Feed Crop Rotations for Supporting a Milking Platform

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Introduction

Forage crops perform an important role in New Zealand farming systems. They provide large quantities of high quality forage when perennial pasture growth is low or of poor quality. The production advantages of forage crops over conventional pasture are varied and relate to the level of utilisable yield of the forage crop. These advantages include : renovation of pasture that is beyond improvement through grazing management (Hook, 1981), use as a break crop to assist weed and pest control, and to confine or reduce the level of overall farm winter pugging.

This paper reviews the off-farm forage cropping opportunities available to dairy farmers. It assumes that the main livestock objectives are to grow young dairy stock at optimum rates, maintain or improve the condition of dry cows, or provide feed for longer term conservation.

Forage crops can be broadly classified into the brassicas and greenfeeds. As brassica crops are covered in detail in another session of this conference, this paper only covers recent brassica research conducted at Lincoln University, particularly with regard to leaf turnips. More detailed coverage is given to the cereal and ryegrass greenfeeds, while the final section gives some suggested cropping sequences to incorporate the forage crops into an overall farming system.

Brassicas

Yield and Quality

Given adequate nutrition, moisture and efficient weed, pest and disease control then temperature, or more specifically the total thermal time experienced by the crop, becomes the main driver of yield (Collie and McKenzie, 1998). These authors sowed three cultivars of turnips on five dates (Table 1). Total dry matter yields ranged from 1540 g/m^2 in the 28 January sowing to 590 g/m^2 in the 25 March sowing. Crops sown on 11 and 25 February achieved canopy closure faster than those from the two March sowings. Plots sown on 25 March did not achieve canopy closure. Reduced canopy development was a result of reduced rate of leaf appearance and leaf expansion. New leaves appeared every 2.9 days (plants sown on 11 February), 3.6 days (sown 25 February), 4.7 days (sown 11 March) and 5.6 days (sown 25 March). Comparisons among sowing dates in thermal time showed no difference between rate of appearance, with one leaf appearing every 40 °C d.

Table 1 : The effect of sowing date on the root, shoot and total DM yield of three turnip cultivars in Canterbury (adapted from Collie and McKenzie, 1998).

Sowing Date	Total DM	Shoot DM (g/m^2)	Root DM
28 January	1540.0 a[1]	1015.0	525.0 a
11 February	1381.1 a	949.1	432.0 b
25 February	1060.5 b	768.5	292.0 c
11 March	842.7 c	791.7	51.0 d
25 March	595.2 d	589.2	6.0 d
$LSD_{P<0.05}$	172.4	115.7	76
CV (%)	15.9	15.6	3.4
Cultivar			
Appin	1105.4 b	891.3	214.1 c
York Globe	1185.4 b	410.0	775.4 a
Green Globe	1327.3 a	742.8	584.5 b
$LSD_{P<0.05}$	127.15	157.1	102.7
Cv (%)	14.45	20.3	46.35

[1] Means followed by the same letter are not significantly different at $P<0.05$

The data in Table 1 also indicate that the later sown crops had a much higher proportion of the total DM as leaf. This higher proportion of leaf has little influence on quality in turnips where the "root" or bulb is not lignified and readily eaten by animals. In kale Stephen (1976) showed that there was also a reduction in yield with delays in sowing time but the early sown crops had lower quality.

Table 2: The effect of sowing time on leaf, stem and total DM yield (kg/ha) of medium stemmed marrostem kale sown at different dates and harvested on June 27 (Adapted from Stephen, 1976).

Component	Sowing Date				
	Sept 11	Oct 10	Nov 13	Dec 4	Jan 3
Leaf	3,760	4,240	4,380	4,920	3,860
Stem	12,300	13,000	10,540	8,450	4,630
Total	16,060	17,240	14,920	13,370	8,490

Delaying sowing from September 11 until January 3 halved the yield from 16,060 to 8,490 kg DM/ha (Table 2).

The September sown crop was 21% leaf while the crop sown in January was 45% leaf. Further examination of the data (Table 3) shows that the early sown crops actually lost leaves with the leaf yield of the September sown crop declining from a peak of 6,230 kg DM/ha on

March 21 to 3,760 kg DM/ha on June 27. In contrast, the leaf yield of the January sown crop continued to increase over this period.

Table 3: The effect of sowing time on leaf yields (kg DM/ha) of medium-stemmed marrowstem kale sown at different dates (Adapted from Stephen, 1976).

	Sowing Date		
Sample Date	September 11	November 13	January 3
March 21	6,230	5,560	2,100
April 18	4,410	4,860	3,060
May 21	3,960	4,450	3,070
June 27	3,760	4,380	3,860

By June 27 there was no significant difference in leaf yield between the crops as they were all in equilibrium with the light environment.

Finally Stephen (1975) measured the digestibility of the various crop components (Table 4).

Table 4: Percentage organic matter digestibility of marrowstem kale sown at two different dates and harvested on July 16 (adapted from Stephen 1976).

Sowing Time	**Leaf**	**Upper Stem**	**Lower Stem**
November 11	89.4	86.9	51.0
January 15	85.9	81.4	64.1

The digestibility values for the leaf and upper stem were similarly high at around 85%. For the lower stem the earliest sown crop had a lower digestibility at 51%.

In conclusion, time of sowing has major effects on both yield and quality of brassicas especially kale. These data suggest that staggered sowings over time may be desirable where the crop is to be fed over several months. They also have significant implications for cultivar selection in that the highest yielding, lignified stemmy crops may have low digestibility. Gowers and Armstrong (1994) found that older cultivars of kale had been bred mainly to produce high yields with little regard for leaf/stem ratio or digestibility. Modern cultivars have been bred for higher leaf/stem ratios and therefore digestibility, but this has occurred at the expense of yield.

Turnips x Rape Hybrids (Brassica campestris x Brassica napus)

There has been considerable interest from sheep farmers in these hybrids, particularly in the North Island. They produce a very small turnip like bulb situated at about ground level and because of this low growing point are capable of producing several grazings. There is no risk of scald compared with rape and they are resistant to club-root.

These hybrids or leaf turnips as they are sometimes called are most suitable for spring-summer sowing to provide feed from late summer to early winter. Initial research at Lincoln has shown they are capable of producing initial ceiling yields of around 8 t DM/ha in about 130 days from an October sowing. This yield is much higher than sheep farmers generally allow before the first grazing, possibly because such crops produce leaves with very thick petioles which are not readily eaten by sheep.

It is suggested that leaf turnips should be considered as an option by dairy farmers to provide high quality feed for young dairy stock over the summer-autumn period. With their regrowth potential they are capable of total yields in excess of 12 t DM/ha. They are however susceptible to drought and aphids and require moderate-high fertility. Where these growing conditions cannot be provided our research would suggest that rape is a better option, but rape may lead to more stock health problems.

Winter greenfeeds

There are two types of winter greenfeed considered, cereals and ryegrasses.

Cereals

Any temperate cereal can be used as a greenfeed but oats are the most common with less reliance being placed on ryecorn, wheat and barley. All cereals have been bred and selected mainly for grain production and from the greenfeed viewpoint this has resulted in three characteristics. Firstly, cereals produce comparatively few and large tillers with rather elevated growing points giving a plant that does not recover well from grazing. Secondly, cereals produce high yields of seed; meaning that seed is usually cheap. Thirdly, the large seed can be sown into a rough seedbed.

The growth and yield characteristics of the main cereal greenfeeds are clearly demonstrated by the data in Table 5 where five greenfeeds were sown at three sowing times, grazed on the 26 July and the regrowth measured on 9 September.

Table 5: Total dry matter yield to 9 September of five greenfeed cultivars sown on three sowing dates and grazed on 26 July (adapted from Hicks, 1997).

Cultivar	Kg DM/ha		
	Yield prior to grazing	Regrowth	Total
Ryecorn	2970 b	1180	4150
Caravelle oats	3690 a	730	4420
Hokonui oats	3610 a	830	4440
Illia barley	3080 b	1500	4580
Moata ryegrass	2280 c	1670	3950
LSD (P<0.05)	321		ns
Interactions	ns	*	ns
Sowing Date			
11 March	5180 a	790	5970 a
27 March	3340 b	1840	5180 b
18 April	860 c	920	1780 c
LSD (P<0.,05)	345		628
Interactions:	ns	*	ns

In this experiment, oats were the highest yielding initially followed by ryecorn and the winter barley. Initially ryegrass was the lowest yielding.

Both oat cultivars showed poor regrowth with both winter barley and ryegrass showing the highest regrowth. These differences in regrowth negated the earlier superiority of the oats so that by September the total yield of all cultivars was the same. If this experiment had continued under grazing for longer then the superiority of the ryegrass would have become progressively greater.

Delays in sowing from March until April caused large reductions in yield, these being associated with reductions in thermal time. The thermal times up to 26 July were 1140, 910 and 660° C days for the 11 March, 27 March and 18 April sowing dates respectively.

In the above experiment sheep showed marked grazing preference for the ryegrass so that by the completion of grazing the utilisation percentage was 69, 65, 73, 72 and 84% for the Ryecorn, Caravelle, Hokonui, Illia and ryegrass respectively.

Ryegrasses

Compared with the cereals greenfeed ryegrasses require high fertility soils, a well prepared seedbed and early sowing (March) to produce maximum yields. Before 1968 Grasslands Paroa Italian ryegrass and Grasslands Manawa ryegrass were the main cultivars used. In 1968 Grasslands Tama, a tetraploid, was released and rapidly gained popularity due to its huge seed size of about 5 mg which gave rapid establishment and very high cool season production of high quality herbage. Tama however, is strictly an annual and since that time there have been a host of other Italian and hybrid type ryegrasses bred and released especially due to the demand from the dairy industry for greater perenniality.

Under dairying conditions of adequate moisture and rotational grazing with cattle some of these modern greenfeed ryegrasses will last for several years, but under dryland conditions on thin soils, with sheep grazing, few plants survive to the second year. Argentine Stem Weevil attack is most severe under these conditions.

There is a huge amount of information available on what are termed "short term" ryegrasses from the National Forage Variety Trials set up by the New Zealand Plant Breeding and Research Association Inc. It is recommended that farmers study these data when choosing cultivars.

As with the other crops discussed the biggest single factor influencing the initial yield of short term ryegrasses is the time of sowing or more precisely, the time of emergence in autumn. An experiment at Kirwee (Scott & Brown, 1979) demonstrates the situation perfectly.

Table 6: Performance of Tama ryegrass form sowing to mid-spring (adapted from Scott and Brown, 1979).

	1977	1977	1978
Summer Fallow	Yes	No	Yes
Soil Moisture %	22	11	13
Days to seedling emergence	7	49	21
Yield March-May (kg DM/ha)	1,700	Nil	700
May-September	3,300	1,800	2,800

The main conclusions from Table 6 are that Tama ryegrass seedlings should emerge in early March, moisture is essential for emergence and growth and that without irrigation a summer fallow is essential.

At Lincoln the Moata ryegrass harvested on 26 July yielded 3,750, 2,500 and 500 kg DM/ha from 11 March, 27 March and 18 April respectively, again demonstrating that delays in sowing cause yield reductions out of all proportion to the chronological time involved. This is because thermal time drives leaf appearance rate which in turn determines light interception and growth.

Although there is plenty of documented information on the seasonal and total yields of short term ryegrass very little is known about animal preference for short term ryegrass cultivars especially in relation to cattle. Experiments with sheep have indicated that substantial differences in grazing preference exist amongst short term ryegrass cultivars. Preference is assessed by counting the number of animals grazing each plot about half an hour after grazing commences, measuring herbage disappearance over time and the final residual herbage yield at the end of the grazing period.

Table 7 presents the number of hoggets per plot during the initial grazing period of several ryegrass cultivars each sown at 300 viable seeds/m^2.

Table 7: The number of hoggets per plot during the initial grazing period of several ryegrass cultivars (adapted from Lee 1999).

Cultivar	Number of hoggets/plot
Concord	1.9
Galaxy	5.4
Maverick	2.3
Moata	1.0
Tama	1.0

LSD = 2

In this experiment Galaxy was clearly the most preferred cultivar with Moata and Tama the least preferred. This preference was also apparent at the end of the grazing period (Table 8).

Table 8: Pre and post-grazing herbage mass (kg DM/ha), apparent intakes (kg DM/ha) and percent utilisation of five ryegrasses before and after five days of grazing by ewe hoggets (adapted from Lee, 1999).

Cultivar	Pre-grazing Mass Kg DM/ha	Post grazing Kg DM/ha	Apparent intake Kg DM/ha	Utilisation (%)
Concord	4710	2150	2260	54
Galaxy	2990	970	2020	68
Maverick	3790	1670	2120	60
Moata	4340	2000	2340	53
Tama	3610	1410	2200	61
LSD	752	645	NS	NS

Table 8 shows that although Galaxy was one of the lowest yielding cultivars initially its high grazing preference raised its apparent intake to the same level as the other cultivars.

In conclusion farmers should consider grazing preference as well as total DM yield when choosing which short term ryegrass cultivar to sow. It is acknowledged however that the grazing preferences of cattle and even different classes of cattle may differ from those of sheep.

Cut lunches or conserved forage

Any dairy system should consider the option of conserving forage as hay, baleage or silage. Such crops may assist pasture control, increase the number of options available for a cropping rotation or provide a flexible feed supply in the longer term to cope with unfavourable climatic events such as drought, floods or snow.

The regrowth potential and high soluble sugar levels of the short term ryegrasses discussed previously makes them excellent candidates for silage production. The application of a nitrogen fertiliser in September or October is likely to increase yields.

Maize is another option for silage production although the risk of frost damage increases further south (Wilson & Salinger, 1992). From a crop rotation viewpoint the harvest time of maize silage in April or even May restricts the options of establishing other crops or pasture species that autumn.

Finally autumn or spring sown temperate cereals may be cut for silage. Experiments by de Ruiter (2001) have once again shown that delays in sowing date reduce yields. Yields of up to 13 t DM/ha were obtained from sowing on 27 August but this was reduced to around 7 t/ha for a late sowing on 2 November. Yield in these crops was best described by a thermal time model with production efficiency varying among trials from 1.08 to 1.77 t/ha/100° C.d.

Cropping rotations

The following rotations or sequences are suggested to exploit the desirable attributes of the cropping options described in this paper. They are offered as guidelines only as each property has it's own unique physical characteristics and management objectives.

Southland/Otago

Short Term Ryegrass

Old Pasture → Swedes or Kale → Spring Cereal Silage → New Grass

Here the swedes or kale should be sown by late November and fed off over winter. The cereal is sown as early as possible in spring and cut for silage in January or February depending on time of sowing. This harvest time enables timely sowing of new grass or short term ryegrass in January or February.

Canterbury Cropping Farm

Cash Crop → Brassica or Cereal Greenfeed → Maize Silage → Winter Cereal

An early harvest (January) allows time for the sowing of a winter brassica crop such as soft turnips or giant rape. This could be used for sheep or calf grazing over winter. Intensive cropping farmers tend to avoid wintering mature cows due to the risk of severe winter pugging. The maize is sown in October and harvested for silage for sale off-farm in April-May, in time for the sowing of a temperate cereal for either grain or whole crop silage.

Dryland Light Land, Canterbury/Otago

Old Grass or Lucerne → Ryegrass Greenfeed → Turnips → New Lucerne

Turnips ↘ Oats → New Grass

To ensure adequate moisture for sowing ryegrass in early March the old grass or lucerne needs to be ripped up no later than about mid November. Choose a rapid establishing ryegrass such as Andy, Archie, Progrow or Tama as this situation only requires an annual. This high quality feed is very suitable for growing young stock or putting condition on dry cows. Strict rotational grazing, backfencing and additional nitrogen will maximise yields.

For turnip sowing in late January, the ryegrass should be cultivated in late October. Soft turnips are best used for maintenance of dry stock over winter. The lucerne is sown in early October. There is also the opportunity to sow lucerne on intensive cropping farms for sale to dairy farms.

Dryland light land is an ideal environment for wintering mature dairy cows as pugging damage is usually minimal on these free draining soils.

On better soils e.g. shallow Templetons, the turnips may be followed by oats for silage followed by new pasture in autumn.

Irrigated Medium – Light Soils, Canterbury/Otago

Old Grass → Leaf turnips → Autumn Cereal Silage → Short term ryegrass

Leaf turnips require high fertility and adequate moisture. They are sown in October-November and provide very high quality feed starting in January. With rotational grazing they will continue to provide high quality feed through autumn. The spring cereal for silage should be sown in May. Irrigation and nitrogen can be used to increase the yield of the silage crop which is harvested in December, again in time for sowing a short term ryegrass. Choose a ryegrass cultivar that will last at least two years as irrigation, adequate fertility and rotational grazing with cattle all promote increased persistence.

Conclusions and Recommendations

The brassicas: swedes, turnips and kale, provide the highest yielding "oncer" crops for winter feed. Yield of these crops is related to thermal time but for kale quality may decline with increasing yield. Turnip x rape hybrids should be considered as an option by dairy farmers to provide high quality feed for young dairy stock over the summer-autumn period. The characteristics of cereal and ryegrass greenfeeds are compared : a wide range of ryegrass greenfeeds is available showing differences in yield, persistence and grazing preference. Conserved forage from pasture, temperate cereal or maize adds flexibility to the cropping programme and feed supply in the longer term. Several cropping rotations or sequences are suggested to exploit the attributes of the cropping options described.

References

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Workshop summary

Questions

- Is there a link between preference and productivity? Yes, but not very obvious.
- Thoughts on regrassing with mixed crop? Ryegrass will take over the crop which is a problem, too aggressive.
- Is grass-to-grass O.K? Generally there is a reason why the grass needs to be upgraded, therefore a crop is often required.
- What is "fallow"? Cultivation then leave, and cultivate again (lightly) with each rain. Stores moisture for the coming crop.
- What was the dry matter percentage of the maize crop on screen? Harvested at the optimal rate for yield (32-35%).
- Any problems with nitrates? Used to think it was from cloudy, frosty weather on highly fertile soils. Less nitrates and milk fever from ryegrasses than cereals.
- How long does the Galaxy last, especially under irrigation? Up to three years under irrigation in Wairarapa. Needs moisture, rotational grazing and fertility. Less of any of them lowers lifespan.

Conclusion

- Brassicas highest yield for winter feed.
- Always consider utilisation %.
- Turnip x Rape hybrids provide high quality feed over the summer and autumn.
- Must sow on time.
- Don't be sucked in by yield alone.
- Remember annual ryegrasses for winter crops. Less initial yield, superior regrowth obviously.