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Use of 'Barkant' turnips and 'Superchow' sorghum to increase summer-autumn milk production

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ABSTRACT

Barkant' turnips and 'Superchow' sorghum were compared as summer-autumn crops for lactating cows. Crops were fed at three levels (0, 4 and 8 kg DM/cow/d) to supplement pasture offered at a constant allowance. Sixty twin cows were used in two experimental periods in February and March 1997. Feeding 4 or 8 kg DM/cow/day increased milksolids (MS) yield/cow by 29% or 36% for turnips, and 26% or 32% for sorghum compared with pasture alone. Turnips gave responses of 58g and 45g MS/kg DM offered, at the lower allowance, in summer and autumn respectively, compared with 45g MS/kg DM in both seasons for sorghum. For both crops, increasing allowance from 4 to 8 kg further increased MS yield. Crop utilisation was lower on sorghum than turnips but substitution rates for turnips were higher than for sorghum at both allowances in both summer and autumn. This means that although both crops have a 'pasture sparing' effect, sorghum contributed more to increased per cow intake.

Keywords: crop intake; dairy cows; milksolids; pasture intake; sorghum; turnips.

INTRODUCTION

A weakness of New Zealand's pasture-based dairy industry is the rapid decline in milksolids (MS) production over the second half of lactation. In the North Island, decline in MS in this period can be as high as 19%/herd/month compared with a theoretical decline of 7%/herd/month (Clark, 1995; LIC, 1997). Additional summer feed would improve milk yield, extend lactation and increase cow condition, enhance raw product consistency for processing and improve processing plant utilisation.

The growth of summer crops for milk production has a long history and has become increasingly important in recent years as stocking rates on dairy farms have increased. Forage crops are utilised for supplementary feeding and as a means of preparing for pasture improvement. Two alternative crop types are brassicas, such as turnips, and C4 green-feed crops, such as sorghum and maize. Newer turnip cultivars, such as 'Barkant,' are a high quality crop (11-13 MJ metabolisable energy (ME)/kg DM) with a yield potential of 10-12 t DM/ha produced over 80-120 days (Percival *et al*., 1986; Notman, 1992). 'Superchow' sorghum has a moderate energy content (9 - 11 MJ ME/kg DM) and a yield potential of 12-16 t DM/ha produced over 80-120 days allowing 2-3 grazings (Clark *et al*., 1996).

This paper describes an experiment conducted at No 1 Dairy, Dairying Research Corporation (DRC), Hamilton, in 1996-97, the second year of a study comparing 'Barkant' turnips and 'Superchow' sorghum for summer-autumn MS yield.

MATERIALS AND METHODS

Site and treatments

Turnips (2 kg seed/ha) were sown on 9 November (1.25 ha) and a second area on 24 November 1996 (1 ha). Sorghum (25 kg seed/ha) was sown on 24 November (1 ha) and a second area on 23 December 1996 (1 ha). The experiment was a 2 x 3 factorial with the two crops break-fed at three levels (0, 4 and 8 kg DM/cow/d) to supplement pasture offered at a constant allowance of 25 kg DM/cow/d.

Animals

There were two 20 day experimental periods in February and March 1997. In each experimental period 60 lactating monozygous twin cows, balanced for current MS yield, age, breed, liveweight and stage of lactation were allocated to six treatment groups (10 cows/group). Each experimental period was preceded by a uniformity period of one week when all cows grazed together on pasture and MS yield was assessed as a covariate. In each experimental period there were two sub-periods of 10 days. Cows changed crops between experimental periods. However, within an experimental period cows remained on the same crop in both sub-periods but changed allowance to one of the two feeding levels they did not use in the first sub-period. This design allowed MS response to different crop levels to be assessed by two replicate herds of 10 cows.

Measurements

Crop yield and composition: Pre- and post-grazing crop yields were measured daily during each sub-period by sampling six, 0.1 m^2 quadrants. The chemical composition of crops and pasture was determined on pre-grazing samples harvested on the last 5 days of each sub-period using near infra-red spectroscopy (NIRS).

Milk yield and composition: Individual milk yield and composition (fat % and protein %) were measured over the final 5 days of each sub-period.

Liveweight gain: Liveweight (LW) was measured at the start and end of each sub-period.

Crop and pasture intake: Pasture intake was estimated using the alkane technique (Dove and Mayes, 1991). Crop intakes were determined using pre- and post-grazing yields. Both pasture and crop intakes were measured over the final 5 days of each sub-period.

Statistical analysis

The data from each period were analysed as a 2 x 3 factorial cross-over design using the mixed models procedure in SAS. Two SEDs for comparison of interaction means are given, one for comparing means between different crops, and the other for comparing means on the same crop. The standard deviation (SD) is given with the mean pre-grazing crop yields.

RESULTS AND DISCUSSION

Crop and pasture composition

The turnip crop yield pre-grazing was, on average, 12.2 t DM/ha (SD 1.9) in summer and 13.3 t DM/ha (SD 1.5) in autumn, with similar proportions of leaf (53%) and bulb (47%). The sorghum measured, on average, 3.4 t DM/ha (SD 0.9) pre-grazing in summer and 2.8 t DM/ha (SD 0.7) in autumn. Total production for 110 days growth, allowing for regrowth since both areas were grazed 3 - 4 times before the end of the experiment (28 March), averaged 12.8 t DM/ha. The sorghum was more immature (61% leaf, 39% stem) at grazing in autumn than in summer (53% leaf, 47% stem).

Turnips had lower acid detergent fibre (ADF) and neutral detergent fibre (NDF) levels than either sorghum or pasture, but higher in vitro digestibility, available carbohydrate and metabolisable energy levels (Table 1). Crude protein levels for turnips were below the 16-18% recommended for lactating dairy cows (NRC, 1985). Sorghum and pasture, however, had crude protein contents above the recommended level.

TABLE 1: Mean chemical composition of whole plant turnip, sorghum and pasture analysed using NIRS.

	Turnips	Sorghum	Pasture
Dry matter (%)	10.1	13.2	-
Crude protein (g/100g DM)	10.6	18.2	22.5
Acid detergent fibre (g/100g DM)	21.1	30.1	26.6
Neutral detergent fibre (g/100g DM)	30.8	54.0	49.1
Available carbohydrate (g/100g DM)	27.4	6.3	6.9
In vitro digestibility (g/100g DM)	76.5	70.3	73.4
Metabolisable energy (MJ/kg DM)	12.1	11.1	11.6

Milksolids yield and response

Both turnips and sorghum increased MS yield when offered at allowances of 4 or 8 kg DM/cow/day in both summer and autumn. Feeding 4 or 8 kg turnips in summer increased ($P<0.001$) MS production over pasture (0 kg crop/cow/d) by 32% or 42% respectively (Table 2). This compared with increases ($P<0.001$) of 28% (4kg) and 37% (8kg) for sorghum. In autumn, feeding 4 kg of either turnips or sorghum increased ($P<0.001$) MS yield 24% while 8kg turnips increased ($P<0.001$) MS production 32% compared with 29% for sorghum. Overall, increasing the crop allowance from 4kg to 8kg resulted in only a small increase in MS yield. In previous trials at TARS and DRC, increasing the turnip allowance above 4kg also had little further effect on MS production (Clark *et al*., 1996, 1997). The reasons for this effect are discussed later in relation to crop utilisation and pasture substitution effects.

As a result of the small increase in MS production with the increase in crop allowance, the MS response (per kg crop DM offered) was higher at the 4kg allowance than at 8kg. This result was similar to that in the first year of this DRC trial (Clark *et al*., 1997). In summer, the MS responses to feeding 4kg or 8kg of turnips (58 or 36g MS/kg crop respectively) were greater than for sorghum (45 or 30g MS/kg crop respectively). In autumn, however, the responses were similar for turnips (45 or 30g MS/kg crop respectively) and sorghum (45 or 28 g MS/kg crop respectively). The higher in vitro digestibility and ME content of turnips compared with sorghum would be expected to give an increased ME intake and hence higher MS response. However, the turnips had a low crude protein content which may have limited the MS response to some extent. Calculations, based on NRC (NRC, 1985) recommendations, using crude protein and metabolisable energy contents of pasture, turnips and sorghum with estimated intakes show that MS production in turnip-fed cows was more likely limited by insufficient protein intake whereas en-

TABLE 2: Effect of turnips and sorghum fed during summer and autumn on milk yield (l/cow/day), milk composition (fat % and protein %) and milksolids yield (kg MS/cow/day).

	Turnips			Sorghum			SED	SED
Allowance: (kgDM/cow/d)	0	4	8	0	4	8	Between crops	Between allowances
Summer								
Milksolids	0.71	0.94	1.00	0.71	0.89	0.95	0.02	0.02
Fat %	5.09	4.94	4.86	5.09	4.94	4.92	0.07	0.06
Protein %	3.41	3.44	3.51	3.43	3.39	3.36	0.03	0.02
Autumn								
Milksolids	0.74	0.92	0.98	0.75	0.93	0.97	0.03	0.02
Fat %	5.60	5.17	5.10	5.40	5.32	5.35	0.07	0.07
Protein %	3.73	3.68	3.74	3.65	3.64	3.66	0.04	0.04

ergy was most likely to be the limiting factor for the sorghum-fed cows.

The MS responses for feeding 4kg turnips in the current trial were slightly higher than those of 36-39 g MS/kg crop in trials at Westpac Taranaki Agricultural Research Station (TARS) and DRC (Clark *et al*., 1996). In the first year of the DRC trial (1995/96) the responses on the 4kg turnips were 43 and 50g MS/kg crop in summer and autumn respectively (Clark *et al*., 1997). The MS responses for sorghum at the 4kg allowance, however, were considerably higher than responses of 25 g MS/kg crop in the first year of the DRC trial (Clark *et al*., 1997). The higher MS responses in the current trial (1996/97) compared with the previous year may have been partly due to the improved chemical composition of the turnips and, in particular, the sorghum. For example the crude protein content of the sorghum in 1996/97 (18.2g/100g DM) was almost double that in 1995/96 (9.6g/100g DM) and therefore within the levels recommended for lactating dairy cows (NRC, 1985). In addition, the sorghum was grazed at an earlier stage of maturity in the current trial compared with 1995/96 thereby ensuring the proportion of stem was lower and therefore feed quality was probably higher.

Milk composition

Changes in milk composition in response to feeding either turnips or sorghum varied across the two measurement periods (Table 2). In summer, feeding of both crops decreased ($P<0.001$) fat %. The decrease was similar for both turnips and sorghum so that allowance, but not crop, had a significant effect ($P<0.001$). In autumn, feeding sorghum did not decrease fat % compared with the pasture control. Feeding turnips, however, did decrease fat % compared with pasture. Consequently turnips fed at both allowances resulted in milk with 0.2 lower fat % but increasing the allowance of both turnips and sorghum from 4 kg to 8 kg had no effect on fat %.

In summer, feeding 8 kg turnips increased ($P<0.01$) protein % but 8 kg sorghum decreased ($P<0.01$) protein %, so that crop, but not allowance, had a significant effect ($P<0.05$) on protein %. Feeding 4 kg of either crop had no effect on protein % however. Despite this there was a crop x allowance interaction ($P<0.001$) effect on protein %. There was no clear effect of allowance on protein % in autumn although the effect of crop was significant ($P<0.05$).

It is difficult to explain the inconsistencies in milk fat % and protein % response to feeding different crops at different allowances. Although relating the changes in milk composition to the chemical composition of the respective crops could offer some clues, the relationship between feed and milk compositions is more complex than this and is affected by metabolic and chemical transformations within the cow (E.S. Kolver pers. comm.). Overall, however, the changes in milk composition were similar to the trends reported for the first year of the DRC trial (Clark et al., 1997).

Crop, pasture and total intake

In summer and autumn intake of both turnips and sorghum (crop intake) increased ($P<0.01$) with increasing allowance, but to a lesser extent than planned, especially for the sorghum (Table 3). Utilisation (% of crop allowance eaten) of both turnips and sorghum decreased with increasing allowance but utilisation was much poorer on the sorghum (Table 3). The lower utilisation, and therefore lower crop intakes, of sorghum compared with turnips at all allowances was probably a result of the stem proportion of the sorghum plant. Cows had obvious difficulty in prehending and consuming sorghum stems and the very high NDF levels in sorghum could be expected to reduce rate of passage and hence intake (Mertens, 1987).

Pasture intake declined ($P<0.001$) with increasing crop allowance for both turnips and sorghum in summer and autumn (Table 3). Total intake (pasture and crop) was greater ($P<0.001$) for cows offered turnips or sorghum at either allowance compared with intake of cows grazing pasture only (Table 3). This result was expected since a pasture allowance of 25 kg/cow/d is low and would limit the intake of cows fed pasture only. However, pasture allowance was deliberately kept low to simulate a summer drought conditions. It is possible, however, that the supplementary effects of feeding a crop on intake and, there-

TABLE 3: Effect of turnips and sorghum fed at different allowances during summer and autumn on pasture intake (kg DM/cow/d) determined using the alkane technique, crop intake (kg DM/cow/d) estimated using pre- and post-grazing measurements, and total intake (kg DM/cow/d). Crop utilisation (%) and pasture substitution (reduction in kg pasture intake/kg crop eaten) rates are also given.

		Turnips			Sorghum		SED	SED
Allowance: (kgDM/cow/d)	0	4	8	0	4	8	Between crops	Between allowances
Summer								
Crop intake	0.0	3.9	7.3	0.0	3.3	4.9	-	-
Pasture intake	13.5	12.1	8.8	12.8	12.1	10.9	0.30	0.38
Total intake	13.5	16.0	16.1	12.8	15.4	15.8	0.31	0.39
Utilisation	-	98	92	-	83	61	-	-
Substitution	-	0.36	0.64	-	0.21	0.39	-	-
Autumn								
Crop intake	0.0	3.9	6.9	0.0	3.4	5.5	-	-
Pasture intake	12.5	11.0	8.5	12.8	11.8	11.0	0.25	0.31
Total intake	12.5	14.9	15.4	12.8	15.2	16.5	0.26	0.31
Utilisation	-	98	86	-	86	68	-	-
Substitution	-	0.38	0.58	-	0.29	0.33	-	-

fore, MS production may be lower if pasture allowance had been higher.

Because of pasture substitution (the decrease in pasture DM intake when 1 kg of crop DM is eaten), total intake of cows eating turnips was similar at 4kg and 8kg allowances in both summer and autumn respectively. Cows offered either 4kg or 8kg sorghum also had similar total intakes in summer. However, in autumn the total intake of cows on the 8kg allowance was greater (P<0.01) than for cows on the 4kg allowance. This was due to an improvement in both the utilisation of sorghum in autumn compared with summer and a reduction in the difference between the two allowances in autumn. Both these effects were probably a reflection of the sorghum in the autumn experiment being more immature and therefore more favourable for grazing and of higher feed quality. The higher substitution rates of cows offered turnips meant that, although sorghum fed cows ate less crop, there was little difference in total intake between turnip fed and sorghum fed cows at the respective allowances. Pasture substitution, for summer and autumn, was higher on the turnips averaging 0.37 (4kg allowance) and 0.61 (8kg allowance) compared with 0.25 and 0.35 respectively on the sorghum. The sorghum, therefore, had a greater supplementary effect than turnips which is the reverse of the previous year (Clark *et al*., 1997). This reversal of trends was probably a reflection of the higher feed quality of the sorghum in the current trial compared with the previous year. Ideally, supplementary crops should have a substitution rate close to zero.

Liveweight gain

Cows grazing sorghum were 11 and 19 kg heavier (P<0.01) than either the turnip or pasture fed cows in summer and autumn respectively. Sorghum allowance had no effect on liveweight. Turnip-fed cows failed to put on any more liveweight than the pasture-only cows. This result agrees with other trials conducted recently at TARS and DRC where turnips did not increase LW compared with pasture (Clark *et al*., 1996) and is similar to the results from the first year (1995/96) of the DRC trial (Clark *et al*., 1997). The much greater fibre levels in sorghum compared with turnips (54.0 v 30.8 g/100g DM) would have led to a higher acetate : propionate ratio. This may, in turn, have led to increased liveweight gain at the expense of MS production (Annison and Armstrong, 1970).

CONCLUSIONS

From a dairy farmer perspective the most important question to be answered is ‘should I grow a summer crop for lactating cows?’ Because of the vast range of conditions under which experiments have been conducted, the inconsistencies in responses, and the different methods which have been used to evaluate crop profitability, this question rarely has a straightforward answer. Recent work on turnips as a summer crop has led to conflicting recommendations. Notman (1992) suggested a break-even yield for turnips of 2.4 t DM/ha based on partial budgeting. Clark (1995), using UDDER simulations, proposed break-even yields of 8 and 10 t DM/ha in dry/drought and normal years respectively. However, Exton *et al*. (1996), using a ‘split farm’ technique, concluded that turnips were not a profitable crop based on trials done over two years on two farms in the Waikato, despite yields over 10 t DM/ha being achieved in the second year. Consequently, many farmers will grow a summer crop simply to prepare a better seedbed as part of a pasture renewal programme rather than in a conscious effort to increase summer milk production. Economics aside, results from this and other trials, have demonstrated feeding both turnips and sorghum can increase summer and autumn MS yield. However, there is little advantage in offering more than 4 kg crop DM/cow/d. Sorghum is a more difficult crop to manage than turnips but is more suitable for late November-January sowing and has the advantage of being able to be grazed several times.

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