Whole-crop cereals for grazing and silage: balancing quality and quantity

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Abstract

There has been a marked increase in the use of cereals for supplementary grazing and silage for the developing dairy industry in the South Island. Cereals provide high energy supplement in autumn/winter or can be used as a high fibre source in spring. Variation in yield potential in cultivar trials in Canterbury was assessed for autumn and spring-sown crops. The aim was to produce high quality cereal feeds with good yield potential by examining the variation among species and cultivar selections in well managed trials. Single-bite crops sown in early autumn in Canterbury provide up to 5.5 t/ha herbage DM yield with at least 17.5 % protein, 12% total soluble carbohydrate including starch (TSC) and metabolisable energy (ME) of 11.3 MJ/kg in mid-June. Multiple graze types (eg. Doubletake triticale) with similar winter productivity and quality to single-bite crops produced an additional 13.5 t/ha biomass for a silage crop. At ensiling, this cultivar had 9.3 MJ/kg ME with mean 19.5% total soluble carbohydrates. Spring-sown cereals for silage produced up to 20 t/ha. Harvest timing was a significant factor in the wide range in quality of herbage for ensiling. Cultivar means ranged from 7.0 - 12.8% DM for protein, 8.7- 31.6% DM for TSC and 8.3-10.5 MJ/kg DM for ME. More mature herbage had reduced organic matter digestibility and higher TSC but reduced ensilability at DM content in excess of 40%.

Keywords: dairying, fibre, forage, herbage quality, metabolisable energy, near infrared reflectance spectroscopy, supplements

Introduction

Dairy animal requirements for supplementary feeds are strongly dependent on the production targets for stage of lactation or to enhance growth rate. Higher milk prices and opportunities to increase per cow production have resulted in increased supplement use in Southern regions of New Zealand (Platfoot & Stevens 2002). The timely use of whole-crop cereals, may provide balanced feed at times particularly when demand for energy is high and the requirement by animals for protein is reduced (Hogg *et al*. 2002). Suboptimal protein intake for lactation is rare under well-managed pasture although benefits may accrue from elevated herbage protein during winter grazing. Energy limitations for lactation can occur when pasture quality is low (Kolver 2000) during summer dry periods (Barker *et al.* 1998; Thom *et al*. 1998). Cereals provide flexible options for use as a grazed herbage with good protein composition for extending autumn lactation (Robinson *et al.* 1998), for winter feeding (Eagles *et al*. 1979; Hughes & Haslemore 1984) or for high energy silage supplement during mid-lactation (Platfoot & Stevens 2002). Cereal cultivars with improved yield and disease resistance (W. Griffin pers. comm.) and low production costs (Platfoot & Stevens 2002) make them an attractive alternative to maize, brassicas or legumes (Douglas *et al.* 1998; Harris *et al*. 1998; Niezen *et al.* 1998).

There are variable reports of yield ranges and the nutritive value of standing herbage and silage made for whole crop cereals. Therefore, in this paper we aim to define these characteristics and establish performance ranges that can be achieved through crop selection, crop breeding, choice of sowing date and with good fertiliser and irrigation management. Yield and quality changes during crop development were used as criteria for fitting cereal supplements with desired nutritional benefits into grass-based production systems.

Methods

All autumn and spring cereal trials were sown at Lincoln New Zealand (Lat. 43°39'S; Long. 173°30'E), on a Templeton silt loam (Typic Ustochrept, USDA soil taxonomy) in the period from 1999 to 2002. Plots were sown with an Oyjord plot drill in 12 m x 1.35 m, 9-row plots and 15 cm spacing between rows.

All yield calculations were based on dry matter content of whole plants (cut 2.5 cm above ground level) by drying in a forced draught oven at 80°C for 24 hours. Samples for quality (total soluble carbohydrate including starch (TSC), protein, neutral detergent fibre (NDF), acid detergent fibre (ADF), organic matter digestibility (OMD) and metabolisable energy (ME)) were frozen immediately after sampling, then freeze-dried and ground to pass a 1 mm screen for analysis by near infrared reflectance spectroscopy (feedTECH, AgResearch) using standard calibrations for whole-crop cereals.

Single-graze autumn-sown trials

Trials comprising 15 new Crop & Food forage oat (*Avena sativa* L.) selections were sown in randomised complete block designs (RCBD) with four replications to determine winter production and temporal changes in herbage quality during winter 1999 and 2000. Check cultivars of Aranui and Doubletake triticale (*x Triticosecale*), and Omaka barley (*Hordeum vulgare* L.) were included for comparison. Sowing dates were 4 March and 10 March in the respective years. The trials were managed for non-limited production. Standard applications of 200 kg/ha of Cropmaster 20 were applied during pre-plant cultivation, and weeds were controlled with 3l/ha of MCPA at the 4th leaf stage. Herbage was sampled for dry matter (DM) yield and for herbage quality at three-week intervals from early May by combining two 0.1 m^2 quadrats.

Multiple grazing autumn-sown trials

Trials were established in 1999, 2000 and 2002, with similar design and plot size as for the single graze trials. Fertiliser (200 kg/ha of Cropmaster 20) was applied pre-sowing and 200 kg/ha of ammonium sulphate was applied in early August after closing for silage. Weeds were controlled by application of 3 l/ha of MCPA in mid April. Biomass was determined on three replicates by pooling three 0.1 m^2 quadrats for each plot. The trials were grazed with sheep in year 1 (30 April and 2 July) followed by mowing to 2-3 cm height. In following years, the trials were mown to 3-cm height without prior grazing. All the multi graze trials were cut twice before closing for a silage crop. Regrowth samples following the second cut (119 days after sowing) were taken at regular intervals from 29 September.

Spring-sown trials

Cultivar trials with RCBD designs and plot arrangement as for earlier trials, were conducted over two seasons at Lincoln. In year 1, (1999/2000), two trials were sown on 27 August (ES1) and 2 November (LS1). Trial entries for the respective trials are shown in Table 1. The trials were managed for optimum production with crop management details described by de Ruiter (2001).

In year 2, early (ES2) and late sown (LS2) trials were sown 8 September and 9 October 2000, respectively. The trials were also RCBD designs with four replicates again managed for optimum production (de Ruiter 2001). Whole-crop biomass was determined on two 0.1 m^2 bulked quadrats per plot. Observations were made at 4-day intervals from flowering until grain maturity.

Data was analysed with Analysis of Variance (Genstat 5). A level of 5% was used to determine significance and appropriate tests were made of the distribution of residuals to validate the use of ANOVA.

Results and discussion

Crop development

All cultivars (except the Omaka barley) in the single graze trials remained vegetative through the sampling period until mid July. Omaka was the only cultivar that produced ears at the time of the final harvest in mid July, however there was no grain development because of frost damage. Oat and triticale cultivars were less susceptible to frosting. Autumn multigraze types progressed rapidly through to grain maturity once closed for silage. For Doubletake triticale, grazing caused a 20-day delay in flowering compared to ungrazed plots.

All cereal cultivars sown in the spring progressed rapidly to flowering. The mean duration from emergence to flowering was 79 (± 6.9) days (955 °C.d) in early-sown crops and 67 (± 7.9) days (853 °C.d) for late-sown crops. There was significant variation in the development rate for both cultivars within trials and for species means over all trials. For example, mean thermal durations from emergence to flowering for barleys were 842 °C.d compared to wheat (950°C.d), oats (909 °C.d) and triticale (888 °C.d).

Single-graze autumn-sown trials

Biomass

There were significant differences ($P<0.05$) in biomass production between cultivars in all harvests of autumn-sown single graze crops. The production pattern was similar in both seasons (Table 2). Yield in excess of 5.5 t/ha was possible by mid June with good autumn growing conditions, particularly in 1999. Biomass growth was linear in year 1 ($r^2=0.98$) and year 2 ($r^2=0.98$) with days from sowing (de Ruiter 2001) with mean production

Table 1 Cereal cultivar/entries in spring trials at Lincoln.

Species	Spring trial entries Year 1 Early sowing (ES1)	Spring trial entries Year 1 Late sowing (LS1)	Spring trial entries Year 2 [1] (ES2 and LS2)
Avena sativa L.	—	Hokonui	Hokonui
Avena sativa L.	—	Stampede	Stampede
Triticum aestivum L.	Sapphire	Sapphire	Sapphire
Hordeum vulgare L.	Omaka	Omaka	Omaka
Hordeum vulgare L.	1828.100	1828.100	—
Hordeum vulgare L	1807.0.11	—	—
Hordeum vulgare L.	—	—	1802.102.13
Triticum (x Triticosecale)	Rocket	Rocket	Rocket
Triticum (x Triticosecale)	Aranui	—	Aranui

[1] entries were the same for two sowing dates in Year 2.

Table 2 Whole-crop biomass (t/ha) accumulated to each harvest date for autumn-sown single graze cereal crops at Lincoln.

Species	Year 1 (1999)				Year 2 (2000)				
	30 Apr.	21 May	11 Jun.	2 Jul.	1 May	22 May	10 Jun.	4 Jul.	3 Aug.
Days after sowing	57	78	99	121	52	73	92	116	146
Oats	2.4	3.8	4.7	5.5	1.6	2.9	4.1	4.9	7.5
Triticale	2.4	4.1	5.5	6.3	1.2	2.7	3.4	4.4	6.9
Barley	3.0	3.8	5.5	6.0	-	-	-	-	-
LSD (5%)[1]	0.91, 0.90				0.94, 0.94				
df [1]	104, 96				150, 135				

Number of cultivars, 1999: oats (10), triticale (2), barley (cv. Dictator); 2000: oats (8), triticale.

[1] LSDs and associated degrees or freedom for comparing cultivar x harvest, and cultivar within harvest, respectively.

levels of 51.1 and 59.5 kg/ha/day in respective years. Leaf weight for successive leaves on main stem culms differed among cultivars and there were also differences in leaf to stem ratio (data not shown). This may have implications for protein composition as other work (Jamieson & Semenov 2000) has shown nitrogen dilution is directly related to differences in mass balance of leaves and stems.

Crop quality

Protein content of the harvestable biomass of Hokonui and Stampede declined progressively from a high near 30% at the first harvest to around 10% by the beginning of August in year 1. Total cell wall constituents (NDF) were relatively consistent (37-45%) over the harvest period (1 May - 13 August). While the biomass yield increased and protein content declined during this time there was a steady increase in the concentration of TSC from a low of 6.2% (Hokonui) and 7.3 % (Stampede), to 16% at the time of final harvest in year 1 (data not shown). Organic matter digestibility declined from 80.6% to 75.8% with maturation. Mean ME values for early and late harvest were 11.1 and 10.5 MJ/kg DM, respectively. Utilisation of this material for grazing will ultimately depend on the seasonal requirements for feed, however these results show there are shifts in quality that need to be balanced against the requirement for high yield.

Season x harvest date effects on herbage quality were examined for two cultivars only (Hokonui and Stampede). There was little difference in protein content, OMD or ME when comparing cultivars, however fibre levels (NDF, P=0.01; ADF, P=0.006) were reduced and TSC levels increased (P<0.001) in Stampede when compared with the commercial standard (Hokonui). There were significant year x harvest interactions for all quality variables. Between-year differences in quality invariably had greater influence than the cultivar effects. For example, mean OMD on May 1 (H1) was significantly

Table 3 Comparative quality of selected oat and triticale (cv. Doubletake) cultivars sown in the autumn (year 2).

Harvest/Cultivar	Protein (% DM)	NDF (% DM)	Total soluble carbohydrates (% DM)	Organic matter digestibility (% DM)	ME (MJ/kg DM)
1 May					
Stampede	28.3	34.7	10.3	84.5	11.7
NZ-SAIA	30.7	35.0	9.3	85.0	12.0
MN94112	26.5	35.9	11.1	85.0	11.8
Doubletake	27.0	29.1	13.1	83.8	11.5
10 June					
Stampede	17.6	40.7	15.1	80.8	11.4
NZ-SAIA	18.1	45.1	12.8	78.9	11.1
MN94112	17.5	44.5	12.8	79.4	12.1
Doubletake	18.0	40.6	12.0	74.6	10.4
3 August					
Stampede	10.4	47.4	16.7	73.6	10.6
NZ-SAIA	10.9	57.7	13.7	67.0	9.8
MN94112	9.4	50.4	16.5	72.7	10.6
Doubletake	11.2	48.1	14.4	68.6	9.9
LSD (5%) [1]	2.11	2.55	1.72	3.63	0.51
LSD (5%) [2]	2.15	2.27	1.52	3.23	0.44

[1]Respective least significant differences for comparing cultivar x harvest means within year, and [2]for comparing means within the same level of harvest.

higher in year 2 (84%) than in year 1 (76%). Protein content was higher in year 2 than year 1 for all harvest dates. Fibre content was initially higher in year 1 (H1) but lower as the crops matured. The opposite pattern occurred for TSC content. Levels were initially lower for the immature crop in year 1 than in year 2 but this was reversed in the mature herbage.

In year 2, quality was determined for six cultivars (Hokonui, Stampede, NZ-SAIA, MN94112, Doubletake and Rocket) at three developmental stages (Table 3). Cultivar differences were significant (P<0.001) for all quality variables. Therefore, there are opportunities for improving the genetic base by selecting new and improved cultivars and also for managing cultivars for the appropriate level of quality required for grazing.

Multiple graze trials

Yield and quality

The mean seasonal production (two cuts plus a silage harvest) was 17.8 t/ha for triticales compared with 14.3 t/ha for Marbella ryegrass. Yields of 13.5 and 13.6 t/ha were available for the silage harvest in 1999 and 2000. In 1999, cv. Doubletake triticale produced the highest yield with up to 19.5 t/ha of accumulated biomass in a 262-day period from sowing comprising 15 t/ha of standing herbage and 4.5 t/ha removed in grazings on 30 April and 1 July. The dry matter content of cereals was not suitable for a direct cut silage harvest until the maximum biomass was reached at the completion of grain filling. Earlier harvest for silage was possible if weather conditions were conducive to wilting. In this case, there would be an added benefit of higher protein concentrations and lower fibre content, but ME and TSC levels would be lower. An old cultivar, Rahu ryecorn, performed surprisingly well in year 1, however its quality was significantly lower than other triticale selections or Marbella Italian ryegrass.

Comparative quality of Doubletake triticale and other forage selections are shown for protein, NDF fibre, TSC levels and ME (Figure 1). Protein content in the first two cuts was high for all forages. These levels declined sharply once stem elongation occurred in the regrowth. At silage maturity, protein content for Doubletake triticale was very low (6.3%). Other cultivars were also low in protein and there is a real possibility of protein limited production if this herbage is fed as a supplement to low quality pasture. Total soluble carbohydrate levels were superior in Doubletake compared with other forages, and the ME values were correspondingly high. There was little difference between forages in fibre content. Good quality silage can be readily made from Doubletake triticale. For example, an ensiled crop sampled from a stack in May 2000 showed the following quality variables and was indicative of a well fermented product: pH 4.1, lactic acid 5.2%, TSC 7.8%, *in vitro* digestibility 67.3%, ME 10.8 MJ/kg, NDF 58.4%, ADF 32.6% and protein 9.4%.

Spring trials

Yield

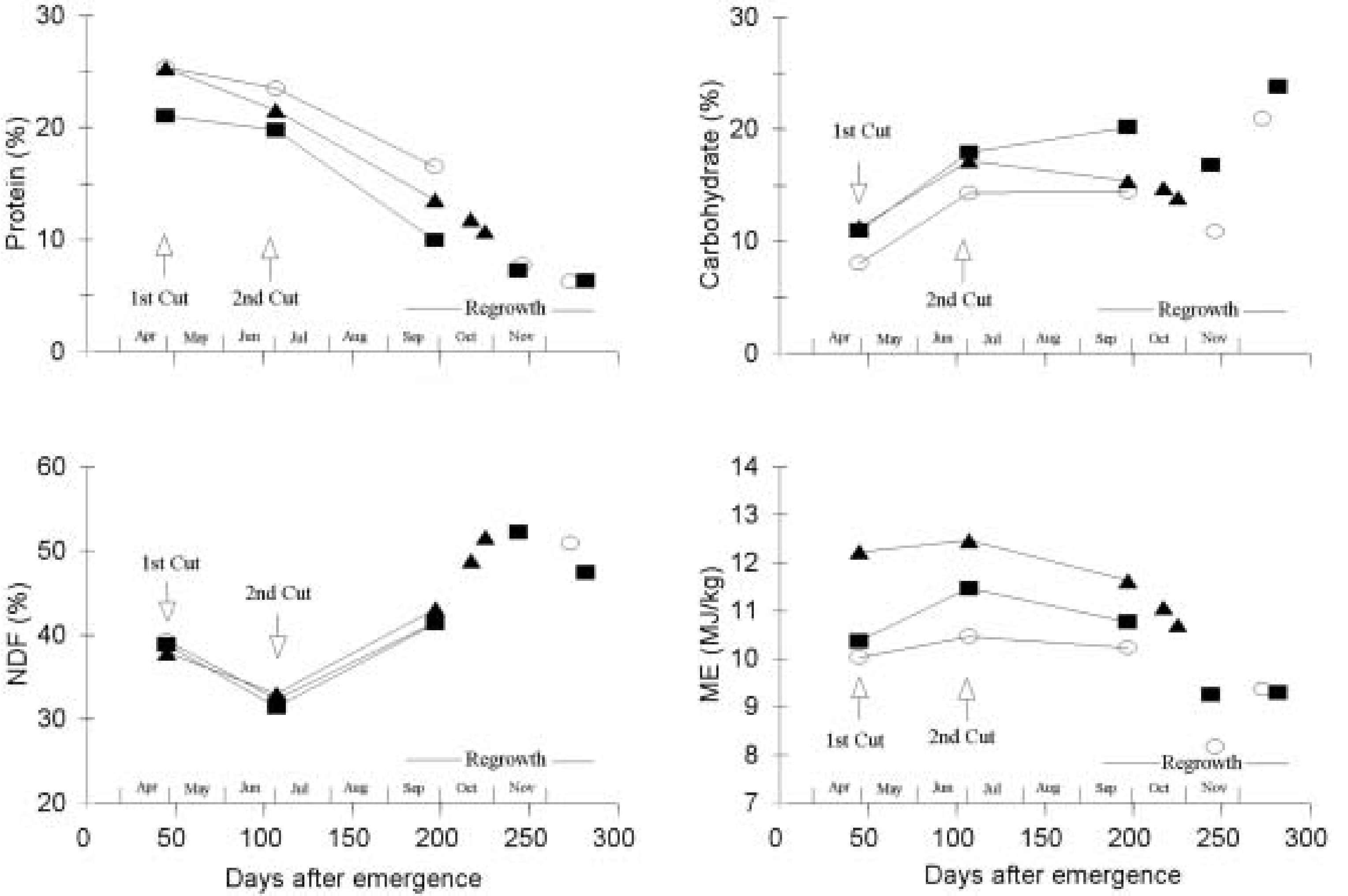
Linear relationships have been shown for biomass production in spring and thermal time accumulation (de Ruiter 2001). The production efficiency in the pre-flowering phase ranged from 1.08 to 1.77 t/ha/100 °C.d but there were significant differences (P<0.05) between trial entries in pre-flowering biomass production. However, it is commonly accepted that intercepted radiation is the prime driver for biomass growth in arable crops, and that strong relationships with thermal time are a result of the high correlation between temperature sum and radiation received by crops. Radiation use efficiency ranged from 0.77 to 1.08 g/MJ of PAR intercepted. In previous work (de Ruiter 2001), it was shown that early canopy closure conferred improved potential for biomass accumulation. Therefore, crop management strategies that improve the efficiency of light interception, such as

Table 4 Mean crop biomass (t/ha) for autumn-sown multi-graze cereal crops at Lincoln from 1999-2002.

	Year 1 (1999)			Year 2 (2000)					Year 4 (2002)	
	30 Apr. 1st cut	1 Jul. 2nd cut regrowth	21 Dec. 3rd cut regrowth	7 May 1st cut	25 Jun. 2nd cut regrowth	10 Aug. 3rd cut regrowth	20 Sep. regrowth	8 Nov. regrowth	2 May 1st cut	5 Jun. 2nd cut regrowth
Days after sowing	57	119	262	66	113	206	248	298	61	93
Triticale [1]	2.2	2.1 [2]4.2	13.5 17.8	1.6	1.1 2.6	0.86	2.9	13.6 16.2	1.8	2.0 3.8
Rahu ryecorn	1.8	2.5 4.4	17.8 22.2							
Marbella ryegrass	1.3	2.0 3.3	11.0 14.3	0.98	1.2 2.1	1.2	3.4	9.4 11.6		

[1]Number of cultivars, 1999, n=4; 2000, n=12; 2002, n=8.
[2]Values below the horizontal lines are accumulated biomass (regrowth plus previous cuts).

Figure 1 Mean quality indicators for Doubletake triticale (■) compared with Rahu ryecorn (○) and Marbella ryegrass (▲) sown on 4 March, grazed twice then closed for silage on 1 July. Data points for regrowth refer to standing biomass only for herbage accumulated after the second cut. Data points linked by lines were for the initial growth, regrowth from first cut and regrowth from second cut, respectively.



increased sowing rate and good N fertiliser practice, may improve total biomass yield.

In the trials reported here, final biomass yields from measurements made at grain maturity showed there was considerable variation, both within cultivar and across seasons. Yields exceeding 20 t/ha were achieved with good management of soil fertility and soil water (Table 5).

Table 5 Comparative yield (t/ha) of spring-sown cereals.

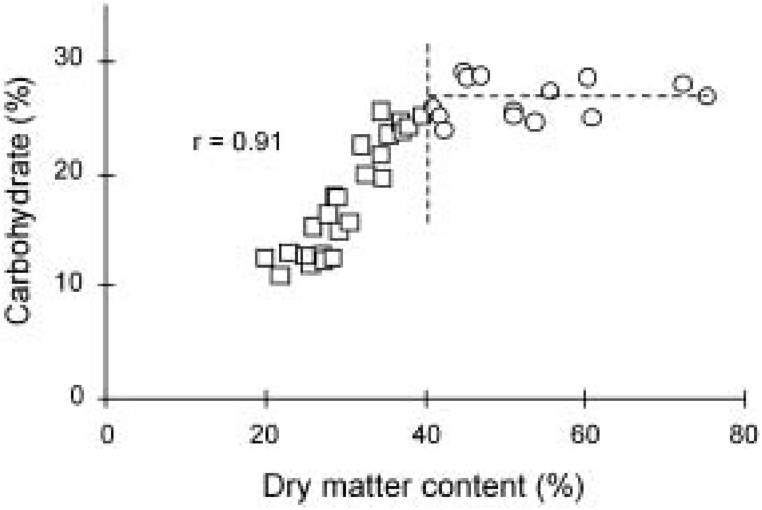
	———— Year 1 (1999) ————		———— Year 2 (2000) ————-	
Species/cultivar	Early sowing (ES1)	Late sowing (LS1)	Early sowing(ES2)	Late sowing(LS2)
Oat				
cv Hokonui	—	14.9	19.1	15.4
cv Stampede	—	15.2	18.1	16.4
Wheat				
cv. Sapphire	12.3	14.4	21.3	15.7
Triticale				
cv. Aranui	15.7	—	20.3	17.5
cv. Rocket	16.2	16.3	21.9	16.0
Barley				
cv. Omaka	13.8	15.4	16.4	19.0
cv. 1802.102.13	14.4	—	13.2	16.9
cv. 1828.100	13.8	14.1	—	—
cv. 1807.0.11	14.2	—	—	—
LSD (5%)	1.90	2.50	4.41	5.53
df	16	10	12	12

Quality

Protein

After flowering, mean protein content fell below 11% and declined progressively to a low of 7-8% at final harvest (Table 6). Very few protein measurements exceeded 10% in the post-flowering period. Protein content, therefore, constitutes a major nutritive value limitation for whole-crop cereal use when supplementing low quality pasture. Small differences in the protein content occurred among cultivars. For example, when the cultivar 1802.102.100 was present in a trial, it invariably had the highest protein content at flowering. The single advantage for harvesting vegetative rather than mature crop in the reproductive phase is the raised protein content. To compensate for reduced protein with advancing maturity, Fisher *et al*. (1974) recommended harvest at the soft dough stage and achieved improved animal intake and performance. Even earlier harvest is recommended if high protein silage is required. For example, Kilcher & Troelsen (1973) suggest oat harvest at the milk stage. However, the moisture content will not be suitable for ensiling unless the crop is wilted. Early harvest may be the only option in wetter zones when decisions on harvest timing are made, not on quality or biomass criteria, but when the first suitable break in weather occurs for cutting and wilting in the field.

Figure 2 Relationship between dry matter content and TSC for whole-crop spring barleys (ES1, LS1, ES2 and LS2 trials). The correlation coefficient is given for dry matter data less than 40% (□). It was assumed there was no change in TSC when dry matter content exceeded 40% (□).



Carbohydrate

Soluble carbohydrates progressively increased from a mean low of 11.7% at flowering and exceeded 24% at maturity (Table 6). The value of whole-crop cereals for silage lies primarily in the energy value of the grain and the carbohydrates that accumulate during grain filling.

Optimum feed value on the

Table 6 Quality of early and late sown spring cereals year 1 (1999/00) and year 2 (2000/01); ES1 = early sowing; year 1; LS1 = late sowing; year 1; ES2 = early sowing, year 2; LS2 = late sowing, year 2.

Trial/Cultivar/ Harvest date	Protein (% DM)	Total soluble carbohydrate (% DM)	Metabolisable energy (MJ/kg DM)
ES1 Trial			
cv Omaka			
29 Nov	10.5	12.9	9.4
6 Dec	10.9	14.9	9.8
20 Dec	8.9	23.6	10.1
6 Jan	8.6	29.1	10.1
cv 1802.102.13			
6 Dec	12.8	11.0	9.4
20 Dec	9.5	16.3	9.6
6 Jan	8.1	24.2	9.5
cv Sapphire			
20 Dec	10.3	11.2	8.6
6 Jan	9.2	18.8	9.4
27 Jan	8.3	27.7	9.6
cv Rocket			
6 Dec	9.9	12.4	8.9
20 Dec	8.6	15.9	9.4
6 Jan	8.3	24.2	10.5
27 Jan	8.4	28.9	10.0
3 Feb	7.2	27.0	9.0
LS1 Trial			
cv Omaka			
5 Jan	9.3	11.8	9.1
17 Jan	9.2	12.5	9.0
27 Jan	8.9	19.5	9.4
7 Feb	7.7	25.1	9.7
14 Feb	7.9	24.6	9.6
cv Sapphire			
18 Jan	10.3	10.7	8.5
27 Jan	10.2	12.8	8.9
7 Feb	9.4	18.3	9.6
22 Feb	8.1	26.5	9.8
29 Feb	9.3	26.7	9.8
cv Rocket			
18 Jan	9.2	8.7	8.2
27 Jan	8.2	9.9	8.1
7 Feb	8.0	14.7	9.0
22 Feb	7.9	23.4	9.6
24 Mar	7.0	26.0	9.5
ES2 Trial			
cv Omaka			
11 Dec	9.9	12.6	8.7
26 Dec	9.3	21.7	9.6
8 Jan	8.2	23.8	9.5
22 Jan	7.8	25.0	9.4
cv 1802.102.13			
11 Dec	10.9	12.4	9.0
26 Dec	9.7	17.9	9.3
8 Jan	7.3	24.5	9.6
22 Jan	7.0	27.3	9.8
cv Sapphire			
11 Dec	–	–	–
26 Dec	10.0	13.5	8.9
8 Jan	8.7	20.0	9.5
22 Jan	9.1	28.6	10.2
29 Jan	7.0	24.2	8.9
cv Rocket			
18 Dec	7.2	9.1	7.7
26 Dec	8.3	12.3	8.4
8 Jan	8.2	19.9	9.6
22 Jan	7.4	27.4	10.1
29 Jan	7.6	31.6	10.3
Trial LS2			
cv Omaka			
3 Jan	10.1	18.0	9.4
16 Jan	8.0	25.2	9.8
30 Jan	8.5	28.5	10.2
12 Feb	8.7	26.8	9.7
cv 1802.102.13			
3 Jan	11.2	15.2	9.4
16 Jan	7.7	25.5	10.1
30 Jan	8.4	25.4	9.0
12 Feb	8.7	28.0	10.0
cv Sapphire			
03 Jan	9.9	11.8	8.3
16 Jan	9.7	18.6	9.5
30 Jan	8.3	25.1	9.5
12 Feb	9.2	24.1	8.9
cv Rocket			
3 Jan	9.4	12.3	8.5
16 Jan	8.2	18.6	9.5
30 Jan	7.9	28.8	10.3
12 Feb	8.2	31.1	10.2

basis of TSC composition requires that the crop is not harvested until grain growth has ceased, to capitalise on the energy value of grain. In whole crop barley, the optimum cutting time to ensure maximum TSC was at a DM content of 40% (Figure 2). This was followed by a cessation of TSC accumulation in the whole-crop. However, there is a compromise with a decline in organic matter digestibility that occurs with increasing lignification of stem material during grain filling. Harvesting for direct cut silage or harvesting followed by wilting to 35-40% DM before ensiling is recommended to restrict anaerobic fermentative and proteolytic losses in wet silages (Ohshima & McDonald, 1978). Excessively dry silages are subject to losses through oxidative fermentation. Requirements for high yield need to be balanced with the expected reduction in fibre quality and digestibility as the crops approach physiological maturity. Early harvest will offset the gains that are likely from improved yield and energy content achieved through grain growth. Other agronomic treatments such as altering the cutting height and use of straw shortening chemicals have a potential influence on the quality of herbage used for animal feeding. Research aimed at defining the herbage quality enhancement from these treatment is continuing.

Metabolisable energy

Measurements of ME were comparatively stable during grain filling although a consistent small increase during this period was observed for all cultivars (Table 6). Levels of ME less than 10 MJ/kg DM did not reflect the high grain component of the herbage at maturity. There is little data available in New Zealand to support the NIRS predictions of *in vivo* metabolic value of whole-crop or silage made from whole cereals. In addition, the information on quality of fresh herbage does not necessarily indicate herbage value after ensiling, as the material can change markedly during the process depending on dry matter losses and methods used in preservation. Metabolisable energy is, however, strongly linked to the soluble sugar and starch fractions, most of which is derived from the grain portion, (Evers & Blakeney 1999). The value of maize as a supplement appears to be more related to the elevated soluble sugar levels than its fibre or starch composition (Burgess *et al.* 1973).

Potential for use of cereals in dairy systems

In this paper, we have shown that cereals provide flexible options for utilisation as grazed herbage or for feeding as silage. Variation in composition of grazed or ensiled whole-crop cereals is an important consideration for maintaining and achieving target performance from animals throughout the season. In early lactation, when pasture quality and pasture growth is low, whole-crop cereal silage provides a valuable high carbohydrate supplement. While the ME values are often marginally lower than in maize (Burgess *et al*. 1973), whole crop does provide an effective fibre source (Clark *et al*. 2000; McCartney & Vaage 1994) to enhance rumen function. Cereal silage fed in late summer has proven to be effective strategy for sparing pasture, particularly if conditions are dry (Clark *et al*. 2000). Supplementation with either standing conserved cereals in autumn and winter can extend the lactation season and maintain milk production levels close to 1.0 kg MS per day late in the season or 2.0 kg MS/day in early lactation (Platfoot & Stevens 2002). Cereals grazed as standing herbage provide a good high protein feed option in winter or can be fed in a cut and carry system improve cow condition. Alternatively, silage made from mature herbage is a practical solution to feed shortages at other times of the year.

Conclusions

Oat and triticale cultivars provide good options for one-off winter grazing from March sowing in Canterbury with production exceeding 5.5 t/ha biomass by early July. Multiple-graze triticales provided additional flexibility with equally good early growth and high protein source for multiple grazing in winter as well as a silage option in late spring. These crops have high nutritive value in the vegetative stage and suitable quality for ensiling.

Sowing date and cultivar selection are important when selecting for best cereal forages for silage production either from an autumn sowing of long-season multiple-grazing type or spring-type cereals with rapid growth, and high grain component. The value of spring sown material as animal feed lies in the carbohydrate content while autumn sown grazed forage cereals produced high protein and lower carbohydrate herbage.

Optimum utilisation will include consideration of the additional biomass achieved with delayed harvest in both autumn single graze types and spring-sown cultivars for silage. Irrespective of sowing time there is a need to balance the increased yield and declining crop quality with maturation.

High productivity, flexible feed utilisation options and herbage quality with acceptable protein, fibre and total soluble carbohydrate composition is the basis for increased use of whole-crop cereals for supplementary feeding in dairy production systems in New Zealand.

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