

Scotland's Rural College

## **The effect of kale cultivar and sowing date on dry matter intake, crop utilization, liveweight gain and body condition score gain of pregnant, non-lactating dry dairy cows in winter in New Zealand**

Cheng, L.; Groves, CD; de Ruiter, JM; Dewhurst, RJ; Edwards, GR

*Published in:*  
Grass and Forage Science

*DOI:*  
[10.1111/gfs.12371](https://doi.org/10.1111/gfs.12371)

First published: 02/07/2018

*Document Version*  
Peer reviewed version

[Link to publication](#)

### *Citation for published version (APA):*

Cheng, L., Groves, CD., de Ruiter, JM., Dewhurst, RJ., & Edwards, GR. (2018). The effect of kale cultivar and sowing date on dry matter intake, crop utilization, liveweight gain and body condition score gain of pregnant, non-lactating dry dairy cows in winter in New Zealand. *Grass and Forage Science*, 73(4), 979 - 985. <https://doi.org/10.1111/gfs.12371>

### **General rights**

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal ?

### **Take down policy**

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

# RESEARCH NOTE

**The effect of kale cultivar and sowing date on dry matter intake, crop utilization, liveweight gain and body condition score gain of pregnant, non-lactating dry dairy cows in winter in New Zealand**

**Short title: Utilization of kale by dry cows**

**L. Cheng\*, C. D. Groves†, J. M. de Ruiter‡, R. J. Dewhurst¶ and G. R. Edwards†**

\*Faculty of Veterinary and Agricultural Sciences, Dookie Campus, 3647, The University of Melbourne, Australia.

†Faculty of Agriculture & Life Sciences, Lincoln University, P.O. Box 85084, Canterbury, New Zealand.

‡The New Zealand Institute for Plant and Food Research Limited, Private Bag 4704, Christchurch 8140, New Zealand.

¶Scotland's Rural College, King's Buildings, West Mains Road, Edinburgh EH9 3JG, United Kingdom.

*Correspondence to:* Long Cheng, Faculty of Veterinary and Agricultural Sciences, Dookie Campus, 3647, The University of Melbourne, Australia. Grant Edwards, Faculty of Agriculture & Life Sciences, Lincoln University, P.O. Box 85084, Canterbury, New Zealand. Email: long.cheng@unimelb.edu.au; grant.edwards@lincoln.ac.nz

## Acknowledgements

Dr Innocent Rugoho, Dr Tom Maxwell and Dr Ao Chen (Lincoln University, New Zealand), Dr Glenn Judson (Agricom, New Zealand), Ms Jiawen Li (Chengdu University of Information Technology, China) and Ms Chloe Charlot (AgroParisTech, France) are thanked for useful discussion. Thanks also to Mr Alan Marshall (Lincoln University, New Zealand) for help with sampling.

## Abstract

An outdoor grazing study on kale was conducted with pregnant, non-lactating (dry) dairy cows over a 42-day winter grazing period commencing 9 June 2008. Kale treatments consisted of two kale cultivars varying in leaf:stem proportion ('Regal', a leafy variety and 'Caledonian', a stemmy variety) and two sowing dates (8 November and 15 December). Measurements were made for dry matter (DM) utilization, apparent DM intake, liveweight

1 gain, and changes in body condition score (BCS) for a total of 120 cows allocated to three  
2 replicate groups of the four factorial treatments. Cows were offered a daily allowance of 10  
3 kg DM/cow of kale and 2.2 kg DM/cow of straw. Pre-grazing DM yield was higher for kale  
4 sown in November (16517 kg DM/ha) than December (13867 kg DM/ha), but was unaffected  
5 by cultivar (average 15192 kg DM/ha). ‘Regal’ kale had a higher percentage of leaf  
6 compared to ‘Caledonian’ (33.6 vs 25.6 %), lower content of NDF (32.4 vs 34.1 %), but  
7 similar metabolizable energy content (12.1 MJ/kg DM for both) in the whole plant. Despite  
8 the differences in pre-grazing DM yield and forage quality among treatments, no differences  
9 were found in DM utilization (between 88.5 and 90.2 %), apparent DM intake (between 9.4  
10 and 9.6 kg DM/cow.day), liveweight gain (between 0.53 and 0.67 kg/cow.day), and BCS gain  
11 (between 0.43 and 0.46 unit/cow over 42 days). Manipulation of kale yield and quality  
12 through choice of cultivar and sowing date had no effect on the performance of pregnant,  
13 non-lactating dairy cows.

14 **Keywords:** brassica, utilization, metabolisable energy, leaf and stem ratio, winter forage

## 15 1. INTRODUCTION

16 In New Zealand (NZ), dairy cow production is often managed under a spring calving system.  
17 Farmers generally aim to dry-off their pregnant cows at a body condition score (BCS) of 4.5  
18 (1-10 NZ scale; Roche *et al.*, 2009) in autumn and allow the animals to gain 0.5 BCS unit  
19 during a six-week period by feeding winter forage. Brassica crops are increasingly used to  
20 feed dairy cattle in the autumn/winter period in NZ to fill the pasture feed gap (Cheng *et al.*,  
21 2016; Rogoho *et al.*, 2010). Kale (*Brassica oleracea* L.) is a common autumn/winter  
22 brassica forage offered to dry cows in southern NZ (Greenwood *et al.*, 2011). Kale produces  
23 a high standing dry matter (DM) yield and nutritional value appropriate for animal condition  
24 gain, when other winter forage species such as annual or perennial ryegrass (*Lolium*  
25 *multiflorum* and *L. perenne* L.) are in short supply (Brown *et al.*, 2007; Gowers &  
26 Armstrong 1994). Traditionally, kale is sown between October and December in NZ to allow  
27 at least five months growth before it is strip harvested/grazed by dry cows. Early sowing of  
28 kale generally results in a higher DM yield, due to increased exposure to thermal duration and  
29 accumulated solar radiation (Brown *et al.*, 2007; Wilson *et al.*, 2004). However, the earlier  
30 sowing may mean the crop is more mature when it is grazed by dry cows and thus have a  
31 reduced quality (Fraser *et al.*, 2001) and potentially lower dry cow performance. The  
32 potential kale yield and quality trade off from early sowing may be offset by selection of kale

1 varieties with higher leaf to stem ratio, and with leaves being more digestible with more  
2 crude protein than in the stems (Judson & Edwards 2008, Rugoho *et al.*, 2010). There have  
3 been few published studies on the effect of different kale cultivars and different sowing dates  
4 on yield and quality, and on dry cow performance. Therefore, the objective of this study was  
5 to investigate the yield and quality difference between sowing date and cultivar treatments of  
6 kale, and to examine the utilization by grazing animals, liveweight (LW) gain and BCS gain  
7 responses over the winter grazing period.

## 8 **2. MATERIALS AND METHODS**

### 9 **2.1 Experimental design and site management**

10 This study was undertaken at Lincoln University Field Service Centre, Canterbury, NZ  
11 (43°38'S, 172°27'E; 15 m.a.s.l), under approval from the Lincoln University Animal Ethics  
12 Committee. The soil at the experimental site is Wakanui silt loam (recent yellow earth,  
13 gleyed). The trial was a randomized complete block design (12 plots) with two cultivars  
14 (leafy 'Regal' (LR) and stemmy 'Caledonian'(SC)) and two sowing dates (8 November 2007  
15 (NOV) and 15 December 2007 (DEC)), replicated three times. Plots 1 - 4 consisted of two 15  
16 m × 125 m strips/plot; plots 5 - 12 were one 15 m × 175 m and one 15 m × 87.5 m strip/plot.  
17 The site was prepared by conventional ploughing and rolling (Dutch harrow). Fertilization  
18 was as follows: 760 kg/ha of super-phosphate (9% P, 11% S and 20% Ca) was applied prior  
19 to sowing to all plots on 5 November 2007. Nitrogen fertilizer (urea) was applied to early  
20 sown plots on 5 November 2007 (50 kg N/ha), 22 January 2008 (50 kg N/ha) and 27  
21 February 2008 (50 kg N/ha), and to late sown plots on 22 January 2008 (50 kg N/ha) and 27  
22 February 2008 (50 kg N/ha). Kale was sown using a Fiona Drill in 15 cm rows at 4 kg/ha. All  
23 plots were irrigated in a single monthly application of 25 mm (11 November 2007 to the  
24 following year 28 March 2008) using a travelling irrigator. Monthly rainfall was consistent  
25 over this period at 55 ± 5 mm per month (Broadfields meteorological station, Lincoln,  
26 Canterbury, NZ).

### 27 **2.2 Pre-grazing measurements**

28 Pre-grazing yield of kale was measured by cutting to ground level. Three randomly  
29 positioned 1 m<sup>2</sup> quadrats per plot were taken at weekly intervals between 9 June and 14 July  
30 2008 during grazing. Total quadrat fresh weight (FW) was measured in the field, and a sub-  
31 sample of three random plants from each quadrat were processed for leaf and stem FW, then  
32 oven-dried at 65 °C to a constant weight to calculate DM% and the leaf to stem ratio (DW

1 basis). Leaf and stem samples were ground and scanned for quality by near-infrared  
2 spectroscopy (NIRS; Model: FOSS NIRSystems 5000, Maryland, USA). The NIRS  
3 calibrations for nitrogen (Variomax CN Analyser; Elementar), water soluble carbohydrates  
4 (WSC; MAFF, 1986), neutral detergent fibre (NDF; van Soest, 1991), and *in vitro* digestible  
5 organic matter content (Jones and Hayward, 1975) were derived from historical kale wet  
6 chemistry and NIRS calibration. R-squares for predictions were 0.98, 0.98, 0.99, and 0.97,  
7 respectively indicating a high level of accuracy. Metabolizable energy (ME) was calculated:  
8  $ME \text{ (MJ/kg DM)} = \text{NIRS digestible organic matter content (g/kg DM)} \times 0.016$  (McDonald *et*  
9 *al.*, 2011).

10 At the 30 June 2008 sampling, a sub-sample of one plant from each quadrat was  
11 separated into leaf and stem. The stem was then cut into four equal sections from the top to  
12 the bottom. The fractions were oven-dried at 65 °C to a constant weight to determine DM%  
13 before grinding and prediction of quality by NIRS.

### 14 **2.3 Post-grazing measurements**

15 The sampling method for post-grazing yield (9 June and 14 July 2008) was the same as for  
16 pre-grazing sampling, except that measurements were taken three times per week and the  
17 number of quadrats increased to three per plot. All plant material was recovered including the  
18 residual leaf and stem fractions on the soil surface and embedded in soil to a depth of 10 cm.  
19 Excess soil was washed from plant material and quadrat plant fresh weight was recorded then  
20 oven-dried at 65°C to a constant weight to determine DM %.

### 21 **2.4 Kale yield calculation, dry cow management and measurements**

22 On 2 June 2008, 120 dry cows were blocked according to their BCS ( $4.44 \pm 0.14$ ; 0-10 NZ  
23 scale) and LW ( $549 \pm 46$  kg), and then randomly assigned to one of the 12 plots (10 cows per  
24 plot). In order to avoid risk of nitrate poisoning, all dry cows were adapted gradually to the  
25 kale over a period of seven days (2 June to 8 June 2008), with full allocation given on 9 June.  
26 At 08:00 h daily, all dry cows were offered 2.2 kg DM/cow/day straw at 7 MJ ME/kg DM  
27 and 0.8% nitrogen (on DM basis) as determined by NIRS. Utilization of straw was assumed  
28 to be 90%. Kale was offered in a single daily break at 09:00 h with a target intake of 10 kg  
29 DM/cow/day achieved by daily adjustment of break width according to prior DM yield  
30 assessment. Each plot was allocated over a 14.5 m face length with break widths of  $4.6 \pm$   
31  $0.91$  m,  $5.2 \pm 0.69$  m,  $4.9 \pm 0.88$  m, and  $6.0 \pm 0.95$  m for the respective dietary treatment  
32 SC+NOV, SC+DEC, LR+NOV, and LR+DEC, respectively. Daily kale break width for each

1 plot was determined by daily kale allowance, DM yield of kale measured from the previous  
2 week, and an assumption of 75% kale utilization. The following equations were then used to  
3 calculate DM yield, DM utilization, and apparent DM intake:

4 Pre-grazing DM yield (kg DM/ha) = average pre-grazing DM yield per 1 m<sup>2</sup> quadrat  
5 (kg DM/m<sup>2</sup>) × 10000 (m<sup>2</sup>/ha)

6 Post-grazing residual DM yield (kg DM/ha) = average post-grazing DM yield per 1  
7 m<sup>2</sup> quadrat (kg DM/m<sup>2</sup>) × 10000 (m<sup>2</sup>/ha)

8 Kale DM utilization (%) = [pre-grazing DM yield (kg DM/ha) - post-grazing DM  
9 yield (kg DM/ha)] ÷ pre-grazing DM yield (kg DM/ha) × 100

10 Apparent DM intake (aDMI; kg/cow.day) of kale = [pre-grazing DM yield (kg  
11 DM/ha) - post-grazing DM yield (kg DM/ha)] per 1 m<sup>2</sup> quadrat (kg DM/m<sup>2</sup>) × break  
12 width (m/day) × break length (m/day) × kale DM utilization (%) ÷ 10 (number of dry  
13 cows/break).

14 All dry cows were weighed at the beginning (9 June 2008) and the end (21 July 2008)  
15 of the six-week grazing period. At the same time, BCS was assessed by two experienced  
16 technicians using the 1-10 NZ scale; the average BCS per cow was then used for statistical  
17 analysis.

## 18 **2.5 Statistical analysis**

19 Data were analysed using GenStat (Version 14, VSN International Ltd, Hemel Hempstead,  
20 UK). Whole plant quality was calculated from the weighted leaf and stem fractions based on  
21 measured leaf to stem ratio (DM basis). Repeated measurements was conducted for pre-and  
22 post-grazing DM yield, kale DM utilization, and leaf to stem ratio with “three replicates” as  
23 block and “sowing date × cultivar” as treatment and “sampling date” as variable. General  
24 ANOVA was conducted for the quality change of five sections of kale plants with “three  
25 replicates” as block and “sowing date × cultivar × five sections” as treatment. General  
26 ANOVA was also conducted for whole plant quality, dry cow intake, changes of LW and  
27 BCS with “three replicates” as block and “sowing date × cultivar” as treatment.

## 28 **3. RESULTS**

### 29 **3.1 Pre- and post-grazing dry matter yield and utilization**

30 Pre-grazing forage yield ranged between 12,500 and 18,500 kg DM/ha, and post-grazing  
31 forage yield was between 800 and 2,600 kg DM/ha (Figure 1). No difference was found  
32 between cultivars for both pre- and post-grazing yield (Figure 1A and C), apart from a higher

1 pre-grazing DM yield observed for SC than for LR in the last two measurement weeks  
2 (Figure 1A). A higher pre-grazing yield was observed for NOV kale compared with DEC  
3 kale (Figure 1B). On the 9 June, 23 June, and 30 June 2008, the NOV kale had 35, 56 and  
4 84% higher post-grazing yield than DEC kale, respectively (Figure 1D). The average DM  
5 utilization of kale crops were 89.2, 89.5, 88.5 and 90.2 % of pre-grazing DM yield for LR,  
6 SC, NOV, and DEC, respectively, with no difference detected among treatment groups.

### 7 **3.2 Kale quality**

8 More than 25% of the total kale DM yield came from leaf and the rest was almost equally  
9 distributed between the four stem sections (Table 1). The cultivar ‘Regal’ had a higher  
10 percentage of leaf (33.6%) than ‘Caledonian’ (25.6 %), ‘Regal’ had lower NDF (32.4 vs 34.1  
11 %), but similar ME content (12.1 vs 12.1 MJ/kg DM) in the whole plant compared to  
12 ‘Caledonian’. There was no difference in the ME content of the kale in the sowing date ×  
13 cultivar treatments. Nitrogen content was significantly different ( $p < 0.001$ ) between sowing  
14 dates. The DEC treatment had N content that was 24% higher than the NOV treatment (Table  
15 1). Across all treatments, ME and N contents were lower in the stem sections than in the leaf.  
16 On the other hand, NDF content was higher in the stem sections compared with the leaf  
17 (Table 1).

### 18 **3.3 Apparent dry matter intake, body condition score gain, and liveweight gain**

19 There was no difference aDMI of kale, LW gain, BCS gain, and ME intake for cows in the  
20 kale cultivar or sowing date treatments (Table 2).

21

22 [Insert Table 1, 2 and Figure 1 here]

## 23 **4. DISCUSSION**

### 24 **4.1 Pre- and post-grazing yield**

25 Higher yield of kale was achieved for early sowing (NOV) compared with late sowing  
26 (DEC). The extended growing season and earlier canopy closure of the NOV sown crop  
27 contributed to the growth advantage driven by higher thermal time exposure and higher  
28 integral of daily solar radiation interception by the canopy (Brown *et al.*, 2007; Wilson *et al.*,  
29 2004). There was a large variation in post-grazing yield (800 to 2600 kg DM/ha) across the  
30 treatments. There were a number of explanations for this such as temporal cow adaptation to  
31 biomass on offer, variation in the estimated biomass on offer within and across the

1 experimental area, and the impact of weather related events. The lowest residual was  
2 observed in the last week of June when a snow event with accompanying low ambient  
3 temperatures (average daily temperature was 2°C and absolute minimum of -4°C). Cows are  
4 known to increase their intake to match their increased ME maintenance requirement (Nicol  
5 & Young, 1981 and Nicol & Brookes 2007) during periods of cold stress. In addition, the  
6 snow caused a loss in efficiency of residue recovery, as there was a higher proportion of plant  
7 material buried in the soil and not recovered. There was high level of DM utilization with a  
8 consistent amount of residual material in the four treatments. The DM utilization achieved in  
9 this study was comparable to the utilization results obtained in 49 kale paddocks grazed by  
10 dairy cows in Canterbury (Judson & Edwards 2008), which had an average utilization of 80%  
11 of the pre-grazing DM standing biomass.

## 12 **4.2 Crop quality**

13 The leaf fraction represented between 25 and 34% of the total kale plant DM yield. This was  
14 lower than the average of 38.4% reported by Gowers & Armstrong (1994), but within the  
15 range (24 to 44%) reported by Judson & Edwards (2008). Leaf had the highest N content,  
16 lowest NDF% and lowest WSC% (on DM basis). The ME content for all treatments  
17 decreased from leaf to the lower stem, and with the lower three sections (upper mid, lower  
18 mid and lower stem). The lower three sections of LR had a higher ME content than SC,  
19 similar to the observation made by Judson & Edwards (2008). The LR contained less NDF in  
20 the lower three sections of the plants compared with SC, and this decrease in NDF of LR  
21 corresponded with an increased digestibility and consequently higher ME (CSIRO, 2007).  
22 Fraser *et al.* (2001) suggested that early sowing may cause a loss in the quality of the whole  
23 crop through ageing and progressive lignification. Lower N content of the NOV compared  
24 with DEC kale in the current study supported the observation of a general decline in quality  
25 with earlier sowing, but there was no difference in the NDF or ME values in the respective  
26 sowing date treatments.

## 27 **4.3 Intake, body condition gain, and live weight gain**

28 Over the six-week feeding period, the average LW gain across all treatments was 25 kg  
29 (range 22.3-28.0 kg), which was within the range of reported values by Keogh *et al.* (2009a  
30 & 2009b) and Greenwood *et al.* (2011). The metabolic energy value of feed during the winter  
31 grazing period is important for adding to animal body condition and values in excess of 11.5  
32 MJ ME/kg appear to be effective in achieving the gain in BCS. In our study, the cow body



1 condition gain over six weeks was 0.44 (range 0.43–0.46) across all treatments, and this was  
2 higher than previously reported (0.23 over eight weeks feeding period from Greenwood *et al.*,  
3 2011) for non-lactating cows fed around 10 kg DM of kale/cow.day The mean crop quality  
4 was high at (~ 12 ME MJ/kg DM) in our study in comparison with the average reported (~  
5 11.5 ME MJ/kg DM) by Judson & Edwards (2008) and Greenwood *et al.* (2011).

6 There was no difference in total aDMI (kale + straw) and ME intake. These are likely  
7 to be the valid reasons for the lack of difference in LW gain and BCS gain across treatments.  
8 It is important to note that the target of 0.5 body condition gain was not achieved in the  
9 current study, although the calculated ME intake (kale + straw) in Table 2 (~ 130 MJ  
10 ME/cow.day) was higher than the recommended 115 MJ ME/cow.day (Nicol & Brooks  
11 2007) for optimum performance. Greenwood *et al.* (2011) also observed that cows did not  
12 achieve 0.5 body condition gain despite an adequate intake of ME. This may have been due  
13 to an underestimation of the maintenance ME requirement for the dry cows. Mandok *et al.*  
14 (2013) conducted a study to estimate the maintenance cost of 52 non-lactating, pregnant dairy  
15 cows in NZ. This showed a daily maintenance requirement of 0.94 MJ ME/kg LWT<sup>0.75</sup> rather  
16 than the 0.55 MJ ME/kg LWT<sup>0.75</sup> from Nicol & Brooks (2007), which has been widely used  
17 for estimating the intake requirements of pregnant, non-lactating pregnant cows. Further  
18 research is needed to determine the reasons for this higher ME requirement for body  
19 condition gain. Factors such as animal size, the extent of energy loss/increment as heat and  
20 anti-nutritional components in feeds are important for optimizing allocation and decision on  
21 animal management. Management of grazing in the trial was designed to replicate a  
22 commercial wintering operation in Canterbury, NZ where large scale single grazing of kale is  
23 common practice. It is important to note the limitations of this grazing study: it was only  
24 conducted for a period of 42 days, in one year and on a single site. From our study, it appears  
25 that options are limited for improving the quality of kale through cultivar selection or timely  
26 sowing of the crop, and it has less influence than management of the grazing process itself.  
27 Future studies should verify the crop and animal interactions over longer period, multiple  
28 sites and seasons.

## 29 **5. CONCLUSIONS**

30 Early sowing of kale (November) increased the pre-grazing DM yield, but led to lower plant  
31 quality (i.e. N content). A leafy kale cultivar ‘Regal’ contained less NDF compared with a  
32 stemmy cultivar ‘Caledonian’. Under the feeding conditions in the trial, the ME intake was

1 similar across four treatments and no treatment differences (cultivar choice or sowing time)  
2 were found for BCS or LW gain over the winter grazing period. Future studies should verify  
3 the crop and animal interactions over longer period, multiple sites and seasons.

## 5 **References**

6 BROWN H.E., MALEY S. and WILSON D.R. (2007) Investigations of alternative kale  
7 management: Production, regrowth and quality from different sowing and defoliation  
8 dates. *Proceedings of the New Zealand Grassland Association* **69**, 29-33.

9 CHENG L., MCCORMICK J., LOGAN C., HAGUE H., HODGE M.C. and EDWARDS  
10 G.R. (2016) Liveweight gain and urinary nitrogen excretion of dairy heifers grazing  
11 perennial ryegrass-white clover pasture, canola, and wheat. *Animal Production*  
12 *Science* **54**, 1651-1656.

13 CSIRO (2007) *Nutrient requirements of domesticated ruminants*. (Eds M Freer, H Dove, JV  
14 Nolan) pp.1-69. (CSIRO publishing, Australia).

15 FRASER M.D., WINTERS A., FYCHAN R., DAVIES D.R. and JONES R. (2001) The  
16 effect of harvest date and inoculation on the yield, fermentation characteristics and  
17 feeding value of kale silage. *Grass and Forage Science* **56**, 151- 161.

18 GOWERS S. and ARMSTRONG S.D. (1994) A comparison of the yield and utilisation of six  
19 kale cultivars. *New Zealand Journal of Agricultural Research* **37**, 481-485.

20 GREENWOOD S.L., DALLEY D.E., PURDIE N.G., RUGOHO I., BRYANT R.H. and  
21 EDWARDS G.R. (2011) Comparison of the performance of dairy cows offered energy  
22 supplements prior to drying off and kale at high and low allowance during the dry  
23 period in winter. *Proceedings of the New Zealand Society of Animal Production* **71**,  
24 33-36.

25 JUDSON H.G. and EDWARDS G.R. (2008) Survey of management practices of dairy cows  
26 grazing kale in Canterbury. *Proceedings of the New Zealand Grassland Association*  
27 **70**, 249-254.

28 KEOGH B., FRENCH P., MCGRATH T., STOREY T. and MULLIGAN F.J. (2009a)  
29 Comparison of the performance of dairy cows offered kale, swedes and perennial  
30 ryegrass herbage in situ and perennial ryegrass silage fed indoors in late pregnancy  
31 during winter in Ireland. *Grass and Forage Science* **64**, 49-56.

- 1   KEOGH B., FRENCH P., MCGRATH T., STOREY T. and MULLIGAN F.J. (2009b) Effect  
2       of three forages and two forage allowances offered to pregnant dry dairy cows in  
3       winter on periparturient performance and milk yield in early lactation. *Grass and*  
4       *Forage Science* **64**, 292-303.
- 5   MANDOK K.S., KAY J.K., GREENWOOD S.L., EDWARDS G.R. and ROCHE J.R. (2013)  
6       Requirements for zero energy balance of nonlactating, pregnant dairy cows fed fresh  
7       autumn pasture are greater than currently estimated. *Journal of Dairy Science* **96**,  
8       4070-4076.
- 9   MCDONALD P., EDWARDS R.A., GREENHALGH J.F.D., MORGAN C.A., SINCLAIR  
10      L.A. and WILKINSON R.G. (2011) Predicting the energy value of foods. In: *Animal*  
11      *Nutrition*. 7th edn. pp 299, London, UK: Prentice-Hall.
- 12   NICOL A.M. and YOUNG B.A. (1981) The heat of warming feed. *Proceedings of the New*  
13      *Zealand Society of Animal Production* **41**, 152-162.
- 14   NICOL A.M. and BROOKES I.M. (2007) The metabolisable energy requirements of grazing  
15      livestock. In: P.V. Rattray, I.M. Brookes, A.M. Nicol (eds) *Pasture and supplements*  
16      *for grazing animals*. pp. 151-172. New Zealand Society of Animal Production  
17      Occasional Publication No.14: New Zealand.
- 18   ROCHE J.R., FRIGGENS N.C., KAY J.K., FISHER M.W., STAFFORD K.J. and BERRY  
19      D.P. (2009) Invited review: Body condition score and its association with dairy cow  
20      productivity, health and welfare. *Journal of Dairy Science* **92**, 5769-5601.
- 21   RUGOHO I., GIBBS S.J., BRYANT R.H. and EDWARDS G.R. (2010) Intake and feeding  
22      behaviour of dairy cows grazing kale and grass at low and high allowances during  
23      winter. *Proceedings of the 4<sup>th</sup> Australasian Dairy Science Symposium* pp. 317-320.
- 24   WILSON D.R., ZYSKOWSKI R.F., MALEY S. and PEARSON A.J. (2004) A potential  
25      yield model for forage brassicas. *Proceedings of the 4<sup>th</sup> International Crop Science*  
26      *Conference* p 1087.
- 27

1

2 **Figure 1.** Pre-grazing yield (**A**) and (**B**), and post-grazing yield (**C**) and (**D**) of kale from two  
3 cultivars (**A**) and (**C**), and sowing dates (**B**) and (**D**) (• represents Regal ° represents  
4 Caledonia ▲ represents November sowing △ represents December sowing) offered to non-  
5 lactating, pregnant dry dairy cows. Error bar = SEM

**Table 1** Chemical composition (DM basis) of five fractions of pre-grazing kale for two sowing dates and two cultivars

	Five sections	% of total DM	Metabolisable energy (MJ/kg DM)	Nitrogen (% of DM)	Neutral detergent fibre (% of DM)	Water soluble carbohydrate (% of DM)
<b>Sowing date</b>						
November	Leaf	27.4	13.0	3.7	25.2	16.4
	Upper	17.7	13.8	2.3	27.8	45.0
	Upper mid	18.1	12.2	1.7	37.3	43.7
	Lower mid	18.5	10.3	1.3	47.7	39.2
	Lower	18.4	10.5	1.2	45.7	38.6
December	Leaf	31.8	12.6	4.0	26.0	13.8
	Upper	16.6	13.9	2.7	27.6	42.8
	Upper mid	16.9	12.8	2.2	35.0	40.6
	Lower mid	17.3	11.0	1.5	44.4	39.6
	Lower	17.5	9.6	1.4	51.6	35.5
<b>Cultivar</b>						
Caledonia	Leaf	25.6	12.8	3.9	24.8	15.1
	Upper	18.1	13.9	2.4	27.6	45.3
	Upper mid	18.5	12.3	1.9	38.1	40.0
	Lower mid	18.9	10.3	1.4	48.1	39.7
	Lower	19.0	9.4	1.3	52.9	36.0
Regal	Leaf	33.6	12.8	3.8	26.5	15.2
	Upper	16.2	13.8	2.6	27.8	42.5
	Upper mid	16.5	12.7	1.9	34.2	44.4
	Lower mid	16.8	11.0	1.5	44.0	39.0
	Lower	16.9	10.7	1.3	44.4	38.0
Significance (sowing date)		NS	NS	***	NS	NS
SED (sowing date)		0.25	0.12	0.07	0.84	1.05
Significance (cultivar)		NS	***	NS	***	NS
SED (cultivar)		0.25	0.12	0.07	0.84	1.05
Significance (five sections)		***	***	***	***	***
SED (five sections)		0.40	0.19	0.12	1.32	1.67
Significance (sowing date × cultivar)		NS	NS	NS	NS	NS
Significance (sowing date × five sections)		***	**	NS	*	NS
Significance (cultivar × five sections)		***	**	NS	**	NS
Significance (sowing date × cultivar × five sections)		*	NS	NS	NS	NS

NS-not significant; \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

**Table 2** Dry matter intake, liveweight gain, body condition gain, and metabolizable energy intake of pregnant, non-lactating dry dairy cows fed kale sown at two sowing dates and with different leaf to stem ratio

	Dry matter intake of kale (kg/cow.day)	Total dry matter intake (kg/cow.day)	Liveweight gain (kg/six weeks)	Body condition gain (unit/six weeks)	Metabolizable energy intake (kale + straw; MJ/cow.day)
<b>Sowing date</b>					
November	9.4	11.4	24.7	0.45	128.4
December	9.6	11.6	25.5	0.43	130.5
<b>Cultivar</b>					
Caledonia	9.6	11.6	28.0	0.43	129.3
Regal	9.5	11.5	22.3	0.46	129.6
Significance (sowing date)	NS	NS	NS	NS	NS
SED (sowing date)	0.19	0.19	3.19	0.021	1.95
Significance (cultivar)	NS	NS	NS	NS	NS
SED (cultivar)	0.19	0.19	3.19	0.021	1.95
Significance (sowing date × cultivar)	NS	NS	NS	NS	NS
SED (sowing date × cultivar)	0.27	0.27	4.51	0.03	2.76

NS-not significant; \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

