HARPER ADAMS
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ANIMAL SCIENCE RESEARCH CENTRE

Evaluation of out-wintering systems based on forage brassicas (stubble turnips) for replacement dairy heifers

By

S. P. Marsh, P. D. Billington, C. Brizuela and S. Kirby

DairyCo Projects – F07/036 & 411007

Funded by DairyCo

With support from Rumenco Ltd, British Seed Houses, Rappa and Tony Binns Livestock Equipment.

Simon Marsh
Senior Lecturer
Harper Adams University College
Newport
Shropshire
TF10 8NB

DairyCo

18 May 2010

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EXECUTIVE SUMMARY

This report describes an experiment to evaluate the performance of in-calf dairy heifers either housed and fed silage or out-wintered on strip grazed stubble turnips with the target to achieve a daily live weight gain (DLWG) of 0.7 to 0.8kg. The study commenced on 21/11/07 and involved 28 in-calf dairy heifers aged 21.8 months old with a mean weight of 476kg. Calving performance and 305 day lactation yields were subsequently recorded.

The out-wintered heifers were strip grazed on stubble turnips and initially offered *ad libitum* straw however this was replaced with haylage (10.6 ME MJ/kg DM) after 48 days. Mineral blocks were offered for free access feeding. The electric fence was moved three times a week. This was implemented to reduce labour costs and it was not an objective to achieve 70-100% utilisation of the stubble turnips since it was considered that this could restrict dry matter intakes (DMI) and hence DLWG on a 'low cost system with extensive stocking'.

The housed heifers were fed *ad libitum* grass silage and whole crop. They were initially fed 1.5kg/concentrates per head per day. This was replaced with 100g of minerals after 48 days. Both groups of heifers were turned out onto grass on 20/03/08 and DLWGs subsequently monitored until 01/07/08.

Summary table for DLWG and live weight

DLWG (kg)	**Housed**	**Out-wintered**	**s.e.d**	**Sig**
Start - 48 days	0.77	-0.30	0.090	***
48 days - turnout	0.90	1.37	0.085	***
Start – turnout (120 days)	0.85	0.70	0.063	*
Turnout - 34 days	0.19	1.00	0.089	***
Turnout - finish (103 days)	0.78	1.08	0.061	***
Start - finish	0.82	0.88	0.037	NS
Liveweight (kg)				
Start	476.6	476.4	11.45	NS
Turnout	578.1	560.4	15.45	NS
Finish	658.6	672.1	17.72	NS

The initial negative DLWGs for the out-wintered heifers necessitated the change from feeding straw to haylage. Significant compensatory growth was subsequently recorded. The housed heifers recorded a marked growth check following turnout which therefore resulted in there being no significant differences in overall DLWG from start to finish. There were no significant differences in condition score (except after 48 days when the housed heifers recorded a higher ($P<0.05$) score), locomotion or dirtiness score.

Utilisation of the stubble turnips was estimated at 38-44% and in this study 0.75ha provided sufficient stubble turnips for 1 heifer for 120 days. One hectare would therefore be required per heifer for a 160 day winter.

Following calving the heifers were fed a total mixed ration (TMR) and housed year round. There were no significant differences between the two treatment groups for calving ease, calf birth weights and 305 day production. Shown below is a summary of the milk yields and milk quality.

Summary table for 305 day milk yields and quality

	Housed	Out-wintered	s.e.d	Sig
Milk (kg)	8,276	8,177	482	NS
Butterfat (g/kg)	39.5	39.7	0.16	NS
Butterfat (kg)	327	325	14.9	NS
Protein (g/kg)	31.9	32.6	0.88	NS
Protein (kg)	264	267	14.7	NS
SCC ('000)	204	213	83.2	NS

In conclusion the experiment has indicated that:

- Target DLWGs of 0.7-0.8kg to achieve 2 year calving can be achieved with out-wintering systems based on stubble turnips and haylage/silage on a 'low cost extensive system'.
- Out-wintered heifers do not suffer a growth check when moved onto a grass sward in the spring.
- There were no welfare implications for the out-wintered heifers.
- Variable costs per kg gain were very similar however the out-wintered heifers recorded significantly lower fixed plus variable costs per kg gain.
- An out-wintering system based on stubble turnips and haylage for in-calf replacement heifers had no significant effect ($p>0.05$) on subsequent heifer calving or lactation performance.

FARMER RECOMMENDATIONS

To achieve the target of 0.7-0.8kg DLWG for replacement heifers out-wintered on stubble turnips the following recommendations are suggested:

- Offer good quality haylage/silage *ad libitum*. Do not feed straw. Bales should be placed across the field before grazing to minimise soil structure damage.
- Offer mineral blocks.
- Weigh record on a monthly basis to monitor performance.
- Allow 1 hectare of stubble turnips per heifer for a 160 day winter.
- In the study the stubble turnips were sown with a 12m headland run back area. Consider a 6m run back area.
- Be prepared to accept relatively low utilisation rates of 35-45%, especially from the roots. Increasing utilisation rates may restrict DMI and DLWG. Roots could subsequently be grazed by sheep.
- Out-wintering will significantly reduce fixed costs. Buildings could be released for herd expansion or an alternative enterprise.

1: INTRODUCTION AND OBJECTIVES

The UK dairy industry has, and continues to be subject to increasing fixed and variable costs. The uplift in milk prices in late 2007 has provided some breathing space, but the relentless increases in the cost of fuel, feed and fertiliser stimulates interest in alternative systems that reduce production costs.

Out-wintering stock is a practice that has been incorporated into rearing systems for many years (Milne, 1990) and forage brassicas can be used to fill forage gaps during the grazing season and, more pertinently, over the winter period as an alternative to housing.

One of the major costs associated with rearing dairy herd replacements is the cost of in-wintering with capital tied up in housing, labour and machinery. Recent studies (French *et al.,* 2006, Hyslop *et al.,* 2006 and 2007) have shown financial benefits of out-wintering, however the work was carried out predominantly with kale and its utilisation by store cattle, dry dairy and suckler cows where either maintenance of live weight or modest rates of DLWG are required. In a comprehensive review on forage brassicas for out-wintering stock (MDC 2007) it was stated that "despite the developments in New Zealand in the use of brassica based out-wintering systems for dry dairy cows, there seems to be no detailed studies on the use of these systems for growing dairy heifers. The use of these systems for dairy heifers is mentioned (e.g. Nichol *et al.*, 2003) but no data on animal performance is given. Leaver, (1983) and (1990) has also recognised the potential for brassica based forage systems to contribute to the feeding of growing heifers but again no data seems to be available from the scientific or advisory literature to advise farmers on any specific aspect of their use".

For the last two winters in-calf dairy heifers have been commercially out-wintered and strip grazed on stubble turnip and forage rape based systems at Harper Adams University College in Shropshire. The forage crops were grown as 'catch crops' following whole crop winter wheat and triticale. 'Satisfactory' performance has been achieved however it has not been possible to monitor and record growth rates and crop yields. Following grazing of the forage crops the fields were subsequently planted with maize. The Harper Adams out-wintering system is based on extensive stocking within a low cost system to provide soil protection.

Whilst it is acknowledged that stubble turnips and forage rape are regarded as 'short keep' crops, recent mild winters have enabled these forages to be effectively grazed through to spring at Harper Adams. Dry matter yields are usually significantly lower with stubble turnips and forage rape compared to kale at 4.2-5t DM/ha and 10t DM/ha respectively (French *et al.,* 2006), however the standard recommendation is to sow kale in late April to early July following a cut of silage. Stubble turnips and forage rape can be sown from late July to the end of August as a catch crop following cereals on a mixed arable and livestock farm and is thus the preferred choice at Harper Adams.

The objective of this experiment was to evaluate the performance of in-calf dairy heifers either housed or out-wintered on stubble turnips with the target to achieve a DLWG of 0.7 to 0.8kg required for calving heifers at approximately 2 years old and to record subsequent calving performance and 305 day lactation yields.

2: MATERIALS AND METHODS

2.1 Experimental design

A batch of 28 in-calf dairy heifers began the trial aged 21.8 months old and a mean weight of 476kg. Within the group were four Holstein cross Brown Swiss heifers with the remainder Holstein. Fourteen cattle were allocated according to live weight and breed to two treatments; either housed or out-wintered.

2.1.1 Out-wintered heifers

Heifers were out-wintered on a strip grazed stubble turnip system. The variety used was *Vollenda* which was sown at a rate of 6.25kg/ha. Seed was treated with *Ultrastrike* to provide protection against pests and diseases during establishment. The crop was direct drilled (Väderstad drill) into wheat stubble land (06/09/07). Previous to this the land was injected with slurry at a rate to provide 35kg N/ha. 15.31ha of land was used for the trial with 10.54ha drilled with crop with a 12m margin left as runback around each field. The fields are classified as grade 2 with clay loam soil type.

Once the trial commenced (21/11/07) the stubble turnip crop was allocated using an electric fence which was moved three times a week (Monday, Wednesday and Friday). The distance moved was dependent on an estimation of crop yield, intakes and length of the feeding face. Triticale straw was made available *ad libitum* from a ring feeder. Bales were placed into the ring feeder sited alongside a farm track. However initial negative DLWG's forced a change of protocol and straw was changed to haylage after 48 days. Rumenco Cattle Plus TAB mineral blocks were available *ad libitum* via a Rocker Feeder. See appendix 1.1 for analysis.

Plate 1. Stubble turnip crop. 12m runback in foreground.

It was not an objective to achieve 70-100% utilisation of the stubble turnips since it was considered that this could compromise DMI and hence DLWG when a target of 0.7-0.8kg is required.

The heifers moved off the stubble turnips on 20/03/08 and grazed on a perennial ryegrass based pasture with the housed heifers until completion of DLWG monitoring on 01/07/08.

Plate 2. Moving the electric fence (Photo courtesy Agribusiness Communications Ltd)

Plate 3. Heifers grazing stubble turnips in December 2007 (Photo courtesy Agribusiness Communications Ltd)

Plate 4. Out-wintered heifers offered straw from a ring feeder sited alongside a farm track

Plate 5. Out-wintered heifers feeding from mineral blocks via the Rumenco Rocker feeder

2.1.2 Housed heifers

Heifers allocated to this treatment were housed in a straw bedded yard, at first (9.8m x 9.6m) and then later (9.8m x 19.2m) as more shed space became available. Fresh bedding was applied using a straw chopper three times per week. Access to a total mixed ration (TMR) was along the front of the pen. The TMR was formulated to achieve 0.8kg DLWG. The forage ration was based on grass silage and cracked urea treated whole crop wheat (Alkalage). Concentrates (Wynnstay Heifer Rearer 600. See appendix 1.2 for analysis) were fed initially at 1.5kg/head/day but stopped after 48 days and replaced by 100g/head/day of Wynnstay Premier Youngstock minerals (see appendix 1.1 for analysis).

Plate 6. Housed heifers

The heifers were turned out on 20/03/08 and grazed on a perennial ryegrass based pasture with the out-wintered heifers until completion of the live weight recording on 01/07/08 prior to the start of calving.

Subsequent first lactation performance was recorded for both groups of heifers.

Plate 7. Weighing the heifers on completion of the trial in July

2.2 Experimental routine

2.2.1 Weighing and condition scoring

Heifers were weighed and condition scored at the start, at approximately 30 day intervals and at the end of the trial. The heifers were double weighed at the start and end of the trial. The weigh cell was calibrated each time and condition scoring conducted by Mr. Simon Marsh. Weighing took place in the afternoon without feed or water restriction with the out-wintered heifers being weighed prior to the movement of the electric fence to minimise variance due to gut fill.

2.2.2 Dirtiness scoring

Heifers were scored for dirtiness using the scoring system as developed by the Meat Hygiene Service (see appendix 1.3). Scoring was carried out by Mr. Paul Billington. As the heifers were relatively clean on both treatments, quarter points were used to add precision to the results.

2.2.3 Locomotion scoring, health and welfare aspects

Both treatment groups were checked daily. During these observations any health or welfare issues were recorded. Prior to being weighed, the heifers were allowed to settle on a flat concrete yard. This opportunity was used to locomotion score the heifers by Mrs. Carole Brizuela. Both groups of heifers were assessed for lameness by locomotion score on five occasions during the trial. The scoring system used was

based on a scale of 1 to 5. One being no lameness present, five being assessed as carrying one leg (see appendix 1.4 for further details). The score was assessed by watching the heifers move on a concrete floor for a distance of approximately 30 meters at both walk and trot.

2.2.4 Feed intakes

2.2.4.1 Out-wintered heifers

Crop yield and utilisation was carried out monthly. The procedure involved taking ten quadrat samples; five from the standing crop and five from the grazed area. Samples were taken at equal distances across the field. Once collected samples were split into roots and leaves and then weighed on a fresh weight basis. Following this, samples were dried at 70^{o}C for 72 hours and re-weighed to calculate dry matter yields. From this means were calculated and scaled up to hectare units and utilisation rates expressed as a percentage.

Intakes per head were calculated by measuring the area of crop allocated with a trundle wheel – calculated in hectares. Daily intakes were then calculated using the following formula.

$$\text{Intake (kg/hd/day)} = \frac{\text{allocated area (ha) x DM yield (t/ha) x Utilisation rate (\%)}}{\text{(Number of stock x Days)}}$$

The quantity of straw and haylage bales was recorded with bales weighed using the college weighbridge.

2.2.4.2 Housed heifers

The daily forage ration was mixed and dispensed using an RMH® mixer wagon, which has weighing facilities as standard to record intakes. In the early part of the trial concentrates were weighed and fed by hand. The number of bales used for bedding was also logged with sample bales weighed using the college weighbridge.

2.2.5 First lactation recording

Calf birth weights, calving ease (see appendix 1.5) and 305 day lactation records were collected from 26 heifers with 13 heifers per treatment with equal breed distribution between the treatments. Two heifers failed to complete their 305 day lactations (one from each treatment) and were dried off early due to high somatic cell counts.

2.3 Feed analyses

Proximate analysis was used to analyse the stubble turnips used in the out-wintered treatment. Samples were collected on four occasions and tested in duplicate. The

stubble turnip plant was split into leaves and roots for comparison. Samples were tested in duplicate with mean values shown in Table 1. As the crop matured, dry matter levels increased. Leaves were considerably higher in crude protein content, while the roots were higher in energy.

Table 1 Analysis of stubble turnips by proximate analysis. Change over time

Nutritional Component	Leaves				Roots			
	Day tested (by cuml days)				Day tested (by cuml days)			
	9	50	75	97	9	50	75	97
DM (%)	8.80	8.40	11.40	12.60	10.70	12.90	11.30	13.70
CP (%DM)	25.99	27.24	20.51	23.56	12.44	12.36	13.78	11.53
Ash (%)	11.41	12.96	10.77	11.29	11.80	10.26	12.12	10.11
EE (%)	2.23	2.14	2.36	2.26	2.35	2.13	2.28	2.09
NDF (%DM)	12.20	12.95	15.92	15.22	10.90	12.40	12.28	13.75
NH3 (% tot N)	2.08	2.08	2.07	2.07	2.14	2.21	2.10	2.18
NCGD (%DM)	86.73	85.46	84.36	85.25	92.95	92.63	91.64	89.13
Est ME (MJ/kg)	12.7	12.5	12.4	12.5	13.6	13.5	13.4	13.0

Triticale straw was used to supplement the stubble turnip diet to day 48. Feed analysis for this was taken from published values, as shown in appendix 1.6.

Analysis of the forages were carried out by Near Infra Red (NIR) analysis and are shown in table 2.

Table 2 Analysis of forages by NIR (courtesy of Rumenco Ltd)

	Grass Silage	Wholecrop	Haylage
DM (%)	23.2	50.1	82.9
CP (% DM)	12.2	10.9	11.2
pH	3.7	4.8	6.4
NDF (% DM)	51.5	42.5	65.0
NH3	2.1	13.0	1.0
Starch (% DM)	-	34.8	-
ME (MJ/kg DM)	11.1	10.3	10.6

2.4 Statistical analysis

Statistical analysis of variance (ANOVA) by Genstat (Version 12) was performed on data obtained during this trial. Growth rates, condition score changes, dirtiness scores, and locomotion scores were tested for any significant difference between the two systems.

3: RESULTS

3.1 Animal performance

As shown in Table 3 heifers on the housed treatment had a significantly ($p<0.001$) higher (+51.4kg) mean live weight than the out-wintered heifers after 48 days from the start of the trial. However, changing the straw for haylage for the out-wintered heifers resulted in significant compensatory growth. There were no significant differences in live weight between the treatments by turnout or at the end of the trial after 223 days.

Table 3 Effect of treatment on live weight change (kg)

	Housed	Out-wintered	s.e.d	Sig
Start	476.6	476.4	11.45	NS
After 48 days	513.5	462.1	12.64	***
Turnout (120 days)	578.1	560.4	15.45	NS
34 days after turnout	584.6	594.4	16.11	NS
103 days after turnout	658.6	672.1	17.72	NS

The recorded DLWGs are shown in table 4. From the start of the trial to 48 days the housed heifers recorded significantly ($p<0.001$) higher DLWGs. Despite negative DLWGs being recorded by the out-wintered heifers farm staff and visitors were satisfied with the visual appearance of these heifers. However the issue of negative DLWGs necessitated a change to the protocol and the decision was taken to replace the straw with haylage. The housed heifers were also gaining condition score and the decision was taken to replace the 1.5kg/h/d of concentrates with minerals. Following these changes the out-wintered heifers exhibited compensatory growth and recorded significantly higher ($p<0.001$) DLWGs from 48 days to turnout. Overall the housed heifers recorded significantly higher ($P<0.05$) higher DLWG from start to turnout. However, it is interesting to note that the out-wintered heifers recorded significantly higher ($p<0.001$) DLWGs from turnout to the end of the trial and as a result there were no significant differences in DLWG from the start to the end of the trial between the treatments.

Table 4 Effect of treatment on DLWG (kg)

	Housed	Out-wintered	s.e.d	Sig
Start - 48 days	0.77	-0.30	0.090	***
48 days - turnout	0.90	1.37	0.085	***
Start – turnout (120 days)	0.85	0.70	0.063	*
Turnout - 34 days	0.19	1.00	0.089	***
Turnout- finish (103 days)	0.78	1.08	0.061	***
Start - finish (223 days)	0.82	0.88	0.037	NS

Both groups of heifers exceeded the desired growth rate target of 0.7-0.8kg per day for 2 year calving.

As shown in table 5 the housed heifers recorded a marked increase in condition score by 48 days after the start of the trial which was significantly higher ($p<0.001$). At this point the out-wintered heifers were at condition score 1.96 which is commercially acceptable. Changing the straw to haylage resulted in an improvement in their condition and by turnout and at the end of then trial there were no differences in condition score. The condition scores of 2.91 and 2.79 recorded at the end of then trial by the housed and out-wintered heifers respectively could be regarded as 'relatively high' but is a reflection of the effect of good quality spring grazing.

Table 5 Effect of treatment on condition score

	Housed	Out-wintered	s.e.d	Sig
Start	2.11	2.07	0.083	NS
After 48 days	2.46	1.96	0.093	***
Turnout (120 days)	2.64	2.41	0.172	NS
103 days after turnout	2.91	2.79	0.175	NS

3.2 Dirtiness scoring

Heifers were scored for dirtiness and results shown in Table 6. There were no significant differences in dirtiness between the treatments. The mean monthly rainfall recorded during the trial in comparison to the means for the last 10 years are detailed in appendix 1.6. The rainfall during the period of out-wintering was noted for being below average for September and October (which also hindered germination of the stubble turnips), average for November and December, above average for January, below average for February and above average for March.

Table 6 Effect of treatment on mean dirtiness score

	Housed	Out-wintered	s.e.d	Sig
Start	1.15	1.10	0.088	NS
Turnout	1.39	1.32	0.073	NS

The coat dirtiness of the housed heifers are illustrated in plate 8

Plate 8. Housed heifers at turnout

3.3 Locomotion, health and welfare observations

Both groups of heifers were assessed for lameness by locomotion score on five occasions during the trial. On no occasion was there the necessity of clinical examination for lameness. One heifer in each group was recorded with a score of 1.5 on one occasion only. The results for locomotion score are displayed in Table 7. There were no significant differences between the treatments.

Table 7 Effect of treatment on mean locomotion score

	Housed	Out-wintered	s.e.d	Sig
Start	1.00	1.00	0	NS
Turnout	1.04	1.04	0.051	NS

Both groups appeared clinically healthy with no obvious difference between the groups.

In terms of behaviour, the out-wintered cattle would take shelter next to hedgerows during wet weather, although at no point throughout the trial did they appear severely unsettled by this. Heifers on the housed treatment, being not prone to any variability in environment remained content throughout.

3.4 Feed intakes

An estimation of dry matter intakes on four dates for the out-wintered group is shown in Table 8. The supporting calculations and assumptions are shown in appendices 1.8 and 1.9. Dry matter intakes increased as the trial progressed and increased markedly with the introduction of haylage.

Table 8 Estimated dry matter intakes (kg/heifer) – out-wintered

	Sample date (by cumulative days on trial			
	9	**48**	**75**	**97**
Stubble Turnips	5.22	4.24	4.19	5.77
Straw	3.91	3.95		
Haylage			6.26	6.14
Minerals	0.09	0.09	0.09	0.09
Totals	9.22	8.28	10.54	12.00
Weighted mean intake	10.22			

Forage intakes were recorded on a daily basis for the housed heifers and total fresh and dry matter intakes per head calculated and shown in table 9. The weighted mean dry matter intakes for the two treatments is very similar over the whole period. Concentrates were fed at 1.5kg/head/day for the first 48 days of the experiment and then replaced with 100ghead/day of minerals.

Table 9 Fresh and dry matter intakes (kg/heifer) - housed

	Total fresh weight	Total DM	kg DM/head/day
Grass silage	1,398	322	2.68
Whole crop	1,654	828	6.90
Concentrates	72	62	0.52
Minerals	7.2	7.1	0.06
Totals	3,131.2	1,219.1	10.16

3.5 Forage crop yield, utilisation and stocking rate

The yield and utilisation of the stubble turnips was calculated on four occasions during the course of the experiment. As can be seen from table 10 dry matter yields ranged from 2,683 to 5,170kg DM/ha with utilisation ranging from 38 to 44%.

Table 10 Stubble turnip yields and utilisation

Day	Crop Yield (kg DM/ha)	Utilised (%)
9	3,531	44
48	3,853	42
75	2,862	39
97	5,173	38

Full details of the forage crop yield and utilisation calculations and location of the sampling points in the fields are shown in appendixes 1.9 and 2.0. The majority of the stubble turnips left ungrazed were the roots with the heifers having a preference to eat the leaves. It was estimated that utilisation of the leaves was 90%.

In this study 10.54ha provided sufficient stubble turnips for 14 heifers for 120 days i.e 0.75ha/hd. One hectare of stubble turnips would therefore be required per heifer for a 160 day winter.

3.6 Financial appraisal

Identifying the cost of the chosen wintering system is the single most important decision making factor – especially in this case with good growth rates on either treatment. Table 11 shows the daily variable and fixed cost per heifer. Calculations were based on actual costs in combination with typical contractor charges and published figures. Full calculations with references are displayed in appendix 2.1.

Table 11 Daily cost per heifer over the 120 day trial period

(£/head/day)	**Out-wintered**	**Housed**
Variable Costs		
Forage	0.89	0.69
Minerals/ Concentrate	0.05	0.15
Bedding	-	0.30
Fixed Costs		
Labour + Machinery	0.31	0.87
Depreciation	0.02	0.25
Total Costs	**1.27**	**2.28**

Variable and fixed costs cost per kg gain were calculated for the winter period (120 days) and for the overall trial period of 223 days and are shown in table 12.

Table 12 Variable and fixed costs (£) per kg liveweight gain

£/kg DLWG	Out-wintered	Housed
Winter Variable Costs	1.34	1.37
Winter Fixed & Variable Costs	1.81	2.70
Overall Variable Costs	0.58	0.77
Overall Fixed & Variable Costs	0.78	1.50

Winter feed costs per kg gain were similar however both variable costs and fixed plus variable costs per kg live weight gain were significantly reduced with the out-wintering system.

3.7 First lactation performance

3.7.1 Harper Adams Dairy Unit

The Harper Adams dairy herd consists of some 330 Holstein, Brown Swiss and Brown Swiss cross Holstein cows. The herd is currently recording an average lactation yield of 9,223 litres per cow @ 3.75% fat and 3.16% protein with an annual average of 8,406 litres @ 3.92% fat and 3.20% protein (NMR - October 2009). The herd is cubicle housed and milked through a 40 point internal rotary parlour. The milking herd is split into two management groups of milking cows and heifers together with lean/small cows and fed a single TMR (see Appendix 2.2). Once calved all the trial heifers were managed in the milking heifer group and fed the TMR and housed year round.

3.7.2 Calf birth weights and calving ease

As shown in table 13 there were no significant differences in birth weight or calving ease between the treatment groups.

Table 13. Effect of treatment birth weights and calving ease

	Housed	Out-wintered	s.e.d	Sig
Calf birth wt (kg)	40.2	39.8	1.31	NS
Calving ease	1.46	1.31	0.156	NS

Details of the calving ease score are shown in appendix 1.5

3.7.3 Milk yield and quality

As shown in table 14 there were no significant differences in 305 day milk yield, butterfat or protein yield or somatic cell count between the treatment groups.

Table 14. Effect of treatment on 305 day milk yield and quality

	Housed	Out-wintered	s.e.d	Sig
Milk (kg)	8,276	8,177	482	NS
Butterfat (g/kg)	39.5	39.7	0.16	NS
Butterfat (kg)	327	325	14.9	NS
Protein (g/kg)	31.9	32.6	0.88	NS
Protein (kg)	264	267	14.7	NS
SCC ('000)	204	213	83.2	NS

3.7.4 Milk value

As shown in table 15 there were no significant differences milk price or value between the treatment groups.

Table 15. Effect of treatment on milk value

	Housed	Out-wintered	s.e.d	Sig
Milk price (p/l)	23.26	23.58	0.729	NS
Milk value (£)	1,925	1,928	95.5	NS

4: DISCUSSION

4.1 Discussion

Heifers wintered on the housed regime had significantly ($p<0.05$) higher DLWGs over the winter trial period compared to the out-wintered group (0.85 v 0.70kg DLWG). Despite this lower DLWG the out-wintered heifers still achieved the target growth rate for dairy heifers calving at two years of age (0.7 – 0.8kg) (Blowey, 1999). However, the housed heifers suffered a marked growth check following turnout with the out-wintered heifers recording a significantly ($p<0.001$) higher DLWG from turnout to the end of the trial (0.78 v 1.08kg). This resulted in there being no differences in either their overall live weight or DLWG. Such growth rates are unique compared to previous studies using stubble turnips grazed *in situ*.

After 48 days on trial the housed heifers recorded a significantly ($p<0.001$) higher condition score. The change from feeding straw to haylage resulted in a marked improvement in condition score with the out-wintered heifers so that by turnout there was no significant difference. The housed group gained an extra 0.19 units of body condition score however this was not significantly different. With hindsight the use of concentrates could have been avoided completely for the housed group therefore reducing costs.

As a consequence of initial negative DLWG's for the out-wintered group a change of protocol was implemented, replacing straw with haylage. Although this is highly undesirable when conducting a research project, the circumstances dictated that action was required. A drop in growth rates is predicted to allow stock to adjust to a brassica diet but this should take no more than 28 days (Woods *et al*., 1995). However negative DLWGs were recorded with the out-wintered heifers for 48 days, hence the decision to switch to haylage. It was not in the interest of the project to compromise animal welfare.

The effects of the switch to haylage was dramatic, with heifers averaging 1.78kg DLWG in the period between introducing haylage and the next weigh date. Accounting for this huge jump in DLWG can be interpreted with SAC 'FeedByte' rationing programme. The ration was based on estimated intakes as shown in Table 8. In addition the stubble turnip portion of the ration was amended to a higher crude protein level (23%) and ME to 12.5MJ/kg. This was based on the findings from the utilisation field work where of the total stubble turnip intake, 90% was estimated from the leaves. It is suggested that the high rejection of the roots was due to soil contamination. The roots could subsequently be utilised by sheep. Table 16 shows a summary of the output from FeedByte. It clearly shows that supplementing the diet with straw simply did not provide sufficient energy for the growing heifers. Protein was never a limiting factor, which if based on the proximate analysis of feed samples could be considered a concentrate feed.

Table 16 Out-wintered ration evaluated using FeedByte software. Based on requirements for a 500kg dairy heifer, 0.7kg DLWG

	Sample date (by cumulative days on trial)			
	9	**48**	**75**	**97**
Stubble Turnips kg/d fresh (*dry*) [23% CP] [12.5 ME]	48.6 (5.22)	46.73 (4.24)	36.96 (4.19)	50.83 (5.77)
Straw kg/d fresh (*dry*)	4.57 (3.91)	4.61 (3.95)	-	-
Haylage kg/d fresh (*dry*)	-	-	7.54 (6.26)	7.40 (6.14)
Ration DM (g/kg)	166	167	231	198
ERDP supplied (g/kg DM)	898	862	1180	1389
ERDP required (g/kg DM)	663	669	883	971
Difference (g/kg DM)	**+235**	**+193**	**+297**	**+418**
DUP supplied (g/kg DM)	310	303	291	332
DUP required (g/kg DM)	99	95	0	0
Difference (g/kg DM)	**+212**	**+208**	**+291**	**+332**
ME supplied (MJ/day)	82	83	109	119
ME required (MJ/day)	90	90	90	90
Difference (MJ/day)	**-8**	**-7**	**+19**	**+29**
Proportion of brassica in total diet DM %	57	52	40	48

Apart from the nutritional capabilities of the out-wintered diet the other potential limitation is dry matter intake. Estimations of dry matter intake are shown in Table 8. As an estimation, calculations were based on a very small original sample size of crop yield and utilisation. Despite this, stubble turnip allocation was never a limiting factor. The low utilisation rates achieved combined with low stocking rate are evidence of this. Table 17 compares the grazing days per hectare and utilisation rates with previous studies using stubble turnips. Crop yield and cattle requirements influence the carrying capacity per hectare, with Hill (2007) noting that crop yield was significantly higher than in the trial conducted in 2005. However high utilisation rates were achieved in both trials, but only positive growth rates in 2005 with the more extensive stocking rate. It seems the low utilisation rates attained with the dairy heifers can be considered a compromise in favour of higher growth rates.

Table 17 Grazing performance on previous trials using stubble turnips

Stock	**Supplement**	**Grazing days per ha**	**Utilisation %**	**DLWG kg**	**Source**
Dry suckler cows	Straw	425	80%	-0.24	Hill, 2007
Dry suckler cows	Straw	116	70%	+0.21	Hill, 2005
Dairy Heifers	Straw/Haylage	163*	40%	+0.70	This study

*grazing days = (120 days on trial x 14 heifers)/ 10.25 ha of crop

In terms of animal health and welfare, both groups of heifers suffered no health issues over the duration of the trial. Anti-nutritive factors are a major concern when feeding brassicas, but with correct supplementation with roughage and minerals posed no threat in this trial. Equally no significant difference was detected between the two treatments when comparing data collected for locomotion. A potential future welfare issue as a result of out-wintering is the consideration for cubicle training heifers once they enter the milking herd. This is a factor for consideration by dairy farmers contemplating out-wintering.

Dirtiness scoring proved no significant difference between the two treatments. This opposes Hyslop *et al*., (2007) findings that cattle were dirtier when out-wintered. However the latter trial was a kale based system, and therefore required higher stocking rates per hectare.

It might be suggested that out-wintering of dairy replacements might have a detrimental effect on subsequent lactation performance. It was demonstrated in this experiment that out-wintering in-calf dairy heifers on stubble turnips and haylage had no significant effect ($p>0.05$) on subsequent calving difficulty or 305 day lactation performance.

When compared to previous studies, albeit carried out with dry dairy and beef cows and store cattle, the trial completed can best be described as an extensive, low input system. A key feature of this is establishing the stubble turnip catch crop at minimal cost into cereal stubble. As a result, it is best placed on a mixed farm or arable areas where such land is not limiting. In addition, the relatively low stocking rate that accompanies lower yielding forage crops reduces soil damage and maintains cleaner cattle. Although allocating a greater area of crop per animal lowers utilisation rates as more is wasted through trampling and soiling.

As a visual assessment, there was no significant poaching of the ground by stock. Bales were placed into the ring feeder sited alongside a farm track. Wheel tracking's and ruts were therefore kept to a minimum. Ideally bales should be placed in the field before grazing to eliminate such damage as recommended by multiple authors (Nichol *et al.*, 2003; Hill, 2005).

Calculations of total costs (Table 11), proved the out-wintered system to be just under half the cost of housed cattle. Variable costs per head per day were reduced with out-wintering from £1.16 to £0.94/hd/day however variable costs per kg gain were relatively similar at £1.34/hd versus £1.37/hd for the out-wintered and housed heifers respectively, which complements the findings of French and Boyle (2007). The major differential was in fixed costs with the out-wintered heifers being wintered with a total cost (fixed plus variable) of £1.27/hd/day compared to the housed heifers at £2.28/hd/day. Machinery costs were based on contractors carrying out all the feeding and bedding for the housed group. Allocating such costs is not a precise science – often such machines (feeder wagon) would feed many more stock, and hence spread costs. Likewise machinery use can be simplified as opposed to

luxuries such as TMR feeding as in this trial. Even so the requirement for machinery is undoubtedly greater for housed systems. The housed system also included an element for building depreciation valued at £0.25/hd. It is unlikely that a dairy farmer would leave a building empty and would probably find an alternative use for it.

Although the wintering costs are significantly less for the out-wintered system in this trial, it does not mean to say that housed systems should be abandoned all together. Out-wintering systems can be introduced to accompany existing facilities in order to facilitate herd expansion while maintaining a low capital requirement. The out-wintering of dairy heifers provides the prime opportunity to do this. Nichols *et al.,* (2003) highlighted that this has long been common practise in New Zealand where farmers source additional land off farm (termed 'run-off') so that the productivity of the home milking platform can be maximised.

In the study a 12m 'headland' runback area was given to the out-wintered heifers. The size of this runback area could be questioned and if in fact a runback area is required with relatively low stocking rates and the establishment of the forage crop using minimal cultivation techniques.

4.2 Study limitations

A key hypothesis of the trial was to determine if growth rates could be achieved from the out-wintered heifers to calve at two years at age. While the desired growth rates were achieved to do this, the heifers were 21.8 months old at the start of the experiment and predicted to calve down at a mean age of 29 months old which is similar to the national average for the UK (Centre for Dairy Information, 2008) five months beyond the target.

The effect of gut fill on heifer live-weights is a limitation by the nature of the trial. With heifers typically consuming 50kg of fresh feed per day then error is likely to be introduced when accounting for live weight change. In an attempt to minimise any variation in gut fill heifers were double weighed at the start and end of the trial and the out-wintered heifers were weighed before the electric fence was moved.

Calculations for crop yield and utilisation were based on a very small original sample size. In this instance the process involved ten quadrat samples collected on each occasion, to be then split into 20 trays (leaves and roots) for drying. More repeats would improve reliability; however due to bulk, sample size was restricted by oven space and demand.

4.3 Recommendations for future study

Out-wintering of dairy heifers is a huge research gap, and one that must be expanded on in the future. Based on this study alone, the first to our knowledge in Europe, the potential to dramatically cut fixed costs will provide great opportunities for dairy farmers. Research into out-wintering as a system needs to be broadened

out, taking into account varying soil types, animal growth patterns, crop choice and environmental impact.

The following experiments are therefore worthy of consideration for yearling and/or in-calf heifers that are predicted to calve at approximately 24 months old:

- Housed versus out-wintered on Swift (Kale/Forage Rape hybrid).
- Heifers out-wintered on Stubble turnips versus Swift.
- Heifers out-wintered on Stubble turnips or Swift with Haylage/big bale silage restricted to either 3kg or 6kg DM/hd/day.
- 0 versus 6m versus 12m runback area.
- Evaluation of environmental impact.

In addition longer term studies are needed to assess the performance of stock throughout their productive life. One of the key advantages of out-wintered stock is their ability to efficiently transfer from a brassica based diet to grass in the spring. As opposed to housed stock they do not suffer a growth check. This and the implications of compensatory growth should be considered in future work.

5: CONCLUSIONS

The out-wintering of dairy heifers offers great potential to reduce costs, in particular fixed costs. The trial conducted, was based on stubble turnips supplemented with straw initially then haylage. The change to haylage was necessary to provide sufficient energy to support animal growth. Heifers on the housed treatment recorded significantly higher growth rates, but both treatments achieved the desired DLWG target necessary to calve at two years of age. The housed heifer suffered a marked growth check following turnout with the out-wintered heifers recording a significantly higher DLWG from turnout to the end of the trial. This resulted in there being no differences in either their overall liveweight gain or DLWG. Additional comparisons of locomotion and dirtiness scoring found no significant differences.

Where housing accommodation is limiting, out-wintering dairy heifers on stubble turnips is a feasible, low capital cost solution.

Further research is required to quantify the effects of out-wintering in the longer term; monitoring heifer performance through to lifetime performance. Additional research using alternative forage crops will expand the potential for successful out-wintering systems.

6: ACKNOWLEDGEMENTS

This study was funded by DairyCo with support from British Seed Houses, Rumenco Ltd, Rappa and Tony Binns Livestock Equipment.

The authors wish to express sincere thanks to the farm staff; David Ferguson, Sean Lewis, David Miller and John Ruscoe, for their help in the execution of the trial.

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APPENDICES

1.1 Mineral analysis

	Rumenco Cattle Plus TAB	Wynnstay Premier Youngstock
Calcium (%)	10	19.8
Phosphorus (%)	3	5
Magnesium (%)	3	5
Sodium (%)	5	
Salt (%)		22.5
Selenium (mg/kg)	30	25
Cobalt (mg/kg)	100	100
Iodine (mg/kg)	350	400
Manganese (mg/kg)	2,000	4,000
Zinc (mg/kg)	4,000	5,000
Copper (mg/kg)	1,500	2,000
Vitamin A (iu/kg)	250,000	320,000
Vitamin D3 (iu/kg)	50,000	64,000
Vitamin E (iu/kg)	1,500	500

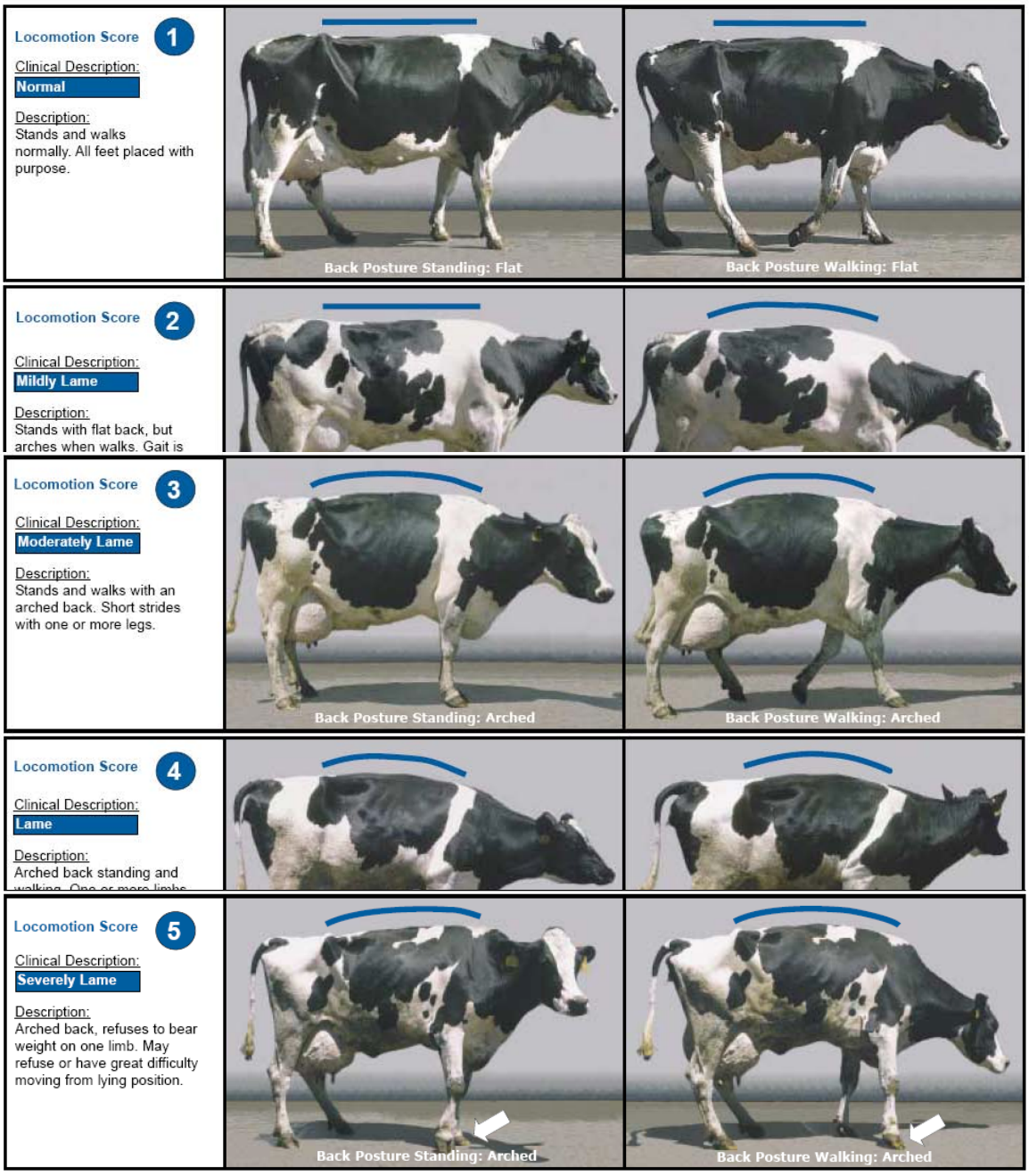
1.2 Wynnstay Heifer Rearer 600 analysis

	% as fed
Dry matter	86.5
Oil (method B)	6.6
Protein	19.9
Fibre	9.5
Ash	7.4
Starch	19.2
Sugar	11.5
NCGD	80.7
NDF	27.1
ME (MJ/kg DM)	13.2

1.3 Dirtiness Score Chart (Food Standards Agency, 2006)

1.4 Locomotion Scoring (Sprecher *et al*., 1997)

Locomotion Scoring is based on the observation of cows standing and walking (gait), with special emphasis on their back posture. This system is intuitive and, therefore, easy to learn and implement. Use of locomotion scoring is effective for early detection of claw (hoof) disorders, monitoring prevalence of lameness, comparing the incidence and severity of lameness between herds and indentifying individual cows for functional claw (hoof) trimming. Animal observations should be made on a flat surface that provides hard footing for cows.



1.5 Calving Ease score

Calving ease was assessed by the herdsmen using the following scale:

1 = unassisted
2 = slight assistance, no ropes
3 = considerable help, ropes and some pulling
4 = veterinary intervention, or considerable manipulation e.g. head back/breach
5 = caesarian

1.6 Analysis of Triticale Straw (Chamberlain and Wilkinson, 1996)

Nutritional Component	Analysis
DM (%)	85.0
CP (% DM)	3.5
NDF (% DM)	80.5
ME (MJ kg DM)	6.0

1.7 Mean monthly rainfall (mm) for 2007/08 in comparison to the seasonal means for 1997-2006.

Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar
2007-2008	24.6	26.6	56.4	64.6	84.4	28.2	60.0
1997-2006	59.7	74.6	60.7	57.0	41.5	42.9	43.4

1.8 Out-wintered Intakes of Straw and Haylage.

Feedstuff	Total quantity fed (kg DM)	Utilisation* (%)	Days	Per heifer
Straw	3646.5	0.8	48	3.93
Haylage	6466.2	0.9	72	6.20

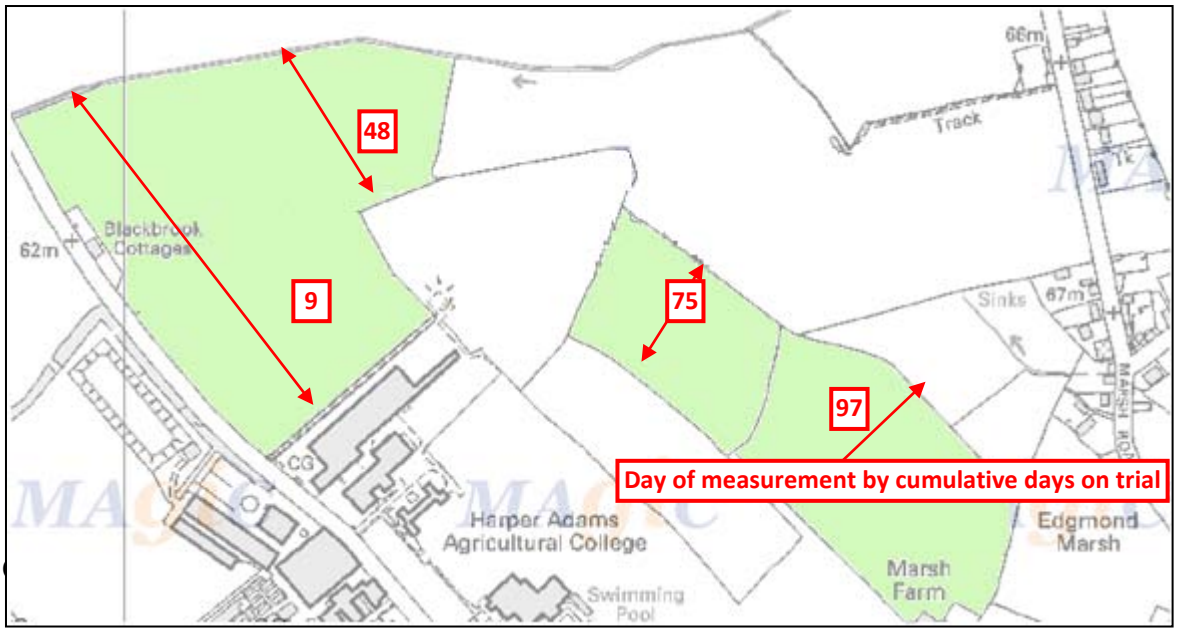
* Utilisation is based on a visual assessment.

1.9 Calculations for Estimated intakes of Stubble Turnips per Heifer

* Crop yield and utilisation were calculated from a simple field trial using a quadrat.

Day	Crop Yield*	Area allocated (ha)	Crop Allocated (kg/DM)	Utilised* (%)	Stock	Duration (days)	Intake (kg DM)	Intake (kg fresh per heifer)
9	3,531	0.268	946	44	16	7	4.29	48.6
48	3,853	0.0417	161	42	16	1	4.24	46.7
75	2,862	0.14	326	39	15	2	4.19	36.9
97	5,173	0.176	910	38	15	4	5.77	50.8

Detailed calculations on four different occasions are shown in appendix 2.0


48
9
75
97
Day of measurement by cumulative days on trial
66m
Track
62m
Blackbrook Cottages
Sinks
67m
CG
Harper Adams Agricultural College
Swimming Pool
Marsh Farm
Edgmond Marsh

Qradrat 35 cm²

30/11/2007 Large Marsh																			
	Plot	Tray (g)	Fresh Weight (g)		Proportionally		Tray Dry Weight (g)	Dry Weight (g)		DM		Plants/ qradrat	Plants/ m2	g fresh weight/m²	kg fresh weight/ha		kg dm ha	
UNGRAZED	10 root	658.0	102.6	average root	61.76	12.95 %	665.6	7.6	average root	6.58	10.7 %	8	65.3	837.6	8375.51	39191.84	892.34	3614.48
	leaf	590.3	377.5	average leaf	415.24	87.05 %	623.6	33.3	average leaf	36.68	8.8 %			3081.6	30816.33		2722.14	
	9 root	590.5	12.5	Total Plant	477.0		591.3	0.8	Total Plant	43.3	9.1 %	4	32.7	102.0	1020.41	13044.90	108.72	1170.89
	leaf	658.0	147.3				671.4	13.4						1202.4	12024.49		1062.18	
	8 root	586.2	90.8				597.6	11.4				10	81.6	741.2	7412.24	77657.14	789.71	6994.76
	leaf	588.1	860.5				649.3	61.2						7024.5	70244.90		6205.04	
	7 root	590.4	52.2				597.2	6.8				8	65.3	426.1	4261.22	43763.27	454.00	3943.39
	leaf	657.4	483.9				693.1	35.7						3950.2	39502.04		3489.39	
	6 root	659.1	50.7				665.4	6.3				8	65.3	413.9	4138.78	21036.73	440.95	1933.62
	leaf	659.4	207.0				699.2	39.8						1689.8	16897.96		1492.67	
					utilisation					DM		average	9.5	77.6	1946.9		38938.78		3531.43
GRAZED	5 root	657.4	82.6	average root	75.8	-22.73 %	667.0	9.6	average root	7.94	10.5 %							
	leaf	592.0	286.7	average leaf	190.78	54.06 %	628.0	36.0	average leaf	27.52	14.4 %				33897.1	kg/fresh/leaf		
	4 root	658.1	62.6	Total Plant	266.6	44.11 %	664.5	6.4	Total Plant	35.5	13.3 %				2994.3	kg/DM/leaf		
	leaf	658.9	291.3				697.3	38.4										
	3 root	658.6	139.1				671.3	12.7							5041.6	kg/fresh/root		
	leaf	653.3	133.6				671.5	18.2							537.1	kg/DM/root		
	2 root	658.2	43.1				661.2	3.0										
	leaf	661.6	127.5				686.5	24.9										
	1 root	590.8	51.6				598.8	8.0										
	leaf	659.0	114.8				679.1	20.1										

11/01/2008 Large Marsh																			
	Plot	Tray (g)	Fresh Weight (g)		Proportionally		Tray Dry Weight (g)	Dry Weight (g)		DM		Plants/ qradrat	Plants/ m2	g fresh weight/m²	kg fresh weight/ha		kg dm ha	
UNGRAZED	10 root	591.2	30.5	average root	64.78	12.45 %	596.1	4.9	average root	8.34	12.9 %	3	24.5	249.0	2489.80	15314.29	320.54	1394.46
	leaf	659.4	157.1	average leaf	455.7	87.55 %	674.5	15.1	average leaf	38.16	8.4 %			1282.4	12824.49		1073.91	
	9 root	591.6	52.2	Total Plant	520.5		596.8	5.2	Total Plant	46.5	8.9 %	4	32.7	426.1	4261.22	39183.67	548.60	3472.99
	leaf	597.0	427.8				627.3	30.3						3492.2	34922.45		2924.38	
	8 root	657.1	83.4				668.6	11.5				4	32.7	680.8	6808.16	47918.37	876.51	4319.05
	leaf	589.9	503.6				629.7	39.8						4111.0	41110.20		3442.54	
	7 root	660.7	92.7				672.7	12.0				7	57.1	756.7	7567.35	51142.86	974.25	4623.23
	leaf	586.1	533.8				630.8	44.7						4357.6	43575.51		3648.98	
	6 root	661.0	65.1				669.1	8.1				6	49.0	531.4	5314.29	58881.63	684.18	5169.87
	leaf	656.5	656.2				717.4	60.9						5356.7	53567.35		4485.69	
					utilisation					DM		average	6	49.0	2124.4		42488.16		3795.92
GRAZED	5 root	591.9	63.8	average root	64.22	0.86 %	599.4	7.5	average root	10.8	16.8 %							
	leaf	590.0	373.7	average leaf	236.64	48.07 %	648.7	58.7	average leaf	42.86	18.1 %				37200.0	kg/fresh/leaf		
	4 root	590.6	62.5	Total Plant	300.9	42.20 %	599.2	8.6	Total Plant	53.7	17.8 %				3115.1	kg/DM/leaf		
	leaf	596.1	332.8				652.0	55.9										
	3 root	657.2	80.7				669.1	11.9							5288.2	kg/fresh/root		
	leaf	659.4	220.2				693.1	33.7							680.8	kg/DM/root		
	2 root	656.4	34.2				663.6	7.2										
	leaf	663.3	145.8				702.4	39.1										
	1 root	589.6	79.9				608.4	18.8										
	leaf	659.7	110.7				686.6	26.9										

Qradrat 35 cm²

30/11/2007 Large Marsh

	Plot	Tray (g)	Fresh Weight (g)			Proportionally	Tray Dry Weight (g)	Dry Weight (g)	
UNGRAZED	10 root	658.0	102.6	average root	61.76	12.95 %	665.6	7.6	average root
	leaf	590.3	377.5	average leaf	415.24	87.05 %	623.6	33.3	average leaf
	9 root	590.5	12.5	Total Plant	477.0		591.3	0.8	Total Plant
	leaf	658.0	147.3				671.4	13.4	
	8 root	586.2	90.8				597.6	11.4	
	leaf	588.1	860.5				649.3	61.2	
	7 root	590.4	52.2				597.2	6.8	
	leaf	657.4	483.9				693.1	35.7	
	6 root	659.1	50.7				665.4	6.3	
	leaf	659.4	207.0				699.2	39.8	
						utilisation			
GRAZED	5 root	657.4	82.6	average root	75.8	-22.73 %	667.0	9.6	average root
	leaf	592.0	286.7	average leaf	190.78	54.06 %	628.0	36.0	average leaf
	4 root	658.1	62.6	Total Plant	266.6	44.11 %	664.5	6.4	Total Plant
	leaf	658.9	291.3				697.3	38.4	
	3 root	658.6	139.1				671.3	12.7	
	leaf	653.3	133.6				671.5	18.2	
	2 root	658.2	43.1				661.2	3.0	
	leaf	661.6	127.5				686.5	24.9	
	1 root	590.8	51.6				598.8	8.0	
	leaf	659.0	114.8				679.1	20.1	

11/01/2008 Large Marsh

	Plot	Tray (g)	Fresh Weight (g)			Proportionally	Tray Dry Weight (g)	Dry Weight (g)	
UNGRAZED	10 root	591.2	30.5	average root	64.78	12.45 %	596.1	4.9	average root
	leaf	659.4	157.1	average leaf	455.7	87.55 %	674.5	15.1	average leaf
	9 root	591.6	52.2	Total Plant	520.5		596.8	5.2	Total Plant
	leaf	597.0	427.8				627.3	30.3	
	8 root	657.1	83.4				668.6	11.5	
	leaf	589.9	503.6				629.7	39.8	
	7 root	660.7	92.7				672.7	12.0	
	leaf	586.1	533.8				630.8	44.7	
	6 root	661.0	65.1				669.1	8.1	
	leaf	656.5	656.2				717.4	60.9	
						utilisation			
GRAZED	5 root	591.9	63.8	average root	64.22	0.86 %	599.4	7.5	average root
	leaf	590.0	373.7	average leaf	236.64	48.07 %	648.7	58.7	average leaf
	4 root	590.6	62.5	Total Plant	300.9	42.20 %	599.2	8.6	Total Plant
	leaf	596.1	332.8				652.0	55.9	
	3 root	657.2	80.7				669.1	11.9	
	leaf	659.4	220.2				693.1	33.7	
	2 root	656.4	34.2				663.6	7.2	
	leaf	663.3	145.8				702.4	39.1	
	1 root	589.6	79.9				608.4	18.8	
	leaf	659.7	110.7				686.6	26.9	

2.1 Full Costings and Supporting Calculations

OUT-WINTERED COSTS

Variable Costs

Growing Costs

			£	£	£
	Details	**£/Ha**	**Total**	**Heifer**	**Heifer/day**
Cultivations	Vaderstad drill	17.50 (a)	184.45	13.18	0.11
Slurry Spreading	@ 35kg N ha	14.20 (b)	149.67	10.69	0.09
Seed		55.00 (c)	579.70	41.41	0.35
		49.83	**913.82**	**65.28**	**0.55**

Other Feed

	Details	**£/tonne**	**Total**	**Heifer**	**Heifer/day**
Straw	13 (bales) @ 330kg	30 (d)	128.70	9.19	0.08
Haylage	26 (bales) @ 300kg	56 (e)	436.80	31.20	0.26
Minerals	6 (blocks) @ 25kg	534 (f)	80.10	5.72	0.05
			645.60	**46.11**	**0.39**

Total Variable	**0.94**

Fixed Costs

Labour + Machinery

	hr/week	**hr/rate**	**£/week**	**Total**	**Heifer**	**Heifer/day**
Moving Fence	1.5	10	15.00 (h)	257.14	18.37	0.15
Feeding Forage	1	15	15.00 (i)	257.14	18.37	0.15
				514.29	**36.73**	**0.31**

Depreciation

Electric Fence	£400 over 10 years		(j)	**40.00**	**2.86**	**0.02**

Total Fixed	**0.33**
TOTAL COSTS	**1.27**

Notes

(a) Direct drilling (Dale, 2008. Pers. Comm. Mr A Dale is the owner and director of Dales Contractors Ltd)

(b) Equivalent to 6 hours work with 1500gal tanker + tractor + driver at £25/hr (Nix, 2007)

(c) Actual cost supplied by British Seed Houses (6.25kg Vollenda treated with Ultrastrike @ £8.80/kg).

(d) Actual cost

(e) Haylage @ 83% DM. Based on a DM cost of £68/t

(f) Actual cost, supplied by Rumenco

(h) Labour costed at £10/hour

(i) For use of JCB Loadall to take straw haylage to field (Dale, 2008. Pers. Comm. Mr A Dale is the owner and director of Dales Contractors Ltd)

(j) Based on basic equipment

HOUSED COSTS

Variable Costs

Forage Costs

	Details	£/tonne	£ Total	£ Heifer	£ Heifer/day
Grass Silage	19,572kg	15.64 (a)	306.11	21.86	0.18
Wholecrop	23,156kg	37.00 (b)	856.77	61.20	0.51
			1162.88	83.06	0.69

Other Feed

	Details	£/tonne	Total	Heifer	Heifer/day
Concentrate	1008kg	200.00 (c)	201.60	14.40	0.12
Minerals	100.8kg	291.00 (d)	29.33	2.10	0.03
			230.93	16.50	0.15

Bedding

	Details	£/tonne	Total	Heifer	Heifer/day
Straw	51 bales @ 330kg	30.00	504.90	36.06	0.30

Total Variable	**1.16**

Fixed Costs

Labour + Machinery

	hr/week	hr/rate	£/week	Total	Heifer	Heifer/day
Feeding Forage	1.5	40.00	60.00 (e)	1028.57	73.47	0.61
Bedding Pens	0.5	20.00	20.00 (f)	171.30	12.25	0.10
Mucking Out/ Spreading FYM [Twice @ 3hrs each time]				258.00	18.43	0.15
				1458.13	104.15	0.87

Depreciation

Building	£8,400 20 years (g)		**30.00**	**0.25**

Total Fixed	**1.12**
TOTAL COSTS	**2.28**

Notes

(a) Grass silage @ 23% DM. Based on a DM cost of £68/t

(b) Wholecrop @ 50% DM. Based on a DM cost of £74/t

(c) Actual cost, supplied by Rumenco Ltd

(d) Actual cost, supplied by Wynnstay Group Plc

(e) For tractor + feed wagon + driver (Dale, 2008. Pers. Comm. Mr A Dale is the owner and director of Dales Contractors Ltd)

(f) For tractor + straw chopper + driver (Dale, 2008. Pers. Comm. Mr A Dale is the owner and director of Dales Contractors Ltd)

(g) Complete buildings – covered straw yard, enclosed with ventilated cladding, concrete floor, with 4m^2 per head floor area. £600 per head (Nix, 2007)

2.2 Harper Adams Milking Heifer group TMR

Feeds	**(kg/cow)**
Maize Silage (34%DM/11.2ME/8%CP)	18
Grass Silage (36%DM/10.4ME/11%CP)	8
Whole Crop (50%DM/11.1ME/8%CP)	3
Lucerne (42%DM/10.5ME/15%CP)	2
Caustic treated wheat (75% DM)	3.25
Beet Pulp	3
Hipro Soya	3
Rapeseed Meal	1.75
Rouxminate Molasses	0.75
Megalac	0.4
Minerals & Limestone	0.325
Total (kg)	**43.5**
Feeding rate	
Concentrate feed rate (kg/cow)	11.9
Concentrate feed rate (kg/l)	0.33
Dry Matter (%)	50.3
% DM from forage	51.8
Milk from Forage (litres)	M+8
Ration analysis	
DMI (kg)	21.9
M/D (MJ/kg)	12
ME supplied (MJ)	262
Crude Protein (% in DM)	17.4
NDF (% in DM)	32.3
Starch (% in DM)	18.6
Sugar (% in DM)	7.7