final report

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Chaff carts as sheep management tools

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Executive summary

The project aimed to demonstrate that chaff carts can benefit sheep enterprises by increasing sheep condition and reducing supplementary feed costs, improving overall farm productivity and profitability. The objectives were to demonstrate these impacts on four properties in Western Australia's Great Southern, with sites running for three years. It was expected that this would show an increase in sheep weight gain and condition scores when grazing paddocks treated with chaff carts compared to those without. These increases were anticipated to result in higher condition scores and lambing rates. In addition, we expected decreased feed costs and labour requirements, utilising benefit-cost analysis modelling to determine the economic impacts of these components and calculate the internal rate of return of chaff carts. Additional objectives were to reinforce understanding of the role of ewe nutrition on productivity. The project was also to lead to improved understanding of the tool as a sheep management tool, and the potential of chaff carts in mixed enterprises. This was expected to lead to increased adoption rates.

The project was undertaken as each year W.A. sheep farmers are faced with the summer-autumn feed gap, essentially a 6-month drought. The feed gap makes it difficult to maintain sheep condition, and limits summer stocking rates. It also often results in poor ewe condition, therefore lower conception and lambing rates. Current practice is extensive supplementary feeding, with the labour and grain costs one of the main expenses associated with W.A. sheep enterprises. It is also a difficult and stressful time, as feed allocation can be difficult to get accurate. Most producers also graze stubble residue, as a majority of W.A. producers run mixed enterprise businesses.

This opens the window for chaff management tools that can be utilised for sheep management, harnessing an under-utilised feed source that is a by-product of cropping. Harvest weed-seed control (HWSC) tools such as chaff carts are on the rise and have anecdotally led to improved sheep productivity. However, there is very little data regarding these tools in regards to the sheep enterprise. Producers are seeking further information about the effectiveness of these tools for both the sheep and crop enterprises and need information to guide their adoption decisions. Running demonstration sites on several properties across different seasons & grazing intensity allows producers to see results for themselves and understand how chaff carts can work for them. Chaff lining was also included in the final year of the project, as producers become more interested in alternative tools. Communication and extension activities allow the findings to be shared widely, with surveys finding that 74% of producers increased confidence in the tool.

Using paired-paddock methodology, performance of sheep grazing paddocks treated with chaff carts was compared to sheep grazing traditionally chopped and spread stubbles. Paddocks were grazed for six weeks over summer and autumn. Stocking rates varied between 4.5DSE/ha and 8.9DSE/ha, using recently joined ewes, or 9-month-old weaners. Pasture tests were conducted at the start and end of grazing, and lambing results collected or modelled using the Lifetime Ewe Condition Score Comparison Calculator.

A wide range of crop types and varieties were grazed, showing producers that all crops can produce beneficial chaff piles from chaff carts. Overall, paddocks with treated chaff, from either chaff carts or

chaff lining, resulted in higher energy, digestibility and crude protein in the feed tested. Sheep that grazed treated chaff were on average 2.12kg heavier than those grazing traditionally chopped and spread stubbles. Site averages varied, with advantages ranging from 1.33kg to 2.94 kg per head. Overall, chaff piles made by carts had an average comparative advantage of 2.4kg per head compared to those in the control mob. This resulted in a condition score comparative advantage of 0.22 CS for mobs grazing chaff piles compared to the traditional control.

The impacts of the weight advantages resulted in improved reproductive performance. On average, lamb survival modelled to increase by 3% in twins, and a 1% increase in singles. This carried on to weaning percentages, with an 8% increase in twin weaning percentage, but no impact on singles. Birthweight is known to drive lamb survival, also being impacted by ewe condition. There was no change in singles birthweight, but twins were modelled to have an increased birthweight of 100g.

To give the impact on feed costs, the amount of feed required to result in the benefit achieved by chaff carts was valued. It is important to remember that this data is calculated using variable stocking rates, sheep class and type, as well as varying feed quality. This resulted in a $18,749 saving in feed costs, or 7.2kg lupins per DSE. This is the average over the six weeks of the grazing period and demonstrates savings across all stock classes. When combining with the costs of owning and running a chaff cart, this was modelled to be a $14,749 saving on a 2,000ha farm, or a 35% IRR.

This means producer confidence in utilising chaff carts as a sheep management tool has been supported, showing that it leads to productivity and profitability benefits. Overall, this means less hand feeding and better sheep health coming into lambing, resulting in higher lamb and weaner survival. Not only is this an economic win, but an emotional one too, as hand feeding is often a stressful, labour intensive time of year. The project showed an increase in producers' knowledge, skills and confidence, as well as adoption rate of condition scoring, with 56% either adopting or planning on adoption condition scoring on their properties. Adoption rates of chaff charts remained low, with 9% of producers adopting chaff carts during the project, and 60% not ready to adopt or believed chaff carts weren't needed on their property. This was predominantly due to wanting more information on other harvest-weed-seed control methods. Further research should be conducted into the impacts of different harvest weed-seed control tools, such as chaff carts, chaff lining and seed destructors, comparing the performance of sheep and weed reduction. Further extension activities would also help share the project's findings

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1 Background

The aim of this project was to demonstrate the impact of grazing chaff piles created by chaff carts had on sheep management in Western Australia's Great Southern region.

The project was undertaken as each year W.A. sheep farmers are faced with the summer-autumn feed gap, essentially a 6-month drought. The feed gap makes it difficult to maintain sheep condition, and limits summer stocking rates. The other significant impact of lack of available feed is on mating ewes' live weight and condition, which is vital for high conception and therefore lambing rates. These limiting factors can be managed by adequate supplementary feeding. However, grain is expensive, time consuming to feed out and accurate feed budgeting is difficult to get right. The solution still limits profits and production. Supplementary feeding over this period is one of the main on-farm expenses, and its reduction would directly increase whole farm profitability.

Most farmers in W.A. are mixed farmers, running livestock and cropping enterprises. Some use harvest weed-seed control (HWSC) tools such as chaff carts - carts are towed behind harvesters depositing chaff in piles or 'dumps' rather than spreading it across the paddock during harvest. Originally created to help reduce weed burdens, there is an indication of advantages to sheep management as a feed source during the autumn-summer feed gap.

Trials run in the nearby shires have demonstrated that grazing chaff cart piles compared to traditionally chopped and spread stubbles can help reduce the feed gap. This is achieved by improving and extending utilisation of stubbles over summer and therefore improve livestock profitability on mixed farming enterprises. 2015 and 2016 trials in nearby shires of Broomehill, Kojonup, Darkan, Cranbrook and Tenterden by AgPro Management demonstrated that sheep grazing chaff piles over a six-week period have had significantly greater weight gain than those that haven't.

Supplementary feeding, or hand feeding, of sheep is a time consuming and labour-intensive task, which can often be neglected, and it is easy to under feed sheep. With sheep being more productive on chaff piles, there is less chance of sheep being underfed and less time spent hand feeding. The benefit of better utilising a feed source already on farm, a by-product of the cropping system, is an environmentally friendly solution that could reduce feed costs and increase production potential of sheep flocks on mixed enterprises in many regions.

This project links not only to past research undertaken by the facilitator, but also other MLA initiatives such as Making More from Sheep. WALRC priorities such as feed base management, practice change, reproduction and lamb survival, and it could be argued, technology, are included and addressed in this project. Many producers in the area do not use chaff carts (estimated 10%), however as a combined sheep and weed management method it can be a valuable tool for mixed farmers. With the introduction of the weed-seed destructor in recent years, the value of weed seed control tools to the sheep enterprise needs to be better investigated.

As part of the evaluation of this project, the group demonstrated a variety of animal and grazing management practices such as ewe nutrition, preparing for joining, condition scoring, livestock handling and weighing, feed analysis and management. These are skills which are highly beneficial to sheep enterprises, and help producers better manage their stock and monitor their nutritional

needs. Producers learnt or honed these management skills throughout the project, with hands-on opportunities.

2 Project objectives

The project aimed to demonstrate that chaff carts can benefit sheep enterprises by increasing sheep condition and reducing supplementary feed costs, improving overall farm productivity and profitability.

The second aim was to foster a better understanding of the use of chaff carts for sheep management, and other sheep management tools such as condition scoring. To achieve these aims the objectives of the project were to, by early 2020, have:

1. Demonstrated the impact grazing chaff piles has on sheep management on 4 properties regarding:
    - weight gain (kg), target of 10% increase over control mobs
    - condition scores (CS), target of 10% increase over control mobs
    - lambing rates (%) via modelling, target of 12% increase over control mobs

2. Demonstrated the economic benefits of chaff carts as a sheep management tool through BCA modelling as used in Appendix 7.4:
    - reduced feed costs per annum
    - IRR on chaff cart as based on a model farm utilizing data collected from the PDS's.
    - labour efficiency as hours saved through time spent not feeding.

3. Led to 70% of the ten core producers adopting chaff carts, and 60% of observer producers indicating they intend to adopt the technology.

4. Increased understanding in the wider industry about the potential role of chaff carts on mixed-farming enterprises.

5. Reinforced understanding of the role of nutrition in ewe productivity, to 120 producers in the region.

3 Methodology

3.1 Demonstration site set up

Demonstration sites were run in W.A.'s Great Southern and South-West in the summer-autumn periods of 2017 to 2020. The number of demonstration sites varied each year, located in Kojonup, Broomehill, Cranbrook and Tambellup. The sites were to be repeated over three years, on four host properties each year. In some cases, hosts could not continue the next year and new sites were found. This enabled comparison across different environments, management and systems, as well testing the accuracy of results.

At each property, two mobs of sheep and two paddocks were monitored. The control paddock was crop stubbles that had been treated with usual farmer practice during harvest, simply being chopped and spread behind the harvester. The chaff treatment involved a chaff cart attached behind the

harvester, which created chaff heaps or 'piles' throughout the paddock. These two paddocks will be referred to as 'chaff treatment' and 'control'. Each paddock was stocked at similar rates, which reflected the farmer's usual summer stocking rates. The stock type varied between farms, with both ewes and hoggets used.

This paired-paddock methodology ensured fair comparison, with all other factors except the chaff treatment kept the same. Paddocks were chosen based on water availability and having similar yield and stubbles (e.g. Flinders barley at 3 tonnes/ha).

Demonstration sites commenced grazing after harvest, between December and February. Generally, sheep grazed for six weeks. However, at some sites grazing time was only three weeks due to water shortages, and others extended the grazing period due to abundant feed in the stubbles.

The producers and core members of the group were directly involved with the field work, giving them immediate involvement to enhance understanding and training in skills such sampling stubbles and chaff, condition scoring as a method of sheep health evaluation and reinforcing understanding of the importance of feed quantity and quality, as well as ground cover over summer and autumn.

In 2020, chaff lining occurred, in addition to chaff carts being run. Chaff lining is where chaff is separated from straw and left in a trail or line directly behind harvester. Similar to chaff carts, it puts weed seeds in an intensive area that can managed through rotting, over competition or spraying (assumed harvester follows the same track every year). This was included as producers are interested in it, being a relatively cheap and new alternative.

3.2 Demonstration site measurements

Measurements were undertaken by core and observer producers, overseen and assisted by a technician in order to reinforce measurement techniques, as well as maintain the reliability and validity of results.

3.2.1 Condition score and weight

Sheep were condition scored and/or weighed at the start and end of the six-week grazing period, as well as at the mid-way mark. This weigh-in, after three weeks of grazing, was to ensure sheep were receiving adequate nutrition from the paddocks and see if there was an optimal grazing period for the chaff treatment.

Condition scoring was the preferred method, which is assessing the level of body fat and tissue over the loin area. This was because condition scoring is a more accurate comparison of sheep's health than weight changes. Weights are less subjective, but will vary based on animal age, pregnancy status and adult standard reference weight. The industry standard condition scoring method is outlined in Fig. 1 below. (LifeTimeWool.com).

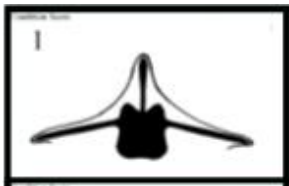
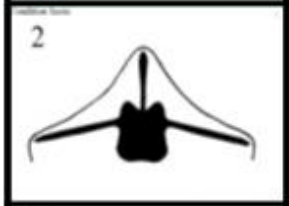
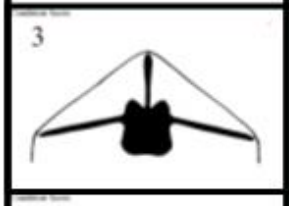
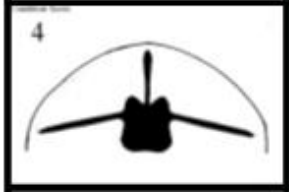
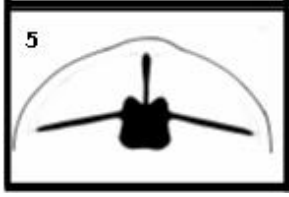
 1	**Backbone** The bones form a sharp narrow ridge. Each vertebra can be easily felt as a bone under the skin . There is only a very small eye muscle. The sheep is quite thin (virtually unsaleable)	**Short Ribs** The ends of the short ribs are very obvious. It is easy to feel the squarish shape of the ends. Using fingers spread 1cm apart, it feels like the fingernail under the skin with practically no covering
 2	**Backbone** The bones form a narrow ridge but the points are rounded with muscle. It is easy to press between each bone. There is a reasonable eye muscle. Store condition- ideal for wethers and lean meat.	**Short Ribs** The ends of the short ribs are rounded but it is easy to press between them. Using fingers spread 0.5cms apart, the ends feel rounded like finger ends. They are covered with flesh but it is easy to press under and between them.
 3	**Backbone** The vertebrae are only slightly elevated above a full eye muscle. It is possible to feel each rounded bone but not to press between them. (Forward store condition ideal for most lamb markets now. No excess fat).	**Short Ribs** The ends of short ribs are well rounded and filled in with muscle. Using 4 fingers pressed tightly together, it is possible to feel the rounded ends but not between them. They are well covered and filled in with muscle.
 4	**Backbone** It is possible to feel most vertebrae with pressure. The back bone is a smooth slightly raised ridge above full eye muscles and the skin floats over it.	**Short Ribs** It is only possible to feel or sense one or two short ribs and only possible to press under them with difficulty. It feels like the side of the palm, where maybe one end can just be sensed.
 5	**Backbone** The spine may only be felt (if at all) by pressing down firmly between the fat covered eye muscles. A bustle of fat may appear over the tail (wasteful and uneconomic).	**Short Ribs** It is virtually impossible to feel under the ends as the triangle formed by the long ribs and hip bone is filled with meat and fat. The short rib ends cannot be felt.

Fig. 1: Condition scoring assesment

Table 1 below summarises the link between condition score and weight, with one condition score equivalent to 19% of the standard reference weight of a sheep.

Table 1: Condition score and stardard reference weight

Standard weight	40kg	50kg	60kg	70kg
One condition score	7.5kg	9.5kg	11.4kg	13.3kg

Source: Lifetime Wool Project

3.2.2 Feed quality and quantity

Feed value of the paddocks with chaff carts run over them were compared to control paddocks that had been traditionally chopped and spread. Members of the core group helped to take ten 0.1sqm samples from the traditional control paddock, collecting chaff and seed. Ten random grab samples were taken from different chaff piles within the chaff pile paddock. The samples were sent for analysis of Feed On Offer (kgDM/ha), digestibility, (%DM), crude protein (%DM) and metabolisable energy (MJ/kgDM). The variety and yield of each paddock was also collected at each site.

3.2.3 Lambing rate

Using the Life Time Ewe Management Condition Score Calculator, the impacts of different grazing treatments on reproduction will be modelled. This included impact on twin and single performance, with birthweights, lamb survival and weaning percentage, as well as impact on ewe survival. This assumes that the condition score advantage occurred pre or during joining, that sheep were originally in condition score 3 (best practice for joining) and that the ewes did not lose condition score before giving birth.

3.3 Economic Analysis

Economic modelling was used to estimate the impact of grazing chaff piles per DSE, as well as the impact on overall farm profitability and an Internal Rate of Return (IRR).

3.3.1 Per DSE

Using the collected data, the cumulative comparative benefits of chaff piles was calculated in terms of grazing days. Cumulative comparative benefit is the difference in overall weight change between sheep on chaff piles compared to the control, also recorded as comparative advantage.

The project was conducted over various stocking rates and grazing lengths, therefore needed to be comparable at different grazing intensities. Therefore, benefits of chaff piles were calculated in terms of grazing days. The definition of a grazing day is one DSE, grazing one hectare for one day. (1DSE/1ha per day). The results are represented in terms of grazing days because it accounts for both the stocking rate and the length of grazing. This is important because the benefit of chaff piles is not linear over time or stocking rate. The use of grazing days also made it possible to compare results to other scenarios with different stocking rates and length of grazing.

The standard industry conversion factor of 3:1 (3kg of grain for 1kg liveweight) was used to determine the value of the extra weight of the sheep on the chaff piles.

3.3.2 Model farm

The impact of using chaff carts and grazing the resulting piles was analysed through a model farm that was representative of an average farm in the Great Southern area. The following was used in the modelling:

- Farm size: 2000ha
- Crop proportion: 50%
- Sheep numbers: 7440 – 4000 ewes, 40 rams and 3400 weaners
- Feed regime: Supplementary feed of lupins, to bring the sheep without chaff piles up to the same weight as the sheep with chaff piles.
- Grain conversion factor (grain feed for 1kg of liveweight): 3:1
- Value of lupins: $350/t

- Cost of chaff cart/year: $4000 (20-year lifetime, initial cost $80 000, sale price $20 000, repairs and maintenance over life $20 000)

3.4 Extension and communication activities

Involvement of the core and observer producers was at the heart of this project, as well as participation of the Gillami group. This provided the platform to conduct extension activities and furthered the reach of any communications and outcomes of the project.

Extension and communication activities included two field walks per year: one held at a three-week weigh in, and the second at the end of the grazing periods in March to look at the data collected. This way, members of the producer group could see the visual results due to the different chaff treatments and discuss the quantitative results available at the time.

These days were advertised through social media, with Facebook, Twitter and WhatsApp, as well as the Gillami email list. Summary sheets of current results were shared at these days. Annual summaries of the project and its findings were distributed through the same channels, as well as the Southern Dirt Annual Trials booklet and presentations state-wide.

At the start of the first year, core producers met to discuss the project, review results and plan the years' activities. This was an opportunity to review key skills such as condition scoring and best practice for weighing.

4 Results

4.1 Sheep condition and weight changes

Over the three years of the project, sheep that grazed chaff piles were better off than sheep that did not. Sheep condition was best recorded as comparative advantage, which was the weight advantage sheep grazing chaff piles had compared to those grazing control paddocks.

On average over the 3 years of the project, sheep grazing chaff treated by carts or lines were 2.12kg heavier that those that did not. Sheep that grazed chaff piles from carts had comparative advantages of 2.4kg, while those grazing chaff lines had average advantages of 1.6kg compared those that grazed the control paddocks.

4.1.1 2018

Across four sites, either adult wethers or ewes were grazed over the summer of 2017-2018, to demonstrate comparative advantages of up to 2.89kg from grazing chaff piles, with an average of 1.94kg/head. This was across stocking rates of 4.8 to 8.9DSE/ha.

Animals without chaff piles had overall weight losses (on average -1.91kg). Chaff pile grazing resulted in three properties seeing net weight and condition increases, and one site recording an average weight loss of 0.29kg (full results Appendix 7.1).

However, as shown in Table 2, those grazing chaff piles experienced higher weight gains (0.54kg more) in the first three weeks of the project, and less weight loss in the last 3 weeks of grazing. Due to this finding, one property, Site 1, continued to graze chaff cart piles for another month after the 6-week weigh in, where the project ceased. On average, sheep did not lose weight but did lose condition in the additional month (0.3CS). This stable weight but lower condition score could be due to the sheep being pregnant. However, the main finding was that the sheep did not continue to lose condition and weight at the same rate occurring in the last 3 weeks of the project.

Table 2: Sheep weight changes over 6 weeks, Year 1 data

2018	**Change after 3 Weeks grazing (kgs)**	**Change after 6 Weeks grazing (kgs)**	**Total Change (kgs)**	**Comparative Advantage (kgs)**
Site 1 piles	3.18	-3.06	-0.10	1.91
Site 1 control	1.36	-3.38	-2.01	
Site 2 piles	-0.06	0.55	-0.29	2.89
Site 2 control	-0.47	0.76	-3.17	
Site 3 piles	2.31	-2.33	0.06	1.33
Site 3 control	2.69	-3.85	-1.27	
Site 4 piles	2.44	-2.01	0.45	1.65
Site 4 control	2.14	-3.29	-1.20	
Average piles	*1.97*	*-1.71*	*0.03*	*1.94*
Average control	*1.43*	*-2.44*	*-1.91*	

Condition scores are shown in Table 3, which did not correspond with the weight changes. When using multiple producers and technicians to condition score, we received very varied results. On average, condition scores were higher in those that grazed chaff piles compared to those on the control paddocks. However, at site 1, grazing chaff piles led to sheep being in much worse condition than those that did not, with a -0.2 comparative disadvantage. In comparison, Site 2 had a 0.41 advantage, while the two remaining sites had very small advantages.

Table 3: Sheep condition changes over 6 weeks, Year 1 data

2018	**Change after 3 Weeks grazing (CS)**	**Change from 3-6 weeks grazing (CS)**	**Total Change (CS)**	**Comparative Advantage (CS)**
Site 1 piles	0.14	-0.23	-0.09	-0.20
Site 1 control	0.11	0.00	0.11	
Site 2 piles	-0.17	0.25	0.06	0.41
Site 2 control	-4.09	0.15	-0.35	
Site 3 piles	0.01	-0.07	-0.07	0.03
Site 3 control	-0.10	-0.01	-0.10	
Site 4 piles	-0.11	0.30	0.19	0.07
Site 4 control	0.02	0.10	0.12	
Average piles	*-0.03*	*0.06*	*0.02*	*0.08*
Average control	*-1.02*	*0.06*	*-0.05*	

4.1.2 2019

Sheep were run at similar stocking rates (7DSE/ha) across the two 2019 demonstration sites, with mob sizes varying from 260 to 370. Sheep used were recently joined ewes at Site 2's, and at Witham's, a mob of mixed sex weaners. 50% of the weaners tagged were male, and 50% female to ensure an accurate representation. The tagged males outperformed the females, with overall average comparative advantages of 1.69kg compared to 1.3kg.

Sheep weight changes can be seen in Table 4 below, showing that grazing chaff piles led to weight advantages compared grazing control stubbles. On average, sheep were 2.18kg heavier after grazing chaff piles for 6 weeks compared to those that did not. At Site 1's there were weight losses in the first 3 weeks, compared to Site 2's animals, which followed the previous year's trend of increased weight in all animals in weeks 1 to 3, followed by decreases in weeks 3 to 6.

Table 4: Sheep weight changes over 6 weeks, Year 2 data

2019	**Change after 3 weeks grazing (kgs)**	**Change after 6 weeks grazing (kgs)**	**Overall average change (kgs)**	**Comparative advantage (kgs)**
Site 1 piles	-0.26	1.32	1.09	1.42
Site 1 control	0.32	-0.52	-0.33	
Site 2 piles	3.68	-1.02	3	2.94
Site 2 control	2.54	-2.77	0.06	
Average				*2.18*

4.1.3 2020

Five sites were run in 2020, all grazing barley, Sheep were run at between 5.9 and 11.7DSE/ha, with mob sizes varying from 220 to 530 ewes depending on the paddock sizes used. Two sites utilised chaff lining, to compare with carts and control treatments. Sheep weight changes can be seen in Table 5 below, showing that for grazing over 6 weeks resulted in average comparative advantage of 1.6kg in favour of chaff lines, and 2.3kg advantage of chaff carts compared to the control. Three weeks into grazing, sheep grazing piles had put on 1.04kg on average, compared to the control mob putting on 0.41kg. When looking at the changes in weeks 3 to 6, chaff piles led to gains of 0.43kg, while the control resulted in losses of 0.92kg. In comparison, grazing chaff lines had average gains in the first 3 weeks of 2.5kg, and 0.3kg total gain per head in weeks 3-6.

Unfortunately, due to water constraints the Site 2 trial only went for three weeks thus their data was not included in the 6-week comparative advantage data. However, this project demonstrated a major weight advantage to the chaff line group of 2.8 kgs in those 3 weeks, resulting in a total of 3.1kg/hd gain.

Table 5: Sheep weight changes over 6 weeks, Year 3 data

2020	Weight change after 3 weeks grazing (kgs)	Weight change from 3-6 weeks grazing	Total weight change	Total comparative advantage of piles/lines over spread (kgs)
Site 1 piles	-0.20	1.60	1.40	1.70
Site 1 control	0.20	-0.50	-0.30	
Site 2 lines	3.90	-	3.90	-
Site 2 no lines	1.10	-	1.10	
Site 3 lines	1.10	0.30	1.40	1.60
Site 3 no lines	0.70	-0.90	-0.20	
Site 4 piles	1.73	-0.22	1.51	2.65
Site 4 control	0.06	-1.19	-1.14	
Site 5 piles	1.60	-0.10	1.50	2.60
Site 5 control	0	-1.10	-1.10	

4.2 Reproduction impacts

The impact of grazing different chaff treatments on lambing rate was modelled based on the weight changes demonstrated. Overall, grazing treated chaff paddocks (piles and lines) resulted in weight advantages of 2.0kg. This converted to be an average condition score advantage of 0.22CS over those that grazed control paddocks. As demonstrated below in Table 6 and in full within Appendix 7.3, this resulted in increased reproductive performance, predominantly in twins. Birthweights were 100g higher in twins, with 3% increase in survival. There was also an 8% increase in weaning percentage. The impact on single-born lambs was much smaller, with a 1% increase in lamb survival and all other measures remaining the same.

This coincided with data collected from the sites. In 2018, Site 1 recorded a 1% increase in twins in chaff grazers, and in 2019 Site 2 recording 6% higher conception rates in those grazing chaff piles.

Table 6: Average impact of grazing on lambing outcome

CS advantage		Birth weight (kg)	Lamb survival (%)	Weaning survival (%)	Ewe survival (%)
0	Single	5.1	91	146	3.8
0	Twin	3.9	73	151	5.8
0.22	Single	5.1	92	146	3.8
	Twin	4	76	151	5.4

4.3 Feed quality and quantity

The feed tests showed the chaff piles to have higher protein, energy and digestibility compared to the control stubbles. Compared to the chaff piles, lines had lower energy, only slightly lower protein levels and higher digestibility.

Table 7: Average three-year performance of chaff treatments in terms of feed quality

	Metabolisable energy (MJ/kgDM)	Crude protein (%)	Dry matter (%)	Digestibility (%)
Average piles	6.7	4.2	87.4	49.6
Average control	4.7	3.6	88.2	40.5
Average lines	6.3	4.1	87.6	51.9
Average control	4.8	4.1	86.5	44.8

When comparing performance of the different crop types used, wheat and barley piles had significantly higher energy compared to canola, with canola having much higher crude protein. Canola also had significantly lower digestibility, similar to the control treatments, as seen in Table 8.

Table 8: Average three-year performance of crop type in terms of feed quality

	Metabolisable energy (MJ/kgDM)	Crude Protein (% of DM)	Dry matter (%)	Digestibility (%)
Wheat piles	7.1	3.7	89.3	50.0
Barley piles	7.0	4.1	88.2	53.4
Canola piles	3.9	5.3	89.2	31.8
Wheat control	5.1	2.4	88.0	40.1
Barley control	4.6	3.9	88.5	44.5
Canola control	3.9	5.3	89.2	31.8

4.3.1 2018

The feed tests from Table 9 showed that chaff cart residue had higher feed value than the control paddocks, with better protein, energy and digestibility. There were substantial increases in energy content due to the chaff treatments, for example site 2's 7.2 MJ/kgDM compared to its control of 4.1MJ/kgDM. This was repeated at each site, the pattern also seen to a lesser extent in the crude protein results. Canola residue was shown to have the highest protein content compared to the cereal residues, with 2018 being the only year it was used in the project. Energy content varied but was highest in cereals.

Table 9: Feed quality at the commencement of grazing in 2018

2018	Metabolisable energy (MJ/kgDM)	Crude protein (% of DM)	Dry matter (%)	Digestibility (%)	Crop Type
Site 1 piles	5.8	5.3	81.5	43	Canola
Site 1 control	3.9	5.3	89.2	31.8	Canola
Site 2 piles	7.2	3.9	89.8	50.2	Wheat
Site 2 control	4.1	0.9	90.4	35.0	Wheat
Site 3 piles	7.7	3.8	91.0	54.0	Barley
Site 3 control	4.5	4.3	87.7	47.5	Barley
Site 4 piles	7.8	4.5	86.4	54.6	Wheat
Site 4 control	4.4	3.2	84.2	36.5	Wheat
Average piles	*7.1*	*4.4*	*87.2*	*50.5*	
Average control	*4.2*	*3.4*	*87.9*	*37.7*	

4.3.2 2019

Both sites grazed cereal crops, with Site 1's Sceptre wheat, and Site 2's Flinders and Latrobe barley. The feed test results show wheat to be the higher energy and more digestible feed, while barley had higher protein. There were few clear trends regarding the difference between chaff piles and traditionally spread stubbles.

Table 10: Feed quality at the commencement of grazing in 2019

2019	Metabolisable energy (MJ/kgDM)	Crude protein (%)	Dry matter (%)	Digestibility (%)	Crop Type
Site 1 piles	6.9	3.5	88.75	49.7	Wheat
Site 1 control	6.8	3.0	89.3	48.8	Wheat
Site 2 piles	5.0	4.3	88.0	39.2	Barley
Site 2 control	5.0	4.4	87.0	38.8	Barley
Average piles	*5.9*	*3.9*	*88.4*	*44.5*	
Average control	*5.9*	*3.7*	*88.2*	*43.8*	

4.3.3 2020

Every mob grazed barley stubble this year, with similar results. Chaff lines and chaff cart piles had on average higher metabolisable energy, digestibility and crude protein than control paddocks. This is interesting to note as chaff lining has been included this year, which outperformed control paddock feed tests.

Table 11: Feed quality at the commencement of grazing in 2020

2020	Metabolisable energy (MJ/kgDM)	Crude protein (%)	Dry matter (%)	Digestibility (%)	Crop Type
Site 1 piles	7.1	4.4	87.2	50.5	Barley

Site 1 control	4.2	3.4	87.9	37.7	Barley
Site 2 lines	6.4	3.9	87	52.8	Barley
Site 2 no lines	4.9	4.1	86.2	42.7	Barley
Site 3 lines	6.1	4.2	88.1	50.9	Barley
Site 3 no lines	4.7	4	86.8	46.8	Barley
Site 4 piles	-	-	-	-	Barley
Site 4 control	-	-	-	-	Barley
Site 5 piles	6.3	4.2	86.5	55.7	Barley
Site 5 control	5	3.9	89.8	48.2	Barley

When comparing the chaff piles to chaff lines in Table 12, the piles had higher energy, crude protein and digestibility. Dry matter was higher in lines, however the interesting thing to note is the difference between the chaff treatment and its paired paddock control. Protein was much higher in piles compared to its control, as was energy. Lines has a lower advantage when compared to its control.

Table 12: Feed quality of chaff piles compared to chaff lines

2020	Metabolisable energy (MJ/kgDM)	Crude protein (%)	Dry matter (%)	Digestibility (%)
Average piles	6.7	4.3	86.9	53.1
Average control	4.6	3.7	88.9	43.0
Average lines	6.3	4.1	87.6	51.9
Average control	4.8	4.1	86.5	44.8

4.4 Economic Analysis

4.4.1 Grazing days

In order to compare the impact of chaff grazing across different stocking rates, the results are discussed as grazing days. This is a known metric used to compare benefits of grazing over different stocking rates and time lengths, or the grazing intensity. Another way to define total grazing days is the number of hectares one DSE is able to graze, reaping maximum benefits from each hectare for 1 day each.

Over the three-year project, the results showed that there are benefits across all stocking rates grazing chaff treatments when compared to sheep grazing control stubbles. Fig. 1 shows that on average, grazing chaff piles resulted in 269 grazing days, achieving a benefit of 2.4kg over those who

did not graze piles. It also shows that the length of grazing time has a linear relationship with benefits, increasing over time within the 6-week grazing window.

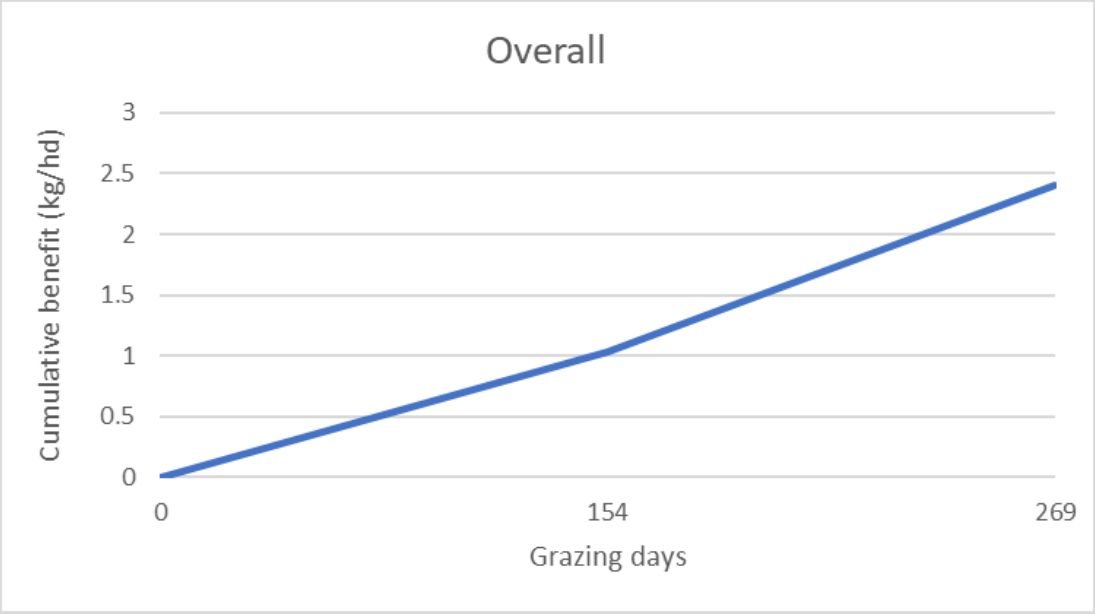


Fig. 1: The overall cumulative liveweight benefit of chaff piles when data from all years and crops are averaged.

4.4.2 Grazing days: 2018

Fig. 2 shows that the benefit of chaff piles per head is greater at low grazing levels. This means that the cumulative benefit is higher when grazing days are maximised. It also indicates that the benefit of chaff piles is greater in wheat paddocks than canola. However, the experiment only had one canola trial, so the robustness of this finding is low. The analysis further reinforces that the first three weeks of grazing leads to the highest benefits with lower gains in the last three weeks of the project, indicated by the slope of the graph from day 161 onwards.

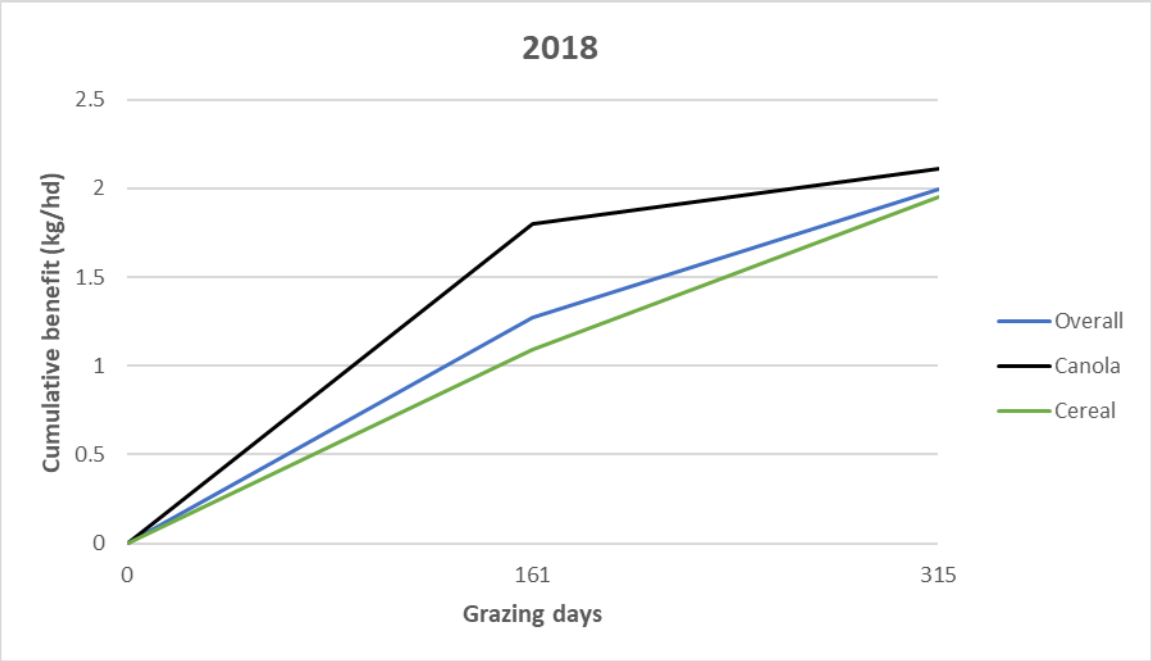


Fig. 2: Cumulative liveweight benefit of chaff piles over standard stubble management for different levels of grazing.

4.4.3 Grazing days: 2019

The 2019 sites were conducted at lower stocking rates therefore the results only capture the benefits at low grazing days, also known as low grazing intensity. The findings suggest that the benefits of chaff piles would continue to increase if the grazing time was longer, or the paddocks ran at higher stocking rates. Compared to 2018's results, Fig. 3 indicates benefits continuing to be high in the final three weeks of grazing, as shown by the change Barley 1's slope, becoming a positive relationship compared to a weakening of the trend in Barley 2.

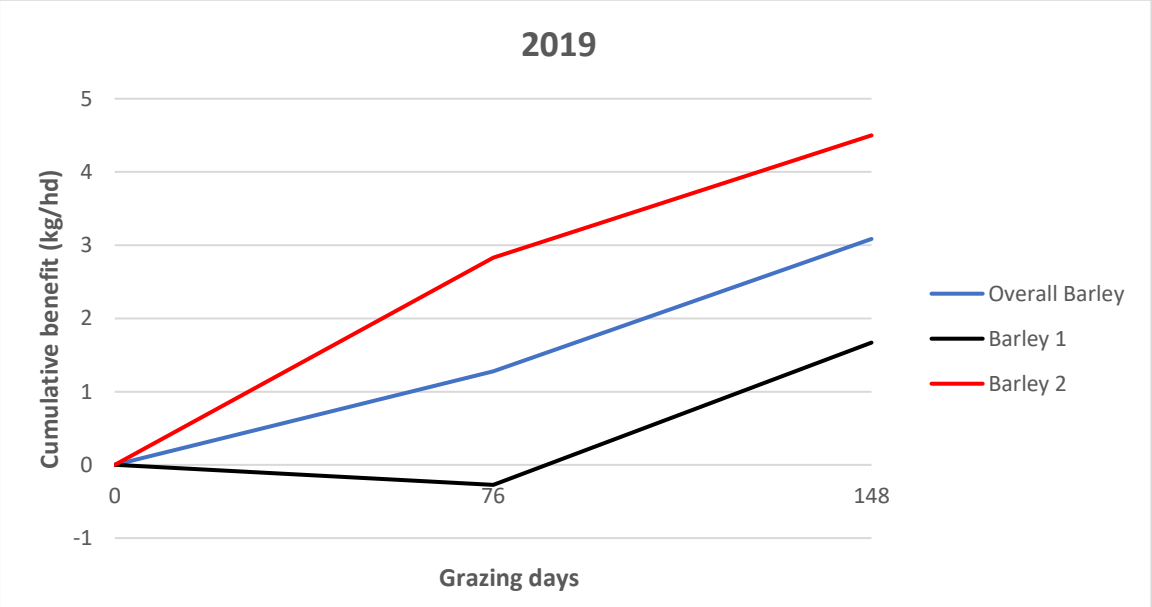


Fig. 3: Cumulative liveweight benefit of chaff piles over standard stubble management for different levels of grazing. The stubbles grazed were barley.

4.4.4 Grazing days: 2020

Fig. 4 shows varying results from the different chaff treatments, however the overall message is the same: grazing treated chaff led to cumulative benefits, despite varying stocking rates. The second point, where the line's gradient changes, indicates where the mid-project mark lay, indicating that again the first three weeks of grazing usually leads to benefits being accumulated more rapidly.

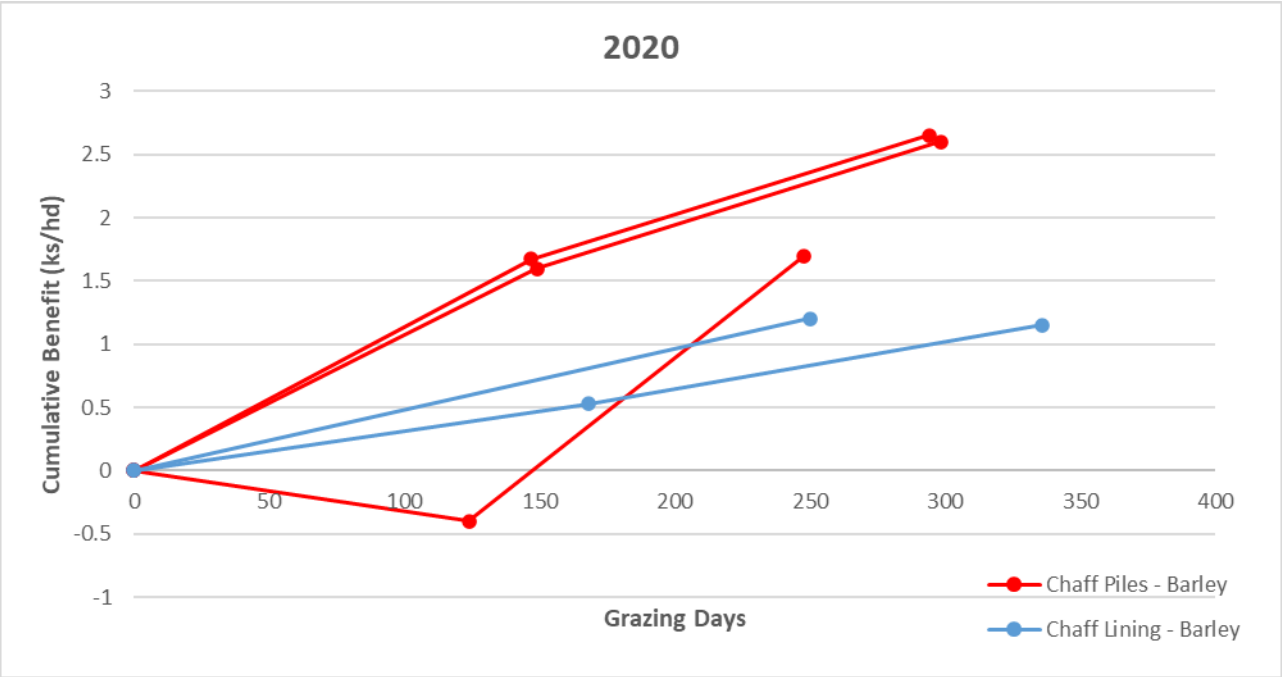


Fig. 4: Cumulative liveweight benefit of chaff piles and chaff lining over standard stubble management for different levels of grazing. The stubbles grazed were barley.

4.4.5 Model farm

The following was used to calculate the benefits of chaff piles at a farm level:

- Farm size: 2000ha
- Crop proportion: 50%
- Sheep numbers: 7440 – 4000 ewes, 40 rams and 3400 weaners
- Feed regime: Supplementary feed of lupins, to bring the sheep without chaff piles up to the same weight as the sheep who grazed chaff piles.
- Grain conversion factor (grain fed for 1kg of liveweight): 3:1
- Value of lupins: $350/t
- Cost of chaff cart/year: $4,000 (20-year lifetime, initial cost $80,000, sale price $20,000, with repairs and maintenance over life $20,000)

Based on the performance over the three-year project, average liveweight benefit for sheep consuming chaff piles is 2.4kg after 269 grazing days (as seen in Fig. 1). To conduct the analysis, it was modelled that all sheep grazed each paddock of crop (assuming all cropped paddocks had utilised chaff carts and grazed the piles), to achieve 269 grazing days. Each DSE grazed for 36 days (269 grazing days x 1000ha / 7440DSE) and will have 2.4kg extra weight than if they had grazed standard stubble. To achieve the same weight on the control paddocks, 7.2kgs of lupins would be required per DSE (over the 6 weeks of grazing), which equates to $18,749 in feed costs.

At 269 grazing days, factoring in the annual cost of owning and running a chaff cart, the overall benefit of chaff piles for the model farm is $14,749 per annum.

The Internal Rate of Return on a chaff cart was calculated to be 35%. This was based on a $80,000 start price, $20,000 salvage price and $1,000 in repairs and maintenance each year.

4.5 Outputs: Extension and Communication Activities

Two field days were held each year, except in 2020 which was impacted by COVID-19 restrictions having only held one field day. There was an average of 14 producers in attendance at each event, ranging from 11 to 20. Discussions at the field days were as follows, focusing on the impact on weight and condition changes and feed availability:

- Lack of summer rain and its impact on summer management
- Variability of stubble and chaff value due to crop type, harvester efficiency and weather
- Optimal stubble grazing time
- Impact of condition score profile on reproduction
- Worm impact and control
- Condition scoring- the need to ‘retest’ your accuracy
- Paddock feed compared to needs
- Feed budgeting throughout summer and autumn
- Nutrition in piles, not just quality and quantity
- Harvest-weed-seed control methods: various tools and outcomes

Annual reports were produced for the Gillami newsletter and the SouthernDirt Trials booklet. Each report can be seen in Appendix 7.7, which were further shared when requested by interested grower groups, individuals or organisations. Case studies have been produced for distribution after project completion, as shown in Appendix 7.8, to give producers’ perspectives of the tool. Seven MLA progress reports were also produced.

The project and its findings have also been shared with all AgPro Life Time Ewe Management groups, local field days and presentations such as Kojonup Ag Supplies field day, ASHEEP’s AGM and The Sheep’s Back workshops. A webinar was also run in conjunction with Australian Herbicide Resistance Initiative, as part of their WeedSmart series.

4.6 Adoption and Practice Change

4.6.1 Changes in Knowledge, Skills and Confidence

30 producers did the pre project survey, where we found that:

- 86% of respondents did not have a chaff chart
- 14% have a chaff chart
- 30% used condition scoring
- 35% thought chaff piles were high quality feed
- 35% believe grazing chaff piles could improve sheep condition & therefore lambing rates.
- 50% thought that chaff carts could improve sheep profitability
- 35% thought they could improve condition score of ewes through chaff piles
- 80% of respondents were concerned about increasing vegetable matter content of wool

The post project survey data was collected from 23 producers in March to April of 2020. It showed that the project resulted in increased producer confidence in chaff carts as a sheep management tool, to an average level of 7.3 out of 10. This was higher in the core producers, at 7.8, compared to the observers with 6.7 out of 10.

There was an increase in producers' knowledge, skills and confidence in chaff carts as a sheep management tool, with 74% of producers increasing their knowledge. Producers surveyed for the closing data agreed that they found the project to be valuable, ranking it 7.5 out of 10, and 74% would recommend the PDS program. Satisfaction with the project was ranked at 7.3 out of 10.

4.6.2 Adoption Rate

There is high interest in harvest weed management tools in Western Australia, beyond the Great Southern area as shown in the extension activities. Core producers have expressed intent to purchase chaff carts or seed destructors, as have producers at presentations.

Adoption rate was measured as above, in the survey responses. Core and observer producer differences were unable to be distinguished, as initial data did not capture this metric. Of the 23 producers who responded to the post-project survey, 60% had never used a chaff cart, 22% had in the past, and 27% currently used one. This is an increase from the 14% of producers who ran a chaff cart before the project, with 9% of surveyed producers having adopted a chaff cart during the project. 70% of surveyed producers said that they were not ready to adopt chaff carts, or that the tool was not needed for their sheep enterprise. Follow up questions identified that this was due to the uncertainty as to which chaff treatment would be most beneficial to their business as a whole, balancing sheep and crop enterprises. Some producers mentioned adopting the Harrington Seed Destructor, which become commercially available during the project.

Condition scoring was another metric measured. In the post surveys, 22% of producers already regularly utilising condition scoring before the project, however the pre-project surveys showed this to be higher, at 30%.

The post-project surveys revealed that 30% of producers had implemented the practice during the project, on top of 26% intending to adopt. 26% felt they were not ready for the change, wanting

more information or training regarding condition scoring. 13% believed it was not needed on their property.

5 Discussion

5.1 Impacts on sheep productivity and health

5.1.1 Comparative advantage

A range of sheep classes were used, ranging from mixed sex hoggets to joined four-year-old ewes. Using different classes demonstrated that chaff cart grazing is beneficial to all sheep on a property. The data clearly shows that sheep are healthier- heavier by 2.4kg and in better condition- grazing chaff piles compared to control stubble, with comparative advantages of 1.33kg to 2.94kgs, as seen in Fig. 5 below. With summer rainfall becoming less common and delayed season breaks, filling the summer-autumn feed gap and keeping sheep in good condition is becoming more and more of a challenge to W.A. producers.

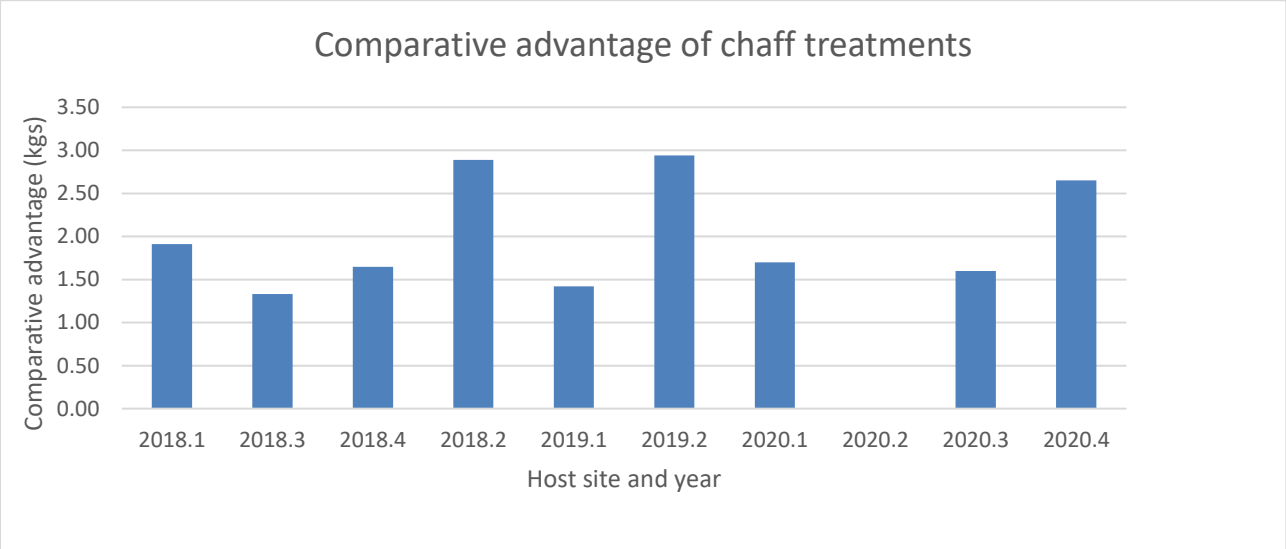


Fig. 6: Comparative advantages of chaff grazing over the six-week period

A clear pattern emerged over the years, with sheep usually gaining weight in all treatments in the first 3 weeks of grazing, and then losing weight for the remaining 3 weeks of the project. However, those on chaff treatments gained more weight in the first three weeks and have lower weight losses in the second period. This is seen in Fig 6, demonstrating comparative advantages. Despite this clear trend, there were sheep at four properties that did not follow this pattern, and lost weight in the first three weeks in both treatments. There were also sheep grazing chaff piles that had negative comparative advantages, as seen each year.

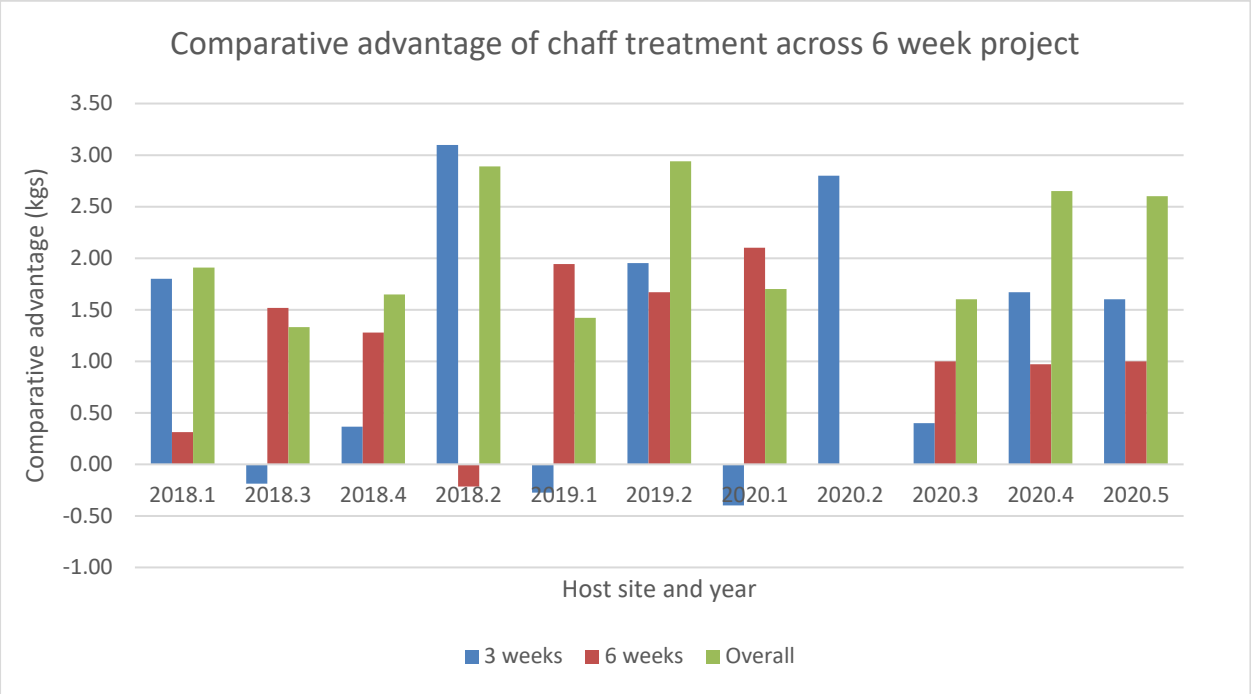


Fig. 6: Changes in comparative advantages of chaff grazing over the six-week period

It is assumed that other factors were at play, perhaps the recorded rainfall event, with the site 2 in 2018. This is shown in the data of weeks 3 to 6, as all other effected sheep gained weight in weeks 3 to 6. This indicates that there is a learning period for sheep grazing chaff piles if they have not been previously exposed to them, resulting in decreased feed intake and therefore weight. This is shown very clearly in thee weaner data from 2019, in Fig. 7 below. Both male and females grazing traditional stubbles gained weigh in the first three weeks, while those on chaff piles lost weight. This aligned with the producer noting that “the sheep didn’t seem to be touching the piles, or even hanging around them”. The figure also showed that sex did have an impact on sheep weight gain, with males outperforming females, despite females on the control paddocks gaining more weight in the first three weeks.

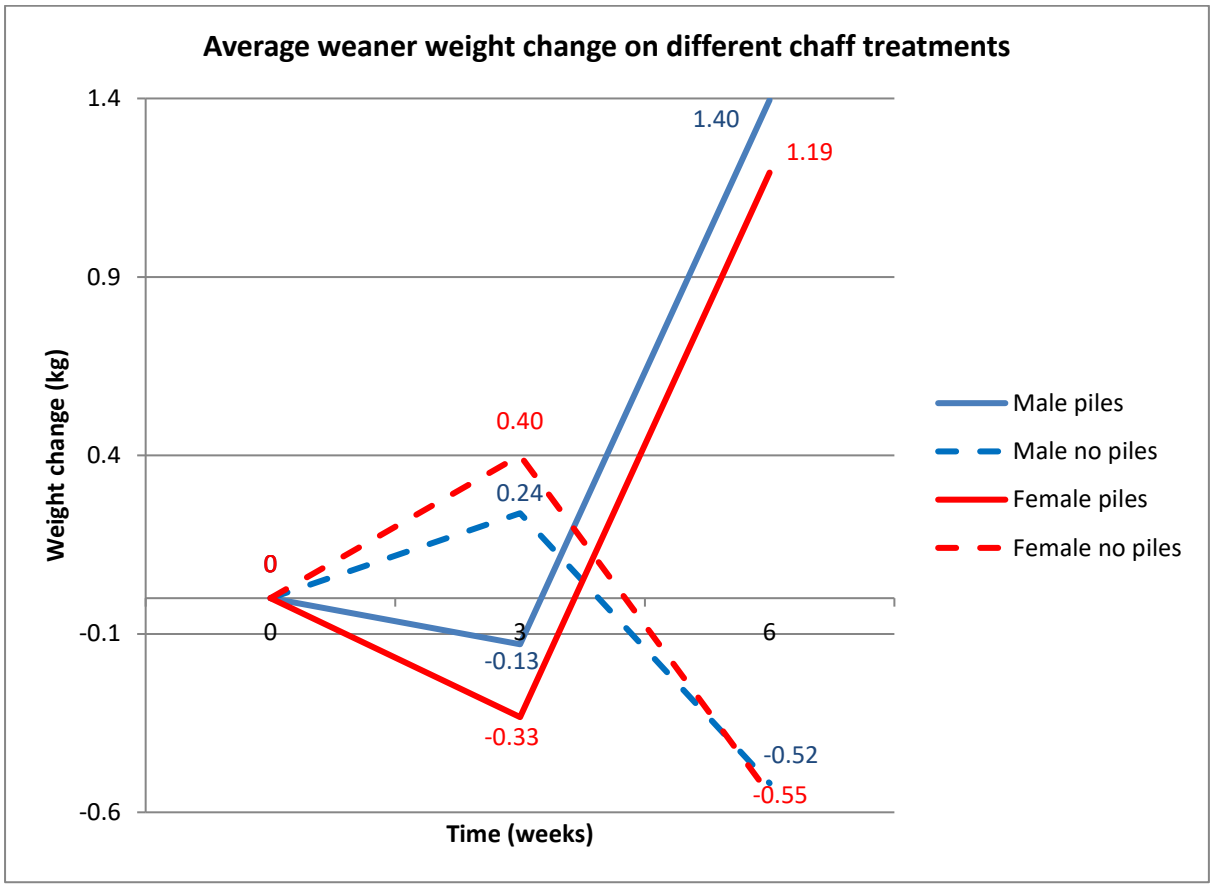


Fig. 7: Changes in female and male weaner weight due to grazing either chaff piles or control paddocks

It is interesting to note that despite sheep being run at varying stocking rates, from 4.8 to 11.7 DSE/ha, the reoccurring pattern of increases in the first three weeks and weight decreases during weeks 3 to 6 still held. Further research looking at weight changes each week at different stocking rates could indicate optimal stocking rates for summer stubbles, identifying the point at which stubbles and chaff piles cannot maintain certain stock classes.

There was not enough canola grazed to make a conclusive finding for sheep response to different crop types, another area in which further research would be useful. Table 13 below shows that within our project, grazing barley chaff piles led to higher comparative advantages than grazing canola or wheat piles. While the results need repeating and a larger sample size to increase its reliability, it is an important find in an area where barley stubble is a very prominent summer feed. It can help also producers to allocate paddocks to sheep with higher nutrition needs, or those what will respond best to weight increases.

Table 13: Average impact of chaff pile grazing on comparative advantage

Chaff pile crop type	**Comparative advantage of grazing chaff piles (kg)**
Canola	1.91
Wheat	1.99
Barley	2.14

5.1.2 Reproduction

The impacts of chaff pile grazing on reproductive performance was modelled using the Life Time Ewe Condition Score Calculator. In turn, condition score changes were modelled based on weight changes as a percentage of standard reference weight. It is hard to measure small changes in condition score, making the scoring unreliable- this is why weights were used, and converted into condition score changes in order to model the impact of grazing chaff piles on reproduction. Given condition scores returned very varying results in 2018, and not aligning with the weight changes seen, using weight changes was the most valid way to model the data. The modelled results did align with available producer records showing higher twin survival, and conception rates.

Managing ewe condition is a well-established way to ensure the high conception and lambing rates. Condition score drives conception, as well as lamb survival through birth weights and ewe survival. This was shown in the modelled results, with chaff grazing animals' comparative advantage of 0.22CS leading to higher birthweights, as well as lamb, ewe and weaner survival. The impacts were more prominent in twins, who are more responsive to condition changes than single-born lambs or single-bearing ewes. Increased conception, and survival rates of lambs and ewes, is a direct benefit to producers' profitability and productivity, particularly if high-value animals such as the twin-bearing ewes are given priority to graze chaff stubbles to take advantage of this outcome.

5.2 Feed test results

A wide range of crop types and varieties were grazed, showing producers that all crops can produce beneficial chaff piles. The value of each paddock varied due to the season, crop variety, yield and harvest losses. This is unavoidable; however yield calculations were used to ensure stocking rates were the same in paddocks that yielded differently on the same farm.

The sampling method needs to be reviewed as straw is not included in the chaff pile sampling but is when taking the traditional stubble feed tests. It is interesting to note that the feed test results did not always align with the comparative advantages achieved at each site, which brings the feed test results further into question. Overall, canola residue was shown to have the highest protein content compared to the cereal residues, which correlated with the highest sheep weight changes. Year 2 had higher average digestibility, but lower protein compared to Year 1. This may have been due to only using cereals in Year 2, as in Year 1, canola chaff had the highest protein (5.3%) while Year 2's highest was 4.4%, in barley. Year 3's data included chaff lining, which had lower protein, protein and digestibility than piles. The chaff lining paddocks outperformed the control, but at a lesser extent than the chaff cart treated paddocks.

5.3 Economic Impacts

The economic impact of chaff carts as a sheep management tool was positive, based on the modelled farm and the liveweight benefits achieved over the three-year project.

Feed costs were based on $350/t for lupins, which varies each year, and a chaff cart purchase cost of $80,000. This purchase cost may have decreased recently, with a redesign in order to reduce costs, and compete with the rising Harrington Seed Destructor, so the calculated benefit of chaff carts in this report may be understated. This would also impact the Internal Rate of Return, calculated at 35%. This would make it more favourable, but of course this depends on what it is being compared to (e.g. IRR of a seed destructor).

Reduced feed costs were the main economic impact, at 7.2kg/DSE saved. At a total of $18,7490 over the total farm, this is a significant financial impact. However, at each farm this would depend on how chaff is managed, with varying grazing intensities and stock classes utilised, resulting in varying productivity impacts, therefore profitability.

There are further economic benefits to running chaff carts which we did not include in this project, which could lead to higher gains than we calculated. We did not calculate the economic value of increased reproductive performance or wool value. Labour saving was not included, as we could not measure the additional time required due to burning chaff piles, or harvest impacts, and actual labour saved also varied with chaff management and grazing strategies.

Chaff carts provided greater benefits than chaff lining, demonstrating higher comparative advantages. However, this may be offset by the cost of a chaff cart and any extra work required to use a chaff cart vs chaff lining. This will be discussed later.

5.4 Considerations for Producers

With summer rainfall seemingly less common and delayed season breaks, filling the summer-autumn feed gap and keeping sheep in good condition is becoming more and more of a challenge to W.A. producers. The project has shown that grazing piles created by chaff carts led to sheep in better health than those on traditional chopped and spread stubbles. This improved feed source can be utilised in many ways. Producers can use chaff piles to create a period of flexibility in their system, decrease hand-feeding requirements, and a time to improve condition in high-value animals, particularly at critical times such as pre-joining.

Stocking rate and grazing intensity of the chaff piles is a dilemma for producers. The analysis showed that the relative benefit of chaff piles per head is greater at low grazing levels. This is understandable because at low grazing levels (i.e. low stocking rate), the sheep on chaff piles are not competing for feed, and have easy access to crop residue, so are able to select the high-quality seed component from the piles. However, the slope of the lines from the 2019 and 2020 data are still positive at the higher levels of grazing, which indicates potentially increased profitability of chaff piles, and possibly higher stocking rates could be achieved

Producers chasing sheep productivity benefits should consider chaff carts. Additional value of increased productivity was not measured, only the feed costs, so the economic value of chaff carts should be much higher. Increased bodyweight and condition score during joining and pregnancy drives lambing performance, in both conception rates and lamb survival. The impact on lamb birthweight is also a key determinant of twin survival to weaning. Condition also determines ewe survival and wool value, which is another productivity benefit that could be harvested using chaff carts.

A key consideration for producers was outlined in the survey data: there are other tools available to manage chaff, and their problematic weed-seeds. The project found that adoption rates of chaff carts are low due to the new harvest weed-seed control (HWSC) tool on the market, the Harrington Seed Destructor, which is more effective at controlling weed-seeds at harvest. Producers need to consider why they are wanting to adopt chaff and weed management: is it for the sheep enterprise or to minimise weeds in the cropping phase? Further research is required here to assist producers in their purchase decisions, demonstrating the effectiveness of different HWSC methods. This is where robust calculation of IRR's could benefit producers. There are also the impacts on management, such as weed control, grazing management, and chaff or stubble residue burning. One of the major downsides of chaff piles is burning - producers note their tendency to smoulder for days, which is risky and time consuming. If the aim is to reduce feed costs, management costs and time feeding then get a chaff cart.

Chaff lining was included in the project due to increased interest in the tool throughout project duration, being a cheaper but relatively rare practice. Lining is easier to set up, less time consuming at harvest and also "less fiddly" as one producer noted, being easier to fix. It also means that necessary chaff pile burning (before paddocks are reseeded) is easier to manage, with less risks. However as previously mentioned, each farm has differing goals when it comes to weed seed and chaff management which will impact the tools suited to their business.

5.5 Data Reliability & Validity

This project was a demonstration site project rather than a research project, which brings its data into question in terms of reliability, however the results have shown repeatability across different properties which increases their robustness. The data has also been welcomed and assessed critically by producers, who are interested in further investigation into chaff management.

The biggest question has been around the feed tests. It is difficult to accurately measure the value of piles, with their varying composition, compared to control stubbles, or chaff lines. For example, it was realized in the second year of the project that collecting samples directly from the chaff piles excludes the straw left in the paddock, which is included when the traditional stubbles are sampled. There is also the question to total amount of feed available in tonnes of dry matter. Further research should be conducted to determine this.

Originally the project was designed to measure the changes in condition score of the grazing animals. In the first year of the project, it was found that condition scores did not change significantly and did not correlate with the weight changes measured, leading to questioning of the

reliability of this data. Therefore, it has been excluded from 2019 and 2020 data, and weight was focused on.

Within the economic analysis, we discovered a linear relationship between benefits and grazing days. This means that results can be extrapolated beyond the recorded number of grazing days (269), to see the value of chaff piles at higher levels of grazing days. However, based on some of the non-linear relationships shown, due to benefits decreasing in the last three weeks of grazing, it is likely that the benefits of chaff piles would decrease or plateau at an unknown point.

5.6 Meeting Project Objectives

The project objectives and deliverables have been met, as outlined below.

The project aimed to demonstrate that chaff carts can benefit sheep enterprises by increasing sheep condition and reducing supplementary feed costs, improving overall farm productivity and profitability. The second aim was to foster a better understanding of the use of chaff carts for sheep management, and other sheep management tools such as condition scoring. To achieve these aims the objectives of the project were to, by early 2020, have:	
Demonstrated across 4 properties each year: Impact of grazing chaff piles on sheep management in regard to: • Weight gain (kg), with target increase of 10% over control mobs • Condition scores, target 10% increase over control mob • Lambing rates (%) via modelling, target increase of 12% over control mobs	Demonstrated across a total of 11 sites: four in Year 1, two in Year 2 and five in Year 3. Higher weights in sheep that grazed chaff piles, with a comparative weight advantage of 2.4kgs compared to the control mobs, and 1.6kgs in chaff lines. Condition score advantage on average calculated to be 0.22CS in chaff pile mobs compared to those on control paddocks. On average, lamb survival modelled to increase by 3% in twins, 1% increase in singles. Birthweights 100g higher in

	twins, no impact on singles. 8% increase in twin weaning percentage, no impact on singles.
Economic benefits of chaff carts as a sheep management tool through BCA modelling on: • Reduced feed costs per annum • IRR on chaff carts based on a model farm (utilising data collected from PDS)	Developed with results as reported above. Estimated $18,749 reduction in feed costs due to chaff pile grazing on a 'model' farm. IRR of 35%. Cost of chaff cart per year estimated to be $4,000, based on 20-year lifetime, initial cost $80,000, sale price $20,000, with repairs and maintenance over life $20,000. Estimated benefit of running a chaff cart on the model 2,000ha farm was $14,749, based on reduced feed costs combined with costs of running and owning a chaff cart.
Increase understanding in the wider industry and 120 observer producers about the potential role of chaff carts on mixed-farming enterprises	74% of surveyed producers said the project had increased their understanding of using chaff carts as sheep management tools. This does not capture the wider industry to who the findings have been presented to, but anecdotal feedback suggests wide reaching impacts
Reinforce the understanding of the role of nutrition in ewe productivity and condition scoring to 100% of the 120 observer producers in the region	All producers involved were reminded with all data distributions, and all meetings, the LTEM principles. 30% of producers now condition score regularly, with a further 26% intending to adopt, and 26% not quite ready to adopt, wanting more information and training

Overall objective is to increase the use of chaff carts as a sheep management tool, with 70% adoption rate in core producers, and 60% over the wider group over the three years of the demonstration.	Initial survey data did not ask to determine if observer or core. The project has led to 9% of producers adopting chaff carts as sheep management tools. 60% said that they were either not ready to adopt, or that chaff carts were not needed on their property. Follow up questions determined that this was due to other tools being available, and unsure which to adopt. This was also due to needing more information about the effectiveness of the chaff cart for weed-seed management after grazing.

Project deliverables have been achieved as outlined below:

• Case studies on each of the 4 PDS hosts on completion of the project.	• 3 host case studies attached as Appendix 7.8.
• Fact sheets for attendees at each field day (also posted on social media after).	• Fact sheets produced for each field day as seen in Appendix 7.9
• Survey results- quantifying attitudes and use of crop grazing.	• Survey results as reported on in Results section and attached in Appendix 7.5 & 7.6.
• Annual progress reports and articles on the findings/experiences of the demo sites.	• Annual articles distributed through Gillami Centre, Southern Dirt and AgPro news channels, attached as Appendix 7.7.
• New knowledge and data from the PDS sites.	• New knowledge and data collected as reported on above.

6 Conclusions/recommendations

Chaff treatment, either using a cart or lines, was shown to lead to weight advantages in sheep of all stock classes compared to sheep that grazed traditionally chopped and spread stubbles. Sheep grazing the chaff cart treated paddocks had higher comparative advantage than those on chaff lined

paddocks as well as the control paddocks, indicating that it may be a more effective tool than lining for the sheep enterprise. Utilising chaff carts resulted in productivity gains for reproduction, as well as decreased feed costs. Overall, the calculated IRR of a chaff cart was 35% in its assumed 20-year lifetime. However, there are many considerations for producers when looking at their harvest weed-seed control tools and chaff management.

The project's timing was opportune, with a series of late breaks highlighting the issue of the summer-autumn feed gap, and producers looking to utilise available options to ensure productivity and profitability of their sheep was sustained. In addition, the development and commercialisation of the Harrington Seed Destructor drew the spotlight back to chaff utilisation and the value of summer stubbles. Other projects were also running assessing the value of modern stubbles, which has also helped spread the project's message and increase interest. The findings will help guide projects' decision-making regarding chaff management tools, having demonstrated that chaff carts, and to a point, chaff lining, are tools that aid sheep management and have economic benefits.

The project has increased involved producers' and the wider industry's understanding of the role chaff carts can play as a sheep management tool. This has come about due to the onsite results, extension and communication activities. Further extension activities could include sharing results in MLA feed base projects, presentation to wider audiences through podcasts, online and at 2021 events post-COVID-19 restrictions. Further research should be conducted comparing the impact of different chaff treatment methods such as lining, carts and the Seed Destructor, looking at not just sheep benefits but including the impacts on crops and weed management. The impact sheep have on weed spread from chaff cart piles was also discussed as a possible research project.

7 Appendices

7.1 Average CS and weight through project

7.1.1 2018 condition score and weight changes

	INITIAL		2nd Weigh in				3RD WEIGH				TOTAL CHANGE	
PILES	Weight	Initial CS	Weight	CS	kg Net change	CS Net change	weight	CS	kg change	CS change	KG	CS
SITE 1	65.22	3.39	68.39	3.52	3.18	0.14	65.33	3.30	-3.27	-0.23	-0.10	-0.09
SITE 2	53.02	3.02	52.18	2.84	-0.06	-0.17	52.73	3.09	0.55	0.25	-0.29	0.06
SITE 3	58.34	2.85	60.73	2.85	2.31	0.01	58.40	2.78	-2.33	-0.07	0.06	-0.07

SITE 4	60.52	2.70	62.98	2.59	2.44	-0.11	60.97	2.89	-2.01	0.30	0.45	0.19
	Initial Weight	Initial CS	2nd Weigh in CHAFF				3RD WEIGH				TOTAL CHANGE	
STUBBLES	Weight	Initial CS	Weight	CS	kg Net change	CS Net change	weight	CS	kg change	CS change	KG	CS
SITE 1	68.06	3.41	69.43	3.53	1.36	0.11	66.05	3.53	-3.38	0.00	-2.01	0.11
SITE 2	52.68	2.98	48.74	2.49	-0.47	-4.09	49.51	2.64	0.76	0.15	-3.17	-0.35
SITE 3	59.59	2.80	62.17	2.71	2.69	-0.10	58.32	2.70	-3.85	-0.01	-1.27	-0.10
SITE 4	60.22	2.65	62.31	2.66	2.14	0.02	59.02	2.77	-3.29	0.10	-1.20	0.12

7.2 Feed test results

7.2.1 2018 feed test results

Feed Quality of feed at commencement of grazing					
Site	DM %	Moisture %	Crude Protein (% of DM)	Digestibility (%)	ME (MJ/kgDM)
CANOLA Site 1 Chaff piles	81.5	18.5	5.3	43	5.8
CANOLA Site 1 Control	89.2	10.8	5.3	31.8	3.9
WHEAT Site 2 Chaff piles	89.8	10.8	3.9	50.2	7.2
WHEAT Site 2 Control	90.4	9.6	0.9	35	4.1
BARLEY Site 3 Chaff piles	91	9	3.8	54	7.7
BARLEY Site 3 Control	87.7	12.3	4.3	47.5	4.5
WHEAT Site 4 Chaff piles	86.4	13.6	4.5	54.6	7.8
WHEAT Site 4 Control	84.2	15.5	3.2	36.5	4.4

7.2.2 2019 feed test results

PDS Site	Treatment	Variety	Crude Protein %	DMD %	ME (MJ/kgDM)
Site 1	chopped spread	Sceptre	3.0	48.8	6.8
Site 1	chaff chart bottom of paddock	Sceptre	4.2	52.0	7.3
Site 1	chaff cart top	Sceptre	3.2	48.3	6.7
Site 2	chopped spread	flinders	3.2	35.2	4.3
Site 2	chopped spread	flinders	4.7	41.5	5.4
Site 2	chopped spread	flinders	4.4	40.1	5.2
Site 2	chopped spread	flinders	3.4	34.9	4.3
Site 2	chopped spread	flinders	5.3	42.2	5.6
Site 2	chopped spread	flinders	5.3	38.9	5.0
Site 2	chaff cart	Latrobe	3.2	34.9	4.3
Site 2	chaff cart	Latrobe	4.8	39.2	5.0
Site 2	chaff cart	Latrobe	5.6	43.0	5.7
Site 2	chaff cart	Latrobe	3.4	35.2	4.3
Site 2	chaff cart	Latrobe	4.7	39.4	5.1
Site 2	chaff cart	Latrobe	4.4	42.5	5.6
Site 2	chaff cart	Latrobe	3.2	35.1	4.3
Site 2	chaff cart	Latrobe	4.4	40.5	5.3
Site 2	chaff cart	Latrobe	4.8	43.0	5.7

7.2.3 2020 feed test results

2020	Crop Type	Dry Matter (%)	Crude protein (%)	Digestibility (%)	Metabolisable Energy (MJ/kgDM)
Site 1 piles	Barley	87.2	4.4	50.5	7.1
Site 1 no piles	Barley	87.9	3.4	37.7	4.2
Site 2 lines	Barley	87	3.9	52.8	6.4
Site 2 no lines	Barley	86.2	4.1	42.7	4.9
Site 3 lines	Barley	88.1	4.2	50.9	6.1
Site 3 no lines	Barley	86.8	4	46.8	4.7
Site 5 piles	Barley	86.5	4.2	55.7	6.3
Site 5 no piles	Barley	89.8	3.9	48.2	5
Site 4 piles	Barley	-	-	-	-
Site 4 no piles	Barley	-	-	-	-
average piles		86.9	4.3	53.1	6.7
average no piles		88.9	3.7	43.0	4.6

average lines		87.6	4.1	51.9	6.3
average no lines		86.5	4.1	44.8	4.8
overall average treated		87.2	4.2	52.5	6.5
overall average not treated		87.7	3.9	43.9	4.7

7.3 Reproductive impacts

	Birth weight (kg)	Birth weight increase (kg)	lamb survival (%)	survival increase (%)	Weaning rate (%)	weaning increase (%)	ewe survival (%)
normal single	5.1		91		146		3.8
normal twin	3.9		73		151		5.8
0.22CS advantage single	5.1	0	92	1	146		3.8
0.22CS advantage twin	4	0.1	76	3	151	8	5.4

7.4 Chaff Piles Economic Analysis Report 2018 – 2020 by M. Young

Aim

Standard harvest practise is to spread chaff from harvesting evenly across the paddock behind the harvester. This forces sheep to graze the whole paddock in order to find any, grain residues, which is the high quality feed compared to the chaff. Collecting chaff and these grain residues into piles is an alternative method farmers can use which makes the feed more available and accessible for livestock, however this requires access to a chaff cart. Farmers can also opt for chaff lining which doesn't require any special equipment however the feed is less accessible than chaff piles.

The aim of this project is to determine the economic value to the livestock enterprise of using chaff carts, compared to standard method of chaff spreading.

Method

The trial was run over three years across 2-5 farms each year. At each farm, the liveweights of 100 sheep were recorded, 50 sheep were run as the control with access to spread chaff and the other 50 sheep had access to chaff piles or lines. The sheep were weighed three times, at the beginning of grazing, after three weeks, and again after 6 weeks of grazing. Sheep gaining or losing more than 450g/hd/day were classified as outliers and removed.

Using this data, the cumulative comparative benefits of chaff piles was calculated in terms of grazing days. Cumulative comparative benefit is the difference in overall weight change between sheep on

chaff piles vs standard. The definition of a grazing day is one DSE grazing one hectare for one day, the results are represented in terms of grazing days because it accounts for both the stocking rate and the length of grazing. This is important because the comparative benefit of chaff piles is not linear over time or stocking rate. The use of grazing days also makes it easier to relate the results to other scenarios where farmers have different stocking rates and length of grazing.

The standard industry conversion factor of 3:1 (3kg of grain for 1kg liveweight) was used to determine the value of the extra weight of the sheep on the chaff piles.

Results

2018

Fig. 1 shows that the relative benefit of chaff piles per head is greater at low grazing levels. This is understandable because at low grazing levels (i.e. low stocking rate) the sheep on chaff piles are not competing for feed and have easy access to all of the crop residue so they are easily able to select the high-quality feed. Whereas the sheep grazing standard stubble do not have as easy access to the high-quality feed therefore it is likely that their diets are not as good. Fig. 1 also indicates that the benefit of using chaff piles on wheat crops is greater than canola, possibly due to the higher quantity of spilt/split grain in wheat crops – which increases the benefit of having all the chaff dumped in one place. However, the experiment only had one canola trial, so the robustness of this finding is low.

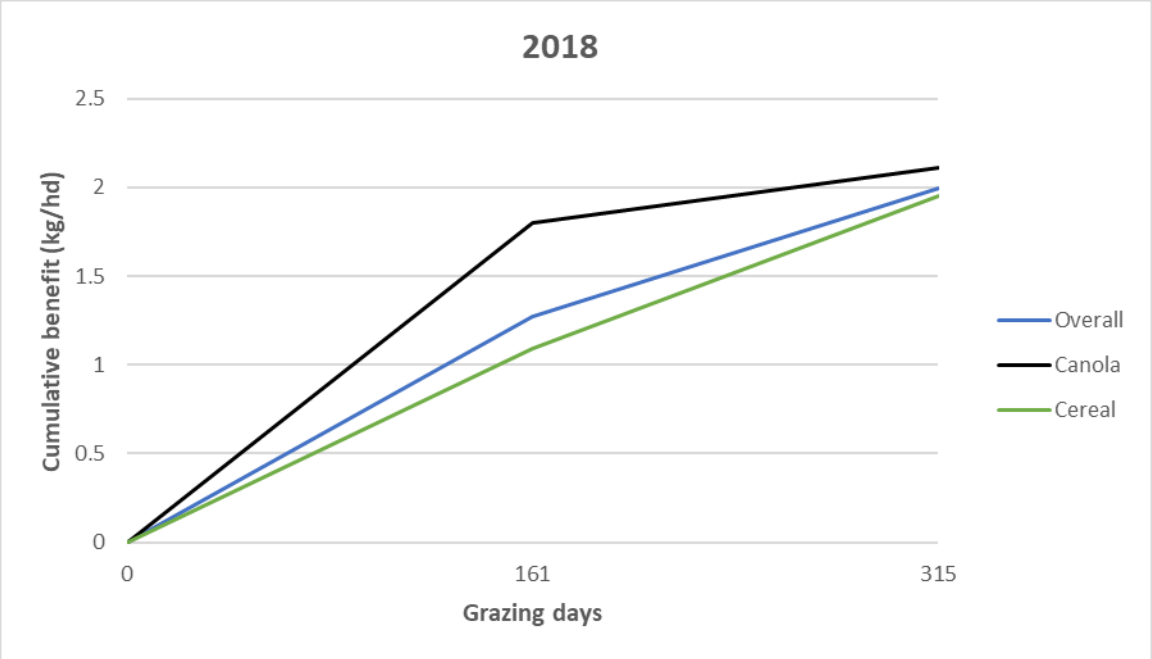


Fig. 1: Cumulative liveweight benefit of chaff piles over standard stubble management for different levels of grazing.

2019

The 2019 trials were conducted at lower stocking rates therefore the results only capture the benefits at low grazing days. The findings suggest that the benefits of chaff piles would continue to increase if the trials were longer or at higher stocking rates.

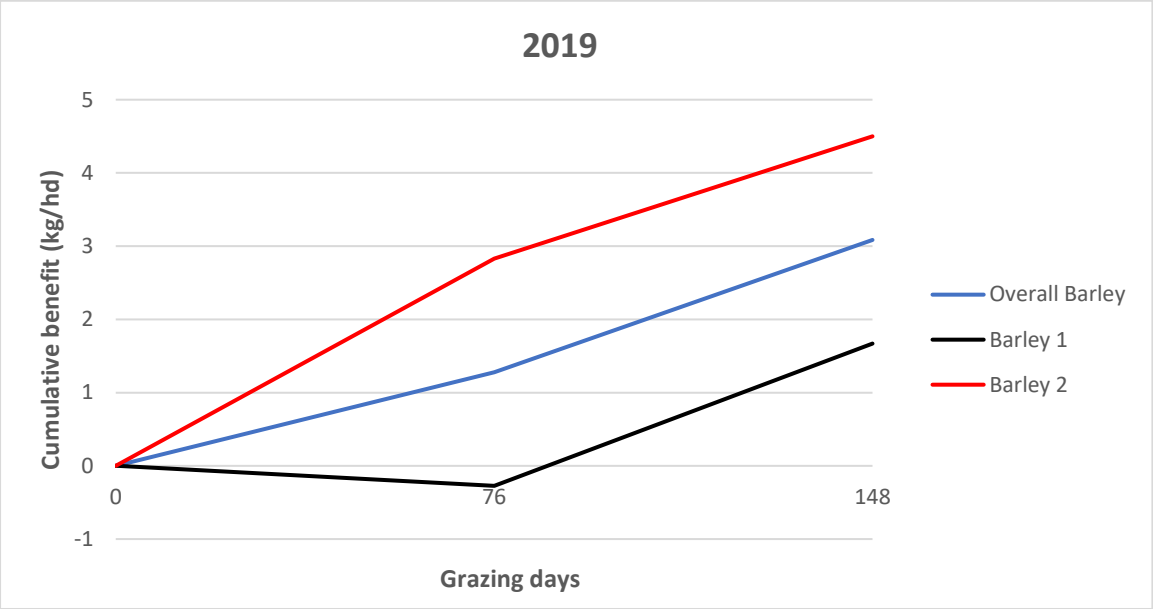


Fig. 2: Cumulative liveweight benefit of chaff piles over standard stubble management for different levels of grazing. The stubbles grazed were barley.

2020

2020 results indicated that both chaff lines and chaff carts are beneficial compared to standard. Understandably chaff carts did provide greater benefits over chaff lining however this may be offset by the cost of a chaff cart and any extra work required to use a chaff cart vs chaff lining.

The slope of the lines in Fig. 2 & 3 are still quite positive at the higher level of grazing, this indicates that at higher levels of grazing than that which was recorded in these experiments would further increase in profitability of chaff piles over standard.

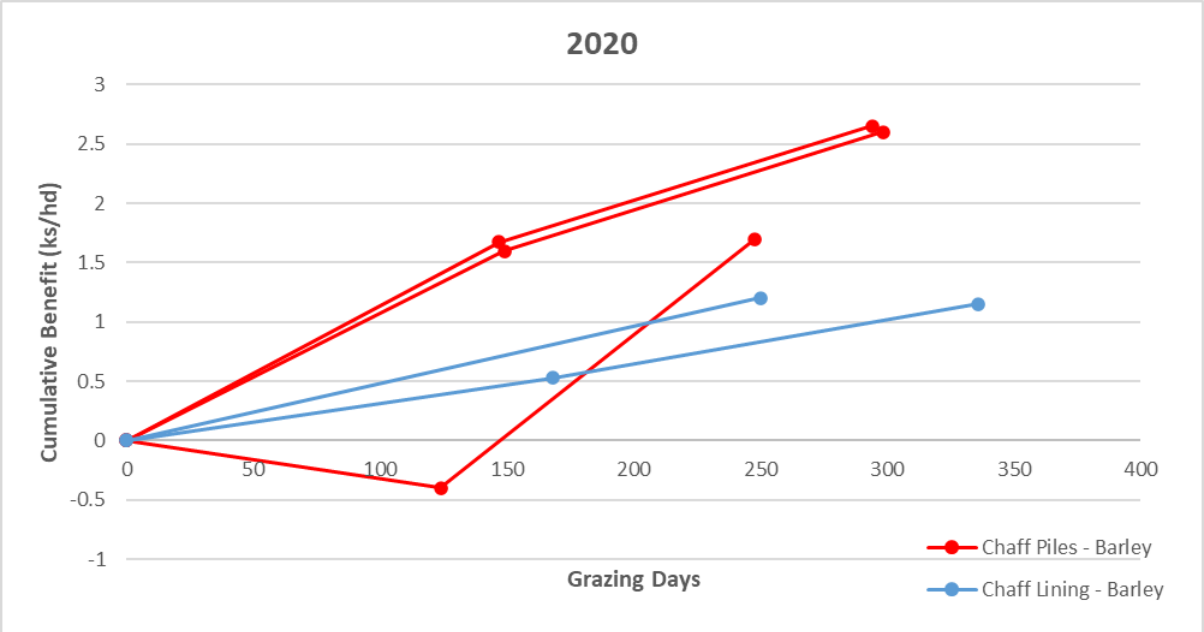


Fig. 3: Cumulative liveweight benefit of chaff piles and chaff lining over standard stubble management for different levels of grazing. The stubbles grazed were barley.

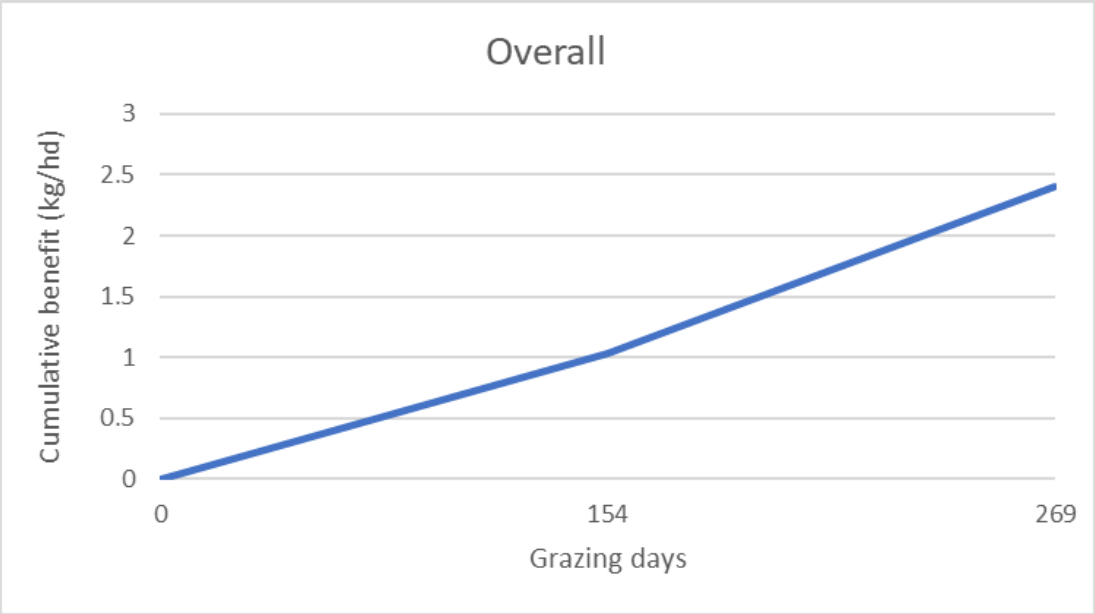


Fig. 4: The overall cumulative liveweight benefit of chaff piles when data from all years and crops are averaged.

Model farm

1. Farm size: 2000ha
2. Crop proportion: 50%
3. Sheep numbers: 7440 – 4000 ewes, 40 rams and 3400 weaners
4. Feed regime: Supplementary feed of lupins, to bring the sheep without chaff piles up to the same weight as the sheep with chaff piles.
5. Grain conversion factor (grain feed for 1kg of liveweight): 3:1
6. Value of lupins: $350/t
7. Cost of chaff cart/year: $4000 (20-year lifetime, initial cost $80 000, sale price $20 000, repairs and maintenance over life $20 000)
8. Benefits of chaff piles: utilising chaff piles for 269 grazing days results in a comparative weight benefit of 2.8kg/hd. 269 days and 2.8kgs are selected because they are the average results from the combination of all the trials (Fig. 4).

The average liveweight benefit for sheep consuming chaff piles is 2.4kg after 269 grazing days (Fig. 4). If all 7440 sheep grazed chaff piles until each hectare of crop had been grazed for 269 grazing days. Each sheep will have grazed for 36 days (269 grazing days x 1000ha / 7440DSE) and will have 2.4kg extra weight than if they had grazed standard stubble.

To achieve the same weight on stubble, 8.4kgs of lupins would be required (2.4kg x 3 grain conversion) at $350/t over 7440 sheep this equates to $21 870.

Factor in the annual cost of owning and running a chaff cart and the overall benefit of chaff piles for the model farm, if each hectare of stubble is used for 269 grazing days, is $17 870pa.

Limitations

The trials didn't cover long periods of grazing, which makes it difficult to determine the value of chaff piles over longer grazing periods. However, it is likely that the benefit of chaff piles will start to slow reduce

7.5 Pre-project survey questions and results

1. **Do you have a chaff cart?**
   86% no
   14% yes

2. **If so, what is its purpose?**
   100% Sheep feed and weed control

3. **Do you use condition scoring on your property as a sheep management tool?**
   30% yes
   70% no

4. **Do you believe chaff dumps are high quality feed?**
   35% yes
   65% no

5. **Do you think grazing chaff piles could improve sheep condition & therefore lambing rates?**
   35% yes
   65% no

6. **Do you think chaff carts could make your sheep enterprise more profitable?**
   50% yes
   50% no

7. **What do you think are the challenges of using chaff carts for the sheep enterprise?**
   80% Vegetable matter wool issues
   20% weed seed spread

7.6 Post-project survey questions and results

7.6.1 Post project survey

MLA Producer Demonstration Sites
Skills Audit template – Post-PDS
Core Participants

PDS Name Chaff Carts as Sheep Management Tools
PDS Code L.PDS.1714
Event name (to fill out by PDS ccoordinator):_____

The following questions are used to determine your level of understanding of *Chaff Carts as sheep management tools.* The knowledge and skills audit is used at the start and completion of the program to allow individuals to track their skill development and adoption of new practices. It will also be used:

1. To improve the content of future project meetings; and
2. As part of the evaluation process for the project

The information will be completely confidential, and individuals will not be identified in the analysis of data.
Name: _____
Date: / /
MLA may contact me to further assess the impact of their programs? ☐ Yes ☐ No
MLA may send me newsletters and inform me of future events? ☐ Yes ☐ No

The information you are providing to Meat & Livestock Australia Limited ABN 39 081 678 364 ("MLA") may be personal information under the Privacy Act. We will collect, hold, use and disclose the email address you have given us and the personal information you provide in the manner set out in MLA's privacy policy (located at http://www.mla.com.au/General/Privacy). If you provide a telephone number, you consent to MLA contacting you for an indefinite period about future products and services that may be of interest to you.

Section A – Your Thoughts on the PDS

A1. Overall, how **satisfied** are you with this PDS?

1	2	3	4	5	6	7	8	9	10
Poor									Excellent

A2. How **valuable** was this PDS in assisting you manage your livestock enterprise?

1	2	3	4	5	6	7	8	9	10
Poor									Excellent

A3. Would you **recommend** MLA's PDS program to others? ☐ Yes ☐ No ☐ Not Sure

A4. General Feedback
Please provide feedback to help us improve the PDS program:

_____

_____

Section B – Knowledge and Skills (If you do not know, please select the 'Unsure' option)

B1. Have you used a chaff cart or grazed chaff piles before?

a. Yes, in the past ☐
b. No ☐
c. Yes, currently ☐

B2. In your opinion, what are the benefits of chaff carts? *(Tick one of the options below)*

a. Weed seed management ☐
b. Sheep feed ☐
c. Combination of weed control and sheep benefits ☐

B3. Has your knowledge of chaff carts and grazing increased due to this project? *(Tick the answer that applies to you)*

a. Yes ☐

b. No ☐

Section C – Confidence and Practices

C1. How confident are you in managing chaff pile grazing?
(please rate out of 10, with 1 being poor and 10 being excellent, by circling your choice below)

1 2 3 4 5 6 7 8 9 10
Poor Excellent

C2. Have you begun implementing changes regarding the following practices, as a result of participating in this PDS?

	Already used before PDS	Implemented this Practice (please indicate on what % of your enterprise this practice has been adopted e.g. 50%)	Intend to implement	Not ready yet (need more training, advice)	Not needed on my property / not relevant
Grazing chaff piles					
Condition scoring					

C3. If you have implemented changes, what impact did they have on your summer feed rations and sheep condition score? *(Please do not answer if you are unsure)*

_____

C4. If you ticked "not ready yet', please indicate what additional information, training or advice you require

_____
_____

C5. If you ticked "not needed on my property", please indicate why

_____
_____

7.6.2 Post project survey results

A1. Overall, how satisfied are you with this PDS?

	1	2	3	4	5	6	7	8	9	10
Response	0	0	0	0	9%	22%	26%	26%	13%	4%

A2. How valuable was this PDS in assisting you manage your livestock enterprise?

	1	2	3	4	5	6	7	8	9	10
Response	0	0	0	0	0	13%	43%	31%	9%	4%

A3. Would you recommend MLA's PDS program to others?

74% yes
22% not sure
4% no

A4. General feedback:

- Too many forms
- Not enough flexibility within project
- Is it research or farmer practices, seems to be unsure of itself

B1. Have you used a chaff cart or grazed chaff piles before?

22% yes, currently
17% yes, previously
61% no

B2. In your opinion, what are the benefits of chaff carts?

30% weed seed management
26% sheep feed
44% Combination of weed and sheep benefits

B3. Has your knowledge of chaff carts and grazing increased due to this project?

74% yes
26% no

C1. How confident are you in managing chaff pile grazing?

	1	2	3	4	5	6	7	8	9	10
Response	0	0	0	0	0	22%	39%	26%	9%	4%

C2. Have you begun implementing changes regarding the following practices, as a result of participating in this PDS?

	Already used before PDS	Implemented this practice	Intend to implement	Not ready yet (need more training, advice)	Not needed on my property / not relevant
Grazing chaff piles	17	9	4	40	30
Condition scoring	22	30	26	13	9

C3. If you have implemented changes, what impact did they have on your summer feed rations and sheep condition score?

- Increased condition score by a little
- Lower feed rates to maintain same summer condition
- Better condition, used normal feed rates in case chaff wasn't what it was cracked up to be

C4. If you ticked "not ready yet', please indicate what additional information, training or advice you require

- More condition score training
- More information about all weed-seed options
- Might get a seed destructor
- More research about seed destructor
- Further investigation about weed control impacts of grazing

C5. If you ticked "not needed on my property", please indicate why

7.7 Annual articles

7.7.1 Final summary

Chaff carts as sheep management tools

By Georgia Reid
AgPro Management

AIM: 1) Demonstrate that chaff carts can benefit sheep enterprises by increasing sheep condition and reducing supplementary feed costs, impacting overall farm productivity and profitability

2) Foster a better understanding of the use of chaff carts and other sheep management tools such as condition scoring.

Each year, W.A. sheep farmers are faced with the summer-autumn feed gap, which is essentially a 6-month drought. Supplementary feeding over this period is one of the main sheep expenses, and its reduction would directly increase whole farm profitability. It is also a period of time-consuming, stressful monitoring to ensure sheep are receiving adequate nutrition.

The feed gap makes it difficult to maintain sheep condition, and limits stocking rates over summer as there is little feed on the ground. The other significant impact of lack of available feed is on mating ewes' live weight and nutrition, which is vital for high lambing percentages. These limiting factors can be eliminated by adequate feed. However, the current solution is expensive, with supplementary feeding.

The MLA supported Producer demonstration sites showed that grazing chaff carts piles can help reduce the feed gap and therefore improve livestock profitability on mixed farming enterprises. Utilising a feed source already on farm, a by-product of the cropping system, is an environmentally friendly solution that could reduce feed costs and increase production potential of sheep flocks on mixed enterprises.

Using identical DSEs, ewe mobs were run in either a paddock with chaff piles, or a paddock that had been chopped and spread (usual harvest methods). The paddocks at each farm were of the same variety (e.g. Zen wheat) and similar yield. The stubbles were grazed for 6 weeks, with sheep weighed and condition scored every 3 weeks.

Results so far from the project showed sheep grazing chaff cart piles weighing between 1.33kg and 2.48kg more than those grazing traditionally spread stubbles, with marginally higher condition scores. Across the entirety of the 6-week grazing period, all sheep grazing stubbles lost weight, while a majority of sites saw sheep grazing chaff piles to have minor weight increases (averaging 0.1-0.45kg).

Sheep gained weight in the first 3 weeks of grazing (except one site) with chaff pile grazing averaging slightly higher weight gains. In the last 3 weeks of the project, the sheep lost weight at different rates depending on the chaff treatment. Those on stubble lost on average 3.3kg/hd, while those on chaff averaged losses between 2 and 3.27kg in the last 3 weeks.

Feed tests showed the feed to have varying energy levels, with chaff piles recording 5.8-7.8MJ/kgDM and the chopped and spread chaff 3.9-4.5MJ/kgDM. Digestibility averaged 42%, and crude protein 4.4%, with little differences between the paddocks. We are still waiting on samples taken from chaff lines in 2020.

The project data is currently undergoing its final analysis, with the last sites wrapping up and the economic analysis being undertaken. This includes comparing data taken from paddocks that had seed destructors or chaff lining treatments.

For more information please contact Georgia Reid. 0447 523 110 or georgia@agpromanagement.com

7.7.2 Year 2 summary

Chaff carts as sheep management tools

By Georgia Reid
AgPro Management

AIM:

1) Demonstrate that chaff carts can benefit sheep enterprises by increasing sheep condition and reducing supplementary feed costs, impacting overall farm productivity and profitability

2) Foster a better understanding of the use of chaff carts and other sheep management tools such as condition scoring.

Background:

Each year, W.A. sheep farmers are faced with the summer-autumn feed gap, which is essentially a 6-month drought. Supplementary feeding over this period is one of the main on-farm expenses, and its reduction would directly increase whole farm profitability. It is also a period of time-consuming, stressful monitoring to ensure sheep are receiving adequate nutrition.

The feed gap makes it difficult to maintain sheep condition, and limits stocking rates over summer as there is little feed on the ground. The other significant impact of lack of available feed is on mating ewes' live weight and nutrition, which is vital for high lambing percentages.

These limiting factors can be eliminated by adequate feed. However, the current solution is expensive, with supplementary feeding, grazing stubbles and manipulating lambing and joining time. The solution still limits profits and production.

MLA supported Producer Demonstration Sites are up and running in the Great Southern area to further investigate the value of sheep grazing chaff piles during the autumn-summer feed gap. The 3-year project aims to show how chaff carts can benefit sheep enterprises by increasing sheep condition and reducing supplementary feed costs, leading to overall increases in farm productivity and profitability.

The Experiment

Trials run in the nearby shires by AgPro Management have demonstrated that grazing chaff carts piles can help reduce the feed gap and therefor improve livestock profitability on mixed farming enterprises. Depositing chaff in piles makes it more accessible to sheep, as well as maintaining its quality for longer compared to chaff spread across by the paddock by traditional harvesting methods. With Sheep being more productive on chaff piles, there is less chance of sheep being underfed and less time needed to be spent hand feeding. The benefit of better utilising a feed source already on farm, a by-product of the cropping system, is an environmentally friendly solution that could reduce feed costs and increase production potential of sheep flocks on mixed enterprises *in many regions.*

2 properties hosted demonstration sites this year, run by The Gillami Centre members around Cranbrook and Tambellup. Using identical DSEs, ewe mobs were split into a paddock with chaff piles, and a paddock that had been chopped and spread (usual harvest methods). The paddocks at each farm were of the same variety (e.g. Zen wheat) and similar yield. Canola, barley and wheat stubbles were grazed for 6 weeks, with sheep weighed and condition scored every 3 weeks.

Results

Results from the 2nd year of trial showed sheep grazing chaff cart piles weighing between 1.33kg and 2.88kg more than those grazing traditionally spread stubbles, with marginally higher condition scores. Sheep gained weight in the first 3 weeks of grazing (except all treatments at Witham) with chaff pile grazing averaging slightly higher weight gains.

In the remaining 3 weeks, the sheep lost weight at different rates, depending on the chaff treatment. Those on stubble lost on average 3.29-3.38kg/hd, while those on chaff averaged losses between 2-3.27kg in the last 3 weeks. Across the entirety of the 6-week grazing period, all sheep grazing stubbles lost weight, and 3 of the 4 properties grazing chaff piles saw minor weight increases (averaging 0.1-0.45kg). This led to the chaff grazing mobs being on average 1.99kg heavier than those grazing traditionally chopped and spread stubbles. In 2017, this result was 1.74kg, and 2016 3.4kg. This could be due to summer rains or more efficient harvesters, with less thrown out the back.

Feed tests showed the feed to have varying energy levels, with chaff piles recording 5.8-7.8MJ/kgDM and the chopped and spread chaff 3.9-4.5MJ/kgDM. Digestibility averaged 42%, and crude protein 4.4%, with little differences between the paddocks. In 2017, canola residues were of better feed quality compared to the wheat and barley residues, which coincided with the highest sheep gains. This was seen again within the chaff piles in 2018, but not the canola stubbles- could be due to harvester efficiency.

The project will continue for another year, with economic analysis to show the impact of the overall farm profitability. For more information, or for field day dates, please contact Georgia Reid. 0447 523 110 or Georgia@agpromanagement.com

7.7.3 Year 1 summary

MLA supported demonstration sites are up and running in the Great Southern area to further investigate the value of sheep grazing chaff piles during the autumn-summer feed gap. The 3-year project aims to show how chaff carts can benefit sheep enterprises by increasing sheep condition and reducing supplementary feed costs, leading to overall increases in farm productivity and profitability.

4 properties hosted demonstration sites this year, run by The Gillami Centre members around Cranbrook and Tambellup. Using identical DSEs, ewe mobs were split into a paddock with chaff piles, and a paddock that had been chopped and spread (usual harvest methods). The paddocks at each farm were of the same variety (e.g. Zen wheat) and similar yield. Canola, barley and wheat stubbles were grazed for 6 weeks, with sheep weighed and condition scored every 3 weeks.

The sheep grazing chaff piles gained on average 1.74kg more than mobs grazing chopped and spread stubbles. Grazing stubbles led to initial increases in condition and weight, before all mobs experienced decreases in the last 3 weeks of grazing as the paddock was grazed out, and feed quality decreased. Those grazing chaff piles experienced higher condition and weight gains in the first 3 weeks of the project, and lesser decreases in the last 3 weeks of grazing, losing 0.5kg less on average. This year showed lower gains compared to previous years' research which indicated chaff piles could lead to an additional 3.4kg compared to grazing normal stubbles. This could be due to summer rains or more efficient harvesters, with less thrown out the back.

Feed tests showed the chaff to have varying energy levels, with chaff piles recording 5.8-7.8MJ/kgDM and the chopped and spread chaff 3.9-4.4MJ/kgDM. Digestibility averaged 42%, and crude protein 4.4%, with little differences between the paddocks. Canola chaff had the highest energy and protein levels, with highest gains (CS, kg) seen in the sheep grazing canola chaff piles and normal stubbles.

The project will continue for another 2 years, with economic analysis to show the impact of the overall farm profitability. For more information, or for field day dates, please contact Georgia Reid. 0447 523 110 or Georgia@agpromanagement.com

7.8 Case Studies

7.8.1 Letter Family, Tambellup, W.A.'s Great Southern

Property owner: Letter Family

Location: Tambellup, South West of W.A.

Enterprises: Self-replacing merino flock – 4,000 breeding ewes

Cropping-wheat, barley, canola, lupins and oats

Soil type: Gravel loams, heavy and light loams

Annual rainfall: 370mm

Introduction

The "Chaff carts as sheep management tools" project has been focused on increasing producers' understanding of the impact chaff carts' impact on sheep management in Western Australia's Great Southern region.

Interest in chaff management and harvest weed-seed control tools is on the rise in W.A., due to the challenge of the summer-autumn feed gap and new tools being developed.

Chaff carts are a tool that anecdotally leads to increased sheep weights and lambing performance. As most producers in the sheep running regions of W.A. are also croppers, it made sense to investigate this claim further. It was found that sheep grazing chaff piles had better reproductive performance and weight gains compared to those that did not. The Letter brothers, Carl and Dion, were one of the host properties for the duration of the three-year project, used to show the impact of chaff carts on their enterprise.

Current Management

The Letter's farm is a family owned, run and managed farm. They are a mixed enterprise consisting of a 4,000 self-replacing merino breeding flock and a crop total of 2000 hectares. They grow predominantly cereals, as well as lupins. The pasture component of the property relies on a sub clover and rye grass base. In recent years, barley has been trickled into these pastures for early growth. In the past, summer rains have meant that summer perennials, such as lucerne, helped to fill the feed gap over summer and autumn. With less summer rains in recent years, this has become more 'opportunistic', with no reliance on the lucerne. Summer management now means rotating mobs across stubbles, and in autumn, usually involves 'sacrificial' paddocks, although the Letters have begun to utilize confinement feeding for the break of the season.

The Letters and chaff carts

The Letters began using a chaff cart in 2017, at the start of this project. To ensure they could assess the impact carts had on their sheep and crop enterprises, a cart was borrowed from the neighbour to do one paddock each year.

The sheep that grazed these paddocks had significant weight advantages over those that grazed on their normal paddocks, with similar crop yield and variety. Dion noted that the benefits to sheep were very clear, and that it was a 'no-brainer' when it came to deciding to use a cart for their sheep. However, as a mixed enterprise, Carl and Dion had other aspects to consider, particularly as their business shifted to be more focused on the crop enterprise.

They found that there was a lot of time involved in burning chaff piles in autumn, which slowed down seeding. The use of the cart at harvest was described as a 'headache', and there was a new tool on the market: the Harrington Seed Destructor. Dion described the destructor as "smashing seeds to smithereens", and believes that this would decrease the value of the stubbles for sheep. But it is a more effective integrated weed management tool than the chaff carts. The Letters purchased a seed destructor after two years of trialling the chaff cart, and noted that the sheep still ate the smashed seeds and chaff components. "There is still some feed value, but its lower than if

we had used the chaff carts. We're basing it on the idea that the value of the weed control offsets the cost of needing an extra road train of lupins".

7.8.2 Witham Family, Toolbrunup, W.A.'s Great Southern

Property owner: Stuart Witham

Property name: Lake Toolbrunup

Location: Toolbrunup, South West of W.A.

Enterprises: Self-replacing merino flock and cropping

Soil type: Heavy, light and gravel loams

Annual rainfall: 380 ml

Introduction

The "Chaff carts as sheep management tools" project has been focused on increasing producers' understanding of the impact chaff carts' impact on sheep management in Western Australia's Great Southern region.

Interest in chaff management and harvest weed-seed control tools is on the rise in W.A., due to the challenge of the summer-autumn feed gap and new tools being developed.

Chaff carts are a tool that anecdotally leads to increased sheep weights and lambing performance. As most producers in the sheep running regions of W.A. are also croppers, it made sense to investigate this claim further. It was found that sheep grazing chaff piles had better reproductive performance and weight gains compared to those that did not. The Souths were one of the host properties for the duration of the three-year project, used to show the impact of chaff carts on sheep productivity and profitability.

Current Management

'Lake Toolbrunup' is a family owned farm, ran and managed by the Witham family. They are a mixed enterprise consisting of a 2,000 head self-replacing merino breeding flock and a crop total of 3000 hectares. They grow barley, wheat, canola, and oats, and have a pasture base of sub-clover and rye grass. In some paddocks, there are remnants of medic and balansa pastures. The breeding ewes are joined for 6 weeks, which results in a 1st of July lambing.

In the crop enterprise, they were using a canola-wheat-barley rotation and finding that ryegrass was becoming an issue in the barley phase. This was particularly bad in wet years, but was a reoccurring issue.

Chaff carts at 'Lake Toolbrunup'

The Withams first used a chaff cart six years ago, utilizing it as part of an integrated approach to controlling the rye grass in their cropping rotation. Any benefits to the sheep were at this point, an added bonus. They have since found their chaff cart to be extremely beneficial to the sheep. Having

such a large portion of their property in crop results in abundant stubbles for sheep over summer, the value of which they believe has been increased by using the cart. Stuart noted that the benefits come from protecting the feed from weathering while the sheep are rotated through the paddocks. He added that "when the sheep are in the paddocks, the tend to camp around the piles, decreasing the time and energy wasted searching for feed."

He has seen conception rates increase by up to 20% in the time that a chaff cart has been used on farm, which is attributed to better sheep condition at joining and in the first trimester. Stuart said that they were now getting more twins than singles, and that the chaff carts were "amazing for sheep".

"I also don't have to get my sheep feed out as early as the neighbours- by at least 6 weeks"

There are the "usual downsides" he added, noting that the extra labour to burn the piles in paddocks going back into crop was a negative, and that it is certainly easier to not use the chart at harvest. This was attributed to the cart leading to additional delays due to breakdown, and the time spent setting it up. Overall, the Withams "love" their chaff cart, and the figures don't lie- so do their sheep.

Stuarts's simple tips

1. Consider what you want the cart to do- is it for the sheep or for weed control?

2. Be careful which days you chose to burn the piles- they smoulder!

7.8.3 Webb Family, Kojonup, W.A.'s Great Southern

Property: Ben and Emily Webb

Property owner: Ben and Emily Webb

Location: Tambellup, South West of W.A.

Enterprises: Self-replacing merino flock

Cropping-wheat, barley, canola, lupins and oats

Soil type: Gravel, heavy and light loams

Annual rainfall: 550mm

Introduction

The "Chaff carts as sheep management tools" project has been focused on increasing producers' understanding of the impact chaff carts' impact on sheep management in Western Australia's Great Southern region.

Every year, W.A. sheep farmers are faced with the summer-autumn feed gap, and its expensive, time- consuming job of hand feeding. It is often difficult to maintain mating ewes' condition, which is

vital for high lambing percentages. Farmers may have a new ally to help reduce these costs and increase on-farm profitability, in the form of chaff carts. Interest in chaff management and harvest weed-seed control tools is on the rise in W.A., due to the challenge of the summer-autumn feed gap and new tools being developed.

Chaff carts are a tool that anecdotally leads to increased sheep weights and lambing performance. As most producers in the sheep running regions of W.A. are also croppers, it made sense to investigate this claim further. It was found that sheep grazing chaff piles had better reproductive performance and weight gains compared to those that did not. The Webbs, Ben and Emily, were one of the host properties for the duration of the three-year project, used to show the impact of chaff carts on their enterprise.

Current Management

The Webb farm is a family owned, run and managed farm. They are a mixed enterprise consisting of a 4,500 self-replacing merino breeding flock and a crop total of 1,200 hectares. They grow predominantly cereals and canola. The pasture component of the property relies on a sub clover and rye grass base. In recent years, barley has been trickled into these pastures for early growth, and they have been utilising crop grazing.

The Webbs and chaff carts

Pictured here with a chaff pile, Ben has been using chaff carts on his 1,200ha crop 5 years ago, with promising results. The property started looking at chaff carts as they had chemical resistance to ryegrass and wanted another 'tool in their belt' to help reduce weed burdens. Ben was also interested to see if he could spend less time sheep feeding during summer and autumn.

Ben found that the use of chaff carts significantly reduced the amount of hand feeding required. Now with chaff piles, supplement feeding only occurs during the month of joining to have ewes in good condition to increase lambing potential, and to the small weaner ewe flock, who receive 50g lupins/day. Ben has even decided not to make hay as he believes there is sufficient feed in the chaff piles as he rotates the mobs across the farm.

Prior to chaff piles, ewes were being fed approx. 250g lupin and 150g oats/h per day for the duration of the feed gap. Using economic modelling based on a typical south-west farm, it is estimated that this could have been a saving of $29,000 each year, just in feed. Lambing percentages were also higher in the mobs that had been feeding on chaff piles compared to those who had not by 25%, due to being in better condition.

Despite the benefits to sheep health and decreasing feed costs, chaff carts still carry large costs. Ben noted that cutting low during harvest (in order to reduce weed burden) led to an increase in rock picking costs. Most importantly, the initial cost of a chaff cart is roughly $80,000, as Ben says, a significant investment. He believes it "pays for itself", which was supported by the trial's economic modelling, calculating an Internal Rate of Return on Investment of 36%.

Ben believes there are other opportunities associated with chaff carts, beyond weed and sheep management. He saw an opportunity to sow earlier due to decreased weed burdens, which could potentially increasing crop yields. He also pointed out unmeasurable benefits such as reducing or

eliminating the need to burn stubble, reducing the impact of ryegrass resistance, and that the chaff cart is an environmentally friendly farm tool.

In summary, the chaff cart was a great success on the Webb's farm. Sheep were in better condition, which led to higher scanning rates, and weed burden is thought to have decreased. Feeding costs were directly cut, as less hand feeding and hay is required, in addition to time/labour savings. The property is also able to help manage chemical resistance to ryegrass by spraying less, and there is potential for early sowing, leading to increased crop yields. Overall, Ben believes that he is increasing overall profitability by harnessing the potential of chaff carts as a sheep-feeding tool.

7.9 Field day fact sheets

7.9.1 Year 1 Field day 1 fact sheet

Chaff Cart Grazing: Fact Sheet 2018

Yield & SR's

	Crop Type	Yield Piles	Yield control	SR piles	SR control
SITE 1	Bonito	1.6	1.15	7.8	5.6
SITE 4	Calingiri	3.5	3.7	4	4
SITE 3	Barley	Same Yield	Same yield	8.9	8.9
SITE 2	Zen Wheat	3	3.2	4.8	4.8

Feed test results

Chaff Piles

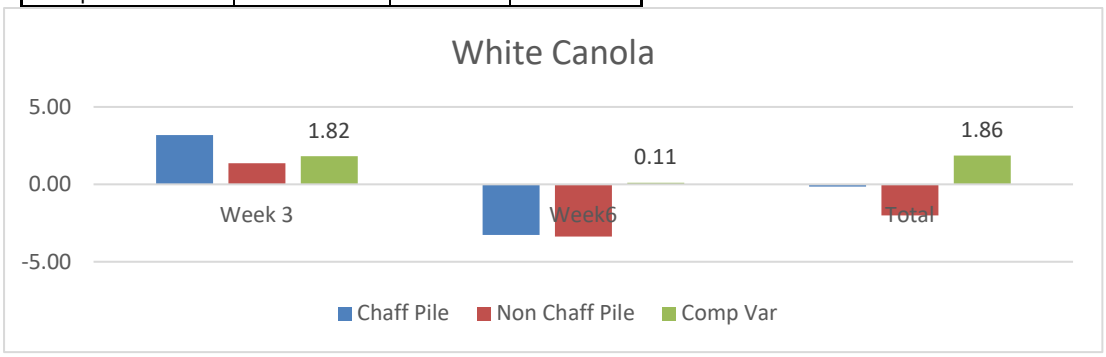
	DM	Moisture	Crude Protein	Digestibility	ME
Site 1	81.5	18.5	5.3	43	5.8
Site 4	86.4	13.6	4.5	54.6	7.8
Bignall	91	9	3.8	54	7.7
Site 2	89.8	10.8	3.9	50.2	7.2

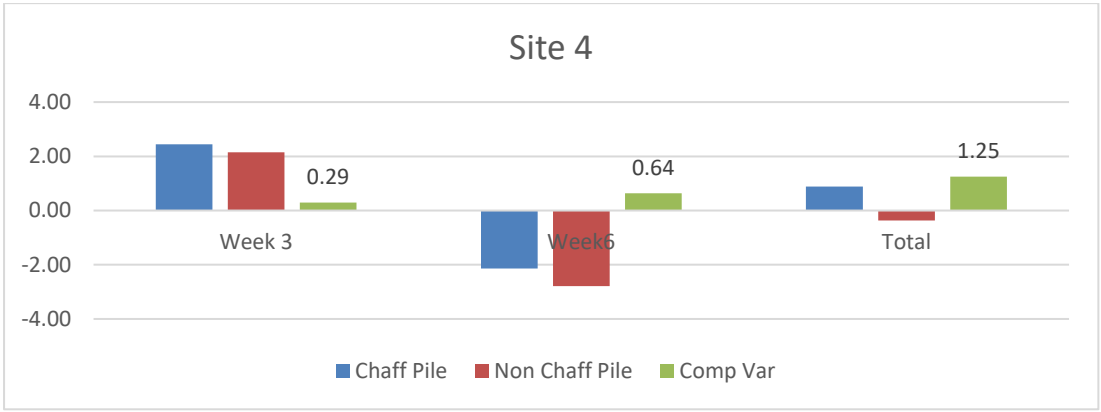
Control

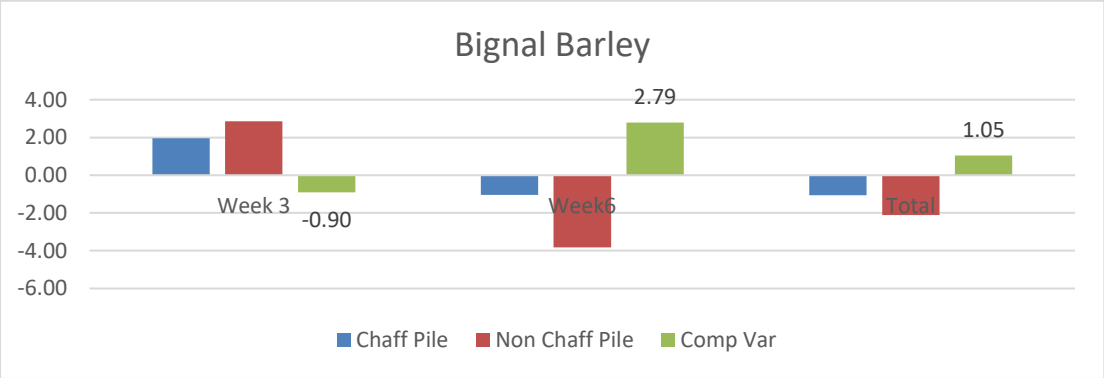
	DM	Moisture	Crude Protein	Digestibility	ME
Site 1	89.2	10.8	5.3	31.8	3.9
Site 4	84.2	15.5	3.2	36.5	4.4
Bignall	87.7	12.3	4.3	47.5	4.5
Site 2	90.4	9.6	0.9	35	4.1

Weight Statistics

Site 1 Canola			
Variation	Week 3	Week6	Total
Chaff Pile	3.18	-3.27	-0.14
Non Chaff Pile	1.36	-3.37	-2.00
Comp Var	1.82	0.11	1.86
Bignal Barley			
Variation	Week 3	Week6	Total
Chaff Pile	1.95	-1.04	-1.06
Non Chaff Pile	2.85	-3.83	-2.11
Comp Var	-0.90	2.79	1.05
Site 4 Wheat			
Variation	Week 3	Week6	Total
Chaff Pile	2.44	-2.14	0.88
Non Chaff Pile	2.14	-2.78	-0.36
Comp Var	0.29	0.64	1.25







7.9.2 Year 1 field day 2 fact sheet

MEAT & LIVESTOCK AUSTRALIA

Sustainable Agriculture In Practice

Fact Sheet: Grazing Chaff Cart Piles 2018

- **Chaff cart piles had more energy and protein compared to feed tests of normal stubble residues.**
- **Grazing piles led to advantages of up to 3.5kg more than sheep grazing stubbles.**
- **All sheep (except Site 2's) gained weight in the first 3 weeks, and lost weight in the last 3, with sup feeding required.**
- **Sheep grazing chaff piles lost less in the last 3weeks, and gained more in the first 3.**

Feed Quality of different chaff treatments					
	Metabolisable energy (MJ/kgDM/ha)			*Crude Protein %*	
	Piles	No piles		Piles	No piles
Site 1 Canola	5.8	3.9		5.3	5.3
Site 2 Wheat	7.2	4.1		3.9	0.9
Site 4 Wheat	7.7	4.4		4.3	3.8
Site 3 Barley	7.8	4.5		4.5	3.2

Walked paddocks to find grains on ground, in 0.1m quadrants found on average:

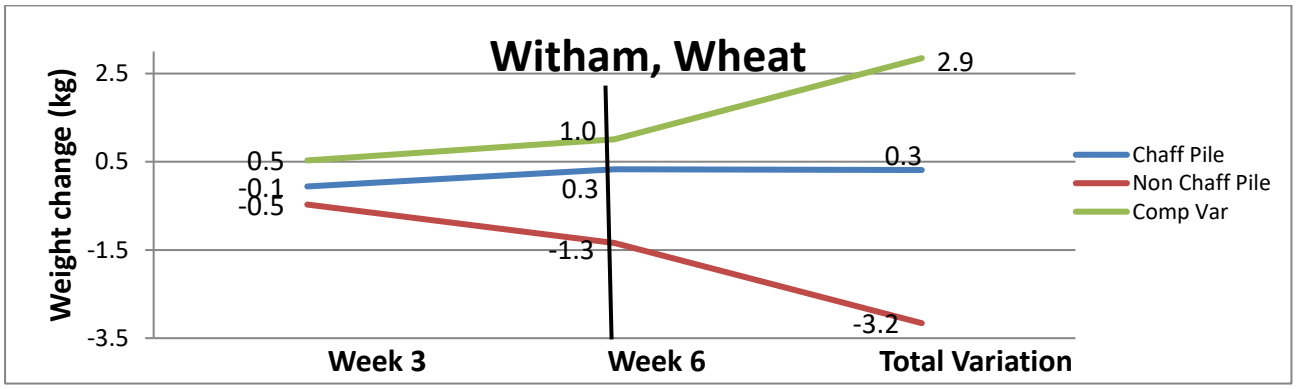
Site 2 Piles: 1.4 grains/0.1m
Site 2 No Piles: 2.1 grains/0.1m
Site 4 Piles: 1.4grains/0.1m
Site 4 No piles: 2.2grains/0.1m

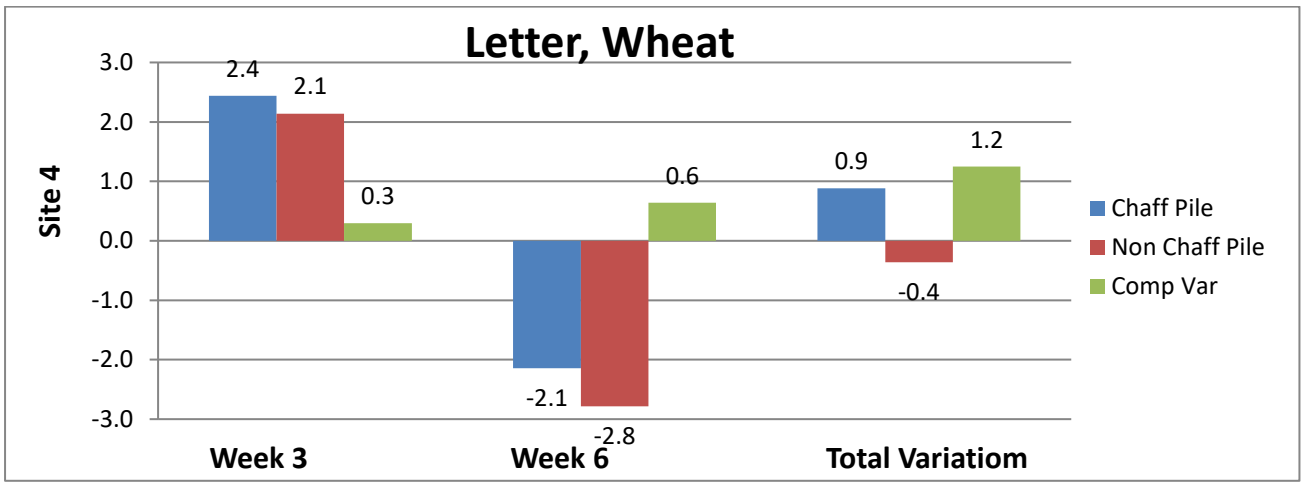
Crop Yield and Stocking Rate data

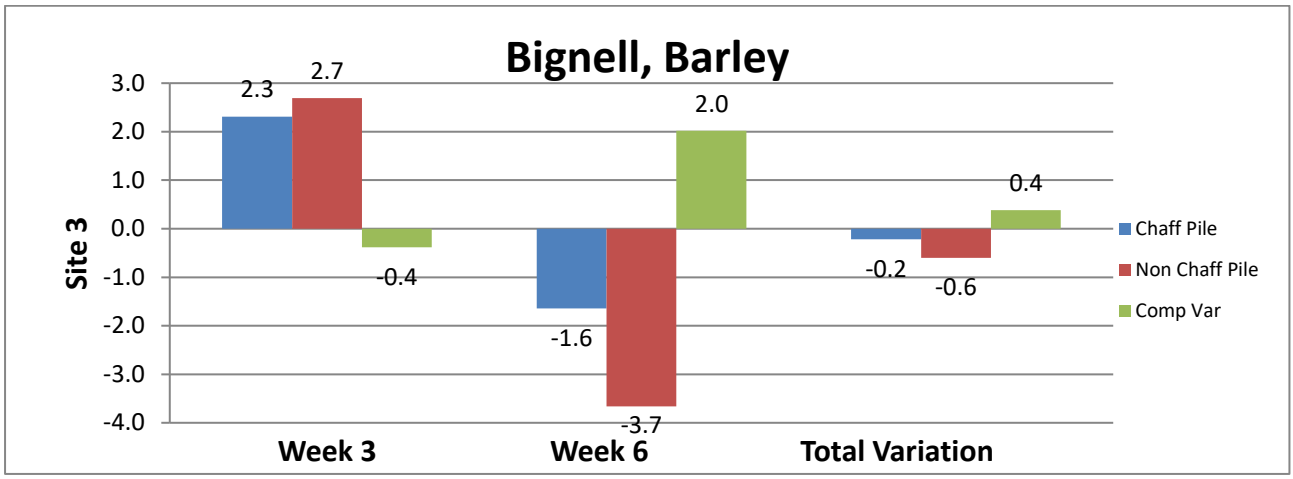
	Crop Type	Yield Piles (t/ha)	Yield no piles (t/ha)	SR piles	SR no piles
SITE 1	Bonito	1.6	1.15	7.8	5.6
SITE 2	Zen	3	3.2	4.8	4.8
SITE 4	Calingiri	3.5	3.7	6.2	6.2
SITE 3	Barley	Same	Same	8.9	8.9

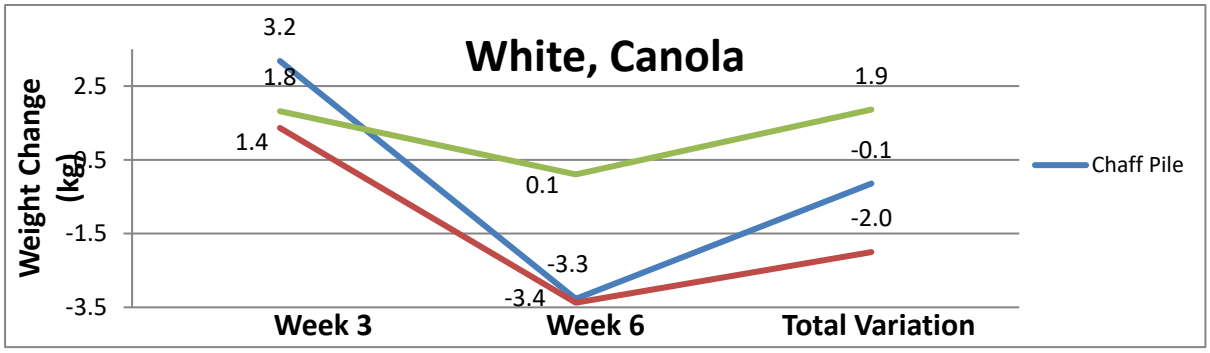
Weight Change

Graphs show average weight changes of chaff and non-chaff pile grazing sheep after 3 and 6 weeks of grazing. The green lines show the advantage of utilising chaff pile grazing compared to the mob grazing traditional chopped and spread stubbles.





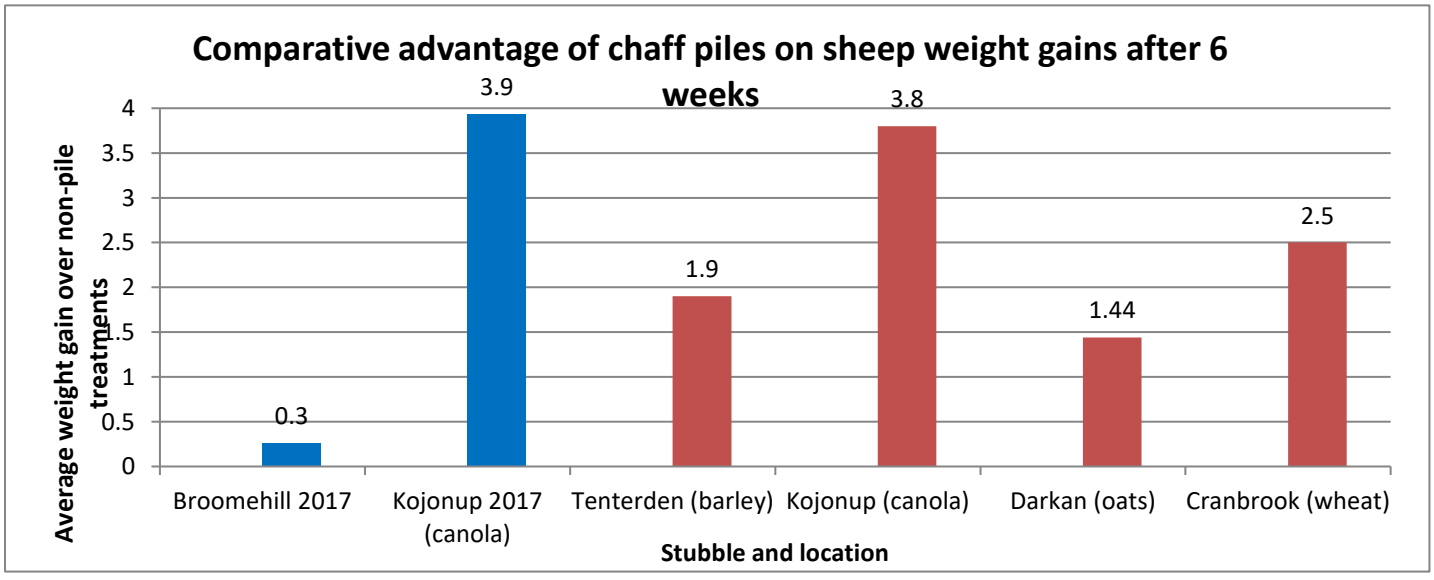




Previous Trials

In previous years, similar gains have been shown with sheep initially gaining weight, before losing in the last 3 weeks of grazing. However, in that trial sheep did not lose weight overall.

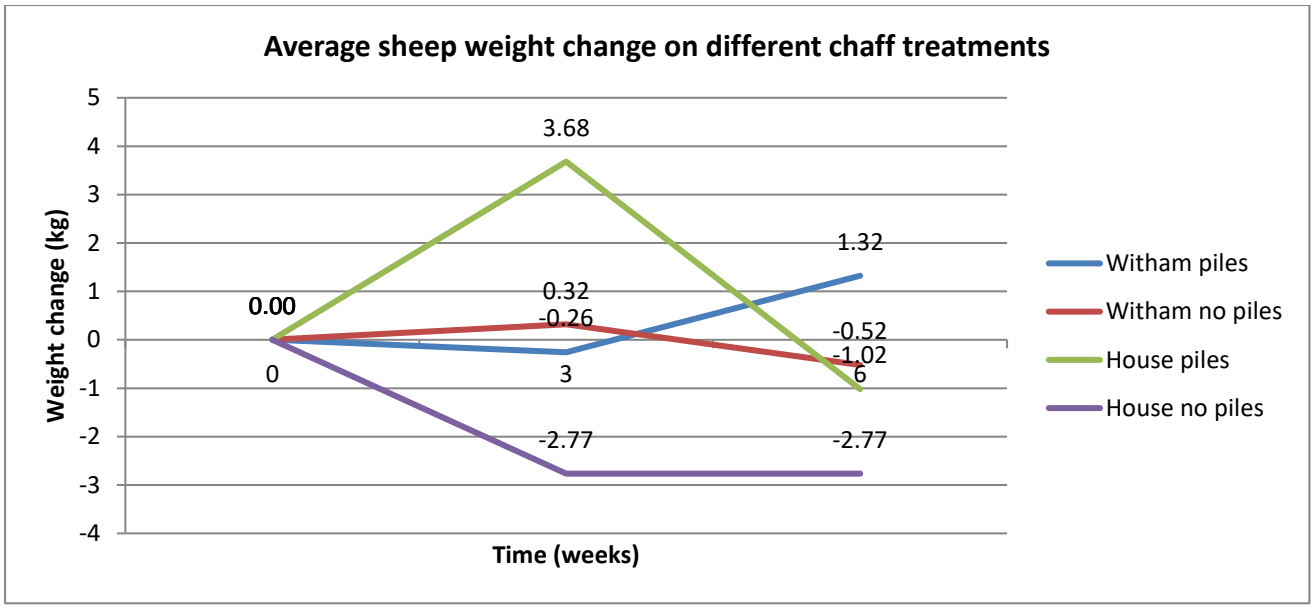
The overall advantage gains when grazing chaff piles compared to traditional stubbles from the previous Great Southern trial can be seen below.

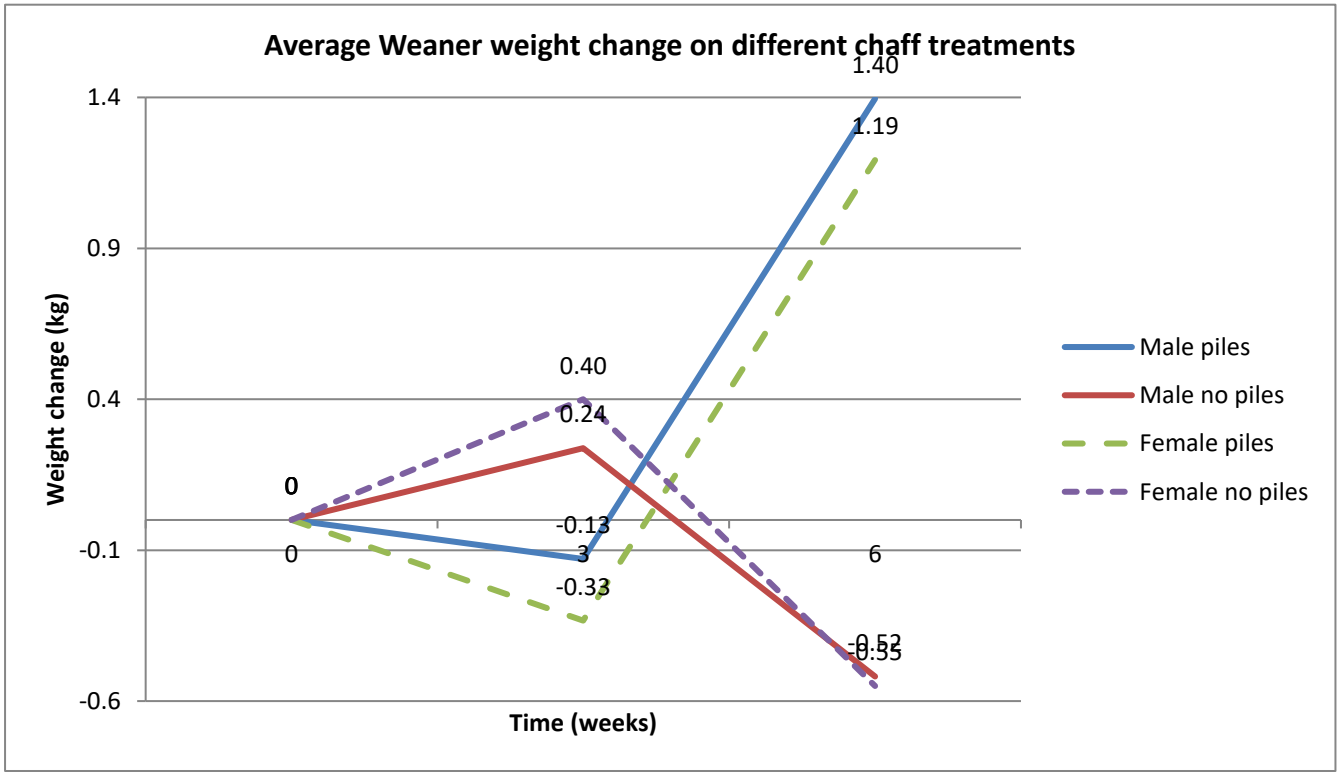


7.9.3 2019 Field day 2

Fact Sheet: Grazing Chaff Cart Piles 2019

- **Chaff cart piles had more energy and protein compared to chopped and spread**
- **Females gained less weight than male weaners**
- **Grazing piles requires a 'learning' period for young sheep before they eat the piles**





7.9.4 2020 Field day 1

Fact Sheet: Grazing Chaff Cart Piles 2020

- **Chaff cart treatment outperforming chaff lines in terms of feed quality and sheep responses**
- **2 more sites to be completed, both with chaff carts**

	Weight Change after 3 Weeks grazing (kgs)	Weight Change from 3-6 weeks grazing (kgs)	Total Weight Change (kgs)	Total Comparative advantage over spread (kgs)
Site 2 lines	3.9	-	3.9	-
Site 2 control	1.1	-	1.1	
Site 3 lines	1.1	0.3	1.4	1.60
Site 3 control	0.7	-0.9	-0.2	
Site 4 piles	1.73	-0.22	1.51	2.65
Site 4 no piles	0.06	-1.19	-1.14	

	Metabolisable Energy (MJ/kgDM)	Crude protein (%)	Dry Matter (%)	Digestibility (%)
Average piles	6.7	4.3	86.9	53.1
Average no piles	4.6	3.7	88.9	42.9
Average lines	6.3	4.0	87.6	51.9
Average control	4.8	4.0	86.5	44.8

7.10 File Note

1714 Go No Go – 9 January 2019

Georgia Reid, Ed Riggall, Russell Pattinson

- This discussion was in relation to the reduced number of demonstration sites for this season
- At the recent Go/No Go discussion everything was organised and going ahead
- However, a combination of seasonal conditions (late rain and poor harvest conditions), lack of water, and mechanical issues, has led to a number of producers being unable to complete the demonstration
    - Site 4- Pulled out Nov 30. Water issues (dry season but expected late spring/summer rains which have not occurred).
    - His replacement had a fire go through the chaff cart paddock so also pulled out.
    - Site 1- chaff cart broke down early in harvest. Did not have time to fix due to a late harvest and consistent delays (lots of cold, damp weather)
    - Site 5- Contractor to do the chaff cart paddock pulled out late (December 17).

    - Site 2- still involved.
    - Site 3- new property involved.
- Two sites remain active and will produce results
- The producers remain committed to the project

Following discussion, it was agreed that:

- Do the two producers this year
- Make a note along the lines of the above in the next milestone report
- Have 6 demonstrations sites next year (seen as very achievable)