Developing supplementary feed systems for dairying in dry environments in New Zealand

J.M. de Ruiter[1], Shane Maley[1], T. Knight[2], E. Francis[3] and D. Jones[3]

[1] New Zealand Institute for Crop & Food Research Limited, Private Bag 4704, Christchurch, New Zealand. *www.crop.cri.nz* Email *deruiterj@crop.cri.nz*
[2] AgResearch, PO Box 60, Lincoln, New Zealand.
[3] Farmer, Culverden

Abstract

Dairying has expanded rapidly in recent years into marginal dry environments in New Zealand under border-dyke and centre pivot irrigation. Increased dairy productivity is dependent on additional non-pasture feed at times of the year when pasture growth and feed quality is less than animal requirements. A three-year (FeedMAX) study was conducted in the Culverden Basin in North Canterbury with 16 participating farmers. The aim was to maximise feed supply and quality by timely planting of spring cereals (barley and triticale), single and multi-graze cereals for autumn and winter grazing, brassicas (turnips and rape) for summer grazing, brassicas (rape, swede, turnips and kale) for grazing during autumn/winter, and annual ryegrass for winter and spring supplements. Species and cultivar selections and appropriate sowing times were made on the basis of yield, herbage quality, individual farm feed requirements and integration in the farming operation.

Key Words

Dairying, cropping system, feed quality, crop productivity

Introduction

In the dry Culverden Basin, in North Canterbury (New Zealand), dairy farmers have experimented with many forage options to supplement pasture production. Suboptimal pasture productivity can occur at any time of year through variability in temperature and rainfall patterns. Livestock feed requirements vary seasonally with stock type, their reproductive cycle, lactation level, and number of stock on farm (Kolver 2000). More bulk feed, produced at low cost, is a requirement for high producing dairy farms limited by readily available grazable feed especially when grass quality is in decline in late spring and early summer and for use as supplements during winter. Farmers have adopted high yielding row crops on land that is primarily used for wintering dry stock to offset feed deficits. A similar approach was used in Tasmania (Eckard et al. 2001) and Victoria (Wales et al. 2006) on irrigated land to boost total biomass productivity. In New Zealand, it is not common for land on the milking platform to be used for short term crops, although is a strategy used when preparing land for renovation with new and improved pasture species. However, production of supplementary feeds on runoff land is increasing as the demand for additional feed, traditionally supplied as hay and silage, has increased with the drive for higher per ha and per cow productivity. Cropping sequences supplying additional forage must satisfy both the seasonal livestock feed requirements and fit into the production pattern driven by climatic influences, as well as being economic.

The flexibility of cereal forages allows different sowing, harvesting and conservation options, depending on seasonal feed supply and demand. New purpose-bred forage oat (single graze) and triticale (multiple graze) cultivars, providing a range of single bite, multi-graze use and/or silage and hay feed supplementation options (Hanson et al. 2006). Short-season cereal crops can be sown in late February/early March to boost late season lactation or to support high growth rates of pregnant stock in winter (de Ruiter et al. 2002). Cereals can also provide a high fibre feed source from spring-sown crops conserved as silage or fed as ‘green chop’ during periods of high demand (de Ruiter, 2000). Brassica crops sown in spring and summer for grazing provide opportunities for boosting milk production through mid to late lactation or for extending lactation. Kale sown in summer for winter grazing and imported feeds such as maize silage and grain also add to feeding options. The project was conducted among farmers comprising a ‘FeedMAX’ group. The purpose of the study was to present growers with valid options for reducing risks of suboptimal feeding and increase the flexibility of forage use using a participatory approach combining research and farmer experience.

Methods

Trials, within five experiments (Table 1), were established on dairy properties in the Culverden Basin, North Canterbury over two seasons (2004-2006) to compare performance of a selected range of established and new cultivars of cereals, brassicas and herbs. Trials were sown with a conventional plot drill in year 1 and a direct drill in year 2. All crops were managed for optimum productivity by timely applications of fertiliser, insecticides and fungicides. Harvests for brassicas and herbs were taken using $0.5m^2$ quadrats and those for cereals and grasses using $0.2m^2$ quadrats. All crops were managed to achieve good weed, insect and disease control, and harvested at their appropriate timing to achieve best yield and quality. Yields were all corrected to dry matter basis and herbage quality variables predicted using NIR spectroscopy (AgResearch FeedTech, Palmerston North).

Table 1. Experimental details for trials.

Experiment	Sowing dates	Species/cu1tivars	Design	Plot size
1. Summer brassicas	10 Jan to 11 Mar 2004	Kale cvs. Sovereign and Kestrel, rape cvs. Bonar and Emerald, swede cv. Dominion and turnip cv. Green Globe.	RCB with 4 replicates	10m x 5m
2. Autumn cereals and Italian ryegrass	5, 11 and 31 March 2004	Late winter cereals cvs. Hokonui and Stampede oats, CRTR22 triticale, winter then silage triticale cvs. Doubletake and CRTR20 and tetraploid Italian ryegrass.	RCB with 3 replicates	15 x 8m
3. Spring sown cereals and cereal/pea mixtures	24 Sep 2004	Cereals (barley cv.CFR2387, triticale cv. Rocket and cv. Monster, wheat cvs. Commando and Raffles), forage peas cv. Provider, and mixes of cv. Provider with Rocket.	Demonstration blocks	100 x 6.6m
4. Spring sown turnips, cereals and herbs	1 Sep, 12 Oct and 23 Nov 2005	Turnips cv. Barkant, barley cv. Cask, rape cv. Winifred, chicory cv. Puna and leafy turnip cv. Pasja.	RCB with 2 replicates	10 x 3.9m
5. Spring sown brassicas and herbs	1 Sep 2005	Pasja leafy turnip, turnips cv. Barkant, rape cv. Winifred), chicory cv. Puna and Feast II Italian ryegrass.	Demonstration blocks with 2 replicates.	15 x 3m

The costs associated with crop production were used to calculate value of the standing herbage (c/kg DM) for the respective crop options. Costs included cultivation, seed, drilling and agronomic management. Additional costs such as irrigation, harvesting, silage making or grazing were not included but need to be allowed for when considering the various crop uses.

Animal requirements for NDF fibre, metabolisable energy (ME) and protein during the winter dry period and in early, mid and late lactation were evaluated using a ration balancing programme, validated with NRC (2001) simulations. Respective milk production levels were set at 0, 2.0, 1.6 and 1.0 kg milk solids/cow/day for a mean animal weight of 500 kg in early lactation. Feed composition differed for each of the feed periods depending on the likely availability of feed sources as follows: winter feed (Italian ryegrass, pasture silage, cereal silage, kale at 1, 4, 2, 3 kg DM/cow/day, respectively); spring feed (pasture, turnips, Italian ryegrass at 12, 2, 2 kg DM/cow/day); summer feed (pasture, cereal silage, turnips at 8, 4, 2 kg DM/cow/day); and autumn feed (pasture, maize silage, rape, single-graze cereal at 4, 2, 2, 4 kg DM/cow/day).

Results and Discussion

Seasonal productivity

Sowing of brassicas, cereals and herbs in multiple trials has demonstrated many options for dairy farmers to offset feed shortage. Use of crops for conservation, such as whole crop cereals, gives the farmer greater flexibility for utilising forage when needed. Conversely, crops produced for direct grazing impose restrictions on the farming operation as these crops need to be allocated when yield and/or quality are at optimum irrespective of the availability of alternative feed on-farm. Grazing imposes significant labour costs in the management of stock and adds to the potential for soil structural damage if grazing occurs in wet soil conditions. The trials demonstrated that a high level of crop productivity can be achieved with appropriate selection of crop and sowing date.

Productivity of brassicas was strongly dependent on sowing date. Brassicas (cv. Dominion swedes) sown in mid-summer produced up to 12.7 t /ha biomass for direct grazing in June. Other brassica cultivars were less productive but provided excellent quality for winter feeding. Late-sown crops struggled to perform in the declining autumn temperatures. For example, in a late sown (11 Mar.) trial, cv. Green globe turnips produced the best yield of 4.8 t/ha harvested in mid-Oct. Mid-summer sowing of brassicas was highly risky when soils were dry and if seedbeds were under-prepared, resulting in poor germination. The risk of crop failure was much reduced on farms with irrigation.

Optimum sowing date for autumn-sown single graze and multipurpose cereals was late Feb - early Mar. Autumn rain and/or irrigation was essential for ensuring good seedling establishment and survival. Trials, repeated over two seasons, showed a yield range of 2.7-4.7 t/ha for a single grazing completed by 22 July. The oat trial entries gave best early growth and were, therefore, most appropriate for early winter grazing. Multipurpose triticale cultivars eg. Doubletake and CRTR20 with good regrowth characteristics yielded up to 18 t/ha total biomass from grazing and silage harvest on 17 Jan. Comparative yield of cv. Feast II Italian ryegrass over the same period yielded 11.2 t/ha from six manual cuts, adjusting for 500 kg/ha residual. A system combining the flexibility of Italian ryegrass grazing and conserved whole crop from the previous year will ensure continuity of supply for late winter grazing and supplementation.

Cereals selected for spring-sown for whole crop silage grown in rotation with late summer sown rape or kale produced an annual yield up to 25 t/ha under centre pivot irrigation. This system has been adopted by one participant (Francis) in the FeedMAX group and was only viable if both crops were irrigated. Soil depth to stones was less then 50 cm with approximately 70 mm available soil water. Neutron probe soil moisture monitoring in demonstration crops showed water deficits not exceeding 25 mm and soil nitrogen availability in excess of crop requirements for the duration of the trial. Under this system there was evidence of reduced annual yields as the soil organic matter declined under continuous cropping.

Intercrops of cv. Rocket triticale with cv. Provider forage pea showed small increases in productivity over monocultures. Protein content of the peas was up to 10% higher in peas than in the cereal. However, the peas did not compete well, accounting for only 32.2% of the biomass at maturity. The timing of harvest was difficult to manage in the crop mix as maturation of the legume component occurred at a faster rate.

Yield potential (tops + bulb) of cv. Barkant turnips in spring was similar for the respective sowing dates and for equivalent duration to harvest. Bulb development was better for later sown crops, and this was reflected in improved soluble sugar + starch content but lower protein. Winifred rape (10.6 t/ha) yielded similar biomass to turnips, and surpassed cv. Pasja leafy turnip (6.1 t/ha) and cv. Puna chicory (3.5 t/ha) at 84 days after sowing. At two other sites, mean yield of respective crops harvested by 17 Jan. were turnips (8.5 t/ha), cv. Winifred rape (7.6 t/ha), cv. Pasja (5.7 t.ha, two cuts), cv. Rocket triticale (10.9 t/ha), cv. Puna chicory (7.2 t/ha, 2 cuts) and Feast II Italian ryegrass (3.4 t/ha).

Feed quality

From the perspective of ration balancing, it was impractical to compare feed values of crops as animal requirements varied according to season, herd characteristics and the systems used for feed production. However, ration balancing using grazed feeds(winter cereals, brassicas, annual ryegrass) or conserved feeds (pasture silage, whole crop silage and maize silage) during winter, and in early, mid and late lactation was useful for demonstrating whether composite feeds met the animal requirements for ME, protein and fibre. Energy deficits occurred only in summer and autumn with a maximum ME shortfall of 30 MJ/cow/day in April, despite the inclusion of maize silage. Protein intake deficits only occurred in summer and autumn, and NDF fibre intake was always in surplus, although marginal in spring, assuming an optimum total feed NDF of 30%. Farm simulations using the UDDER model (Larcombe 2004) with inputs for actual milk production and pasture cover over a full annual production cycle confirmed that additional energy and protein-rich supplements during mid to late lactation would enhance milk solids production.

Cost of crop production

The costs associated with growing crops varied according to forage type (Table 2). These ranged from $548 per ha for autumn-sown cereals and ryegrass to $1100 per ha for spring cereals. Summer-sown brassicas averaged $812 per ha. Without allowing for herbage quality, the seasonal value of the feed to the farmers was best calculated as cost per kg DM produced. Feeds produced during times of high crop productivity gave best responses.

Table 2. Feed cost per kg DM.

Crop	Sowing	Cost (c/kg)
Brassica	Summer	7.0
Cereal and annual ryegrass	Autumn	14.0 – 15.5
Cereal	Spring	8.8 -9.6
Turnip	Spring	6.8 – 9.6
Pasja	Spring	15.0
Chicory	Spring	23.0
Annual ryegrass	Spring	6.7

Future work will involve implementation of optimised feed production and feed allocation plans tailored for individual farm needs and utilising the variation in production potential of specific crops and farms systems for increasing feed supply. The data will be used to assist farmers to feed stock according to animal requirements and ensure that feed is produced both economically and sustainably.

Conclusions

Yield and herbage quality from forages grown or conserved showed that row crops have a place in complementing pasture-based dairying in irrigated systems. Growing these crops in dryland situations is considered too risky. Descriptions of crop productivity and quality of herbage of a range of feed types has assisted dairy farmers in evaluating options for managing feed reserves. Prescriptions were given for growing crops in short-term crop rotations within a grass-based system.

Dairy farmers were introduced to cultural practices required for maximising productivity, and assisted with trials comprising new cropping options giving improved annual cycle of feed production with sustainable nutrient management practices. Options for crop selection, crop agronomy and managing bulk feed supply were demonstrated in on-farm trials. A menu of forage options were presented for use on dairy blocks and runoff properties based on trial data over two growing seasons. Experiences of all farmers in the FeedMAX group were used to help solve feed deficits during the milking season and for over-wintering stock.

Acknowledgements

This research was funded by MAF Sustainable Farming Fund and Foundation for Research, Science & Technology.

References

de Ruiter JM, Hanson R, Hay AS, Armstrong KW, and Harrison-Kirk RD (2002). Whole crop cereals for grazing and silage: balancing quality and quantity. Proceedings of the New Zealand Grassland Association 64, 181-189.

de Ruiter JM (2000). Comparative growth and nutritional quality of oat herbage. Proceedings of the 6th International Oat Conference, Lincoln University. 13-16 November, pp. 61-73.

Ekard RJ, Salardini AA, Hannah M, Franks DR (2001). The yield, quality and irrigation response of summer forage crops suitable for a dairy pasture renovation program in north-western Tasmania. Australian Journal of Experimental Agriculture 41, 37-44.

Hanson R, Armstrong KW, de Ruiter JM, Hay AS, and Milne GD (2006). Cereal Forage Breeding for New Zealand Agriculture. Proceedings of the 13th Australasian Plant Breeding Conference (CD release).

Kolver E (2000). Nutritional guidelines for the high producing dairy cow. Proceedings of the Ruakura Dairy Farmers' Conference 17-28.

National Research Council (2001). Nutrient requirement of Dairy cattle, 7th edition. National Academy Press Washington DC.

Wales WJ, Heard JW, Ho CKM, Leddin CM, Stockdale CR, Walker GP and Doyle PT (2006). Profitable feeding of dairy cows on irrigated farms in northern Victoria. Australian Journal of Experimental Agriculture 46, 743-752.

Larcombe M (2004). UDDER, Version 2.9. WPC Computing.