Cereals as summer and winter forage supplements for beef cattle

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Abstract

Supplementary forages are used to meet seasonal deficits in pasture production in both winter and summer. Traditional practice in Canterbury is to use rape for summer feed, with turnips, turnip/grass mixtures, kale, or oats for winter feed. The objectives of this trial series were to identify superior breeding lines of oats and barley as potential forage cultivars, to determine optimum planting and harvesting regimes, and to develop comparative cattle growth rate/feed allowance relationships for turnips, oats, and barley. Cereal forage trials were autumn sown/winter harvested at 3 sites in Canterbury for 3 seasons and for an extra season at Lincoln. Two spring sown/summer harvested trials were conducted in separate seasons at Lincoln and Greenpark. Cereal-legume mixtures were included in the Greenpark trial. Dry matter (DM) yield and digestibility were recorded. The grazing trial was sown in February 1991 at Templeton and winter grazed for 56 days. Yields in the winter trials ranged from approximately 3 to 6 tonnes DM/ha with DM digestibilities of 70 to 88%. Summer yields ranged from 7 to 11 tonnes DM/ha with digestibilities of 53 to 71%. Good disease resistance and winter hardiness contributed strongly to high yields. Otama oat and two advanced breeding lines consistently yielded above the standards, as did WPBS 21/82 barley, but this line is suitable only for early sowing and utilisation. The grazing trial provided robust estimates of liveweight/feed allowance relationships for turnips and oats, and indicative relationships for barley which suggest that the latter would be a preferable option to meet early season requirements.

Part I - Forage Trials

Introduction

Cereal forage crops have been grown in Canterbury since the inception of pastoral agriculture here. They are used to provide either a large volume of good quality standing dry-matter for grazing or to be stored as silage or hay for times of future shortage. This allows farmers to increase their options regarding retention or purchase of livestock to achieve optimum prices, and to reduce the amount of pasture required for winter grazing or hay production, thereby releasing more ground for cropping and other options.

Autumn sown forage cereal crops are ideally suited to mixed cropping systems, to occupy otherwise fallow land between arable crops, providing a source of DM to be grazed once during the winter months of May to September by sheep, beef or, increasingly, dairy cattle, before sowing a spring cereal or legume crop.

In contrast, spring sown forage cereal crops are more suited to pastoral or dairy systems where there is excess spring land after winter feed, or pastures which require renewal, by providing farmers with extra dry-matter for storing as silage or hay and then allowing the sowing of a winter forage crop or new pasture.

The New Zealand Institute for Crop & Food Research Ltd. (formerly DSIR Crop Research), conducts a grain oat breeding programme and releases cultivars suitable for the milling industry. In most circumstances a grain oat cultivar will also produce good forage DM, but there are some breeding lines which may be rejected due to poor grain characteristics yet produce more dry matter than the grain cultivars. With the increasing demand for forage cereals in Canterbury from new dairy farms and beef producers, Crop & Food Research has been evaluating a range of cereals for forage production. This paper presents the results of trials conducted in Canterbury since 1989.

Materials and Methods

Autumn trials

Trials at a range of Canterbury locations from 1989-92 (Table 1) were all randomised complete block designs, with 3 replicates. All were sown with a 9 row

Table 1. Autumn forage trials - site details.

	Year / sites			
	1989	1990	1991	1992
	Lyndhurst, Wakanui and Charing Cross	Lyndhurst, Wakanui and Darfield	Lyndhurst and Wakanui	Lincoln
Sown	late Feb.	early Mar.	early Mar.	late Mar.
Harvested	mid July	mid July	early July	late Sept.
Plot size	3.0 m^2	5.4 m^2	5.4 m^2	10 m^2
Crown rust pressure	Heavy	Heavy	Light	Light
Seasonal weather	Dry autumn, cool winter	Mild autumn and winter	Mild, wet autumn	Cold, wet autumn and winter

Oyjord small plot cone seeder drill with row spacing of 14.5 cm and a sowing rate of 90 kg/ha. The plot size, sowing and harvesting dates varied from year to year (Table 1). The trials were situated in a paddock of similar crop and were subjected to the growers management. The Lyndhurst and Wakanui sites were irrigated when necessary. All trials were harvested using a small plot flail-bladed forage harvester with a cutting width of 90 cm.. The fresh weights were measured at the cutting site and a 500 g sub-sample was bagged for oven drying to determine the DM percentage. A sub-sample of the dry-matter was ground through a 1 mm sieve for digestibility analysis by the Animal Sciences Group, Lincoln University. Digestibility analyses were not performed on the 1989 trial samples.

Spring trial

One spring trial was conducted in 1989, on irrigated heavy Motukarara soil at Greenpark in North Canterbury, using a 3 replicate randomised complete block design. The trial was sown on 7 November, after a very wet spring, and harvested on 23 January using similar techniques to those described for the autumn sown trials. Three pea cultivars were included as growers currently use these to increase the protein content of the crop and a vigorous barley was included to identify the relative performance compared to oats. The sowing rates for barley and peas were 112 kg/ha and 140 kg/ha respectively. The harvested plot size was 7.2 m^2. This was also sub-sampled and analyzed for digestibility percentage at Lincoln University.

Results and Discussion

Autumn trials

Otama was used as the standard cultivar in all trials. It has good levels of resistance to crown rust (*Puccinia coronata)* and good levels of winter hardiness.

The relative yield results show a range of yields among cultivars (Table 2). This range varies from season to season and appeared to be largely influenced by the seasonal weather and the disease resistance of each cultivar. In 1989 and 1990, when there was heavy disease pressure, the cultivars with poor resistance, Caravelle, Omihi and Makuru, performed poorly, but their performance in low disease pressure years was similar to or better than the more resistant cultivars.

The data from 1992 were only from one site and the trial was sown and harvested at dates outside the normal range of times practised, resulting in a high mean trial yield. This could have influenced the yield of the earlier maturing cultivars which may have responded to the spring growing conditions more than the later maturing cultivars.

Winter hardiness scores were also recorded, as this trait is important for the maintenance of forage quality during the winter months of cool temperatures and heavy frosts. Frosts can cause the leaf cells to freeze and burst which, when combined with any physical wind damage, can destroy the cells, reducing new plant growth and reducing the digestibility of the damaged plant material.

Spring trial

This irrigated trial was sown later than desired and

Table 2. Autumn trials - mean relative yield of the cultivars (Otama =100%) and comments.

	Year				Comments	
	1989	1990	1991	1992		
Otama Yield (t DM/ha)	2.73	2.95	3.50	4.40	Winter hardiness	Resistance to crown rust
Otama	100	100	100	100	Good	Good
Caravelle	82	87	103	118	Good	Poor
Omihi	82	-	96	108	Good	Poor
Makuru	92	87	-	122	Good	Poor
Awapuni	96	103	-	118	Poor	V. good
909.01/2	-	110	97	113	V. good	V. good
346.02	113	109	101	-	Good	Good
C.V.%	14.5	11.0	7.3	6.5		
LSD $_{(0.05)}$	25	20	18	15		

grew vigorously. It was harvested when most oats were at the normal milky dough stage. Not all cultivars were at the same stage of maturity, with the barley (WPBS 21/82) 7-8 days ahead of the remaining oats. In spite of this slightly more advanced maturity, the barley had a higher digestibility that the oats, and thus a substantially higher yield of digestible DM (Table 3). The addition of peas to the forage had little effect on digestibility or yield with the data indicating good compatibility between the pea Mega and both Awapuni oat and WPBS 21/82 barley.

Table 3. Relative yield and digestibility, Greenpark 1989/90.

Cultivar	Digestibility of DM (%)	Digestible dry matter (t/ha)	Relative digestible DM yield
Otama	54	4.14	100
Caravelle	57	5.03	121
Makuru	59	4.63	112
Awapuni	57	4.68	113
WPBS 21/82 barley	71	8.09	195
WPBS 21/82 + Triffid pea	74	7.57	183
WPBS 21/82 + Mega pea	70	7.72	186
WPBS 21/82 + Whero pea	64	6.55	158
Awapuni + Triffid	56	5.01	123
Awapuni + Mega	56	5.81	140
Awapuni + Whero	57	4.51	109
C.V. %	5.6	12.4	
LSD $_{(0.05)}$	6	1.15	

Conclusions

Superior breeding lines of oats and a well-adapted breeding line of barley have been identified from the results of this trial series. The numbered oat lines are scheduled for release by the NZ Institute for Crop & Food Research Ltd in 1994. Additionally, planting and harvesting regimes have been identified to enable the scheduling of supplementary forage availability based on cultivar choice determined by disease reaction and winter hardiness.

Specific comments for each cultivar are:

- **Otama** (formerly Charisma) is a useful grain oat that has good levels of crown rust resistance and winter hardiness. It is suitable as a general purpose grain and forage oat in Canterbury.

- **Caravelle** is used as a forage oat with good winter hardiness but has poor resistance to crown rust especially when sown early.

- **Omihi**, is now used only as a forage oat and has good winter hardiness but little resistance to crown rust.
- **Makuru**, used as a general purpose grain and forage oat is now being replaced by Otama. It has poor crown rust resistance.

- **Awapuni** does not have good winter hardiness and is not recommended for autumn forage sowing in Canterbury unless it is grazed before severe frosts occur. However it has excellent resistance to crown rust and could be sown and grazed early in many areas.

- **909.01/2** is a small grained special purpose forage oat with excellent crown rust resistance and winter hardiness. It has an erect plant habit which allows it to withstand snow and harsh conditions. It is suited to the most extreme forage growing areas and can be sown early to take full advantage of good early autumn growing conditions.

- **346.02** is a special purpose forage oat with good crown rust resistance and good winter hardiness. It achieves high dry-matter production in all situations and is well suited to any conditions. Less erect than 909.01/2, it is best suited to less extreme conditions.

- **WPBS 21/82** is a high yielding spring forage barley suitable for silage production.

Part II - Grazing Trial

Introduction

The aim of this grazing trial was to establish cattle growth rate/feed allowance relationships for oats and barley compared with turnips, the more widely used supplementary winter forage option.

Materials and Methods

Forage establishment

Eleven hectares of Templeton silt loams located at MAF Technology's Templeton Research Station were sown in either barley, oats or turnips on 13-14 February 1991. Previous cropping history included peas and 1-2 years of ryegrass, cv. Grasslands Moata.

Green Globe turnip seed was broadcast on 13 February at 1.62 kg/ha bare seed (2.0 kg coated) using 'Blackmore' coulters (designed to spread seed in a broad band rather than a single row) and harrowed. Barley, cv. Illia, and oats, cv. Awapuni were drilled on 14 February at 132 kg/ha and 146 kg/ha respectively. Approximately 190 kg superphosphate was applied to all treatments at sowing (reverted for turnips).

Twenty-five mm of rain fell within 24 hours of sowing. Establishment of all forages was good and initial growth rates excellent. Yellowing in the barley was observed in early April and a fungicide (Tilt) applied to control leaf rust (*Puccinia hordei*) on 26 April. in March, due to purpling of leaves of turnip and low leaf nitrogen status (2.78%), 90 kg/ha of urea (41.40 kg N/ha) was applied in April to ensure continued growth.

Animals

On 4 April, 1991 ninety Hereford steer calves weighing approximately 170 kg were purchased from one source (Huxley George) and grazed at Templeton on irrigated ryegrass-white clover pastures until the commencement of the grazing trial on 3 July. All calves were treated with 'Ivomec Pour-On' (Ivermectin) on 17 April and concurrently dosed with selenium. Supplementary hay was fed in May and June to familiarize cattle to handling and confined areas. To minimise the variability among animals the six heaviest and 12 lightest calves were removed prior to tagging and weighing on 3 July, leaving 72 animals with a mean liveweight of 196 kg and a CV of 5.2% at the start of the experiment.

Design

Liveweight changes of 72 beef weaners grazing three forages (turnips, oats, barley) during winter were compared at four herbage allowances expressed as a proportion of liveweight (1.8, 3.3, 4.8, 6.3%). Each treatment group (N = 12) contained six animals which were allocated to treatments on 3 July 1991 after restricted randomisation based on liveweight.

Grazing System

The experiment commenced on 3 July and continued for 55 days until 27 August. Due to insufficient herbage yields, the barley treatments ceased on 16 August, after a grazing period of 44 days. There were 14 shifts of cattle, each shift varying from 2-5 days but averaging approximately four days. Areas of forage were calculated from pre-graze herbage yields measured at four intervals during the experiment. Herbage allowances were expressed as a proportion of liveweight and absolute quantities varied according to group mean liveweights. Differences in herbage allowances were obtained by varying grazing areas and were adjusted four times during the experiment.

Because of initial variability in the measurement of herbage yields prior to and at the commencement of the experiment a cumulative mean yield assessment was used to allocate grazing areas. However all herbage allowance and residual data have been calculated on the basis of actual yields.

Measurements

Cattle liveweights were recorded off-pasture at the end of a grazing break. There were seven recordings of weights including an initial and a final weight together with a final overnight fasted weight. Herbage yields prior to grazing were measured by cutting four 1 m^2 quadrants to ground level. Herbage yields measured post-grazing were recorded on 10 of the 14 shifts and were selected at random throughout the experiment. The proportions of green material in the forage were assessed in the pregrazing samples on 7 August 1991 and the post-grazed samples on 16 August 1991. Samples were also retained for digestibility analysis.

Statistical analysis

Liveweight changes were compared using analysis of variance with quadratic functions fitted to interpret allowance trends. Linear contrasts were used to compare cereals with turnips.

Results

Pre-graze herbage yields

Growth of barley was retarded by the rust infection which was reflected in the lower dry matter yields during the winter (Fig. 1). Although oats were slightly affected by rust, symptoms did not appear until later June, which together with frosting damage severely reduced the amount of green material in the crop. Levels of phosphorus, sulphur, magnesium, calcium, and potassium were adequate for pasture growth in all forages but high sulphur and iron levels in turnips could have reduced copper availability. There was no evidence of copper deficiency in the cattle.

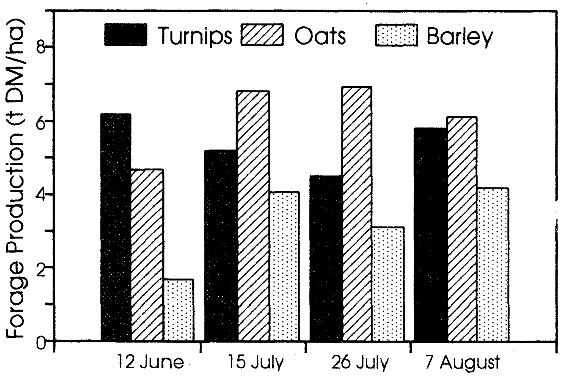

Figure 1. Pre-grazed forage dry matter yield at four dates during the experiment.

Preliminary measurements of forage yields recorded in late May indicated yields of 3440, 4084 and 1527 kg DM/ha for turnips, oats and barley respectively. Subsequent yields measured between June and August are given in Table 4. Yields of barley were lower than anticipated due to rust infection, although there was considerable variation as indicated by the high coefficient of variation. The relative consistency of the turnip and oats treatments can be seen in Figure 1.

The proportion of green material in the pre-graze forage samples ranged from 100% in turnips to only 30.7% in oats with barley intermediate at 55.7%.

Post-graze herbage yields

Residual herbage yields averaged over 10 cuts are presented in Table 5. High variability in post-graze yields is a factor of both sampling variability, and animal response to treatments imposed. Residuals in the barley (3.3% LW treatment) were higher than other high allowance barley treatments.

Turnips were estimated to contain 100% green material in both offered and refused samples. No green material was recovered from grazed oat samples and less than 6% from barley residuals where animals were fed the low herbage allowance (Table 6). The selection for green material in barley was evident by the larger amount of green material as the DM allowance increased.

Herbage allowances and apparent intakes

Herbage allowances of turnips and oats varied from 3.3 to 13.7 kg DM/h/d (Table 7) and were close to targeted allowances when expressed as a percentage of mean animal liveweight. However allowances of barley were higher than targeted due mainly to a greater than estimated growth of barley in August and the use of a cumulative yield value to calculate areas with the consequent over estimation of the grazing area required.

All herbage DM refusals increased with increasing allowance but because of a lack of green material in the refusals of oats, the quantity of green material refused was also zero.

Table 4. Mean herbage yields from the four pre-graze harvests (kg DM/ha). Individual harvest means are shown in Fig. 1.

	Yield (kg DM/ha)		
	Turnips	Oats	Barley
Mean	5449	6087	3222
CV %	12.5	17.5	32.6

Table 5. Post-graze herbage yields (kg DM/ha).

Allowance (% LW)	Forage Type					
	Turnips	(CV%)	Oats	(CV%)	Barley	(CV%)
1.8	253	101.0	1779	76.8	570	72.2
3.3	966	55.1	2845	41.3	2476	48.2
4.8	1789	26.8	3268	28.3	1843	46.2
6.3	2243	26.4	3879	21.7	2235	33.7

Table 6. Green matter in post-graze barley forage samples (%), 16 August.

Allowance (% LW)	% Green matter
1.8	5.7
3.3	33.6
4.8	34.3
6.3	43.7
Mean	29.3

Table 7. Herbage allowances and apparent intakes of cattle grazing winter forages.

	Turnips					Oats					Barley				
Allowance (% LW)	1.8	3.3	4.8	6.3	Mean	1.8	3.3	4.8	6.3	Mean	1.8	3.3	4.8	6.3	Mean
Allowance (kg DM/h/d)	3.3	6.8	10.2	13.7	8.5	3.5	6.6	9.8	13.0	8.2	3.8	7.6	11.4	14.9	9.4
Allowance (% of mean LW)	1.8	3.3	4.9	6.4	4.1	1.9	3.2	4.7	6.3	4.0	1.9	3.6	5.4	7.0	4.5
Allowance (green DM/h/d)	3.3	6.8	10.2	13.7	8.5	1.1	2.0	3.0	4.0	2.5	2.1	4.2	6.3	8.3	5.3
Refused (kg DM/h/d)	0.1	1.0	3.1	5.7	2.5	1.0	3.2	5.4	8.4	4.5	0.8	7.6	8.1	12.3	7.2
Refused (green DM/h/d)	0.1	1.0	3.1	5.7	2.5	0.0	0.0	0.0	0.0	0.0	0.0	2.6	2.8	5.4	2.7
Intake (kg DM/h/d)	3.2	5.8	7.1	8.0	6.0	2.5	3.4	4.4	4.7	3.7	3.0	0.0	3.2	2.6	2.2
Intake (% of mean LW)	1.7	2.8	3.4	3.7	2.9	1.3	1.7	2.1	2.2	1.8	1.5	-	1.5	1.2	-
Intake (green DM/h/d)	3.2	5.8	7.1	8.0	6.0	1.1	2.0	3.0	4.0	2.5	2.1	1.7	3.6	2.9	2.6
Utilisation Intake/Allowance (%)	96.7	85.3	69.6	58.4	70.5	71.4	51.5	44.9	36.1	45.1	78.9	-	28.0	17.4	-
Efficiency (kg DM consumed/kg LWG)	-	6.8	8.3	8.8	8.0	-	8.5	8.5	9.0	8.7	-	-	-	-	-

The quantities of feed consumed (apparent intake) increased with increasing allowance when expressed both on an absolute and percentage liveweight basis. However the mean intake of oats (3.7 kg DM/h/d) was substantially lower than turnips (6.0 kg DM/h/d) probably due to the lower levels of green material on the herbage offered.

Variability in yield assessment of barley resulted in variable estimates of apparent intake. While the high residual yield estimates in treatment 3.3% allowance may be implicated it is probable that pre-grazed herbage yields were also higher. Average pre-grazed yields were based on four cuts, each cut being derived from one allowance treatment. Cuts in the 3.3% allowance treatment were consistently higher than the other allowances, although further cutting would have been required to confirm this.

Calculation of feed intakes per unit liveweight increase showed that efficiencies (and utilisation) decreased with increased allowances.

Liveweights

Liveweights started at 196 kg and increased to 246 kg on the high turnip allowance (6.3% of LW) by 27 August (Table 8). The sudden increase in liveweight of the 1.8% barley treatment on 16 August is unexplained which, together with variable estimates of herbage intakes, suggests this weight be treated with caution.

Interim weight gains

Weight gains between 3 July and 5 August (N = 33 days) are presented for all forages in Table 9. This period enables the simultaneous comparison of all forages and allowances. For all forages increasing herbage allowance from 1.8% of liveweight to 3.3% of liveweight significantly ($P < 0.05$) increased liveweight gain with reduced response thereafter. The liveweight response to feed allowance showed significant linear and quadratic trends with a herbage allowance asymptote of approximately 3.3% of liveweight.

The reasons for the better weight gains of calves grazing barley is not clear. While the proportion of green material was higher than oats, intake data were variable and poorly correlated with liveweight performance.

Overall liveweight gains

Liveweight gains over the total grazing period of 55 days (3 July - 27 August) are presented in Table 10. Up until 5 August, the liveweight performance of cattle grazing oats and turnips was similar. Thereafter the weight gains of cattle grazing oats declined relative to cattle grazed on turnips. Poorer food quality as assessed by the proportion of green material and digestibility is suggested to account for this decline.

Liveweight gains increased rapidly from 1.8% to 3.3% herbage allowances ($P < 0.05$) but increased only slightly thereafter. The liveweight response to allowances were consistent for both forages. Expression of results on the fasted liveweight basis did not alter the relatively of response (Fig. 2).

Table 8. Effect of forage and herbage allowance on unadjusted cattle liveweights (kg).

	Allowance (kg DM/100 kg LW	3 July	12 July	24 July	5 Aug	16 Aug	27 Aug
Barley	1.8	195	202	199	201	222	-
	3.3	196	206	209	220	235	-
	4.8	196	208	212	224	242	-
	6.3	196	204	209	224	239	-
Oats	1.8	196	190	185	187	188	190
	3.3	196	199	198	205	208	218
	4.8	195	199	202	210	212	224
	6.3	197	203	204	207	212	225
Turnips	1.8	196	182	177	183	187	198
	3.3	196	187	190	206	221	243
	4.8	196	192	197	212	222	243
	6.3	196	197	199	215	226	246
LSD			11.6	12.5	12.7	13.8	15.1

Table 9. Effect of forage type and feed allowance on liveweight gains from 3 July to 5 August (kg/day).

	Herbage Allowance (kg DM/100 kg LW)				
	1.8	3.3	4.8	6.3	Mean
Turnips	-.409	.293	.465	.556	.226
Oats	-.273	.298	.439	.328	.198
Barley[1]	.172	.620	.800	.820	.603

$LSD_{(0.05)}$ = .187 for allowance means and .094 for forage means

[1] Adjusted to common allowances

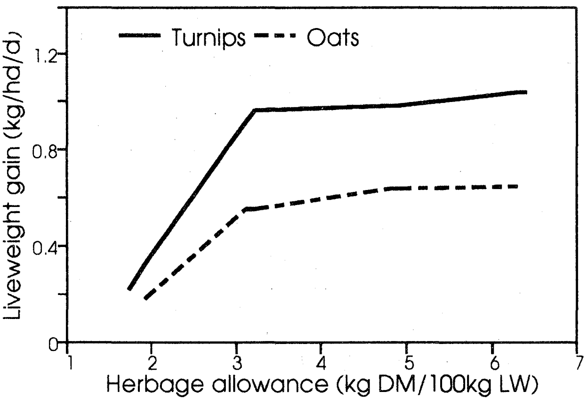

Figure 2. Fasted liveweight gains from 3 July to 27 August.

Discussion

The results indicate that maintenance of liveweight can be achieved at feeding levels of approximately 1.8% of liveweight for both turnips and oats and that over 0.8 kg/day can be achieved on a allowance of approximately 7 kg DM of turnips per day (3.3% of liveweight). The lower performance on oats was associated with lower green dry matter apparent intakes at all allowances.

Cultivar choice of the cereals, which was unfortunately dictated by seed availability at the time, had a major impact on liveweight performance results. Thus the inferior performance on oats and barley reported should not be extrapolated to those cereals in general. As the results of the cultivar evaluation trials in Part I of this paper show, disease reaction and winter

Table 10. Effect of forage type and feed allowance on liveweight gains from 3 July to 27 August (kg/day).

	Herbage Allowance (kg DM/100 kg LW)			
	1.8	3.3	4.8	6.3
Forage				
Turnips	.027	.848	.855	.903
Oats	-.097	.400	.518	.518
Barley[1]	-	-	-	-

$LSD_{(0.05)}$ = .155

hardiness determine both quantity and quality of supplementary forage.

Additionally, trial design constraints meant that barley was compared at a temporal disadvantage. It could be inferred that Illia barley may have produced a higher yield of high quality forage if it had been sown later in the autumn (when normally sown for grain production) to avoid rust infection.

Notwithstanding these limitations, the following conclusions are drawn from this grazing study:

- Good estimates of liveweight/feed allowance relationships were obtained with turnips and they provide a useful data base. Maintenance of liveweight was achieved with the allowance of 3.3 kg DM/h/d (1.8% of liveweight) with over 0.8 kg LWG/d being achieved with allowances over 6 kg DM/day. Optimum liveweight gains occurred with an allowance of 3.3% of liveweight (6.8 kg DM/h/d) little response occurring thereafter. Turnips proved a valuable sole source of winter feed with 100% being assessed as green material.

- Similar liveweight/allowance relationships in oats were established, but with material which was badly frosted and affected to a limited extent by fungal pathogens. The proportion of green material in the herbage offered was only 30% hence intake of green forage and liveweight performance was considerably lower than with turnips.

  Different sowing dates would be required to enable comparison of forages at a similar stage of maturity. Alternatively, forages could be compared at different growth phases using early and mid winter performance evaluations.

- Estimates of animal performance on barley treatments should be treated with caution. The effect of rust on barley growth rate was substantial with yields averaging only 3222 kg DM/ha compared with 6087 kg DM/ha for oats. However the delayed growth resulted in higher contents of green material with substantially improved liveweight gains. During the last weight period for the barley treatments (5-16 August) maintenance animals (1.8% of LW) gained weight at a similar rate to higher allowance treatments. No measurable explanation for the divergence from previous performance is available.

Estimates of barley refusals were variable resulting in zero intake values in some treatments which lends further support to the inconsistency of forage/animal response with barley.

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