Woodchip compost – options for use

Report 6

Woodchip for Livestock Bedding Project

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HCC

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Mae'r Prosiect Sglodion Pren ar gyfer Sarnau Da Byw a gyflenwir gan Hybu Cig Cymru yn derbyn arian cyfatebol gan y Comisiwn Coedwigaeth, Asiantaeth yr Amgylchedd Cymru a Llywodraeth Cynulliad Cymru fel rhan o Cyswllt Ffermio.

INTRODUCTION

The Woodchip for Livestock Bedding Project has shown that woodchip can be successfully used for housing animals and a high degree of health and cleanliness is maintained (see Report 1). However, the question often raised by farmers is 'what do you do with it after it as been used as bedding?'

This report summarises three studies that were undertaken to investigate the options for using composted woodchip in agricultural and horticultural settings and to establish whether these outlets are worth exploring by farmers.

The options for using composted woodchip are:

1) **Apply to fields as a source of nutrients**
   It is well recognised that straw based manure can be stored in a muck heap and then spread onto fields to provide a valuable source of organic matter and nitrogen. However, investigations were needed to determine whether the same applies for woodchip based manure and, if not, what the alternative options are.

2) **Re-use as animal bedding**
   The potential for re-using composted woodchip as animal bedding required investigation particularly to ensure there is not a risk of pathogens being carried in the material. It was also important to ensure the health and cleanliness of the animals was of a high standard as essentially they were being housed on material containing manure from the previous season.

3) **Develop as a horticultural product**
   With the increasing market for peat free gardening products, the option of creating a horticultural product is attractive as it has the potential to provide an income. However, there are a number of hurdles to overcome which are discussed.

The work was undertaken at the three Development sites. IGER-Aberystwyth (IGER) and ADAS-Pwllpeiran (Pwllpeiran) investigated the effects of applying composted woodchip to spring barley and grass plots. Glynllifon College investigated the practical and financial implications of re-using composted woodchip as animal bedding and Bangor University explored potential markets for composted woodchip in an agricultural and horticultural context.

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1) THE EFFECT OF COMPOSTED WOODCHIP ON THE GROWTH OF SPRING BARLEY AND GRASS

Objective

The purpose of this study was to determine whether composted woodchip encourages the growth of spring barley and grass when applied to the land.

Introduction

There was a lack of information available on how long woodchip bedding should be composted after use before spreading it on fields. It was also not clear whether woodchip-based manure provides similar levels of nutrients as straw based manure. Two separate demonstrations were carried out at Pwllpeiran and IGER between March and September 2007, to show the effects of using woodchip based manures in comparison with straw based manures and artificial nitrogen (N) fertilisers.

Materials and methods

IGER Aberystwyth used spring barley plots and ADAS Pwllpeiran used grass plots for their demonstration. The composted woodchip used at each site was the product of previous demonstrations to illustrate the effectiveness of using woodchip as a bedding material. Full accounts of this can be found in Report 1.

IGER Aberystwyth

The following plots were set up at IGER. A 50m x 15m grass area was marked out and herbicide containing glyphosate was applied at 4 l/ha on the 6th March 2007 to destroy the previous crop. Soil analysis indicated a soil phosphorus (P) index of 3, a potassium (K) index of 2 and a pH of 6.9. An additional 89kg/ha P_2O_5 and 89 kg/ha K_2O was applied to the whole area to ensure that P and K were not limiting to barley growth. Thirteen plots 12m x 3m were marked out and allocated to one of the following treatments;

Treatment 1	No Nitrogen
Treatment 2	25 kg/ha N as $NH_4\ NO_3$
Treatment 3	50 kg/ha N as $NH_4\ NO_3$
Treatment 4	75 kg/ha N as $NH_4\ NO_3$
Treatment 5	100 kg/ha N as $NH_4\ NO_3$
Treatment 6	75kg/ha N as Cattle/Straw/Hay Compost
Treatment 7	75kg/ha N as Cattle/Straw/Silage Compost
Treatment 8	75kg/ha N as Cattle/Woodchip/Hay Compost
Treatment 9	75kg/ha N as Cattle/Woodchip/Silage Compost
Treatment 10	75kg/ha N as Sheep/Straw/Hay Compost
Treatment 11	75kg/ha N as Sheep/Straw/Silage Compost
Treatment 12	75kg/ha N as Sheep/Woodchip/Hay Compost
Treatment 13	75kg/ha N as Sheep/Woodchip/Silage Compost

(N.B. The treatments were categorised according to the species, type of bedding and diet of the animals. For example, Treatment 6 is compost produced from the bedding of cattle housed on straw and fed hay).

The composts were sampled prior to application to assess their N, P and K content and then applied to 10m x 3m area at rates equivalent to 75kg N/ha on the 26th March. The plot area was ploughed to a depth of 100mm on the 27th March and power harrowed and sown with spring barley (cv. Riviera) at a rate of 185kg/ha on the 2nd April. The plots were then rolled and ammonium nitrate (34.5 %N) was applied by hand to the control plots at rates varying from 25kg to 100kg N/ha.

At harvest an area of 10m x 1.5m was harvested from the middle of each plot using a Wintersteiger plot combine. Grain yield and dry matter was assessed along with straw yield and its corresponding dry matter. Grain hectolitre weight, thousand seed weight and nitrogen content were assessed.

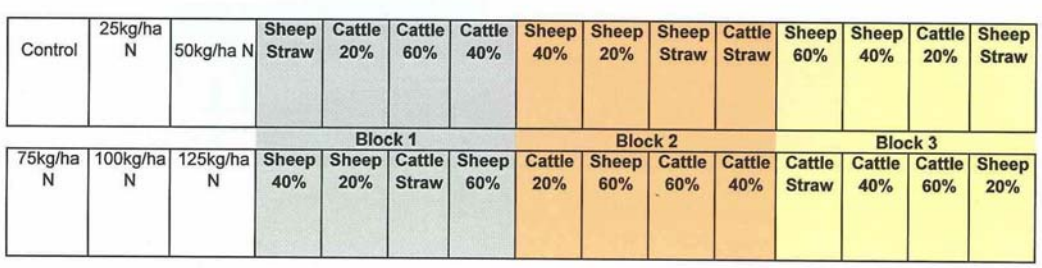
ADAS Pwllpeiran

The grass plots at Pwllpeiran were sited in a 4.1ha field of predominantly perennial rye grass sown in August 1999. The field was 270m above sea level. Preliminary soil samples (to 7.5 cm depth) were collected during spring 2007 and analysed for P and K status. Following soil analysis, P and K were applied to the plots at a rate of 50 and 60 kg/ha respectively before the application of the composted materials, and 25 and 80 kg/ha after the first cut.

The demonstration consisted of 30 grass plots (each 6 x 3m). Six unreplicated reference plots received artificial N at the following rates; of 0 kgN/ha, 25 kgN/ha, 50kgN/ha, 75 kgN/ha, 100 kgN/ha, 150 kgN/ha respectively as ammonia N (NH_4 NO_3). The treatment grass plots received 10 t/ha of either Sheep 20% moisture chips, Sheep 40% moisture chips, Sheep 60% moisture chips, Sheep Straw, Cattle 20% moisture chips, Cattle 40% moisture chips, Cattle 60% moisture chips or Cattle Straw. These were replicated three times in a randomized complete block as shown in figure 1. Nitrogen and composts were applied evenly to the whole area of the plots by hand on the 11th May 2007. No additional fertilizer was added after the first cut. (N.B. the treatments were categorized according to the species and moisture content of the bedding they were housed on. For example, sheep 20% moisture chips refers to compost produced from housing sheep on woodchip with a moisture content of 20%.)

Grass growth was monitored throughout by taking regular sward heights (Tables 5 & 6).The first cut was taken on July 11th and yields were measured. The second cut was taken on September 6th. In addition to yield (Table 7) the quality of the grass was also determined (Tables 9 & 10).

Figure 1. Plot layout at ADAS Pwllpeiran



Results

a) Effects on growth of spring barley - IGER Aberystwyth

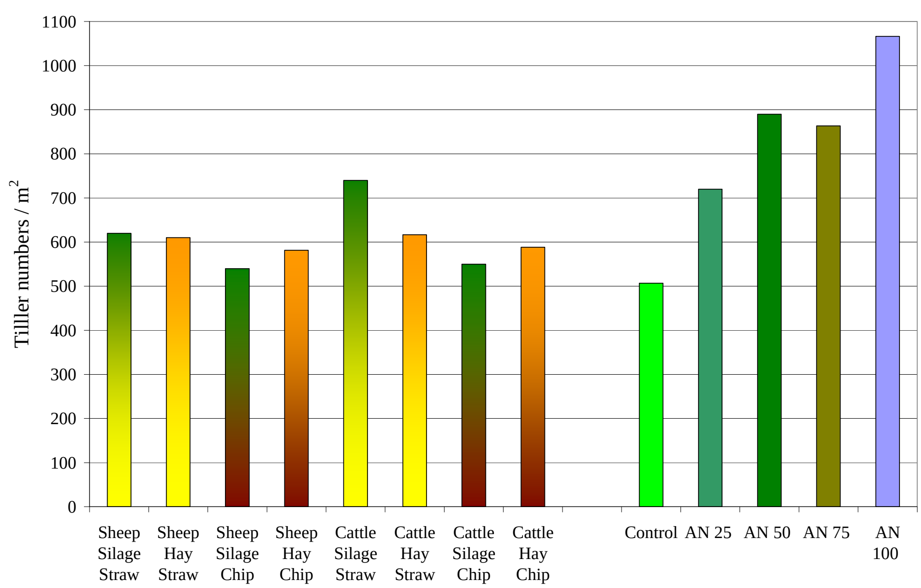
Sub samples of compost stored under cover in ½ tonne dumpy bags over the winter were taken on the 22 February to assess their N content. The nitrogen content of the composts were used to calculate the weight of compost required to apply 75kg N/ha (Table 1).

Table 1. Nitrogen content of composts and quantity required to apply 75kg N/ha at IGER

	Compost Nitrogen content (g/kg)	Compost required to apply 75kg N/ha (kg/ha)
Cattle /Straw /Hay Compost	11.6	6453
Cattle /Straw /Silage Compost	14.9	5018
Cattle /Woodchip /Hay Compost	4.2	17668
Cattle /Woodchip /Silage Compost	4.6	16308
Sheep /Straw /Hay Compost	11.6	6447
Sheep /Straw /Silage Compost	17.2	4366
Sheep /Woodchip /Hay Compost	6.8	10977
Sheep /Woodchip /Silage Compost	7.4	10084

Six weeks post sowing tiller numbers were assessed (Figure 2). Ammonium nitrate fertiliser had a large effect on tiller numbers with numbers more than doubling when applying 100kg N/ha compared with no nitrogen. Small increases were observed in tiller numbers where composts were applied, with straw composts showing higher numbers than woodchip composts.

Figure 2. Barley tiller numbers at 6 weeks growth (tillers/m^2) at IGER



Very few weeds were observed in the barley crop and a herbicide application was not required. The barley plots were harvested on the 20 August 2007.

Grain and straw yields are shown in Table 2. Grain yield increased with increased ammonium nitrate application, with the zero N plot yielding 2796kg/ha and the AN 100 plot yielding more than double that at 6037kg/ha. Grain yield from the compost treated plots ranged from 2716 to 3458kg/ha. All the compost plots yielded less grain than the AN 25 plot. The four woodchip compost plots yielded an average of 2908 kg/ha grain whilst the straw compost plots yielded an average of 500kg more at 3411kg/ha.

Table 2. Grain and straw yield, grain hectolitre weight and thousand seed weight (TSW) at IGER.

	Grain Yield (kg/ha at 15% mc)	Hectolitre wt (g)	TSW (g)	Straw Yield (kg/ha at 15% mc)
Zero N Control	2796	642	50.3	2045
Ammonium Nitrate 25	4013	632	50.4	3132
Ammonium Nitrate 50	5061	656	51.9	4386
Ammonium Nitrate 75	5398	649	52.3	5211
Ammonium Nitrate 100	6037	653	51.4	5789
Cattle /Straw /Hay Compost	3458	650	50.0	2846
Cattle /Straw /Silage Compost	3406	646	50.4	1927
Cattle /Woodchip /Hay Compost	2716	648	50.5	2064
Cattle /Woodchip /Silage Compost	3030	650	52.2	2079
Sheep /Straw /Hay Compost	3382	641	51.6	2901
Sheep /Straw /Silage Compost	3400	650	52.6	2553
Sheep /Woodchip /Hay Compost	3001	647	50.6	2162
Sheep /Woodchip /Silage Compost	2884	647	52.5	2117

Straw yields from the ammonium nitrate plots also increased with increasing N application, with the zero N plot yielding 2045kg/ha and the AN 100 plot yielding 5789kg/ha. Straw yield from the compost treated plots ranged from 1927 to 2846kg/ha. All the compost plots yielded less straw than the AN 25 plot with the four woodchip compost plots yielding an average of 2106 kg/ha grain whilst the straw compost plots yielded an average of 2557kg/ha.

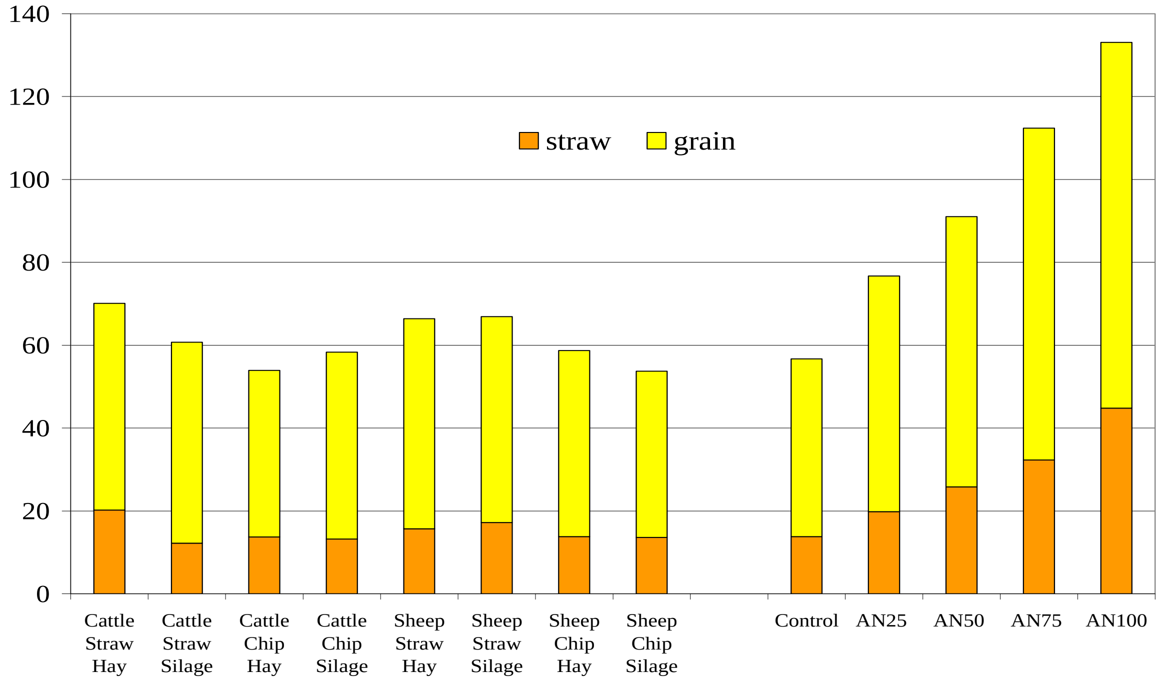
There was a trend for the plots receiving more ammonium nitrate to produce grain with slightly higher thousand seed weights (TSW). With the compost treatments there was a trend for the composts derived from animals fed silage to give higher TSW than the composts from hay fed animals. There were no differences observed in the hectolitre weights of the grain from the different treatments.

The nitrogen offtake from the different treatments was calculated and is shown in Table 3 and Figure 3. Nitrogen offtake as grain and straw from the plots receiving ammonium nitrate fertiliser increased linearly with increased fertiliser application and nitrogen recovery from the artificial fertiliser was between 68 and 80%. In contrast nitrogen recovery from the composts was much lower and ranged from -4 to 18%. The mean nitrogen recovery from the straw composts was 12% whilst the mean nitrogen recovery from the woodchip compost was -1%.

Table 3. Nitrogen offtake as grain and straw (kg/ha) at IGER

	Nitrogen offtake in straw (kg/ha)	Nitrogen offtake in grain (kg/ha)	Total Nitrogen offtake (kg/ha)	Nitrogen Recovery (%)
Control	13.8	42.9	56.7	-
Ammonium Nitrate 25	19.8	56.9	76.6	79.6
Ammonium Nitrate 50	25.8	65.2	90.9	68.4
Ammonium Nitrate 75	32.3	80.1	112.5	74.4
Ammonium Nitrate 100	44.8	88.3	133.1	76.4
Cattle /Straw /Hay Compost	20.2	49.9	70.1	17.9
Cattle /Straw /Silage Compost	12.2	48.5	60.7	5.3
Cattle /Woodchip /Hay Compost	13.7	40.2	53.9	-3.7
Cattle /Woodchip /Silage Compost	13.2	45.1	58.3	2.1
Sheep /Straw /Hay Compost	15.7	50.7	66.4	12.9
Sheep /Straw /Silage Compost	17.2	49.7	66.9	13.6
Sheep /Woodchip /Hay Compost	13.8	44.9	58.8	2.8
Sheep /Woodchip /Silage Compost	13.6	40.1	53.7	-4.0

Figure 3. Nitrogen offtake from plots as barley grain and straw (kg N/ha) at IGER



b) Effects on grass growth - ADAS Pwllpeiran

Prior to the application of the composted material, the compost was analysed for its fertiliser value (Table 4).

Table 4. Fertiliser Value of Organic Manure at Pwllpeiran

	Total N		Total P		Total K	
	units/tonne	kg/tonne	units/tonne	kg/tonne	units/tonne	kg/tonne
Cattle Straw	25.0	12.5	13.5	6.7	36.4	18.2
Cattle 20%	9.2	4.6	3.4	1.7	9.2	4.6
Cattle 40%	7.5	3.7	2.6	1.3	8.0	4.0
Cattle 60%	9.7	4.9	3.6	1.8	9.6	4.8
Sheep Straw	32.3	16.2	17.7	8.8	76.9	38.5
Sheep 20%	16.7	8.3	5.8	2.9	26.2	13.1
Sheep 40%	3.0	1.5	3.8	1.9	18.9	9.4
Sheep 60%	9.7	4.8	3.7	1.8	15.5	7.7

There was more N, P and K in the composted straw, and in particular in the sheep straw. The N, P and K content of the sheep woodchip was higher than that in than cattle woodchip. The 20% moisture chips had higher levels of N, P and K than the 40% and 60% for sheep but the moisture content of the cattle woodchip did not affect the amount of N, P and K in the composts considerably.

Sward heights

The sward heights on application averaged 5.5 cm on the 11th May. The sward heights showed no significant difference between treatments (Tables 5 & 6). There were occasionally a few anomalies with the reference plots such as when 100kg/ha is less than the 75 kg/ha (23/05/2007) and the 75 kg/ha less than the 50 kg/ha (06/06/2007) before the first cut. This is likely to be due to large sward heights. Sward height values over 20cm should be used with caution as grass tends to lean over and values decrease. Some anomalies were again seen in the early stages in the aftermath growth (Table 6).

Table 5. Average sward heights before 1st cut (July 11th) at Pwllpeiran

Treatment	23/05/2007	06/06/2007
0	7.7	12.7
25 kgN/ha	10.8	19.9
50 kgN/ha	12.1	27.5
75 kgN/ha	14.1	25.8
100 kgN/ha	12.5	28.3
125 kgN/ha	16.9	25.8
Cattle 20%	12.3	23.0
Cattle 40%	10.7	21.3
Cattle 60%	13.2	23.9
Cattle Straw	13.6	25.1
Sheep 20%	12.1	23.5
Sheep 40%	12.6	22.1
Sheep 60%	12.2	23.6
Sheep Straw	10.7	25.7

For the first cut the sward heights suggest that the straw-based composts gave the most growth followed by the 60% moisture woodchip (cattle and sheep), then the 20% moisture woodchip followed by the 40% moisture woodchip. The sheep compost generally gave better growth than cattle compost and this generally reflects the fertilizer value of the composts.

There were no significant differences in sward heights for the aftermath grass with the various treatments although the sward heights of the aftermath showed the greatest growth from the cattle 40% moisture woodchip compost. The sward heights suggest that there may be some delay in the woodchip compost taking effect, in particular the 40 % moisture content woodchip which was a larger size chip. It is possible that some nitrogen may be locked up by microbial activity breakdown in this larger woodchip with the nitrogen becoming available to plants at a later date.

Table 6. Average sward heights for 2nd cut (September 6th) at Pwllpeiran

Treatment	19/07/2007	27/07/2007	03/08/2007	24/08/2007
0	11.5	11.0	12.8	20.2
25 kgN/ha	9.5	12.9	13.5	21.0
50 kgN/ha	10.4	12.3	14.4	21.6
75 kgN/ha	11.0	15.7	15.5	25.2
100 kgN/ha	14.1	15.2	17.1	27.3
125 kgN/ha	11.6	14.0	18.0	27.2
Cattle 20%	12.6	14.5	14.5	22.8
Cattle 40%	12.7	14.7	15.8	25.2
Cattle 60%	12.6	15.2	14.7	24.4
Cattle Straw	13.0	14.4	15.8	24.1
Sheep 20%	12.3	14.3	15.8	24.0
Sheep 40%	12.0	15.5	14.5	24.0
Sheep 60%	13.3	14.7	16.0	24.9
Sheep Straw	13.1	16.3	15.7	24.6

Yield

There was a large variation in yield between the first and second cut (Table 7) with the yield being at least double the amount obtained in the first cut. This is probably due to no fertilizer being added after first cut. At the first cut a significant difference was seen in the yield between treatments (p=0.002). The composted straw gave the highest yields with the sheep straw yielding 4.49 t/ha DM and cattle straw yielding 4.14 t/ha DM. The 60% moisture content woodchip produced the highest yields of the woodchip compost, and the sheep compost generally gave higher yields than the cattle compost. The yields generally reflect the fertilizer value of the composts.

Table 7. First and second cut yields at Pwllpeiran

Treatment	Average of T/ha DM Cut 1	Average of T/ha DM Cut 2
0 kgN/ha	1.57	1.12
25 kgN/ha	2.87	0.90
50 kgN/ha	5.37	1.02
75 kgN/ha	5.57	1.51
100 kgN/ha	5.89	1.84
125 kgN/ha	6.01	1.76
Cattle woodchip 20% moisture	3.23	1.77
Sheep woodchip 20% moisture	3.51	1.44
Cattle woodchip 40% moisture	3.37	1.60
Sheep woodchip 40% moisture	3.26	1.41
Cattle woodchip 60% moisture	3.56	1.75
Sheep woodchip 60% moisture	3.99	1.89
Cattle Straw	4.14	1.72
Sheep Straw	4.49	1.59

There was no significant difference between any of the treatments at second cut ($p>0.05$) and there was very little variation in yield between plots (0.48 t/ha DM). The sheep 60% moisture content woodchip (WC) compost had the highest yield (1.89 t/ha DM), then cattle WC 20% (1.77 t/ha DM), then cattle WC 60%, cattle straw, cattle WC 40%, sheep straw, sheep WC 20%, sheep WC 40%. The yield results from the second cut suggest that woodchip and cattle compost may have a slight delayed effect compared to the plots receiving nitrogen as ammonium nitrate. This is possibly due to the nitrogen being locked up by microbial activity in the breakdown process.

Nitrogen

The yield results of the reference plots (0, 25, 50, 65, 100 & 125 kg/ha N), were used to estimate the quantity of nitrogen released from the composted material (Figure 4 & Table 8). To do this, the yields from the reference plots were plotted on a graph and a polynomial trend line was added with a quadratic equation and R^2 value to estimate the quantity of nitrogen in the composted woodchip and straw. The high R^2 value (0.96) shows that this trend line is very reliable.

Figure 4. Relationship between nitrogen released and yield of plots at Pwllpeiran.

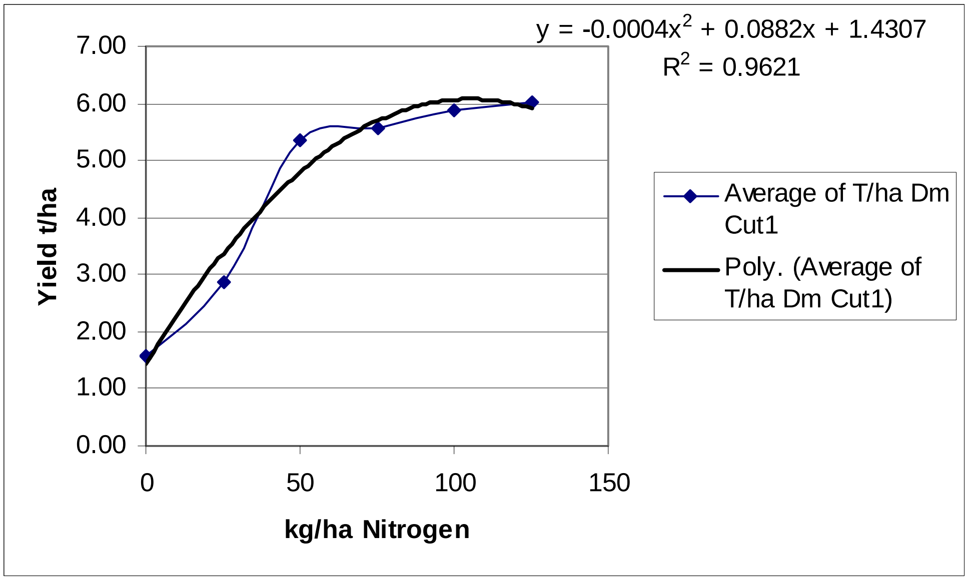


Table 8 shows that larger volumes of woodchip compost than straw-based farmyard manure (FYM) will need to be applied to replace standard nitrogen application for first cut silage.

The straw-based composts were found to have higher nitrogen levels than the woodchip composts and sheep straw contained more nitrogen (43.14 kg/ha N) than the cattle straw (36.92 kg/ha Nitrogen). Likewise the sheep woodchip compost generally contained higher levels of Nitrogen than the cattle woodchip compost. Of the sheep woodchip compost, 60% moisture woodchip compost had the highest level of Nitrogen 34.40 kg N/ha, then the 20% moisture woodchip (26.89 kg N/ha), then the 40% moisture woodchip (23.17 kg N/ha). The cattle woodchip compost nitrogen levels increased with increasing moisture.

Table 8. Nitrogen equivalent of composted manures (kg/ha) at Pwllpeiran

	Sheep				**Cattle**			
	WC 20%	**WC 40%**	**WC 60%**	**Straw**	**WC 20%**	**WC 40%**	**WC 60%**	**Straw**
1st Cut	26.89	23.17	34.40	43.14	22.81	24.83	27.55	36.92

Visible appearance
Ten days after application there was very little woodchip visible on surface and by 25 days after application there was no woodchip visible on surface; the grass had grown through the woodchip. After the first cut was taken (60 days after application) very little woodchip could be seen in the grass and a small amount of the FYM could be seen while raking. Some of the FYM could be seen on plot surface. Very little woodchip could be seen on the 20% and 60% moisture plots of both cattle and sheep. Some larger pieces of woodchip could be seen on the 40% moisture woodchip. By the time the second cut was

taken there was very little evidence of composted material, although there was some evidence of woodchips on the plots that received 40% and 60% moisture content woodchips.

Silage quality

The ensiling quality of the first cut is shown in Table 9. All plots had acceptable dry matters, averaging 22.2% for the first cut and this varied from 16.8% to 24.4%. The plots that received composted straw had lower dry matters than the plots that received woodchip compost due to more growth.

There was no obvious difference between cattle and sheep or the different moisture content chip. The crude protein values are acceptable on the majority of the plots for first cut. The straw and 40% moisture content woodchip have higher crude protein values.

The MAD Fibre values were also found to be acceptable with the straw values being the lowest (28%) which equates to a 'D' value of 66. The woodchip composted plots had slightly higher MAD Fibre values up to 30.8% (68 D) for Sheep WC 20% moisture.

The soluble carbohydrate values were adequate enough to ensure that a good fermentation was obtained during ensilage. The cattle compost grass had the most soluble carbohydrates and the straw composted grass plots had more water soluble carbohydrates than the woodchip composted grass plots.

Table 9. Ensiling quality of 1st Cut at Pwllpeiran

	Dry matter %	Crude Protein (NIR) %DM	MAD Fibre (NIR) %DM	Nitrate	Soluble Carbohydrate (NIR) %DM
0 kg/ha N	23.9	8.8	31.2	<0.01	19.2
50 kg/ha N	20.2	10.9	31.5	<0.01	15.4
100 kg/ha N	16.8	18.7	30.1	<0.01	8.2
Cattle Straw	21.5	9.3	28.3	<0.01	23.3
Cattle 20%	24.3	7.4	30.7	<0.01	20.1
Cattle 40%	23.6	8.6	28.5	<0.01	22.6
Cattle 60%	23.3	7.4	30.6	<0.01	20.7
Sheep Straw	21.3	10.0	28.4	<0.01	19.4
Sheep 20%	23.2	7.1	30.8	<0.01	19.4
Sheep 40%	21.8	9.3	30.0	<0.01	19.2
Sheep 60%	24.4	6.5	28.9	<0.01	16.0

The ensiling quality of the second cut is shown in Table 10. All plots had higher dry matters than the first cut and the second cut dry matter averaged 25.1% varying from 22.6 to 28.6%. Again there was no obvious difference between cattle and sheep or the different moisture content chip. The crude protein values were lower for the second cut than first cut but were still acceptable. The MAD fibre values were, on average, slightly lower in the second cut than the first cut whilst the soluble carbohydrate values of the second cut were higher than the first cut and higher than expected.

Table 10. Ensiling quality of 2nd Cut at Pwllpeiran

	Dry matter %	**Crude Protein (NIR) %DM**	**MAD Fibre (NIR) %DM**	**Nitrate**	**Soluble Carbohydrate (NIR) %DM**
0 kg/ha N	28.6	7.8	28.7	<0.01	27.1
50 kg/ha N	26.9	6.9	29.4	<0.01	23.0
100 kg/ha N	26.4	7.7	29.7	<0.01	18.8
Cattle Straw	22.6	4.5	27.3	<0.01	27.7
Cattle 20%	25.5	7.0	28.5	<0.01	25.6
Cattle 40%	25.7	6.3	26.9	<0.01	26.9
Cattle 60%	25.9	5.8	27.8	<0.01	29.4
Sheep Straw	25.6	7.8	29.5	<0.01	20.3
Sheep 20%	22.6	6.4	27.2	<0.01	30.0
Sheep 40%	24.0	5.0	28.8	<0.01	29.9
Sheep 60%	22.6	8.5	28.2	<0.01	23.0

Discussion

On the whole the yield response from the various composts was disappointing when compared to the ammonium nitrate fertilizers.

At IGER, the straw-based composts yielded more straw and grain than the woodchip composts, but yields were still lower than that produced by 25 kg N/ha applied as ammonium nitrate.

In the study at Pwllpeiran similar results were seen with the woodchip and straw-based composts being outperformed by the artificial fertilizers. It was also observed that sheep composted material generally performed better than the cattle composted material and this was due to the higher N, P and K content of the sheep composted materials.

The woodchip composts with higher moisture contents at Pwllpeiran performed better than the lower moisture content woodchip with regards to grass growth. This is not expected as it was assumed that the lower the moisture content of the woodchip the higher the nutrient content would be due to a greater absorption. It is not clear what the reasons for this may be but factors that may affect it include; the composting process, animal weight or feed intake.

It was also anticipated that the nutrient levels of the compost would reflect the nutrient contents of excrement from the two species with the cattle compost having higher nutrient levels than the sheep compost. However, the results showed that the cattle compost did, in fact, have lower nutrient values than the sheep composts. This was probably because the feed area of the cattle pens was scraped out on a regular basis and this material was not returned to the bedding for the composting process, whereas all of the sheep's dung was incorporated into the composts. The sheep also received more concentrates per kg body weight.

The results suggest that nitrogen has been locked up in the short term resulting in very little yield benefit from the composts. Longer term evaluation would be beneficial to evaluate the effect of composts over a longer time period.

2) RE-USING COMPOSTED WOODCHIP AS ANIMAL BEDDING

Objective

Composted woodchip which has only been used once as animal bedding still contains a large proportion of wood pieces that have not been broken down. The purpose of this demonstration was to investigate whether there are separate uses for the wood pieces, as animal bedding and for the finer particles, either for spreading on fields or as a potential horticultural product.

Introduction

This part of the project was carried out at Glynllifon College between January and April 2007 using composted woodchip produced as part of previous demonstrations at Glynllifon College as part of the Woodchip for Livestock Bedding Project. A full account of this demonstration can be found in Report 1.

Materials and methods

The composted woodchip was sieved prior to being re-used as animal bedding using a portable industrial sieving machine used for grading quarry material. As the composting had been done outdoors and the composted materials subsequently stored outdoors this created problems for the sieving process because they were very wet. It was found that the sieves clogged very easily making the whole process very difficult, time-consuming and hence more expensive. The composted 'cattle softwood' was too wet to sieve at all and was used in its entirety. It was also found that the quantities of each type of composted woodchip were too small to be used individually. Therefore, the composts produced from softwoods and used for cattle and sheep were mixed together to create one 'softwood compost' and likewise for the hardwood composts. Approximately 8m^3 of softwood compost and 8m^3 of hardwood compost was produced.

Due to the relatively small volumes of composts produced additional fresh woodchip was required for the bedding demonstration. This was sourced from the college with a total of 55m^3 of fresh chip produced. These chips were a uniform size (30mm x 20mm) and the same machine was used to chip the hard wood and soft wood.

The housing demonstration began in January 2007 when both the sheep and cattle were housed.

The cattle were housed on the 29th January and were clipped on their flanks and rump to ensure they all began at the same standard of cleanliness. Table 11 shows the number of pens, the type of bedding used, the number of animals per pen and the size of the pen.

Table 11. Cattle pens at Glynllifon College

Pen Number	Bedding type	Cattle numbers	Pen Area (m^2)
1	Hardwood	6	20.3
2	Softwood	6	20.3
3	Straw	6	20.3

The cattle were fed dry big bale silage *ad libitum* and 1.5kg of concentrates per day at a feed barrier at the front of the pens. The standing area was cleaned twice each week. Live weights and condition scores were assessed on a fortnightly basis and cleanliness scores were measured weekly.

At housing the sieved material was placed in the bottom of the pens and provided a base with a depth of 10cm. All subsequent applications of woodchip bedding were of freshly chipped material as shown in Table 12.

Table 12. Details of cattle woodchip and straw application at Glynllifon College

Date	**Straw**	**Bags woodchip per pen (dumpy bags)**	**Quantity chips m^3 (per pen)**
January 29th	110kg	2.75 (10cm depth)	2.02 used chip
Feb 5th	110kg	2	1.63 new chip
Feb 12th	110kg	2	1.63
Feb 19th	110kg	2	1.63
Feb 26th	110kg	2	1.63
March 5th	110kg	2	1.63
March 12th	110kg	2	1.63
March 19th	110kg	2	1.63
March 26th	110kg	2	1.63
April 2nd	110kg	2	1.63

(*Each dumpy bag contained on average 260kg woodchip / 0.81 m^3*)

The actual quantities of hardwood, softwood and straw used for the cattle are shown below in Table 13.

Table 13. Quantities of each type of bedding used m^3 (Cattle)

Soft wood	2340 kg new chip, 14.67 m^3	715 kg used chip, 2.02 m^3
Hardwood	2340 kg new chip, 14.67 m^3	715 kg used chip, 2.02 m^3
Straw	1100 kg	

The sheep, predominantly yearlings, were housed on the 29th January and were fed hay *ad libitum*. Pens 1 and 2 had hay racks running along the back of the shed while pen 3 had a walk through trough. Consequently pen 3 had access to hay on either side of the pen. The sheep pens were not of uniform size and the smaller pen contained fewer animals as shown in Table 14.

Table 14. Sheep pens at Glynllifon College

Pen Number	Bedding type	Sheep numbers	Pen Area (m^2)
1	Hardwood	40	54
2	Softwood	40	54
3	Straw	34	35.3

Cleanliness scores for the sheep were determined weekly on a group basis. At housing all the sheep had a cleanliness score of one. Condition scores were measured at two weeks post housing and at lambing.

As with the cattle the sieved woodchip was used as the base material to a depth of 10cm. All subsequent bedding consisted of freshly chipped wood as shown in Table 15.

Table 15. Details of sheep woodchip (m^3) and straw application at Glynllifon

Date	**Hard chip wood**	**Straw**	**Soft chip wood**
Jan 29th	6.00	110 kg	6.00 used chip
Feb 5th	0.81	40 kg	0.81 new chip
Feb 12th	0.81	40 kg	0.81
Feb 19th	0.81	40 kg	0.81
Feb 26th	0.81	40 kg	0.81
March5th	0.81	40 kg	0.81
March12th	0.81	40 kg	0.81
March19th	nil	nil	nil

Table 16. Quantities of each type of bedding used m^3 (Sheep)

Soft wood	1560 kg new chip, 4.86 m^3	1926 kg used chip, 6.0 m^3
Hard wood	1560 kg new chip, 4.86 m^3	1926 kg used chip, 6.0 m^3
Straw	350 kg	

Results

Health and Welfare

There were no health issues recorded for either the sheep or the cattle and there appeared to be no difference between hardwood, softwood or straw in terms of the animal's performance (Table 18). Reports from the shepherd suggested that the condition of the sheep's feet was better on the woodchip than the straw. The sheep housed on woodchip had dry feet that were free from scalding and unpleasant odours. In comparison the sheep housed on straw had softer feet with slight evidence of scalding. Three of the ewes housed on straw displayed signs of lameness.

The sheep and cattle acclimatized well to the bedding but the cattle did appear to settle quicker than the sheep. The cattle showed no preference to woodchip or straw, however the sheep on the woodchip seemed a little uneasy for a few days and would be seen standing for longer periods. This was a factor that was also noted in the first year demonstration (see Report 1) but only lasted for a few days.

The intention was to lamb the ewes on the woodchip in exactly the same way as on the straw. It was observed that those on the straw would attend to the lambs immediately at birth and clean the lambs. However those on the woodchip, regardless of wood type, would not always clean the lambs, displayed greater nervousness and in some instances rejected the lamb for several days. As a consequence as lambing progressed straw was added on to the woodchip and this behaviour ceased. The ewes were at ease, cleaned the lambs at birth the earlier behavioural concerns were not an issue.

Cleanliness

All the ewes had an initial cleanliness score of 1 at housing. The sheep were assessed weekly as a group in each pen as shown in Table 17. Seven of the ewes housed on woodchip had slight wool contamination from the bedding resulting in the cleanliness scores of 2 as shown in the table. The sheep on the straw remained clean throughout the demonstration, maintaining a cleanliness score of 1. Fresh bedding was given to the sheep on a weekly basis (Table 15).

Table 17. Cleanliness scores for the sheep at Glynllifon College

Bedding Type	29th Jan	5th Feb	12th Feb	19th Feb	26th Feb	5th March	12th March
Hardwood	1	1	2	1	2	2	2
Softwood	1	1	1	1	2	2	1
Straw	1	1	1	1	1	1	1

Table 18 shows the cattle cleanliness scores. All the cattle had a score of 1 at housing and all became slightly dirtier and had a score of 2 at the end of the demonstration. A few of the cattle had a score of 3 during the demonstration (hardwood pen) but the muck soon dried and rubbed off after fresh bedding was applied.

Table 18. Details of cattle recording and performance.

Group	Date	Condition Score (Av)	Av Weight (kg)	DLWG (kg)	Cleanliness Score
1 (hardwood)	09/02/07	2.5	320	0.7	1
	23/02/07	2.5	330	0.7	2
	09/03/07	3	341	0.8	3
	23/03/07	3	352	0.8	3
	06/04/07	3	361	0.7	2
	20/04/07	3	373	0.9	2
2 (softwood)	09/02/07	3	340	1.0	1
	23/02/07	3	354	0.9	1
	09/03/07	3	366	0.9	1
	23/03/07	3.5	378	1.1	2
	06/04/07	3.5	393	1.0	2
	20/04/07	3.5	405	1.0	2
3 (straw)	09/02/07	3	395	0.8	1
	23/02/07	3	406	0.8	1
	09/03/07	3	417	0.9	1
	23/03/07	3.5	430	0.8	1
	06/04/07	3.5	444	1.0	2
	20/04/07	3.5	458	1.0	2

Performance
Table 18 also shows the average daily liveweight gains for the cattle during the housing period. The bedding type had no effect on their performance and liveweight gains were similar for all groups.

Costings

The following figures are the actual costs incurred by Glynllifon College. The purpose of them is to provide an indication of the costs involved but it is feasible that higher or lower costs could be encountered under different circumstances.

(1) Woodchip

Sieving the composted woodchip;
Under ideal conditions (i.e. dry compost) it was estimated that the machine is capable of sieving 30 tonnes/day at a cost of approximately £5/tonne.

Total cost at Glynllifon including delivery of machine and fuel		**£150**

(this cost excludes labour and the cost of using other related machinery)
Cost of chipping fresh woodchip;
The cost of purchasing wood for chipping was £30/m^3

	20m^3 @ £30/m^3 =	**£600**
Labour, additional machinery and fuel		**£120**
Chipping costs at £200/hour		**£587**
	Total cost =	**£1457**

(2) Straw

Cost of straw per tonne = £52

Total amount of straw used = 1.45 tonnes @ £52/t =	**£75.4**

As few farmers have the facilities for measuring m^3 it is also useful to give the costings on a per kg basis. In this case the cost of sieving is not included because it is not considered an essential operation (see Discussion for further explanation).

Cost of **straw** per kg = £75.4/1.45t = **5.2p per kg**

Cost of **woodchip** per kg
From weighing 1m^3 of woodchip it was shown that 1m^3 = 360kg
55m^3 of woodchip was produced which = 19,800 kg
£1307 (Total cost of woodchip – sieving costs) / 19,800kg (total amount of chip used)
= **6.6p per kg**

If farmers had their own source of wood then the cost per kg for just chipping the wood = £707 / 19,800 kg = **3.6p per kg**
However, it is advisable for farmers to consider the commercial value of their wood before chipping it for bedding.

It must be remembered however, that during these demonstrations there were two pens of cattle and two pens of sheep housed on woodchip compared to just one pen of cattle and one pen of sheep on straw. The following tables give a more accurate comparison of the cost of housing cattle and sheep on woodchip compared to straw.

*Table 19.*Quantities (m^3 and kg) and cost of each type of bedding used by cattle

Bedding type	Amount m^3	Amount kg	3.6p/kg	6.6p/kg
Hardwood	14.67	2340	£84.24	£154.44
Softwood	14.67	2340	£84.24	£154.44
Straw		1100	£57.20 @ 5.2p/kg	

Table 20. Quantities (m^3 and kg) and cost of each type of bedding used by sheep

Bedding type	Amount m^3	Amount kg	3.6p/kg	6.6p/kg
Hardwood	4.86	1560	£56.16	£102.96
Softwood	4.86	1560	£56.16	£102.96
Straw		350	£18.20 @ 5.2p/kg	

Discussion
As the project work done at Glynllifon College has been on a demonstration scale the quantities of composted woodchip produced were very small. This meant that after sieving had taken place there was only sufficient composted woodchip available to form the base layer in the animal pens. All subsequent applications of bedding material consisted of freshly chipped woodchip. In an ideal scenario it would have been preferable to apply composted woodchip as bedding (instead of freshly chipped material) to further test the potential of re-using composted woodchip. In practice it is likely that there will be a reduction in volume of the woodchip after composting and so further wood may be have to be chipped to provide enough bedding to complete the housing period. In this situation the woodchip bedding available for re-using provided a useful base layer and so reduced the cost of new woodchip required.

The total cost of sieving the composted woodchip was £150. This cost is hard to justify and it may be more cost effective not to sieve the woodchip and re-use it in its entirety. Of course, if a lucrative market is found for the sieved fraction then it may well be worth sieving but under most farming situations this is unlikely.

For heavily pregnant ewes housed on woodchip, the practice of applying straw to the pens immediately prior to lambing is a very sensible and practical approach. It has been noted by a few farmers who have attempted to lamb ewes on woodchip bedding that the ewes are often reluctant to lick their lambs because of pieces of woodchip stuck to the lamb's coats. They found that a layer of straw over the woodchip instantly remedied the problem.

As shown in Report 1, this demonstration illustrates that woodchip bedding is a viable alternative to straw in terms of the health, welfare and cleanliness of the animals. However, it is not a viable alternative when the costs are taken into consideration. Even with the increasing haulage costs that may cause straw prices to rise, it is unlikely that woodchip will become financially viable as an alternative bedding material in the near future.

3) POTENTIAL HORTICULTURAL USES AND MARKETS FOR COMPOSTED WOODCHIP BEDDING

Objective
The objective of this part of the report is to assess whether there are potential commercial markets for composted woodchip bedding. It is also important to highlight any legislation or codes of practice that must be adhered to.

Introduction
Within the horticultural industry there is increasing interest in composts that are not peat based. It would be natural to assume that composted animal bedding could provide a source of peat-free compost and hence provide a lucrative income to the farmer.

However, before establishing these commercial markets there are a number of factors to consider:

- A full Environmental Permit (issued by the Environment Agency) is required if a farmer's on-site operating volume (including bedding in use, part and finished compost) is greater than $1000m^3$.

- The average individual farm-scale production volumes and infrequency of supply exclude farmers, economically, from securing large or long-term contracts.

- There are regulatory and licensing costs which must be factored into any business plan.

- A commercial product needs to be standard and consistent and there are a number of factors which affect the standardisation of composted woodchip bedding. These include:

    - Variable moisture content of the woodchip pre-bedding
    - Wood species
    - Type of livestock housed – sheep or cattle
    - Diet of animals housed
    - Quantity of woodchip used – affecting the ratio of woodchip to manure in the compost
    - Weather during composting process (if done outdoors)
    - Management of composting process – turning regime, addition of extra water

BSI PAS 100 specification

PAS 100 is the British Standards Institution's Publicly Available Specification for composted material. It has been adapted from the existing Composting Association Standards for Composts. The aim was to produce a baseline specification for compost that includes guidance to inform compost producers of what end users require from compost products. PAS 100 outlines:

- The minimum requirements for the process of composting
- The selection of materials from which compost is made
- How the compost is labelled

This specification was launched in November 2002 and was developed in conjunction with the Waste and Resources Action Programme (WRAP) and the Composting Association.

In order to satisfy PAS 100 the compost must reach a temperature of 65°C for 7 days as this is deemed to sanitise the compost. The ability of the compost to reach these temperatures is dependant on several factors as listed in the introduction to this section. The influence of these variables in different combinations causes irregular decomposition rates and chemical composition of the compost making it very hard to achieve a standard and consistent product.

Certification can be costly as regular laboratory samples of the end product are required; hence it is unlikely to be worthwhile if production volumes are small. As a rough guide, a farmer housing 200 sheep for lambing would produce only 40-50m^3 of composted material.

Further information on the PAS 100 specification can be found in Appendix 1.

Possible uses for composted woodchip

There are many potential uses for composted woodchip including the following;

On farm
- Re-use as bedding
- Use as a soil improver/fertilizer
- Use in another farm enterprise eg. plant/tree nursery
- Mushroom growing medium

Off farm
- Farm gate sales of compost to gardeners
- Compost sales to market gardens, mushroom farms etc

As already outlined in this report, re-use of composted woodchip offers real potential for using the product again and providing cost savings on the following year's bedding costs. Its use as a soil improver or fertiliser is more dubious and further work would be beneficial to establish the length of time required and the processes involved to produce a compost that will enhance the soil structure and fertility on farm.

Producing composts that could be sold from the farm is not as simple as it sounds and the farmer needs to consider the following points;

- Is enough material produced on an annual basis to produce a consistent product that meets the specifications?
- Is a waste management licence required?
- Is a suitable market available that could cope with inconsistent supplies?
- Is it worth expanding the composting enterprise to ensure a consistent supply can be maintained?

Some farmers have diversified to develop composting facilities that take green waste from local authorities. Guidance should be sought from local authorities to ensure planning regulations and legislation is adhered to when developing such an enterprise.

Legislation

The legislation referred to in this report is the situation at the time of writing (i.e. May 2008). However, the exemptions are being reviewed during the summer of 2008 and the situation is likely to change. The Environment Agency will be able to provide full details of any changes.

The regulations surrounding the sourcing, use and sale of composted woodchip bedding are complex. Firstly, for a waste activity to be exempt from license the waste must be recovered or disposed of without endangering human health and without using processes or methods which could harm the environment. In particular, they must not cause;

- Risk to water, air, soil, plants or animals
- Nuisance through noise or odours
- Adverse affects on the countryside or places of special interest.

If any one of the specific limitations is unlikely to be met then an environmental permit (formerly called a waste management license) will be required. Further advice and information should be sought from the Environment Agency.

Specific regulations that may affect farmers composting woodchip bedding are outlined in the Waste Management Licensing Regulations 1994 (as amended no.3 regs 2005) (WMLR). Some of these regulations are summarised below with further explanations and scenarios given (see points 1 – 7 in the following section);

- If the woodchip comes from a waste source (eg. pallets) exemption (under paragraph 15 of schedule 3, WMLR 1994) must be registered to use the woodchip.

- Compost storage, transportation and application to land are controlled by the WMLR; exemptions permit compost and some uncomposted wastes to be spread to land for agricultural benefit under paragraph 7A of schedule 3.

- Composting of less than 1000m^3 can be registered exempt under paragraph 12, schedule 3 WMLR, but greater than 1000 m^3 requires an Environmental Permit.

- A paragraph 12 exemption must be registered to compost the woodchip. An exemption is unlikely to be granted where the proposed site is within 250 metres of a building or location occupied by people due to concern over bio-aerosols. This is dependent on the volume and type of compost, operating methods, prevailing wind and risk management provisions.

- The compost must meet the Code of Good Agricultural Practice (COGAP) requirements summarized as follows;
    - Run-off from field heaps must not cause water pollution (which would be an offence under the Water Resources Act 1991).
    - Run-off from stores on concrete bases should be collected and contained.
    - Poultry manure stored outside must be in narrow A-shaped heaps to shed rainwater.
- The Environment Agency has produced a Quality Protocol that sets out the criteria for the production of quality compost from biowaste (see Appendix 2). Compost that is Quality Protocol certified (which includes the PAS 100 standard) can be sold and moved without license. Otherwise, it's considered 'waste'. PAS 100 certification can be obtained through the Composting Association.

<u>Legislation required for most commonly encountered scenarios</u>

1. Re-using composted woodchip as bedding the following year.
There are no legislative requirements for re-using the product on your farm but by ensuring the PAS 100 temperature specifications are met the farmer can be confident that the product does not endanger human, animal or environmental health.

2. Using part-composted or fully composted woodchip as a soil improver or fertilizer.
From a legislative perspective woodchip compost can be spread on fields but as this report has already highlighted, this may not be beneficial to crop growth if the woodchip is not fully composted. An exemption is only provided if agricultural benefit is conferred by ploughing in composted woodchip. If no benefit is realised it becomes a disposal activity and is not allowed under an exemption. If it has not reached PAS 100 temperature specifications it must not leave the farm. The WMLR exemption paragraph 7A allows up to 50t/ha to be spread on the farm of origin without an exemption being registered.
Any spreading activities must also meet the COGAP requirements

- 10 metres from a watercourse
- 50 metres from a spring, well or borehole
- No spreading on waterlogged ground
- No spreading on steep slopes
- No spreading on frozen land – ie. frozen for more than 12 hours in a 24 hour period.

3. Using composted woodchip as mulch (e.g as tree mulch in orchards).
Woodchip produced from recycled wood (e.g. pallets) is considered a waste material and exemptions need to be registered under paragraphs 7 and 12 of the WMLR and the composted woodchip can only be used on the farm of origin unless PAS 100 certification is achieved. Woodchip produced from virgin wood (e.g. tree offcuts) are not considered to be waste and can be used as mulch without an exemption.

4. Using composted woodchip as a medium for growing mushrooms.
The same applies for mushrooms grown for home consumption and those that are sold off the farm. Providing the mushrooms are grown at the site of compost production, then only an exemption 12 is required. The volume of compost allowed on the site of production at any one time, specifically for the purpose of mushroom cultivation, is up to 10,000m^3 before a full license is required.

5. Using composted woodchip in an on-site plant/tree nursery.
The only exemption that needs to be registered is exemption 12. There can only be 1000m^3 of compost on the premises at any one time.

6. Using composted woodchip to fill in wet gateways and paths.
Composted woodchip is not included in exemption 19A and therefore this activity is not permitted because of its significant risk of pollution and harm to the environment.

7. Farm gate sales of PAS 100 certified compost.
Even with PAS 100 certification the compost is still regarded as waste and the operating volume on-farm must remain below 1000m^3 before a full license is required. A gardener, for example, buying small quantities for his own use, will not require a waste movement license as once it leaves the site of origin it is classed as a product. However, the producer is required to keep a record of sales.

CONCLUSIONS AND RECOMMENDATIONS

The main conclusions that can be drawn from this particular study are as follows.

Firstly, neither straw nor woodchip based compost provides adequate nutrients for growing a crop when compared with artificial fertilisers. However, if spreading the composts on to fields is the only option the management practices outlined below should be considered to maximise their potential.

Secondly, composted woodchip can successfully be re-used as bedding but it is unlikely that sufficient quantities would be left at the end of the composting process to provide the majority of the following season's bedding requirements.

Thirdly, there is potential for producing a saleable product by composting the woodchip bedding but as this report outlines the legislative requirements may make it unattractive to some farmers. However, some farmers have successfully established composting facilities illustrating what can be done with a little drive and determination.

The following recommendations are based on work done as part of the Woodchip for Livestock Bedding Project. Their purpose is to encourage farmers to use woodchip bedding as efficiently and effectively as possible and ensure a usable end-product.

- Ensure woodchip is dry prior to use i.e. less than 30% moisture content
- Only apply fresh bedding when the animals begin to appear dirty to avoid excessive use of woodchip which is both costly and will take longer to compost
- If any dung is scraped away from feeding passages this should be returned to the dung heap for composting to provide the necessary nitrogen levels
- Turn woodchip compost heaps on a monthly basis to provide necessary aeration
- Consider composting woodchip based material for two years or more before applying to fields
- Re-using composted woodchip as bedding is the best option as this is more cost effective and allows additional nitrogen to be added to the material which will aid further composting.

Useful links to on-line documents

Code of Good Agricultural Practice (COGAP) – The Water Code
http://www.defra.gov.uk/farm/environment/cogap/pdf/summary.pdf

Quality Protocol (see Appendix 2) http://www.environment-agency.gov.uk/commondata/acrobat/compostqp_1721787.pdf
PAS 100 – 2005 specifications (see Appendix 1)
http://www.wrap.org.uk/downloads/Introduction_to_BSI_PAS_100-20052.1b347d5a.pdf

Schedule 3 – Waste Management Licensing Regulations 1994
http://www.opsi.gov.uk/si/si1994/Uksi_19941056_en_5.htm#sdiv3

ADAS (2005-06) Exotic Mushroom Trials, undertaken for CALU as part of Farming Connect
http://www.calu.bangor.ac.uk/infosheets/Mushroom_Report05V2.pdf

The use of composted woodchip as a substrate for growing varieties of edible mushrooms 2004 undertaken for Organic Centre Wales, UWA under Farming Connect
http://orgprints.org/10864/01/woodchip_mushroom_trial_2004.pdf

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