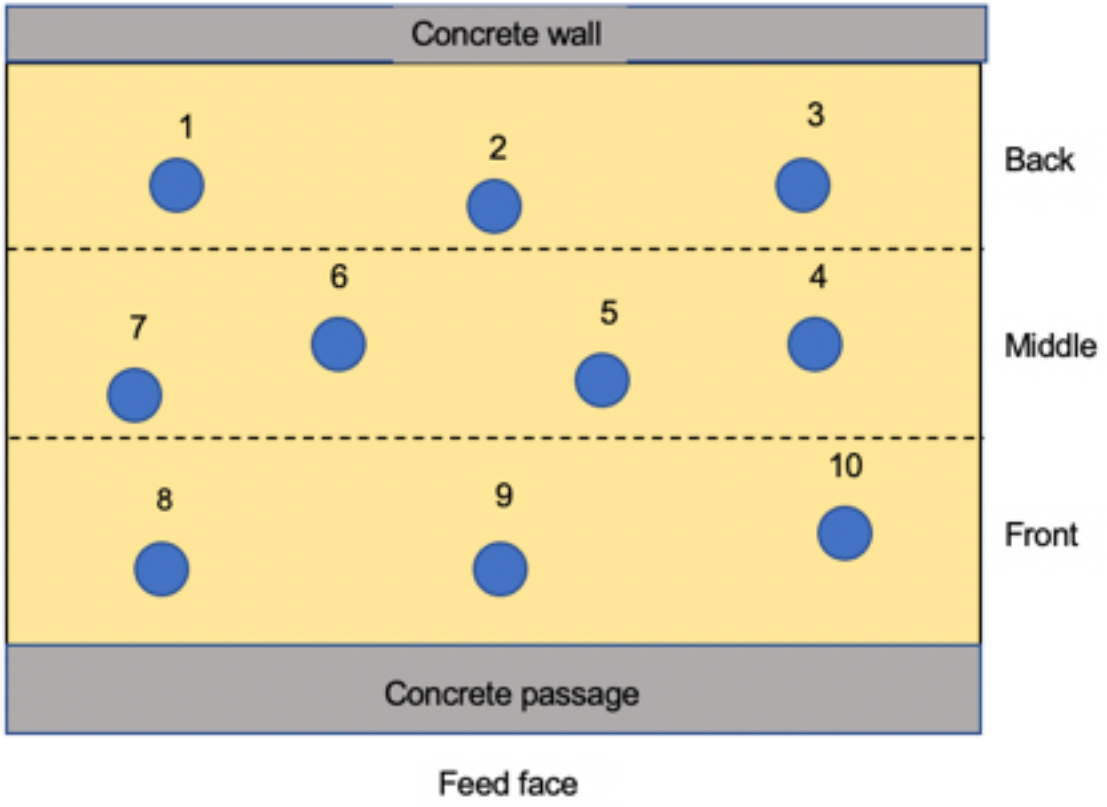
Nesting score was used as a measure of the depth of the bed. The nesting score was measured on a scale of 1 to 3 as used by Largo *et al.,* (2006), with score 1 being assigned if cattle appear to be lying on top of the bed with legs exposed. Score 2 was assigned if the cattle were slightly nestled into the bed with part of the legs showing. And score 3 was assigned if the cattle were nestled deeply into the bed with no legs visible. On the afternoon of spreading the pens were check for cattle lying down and an average nesting score was taken across the pen.

2.4.3 Bedding quality

The bedding quality was measured by taking ten different measurements starting with three at the back of the pen, four in the middle, and three at the front of the pen. The measurements in each section of the pen were taken at random using a tape measure. On the morning of spreading before the new straw was spread the pens were checked for bedding depth using the tape measure to identify the initial depth of the bed, to determine the longevity and a nesting score was given. Once spreading was finished the beds were again measured in ten locations using the

same pattern across the pen (see Figure 4).

Figure 2. 5*: Location of depth samples within each pen.*



The straw length was measured post-spreading to assess how the two different spreading methods affect the quality of the straw, as the Spread-a-Bale put the bale through two beater that spread the straw without smashing it up. Whereas the Kidd 450 sends the straw through a knifed beater and fly wheel at a much higher rpm which may break the straw up more than the other machine.

2.4.4 Cattle cleanliness

Cattle cleanliness was measured as a longer lasting bed was thought to keep cattle cleaner by preventing them from lying in dirty patches within the bed, whereas a shorter bed longevity leads to cattle becoming dirty more quickly. The scoring system used for cattle cleanliness was used by Hughes, (2006) and gives a score of 1 to 4 for the lower leg and upper leg. For each section of the leg, score 1 is no manure, score 2 is minor manure, score 3 distinct plaques of manure with hair showing through and score 4 is confluent plaques of manure. Cattle were assessed on bedding days once let onto the feed face after spreading of the straw to get the best view of the cattle.

2.4.5 Fuel usage

Fuel usage between the two machines was measured during the spreading by recording the litres per hour used by the Manitou and JD. It Is not only an

important measurement for the efficiency and running costs but also the impact that each machine has on the environment. The fuel usage influences the green credentials and carbon footprint of each machine, and the monitoring of the fuel was used to see which machine would be better for the farms carbon footprint. Both the Manitou and JD were different horsepower and were powering each machine differently which would be considered to have an effect which is why it was measured; this should be considered when deciding between a power take off (PTO) powered machine or oil pump powered machine, such as the two in this trial. The litres/hour (L/hr) was recorded once both machines started spreading, with the JD the recording started once the PTO was engaged and stopped once it was disengaged. For the Manitou the recording started once the auxiliary hydraulics were engaged and stopped once they were disengaged. The JD was set to 1800 rpm to run the PTO at 540 rpm, so the reading was consistent if the bales fed evenly. However, the Manitou, was hydrostatic causing a greater fluctuation in fuel usage. For this reason, an average of both machines was taken at each spreading and recorded for the L/hr used.

2.4.6 Time taken by both machines

Time difference was measured as this can have a large effect on not only labour but the running costs of each machine. The time taken for loading was measured using a stopwatch. The stopwatch was then lapped to begin timing the journey to the shed. Once at the shed the stopwatch was lapped to record the spreading time of each machine, then lapped one final time to record the time taken to return to the starting position. Loading, spreading, and total time taken for each machine were recorded and put into the spreadsheet. All the bales were set out prior to loading in one of the farms empty silage pits. The same start and finish point was used for each machine to get a representative total time.

For the Kidd 450, the stopwatch was started when the back door was lowered for the bale to be put into the machine with the Manitou. It was then stopped once the strings were cut, removed, and the operator was in the cab with the back door into transport position. Time taken to get to the shed was then recorded and the lap for the spreading time started once the PTO of the tractor was engaged and stopped once the PTO was disengaged. Once the tractor was back at the starting point the time was recorded in the spread sheet.

For the Spread-a-bale the time started once the machine was next to the bale and the front was being loaded. As the side mounting was being used the bales were loaded from the side rather than driven into if it were front mounted. The stopwatch was lapped once the strings were cut and pulled out and the operator was back in the machine. As with the other machine time to the shed was recorded and the spreading lap started once the beaters were engaged and stopped once they came to a stop. The total time was recorded once the Manitou was back at the starting point.
The times recorded on the stopwatch were converted from minutes and seconds into seconds for data analysis in GenStat.

During the first trial the Kidd 450 had 3 breakdowns caused by the machine getting blocked. The time taken to get the machine running again was recorded as down time for any machine costs money.

2.5 Data analysis

The first method used was analysis of variance for comparing between treatments and blocking on pens using repeated measures analysis of variance (ANOVA). This method was used on the raw data produce from the straw depth pre- and post-spreading and the straw length in each pen. One way ANOVA for the data including fuel economy, spreading time and bales used and all data was checked for normal distribution. $P<0.05$ was accepted as significant, tendencies for an effect are reported where $P<0.10$ but greater that 0.05. Chi squared test run to test the incidence of breakdowns between both machines.

2.6 Ethical concerns

The cattle were directly studied in this project however, the dust effects may be of concern due to inhalation or dust getting in the cattle's eyes. All efforts were made to ensure that the dust did not affect the heifers' eyes by reducing the amount of straw directly fired at the cattle when bedding. Though to use both machines in a way that gave comparable data the cattle had to be in the pens during spreading.

3: Results

3.1 Bedding

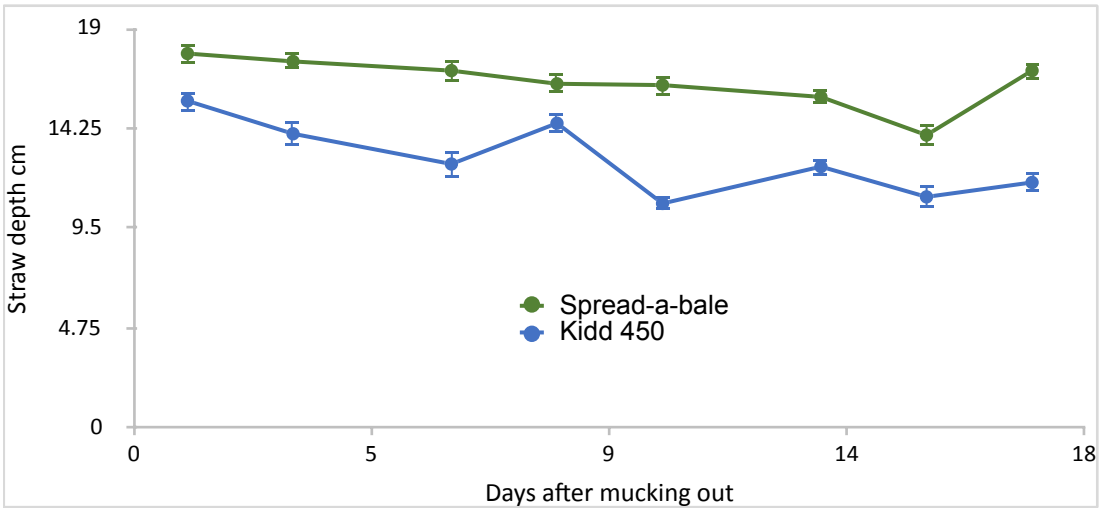
Figure 3. 1: Bed produced by the Spread-a-bale

Figure 3. 2: Bed produced by the Kidd 450.

3.1.1 Bed depth pre-spreading

There was a significant effect (P <0.001) of machine used for bedding up on the depth of bed pre-spreading, with the pens that had straw spread with the Spread-a-bale having a greater depth of straw. There was a significant effect (<0.001) of time on bedding depth (Figure 4.1) but no significant effect of location within the pen on bedding depth. The means pre-spreading straw depth was 12.8 cm for the Kidd 450 and 16.5 cm for the Spread-a-bale.

Figure 3 3 *: The mean depth of straw before each spreading of straw from the Spread-a-bale and the Kidd 450.*
Day 0 is the day of mucking out.



3.1.2 Bed depth post spreading

There was a significant effect (P<0.001) of straw spreading machine on the depths of bed post spreading, with no significant effect (P=0.286) of treatment over time and effect of pen location (Figure 4.2). Overall mean straw depths post-spreading were 19.9 cm for the chopper and 25.0 cm for the Spread-a-bale.

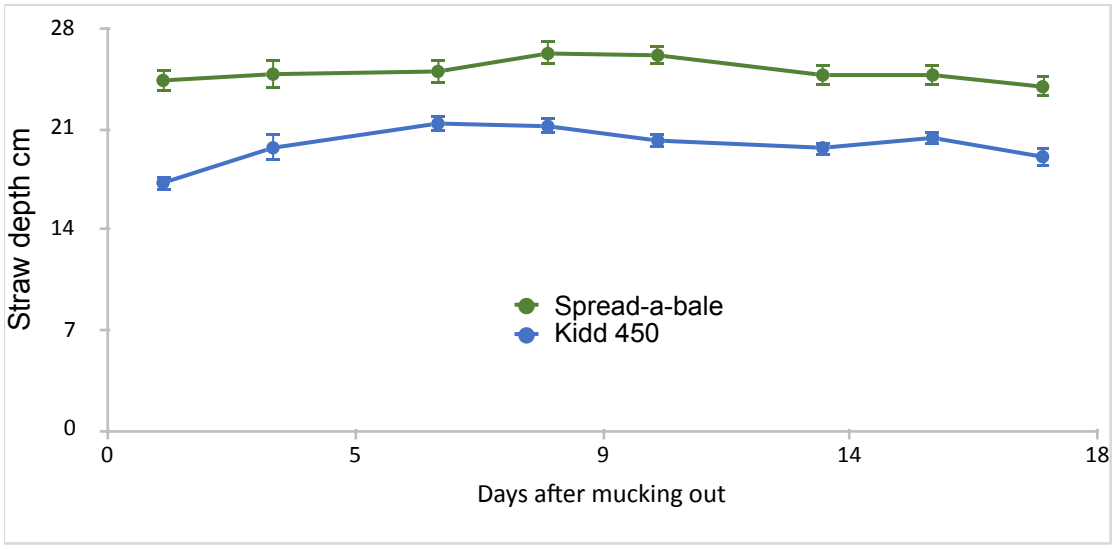


Figure 3 4: *The mean depth of straw after each spreading with the Spread-a-bale or Kidd 450. Day 0 is day of mucking out.*

3.3 Bedding quality

3.3.1 Straw length

The straw spread using the Spread-a-bale was significantly longer (P<0.001) with no effect of location in the pen (P=0.802). There was also a significant effect (P<0.001) over time. The overall mean was 46.25 cm for the chopper and 59.45cm for the Spread-a-bale (Figure 4.3).

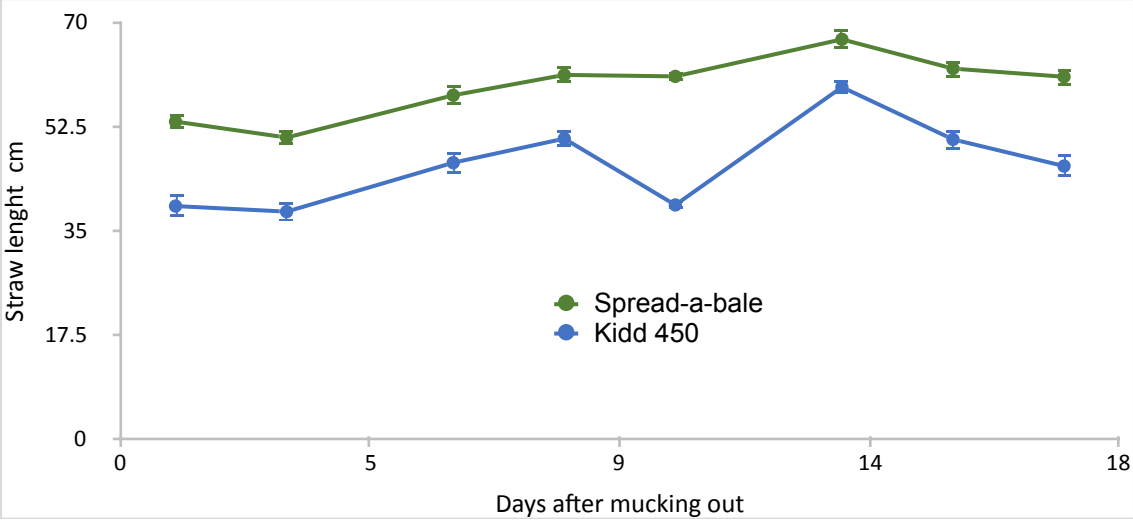


Figure 3 5: *The mean depth of straw after spreading each day from the Spread-a-bale and the Kidd 450 straw spreaders. Day 0 is day of mucking out.*

3.3.2 Nesting score

Nesting scores were measured for any heifers lying down pre and post spreading of straw. The mean scores are shown in Figure 3.6 and 3.7, respectively.

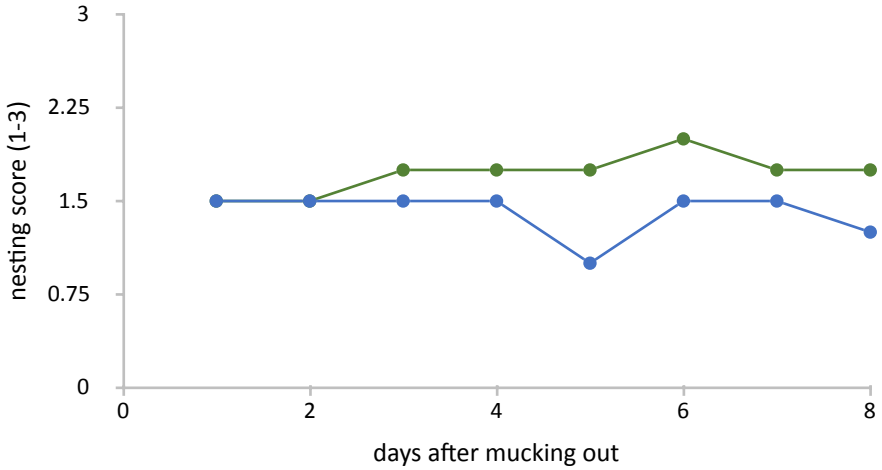


Figure 3. 6: *The mean nesting score before spreading each day from the Spread-a-bale and the Kidd 450 straw spreaders. Day 0 is day of mucking out.*

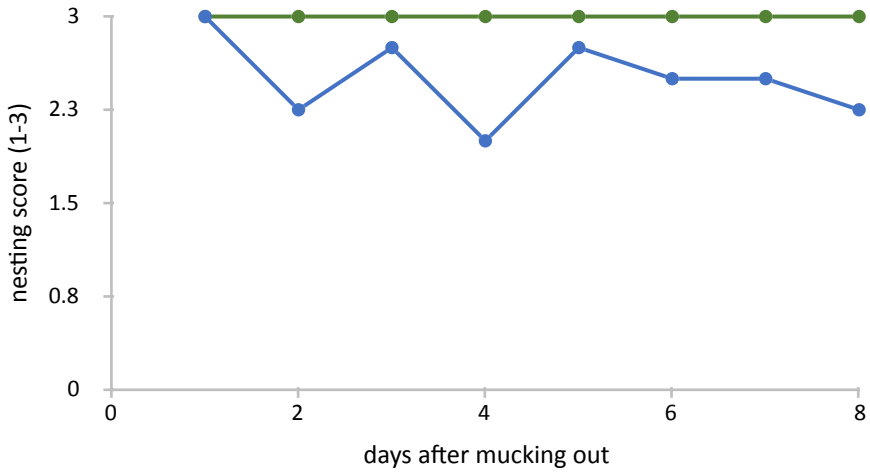


Figure 3 7: The mean nesting score after spreading each day from the Spread-a-bale and the Kidd 450 straw spreaders. Day 0 is day of mucking out.

The number of heifers lying down at each observation was variable, so the means are presented without statistical analysis.

3.3.3 Cattle welfare

During the study period there were instances of what is believed to be New Forest eye among the cattle. There were three affected heifers in each of the treatment groups meaning that treatment had no significant effect on the incidence of New Forest eye.

Cattle cleanliness scores were recorded for the first two weeks of the study. However, as it was evident that all cattle scores were one and two over this time, scoring was not continued.

3.4 Machine running variables

3.4.1 Fuel consumption

The mean value for L/hr consumed by each machine are shown in Table 4.1. There was a significant effect ($P<0.001$) of the machine used on fuel consumption. The grand means were 22.1 l/hr for the JD and 12.5 l/hr for the Manitou

Table 1: Mean values and standard errors of the means (SEM) with their significance for the one-way ANOVA.

Variable	Spread-a-bale		Kidd 450		P Value
	Mean	SEM	Mean	SEM	
Fuel usage (l/h)	12.5	± 0.40	22.1	± 0.48	P<0.001 S
Loading time (Sec)	98	± 7.00	145	± 8.13	P<0.001 S
Spreading time (Sec)	53.9	± 4.09	206	± 29.5	P<0.001 S
Total time (Sec)	343	± 5.8	599	± 21	P<0.001 S
Straw use (Kg)	359	± 28	303	± 22	P= 0.130 NS

S = Significant

NS = No Significant

3.4.2 Time comparison

Firstly, there was a significant effect (P<0.001) on the loading time of each machine with the Spread-a-bale being significantly quicker. The same was also true for the spreading time with a significant effect (P<0.001) of machine on spreading time. Lastly there was a significant effect (P<0.001) of machine on total time for the spreading operation.

3.4.3 Straw use

There was no significant effect of straw-spreading machine on the weight of straw used (Table 1) to bed up the pens.

3.4.4 Breakdowns

Break downs were recorded on three out of 16 days (23%; P= 0.07) with the Kidd 450. Breakages included a broken shear bolt on the first day, blocked spreader on the second, and loose slip clutch caused by the blockage. There were no breakdowns recorded for the spread-a-bale and it had to be used in place of the Kidd 450 on one of the days.

4: Conclusions

This study found that the machine used to spread straw affected bedding quality and the longevity of the bed. It was found that:

- the beds produced by the Spread-a-bale were deeper than the beds produced by the Kidd 450 post spreading.
- straw beds lasted longer with Spread-a-bale compared to the Kidd 450, with pre-spreading beds being deeper.
- straw length was greater from the Spread-a-bale. The Kidd 450 is designed to chop straw as it is spread, while the Spread-a-bale is designed to fluff the straw and maintain straw length.
- there was no significant difference found in straw usage between the machines.
- fuel consumption was significantly different. However, in future studies a more appropriately sized tractor should be used for a more representative comparison of fuel consumption.
- spreading time was reduced by the Spread-a-Bale.

5: References

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