The importance of grazing management

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Summary

Autumn

- Priorities are to slow the rotation down and build up an adequate farm cover before the herd is dried off.

Early Spring

- Maintain a slow rotation to ensure farm cover does not reach its lowest level until mid-September.

Late Spring

- Fully feed the herd while maintaining high quality pasture and ensuring that conservation methods are used to harvest any excess and to maintain feed quality.

Summer

- Slow rather than fast rotation (30-40 vs. 15-20) will ensure farm pasture covers are maintained at an appropriate level.

Introduction

I have been concerned by what I see as a move by many New Zealand dairy farmers away from a low-cost, traditional pasture-only feeding system. I hesitate to use the words low-cost as this often conjures up visions of a run down system, but it best describes the farming system practiced so successfully in New Zealand for the last 50 years. The methods advocated by Dr. McMeekan in the 1950's and 60's and then Dr. Bryant in the 1980's and 90's are as applicable now as they were then.

New Zealand dairy farmers have relied on their ability to produce milksolids cheaply. This has been the competitive edge they have always had. This approach demands that costs be reduced to a minimum. A survey by Brendan Attrill of Livestock Improvement Corporation in 1996 highlighted the changes that had occurred in New Zealand over the previous 10 years. This showed that farm production and gross farm income had both increased but unfortunately net income had not, mainly because of large increases in variable costs. This trend is also evident in the USA, where farmers are making a loss because of over capitalisation due to a high-cost farming system. The situation can be summed up by this statement: "Anything which you put between a cow and a blade of grass has to be paid for by the cow!"

New Zealand dairy farmers should be aware that the low-cost approach New Zealand has had, is now being embraced by other developing dairy farming countries. If we are not careful, our competitors will overtake New Zealand in the production of low-cost milk products. These countries have huge land and labour resources available to them, and are fast moving away from high-cost feed systems. They could soon become very competitive.

For this reason, I believe New Zealand dairy farmers need to examine just where they are heading. We know that New Zealand dairy cows are just as efficient as those from other countries, and if they are fed better they will produce more than they do at present. But is this what we want? I am not against high cost systems as long as they do not reduce the net return to the farmer. We have to be careful that in the move to increase production per cow and per hectare, we do not lose sight of profitability. At the end of the day, the most important aspect is how much money reaches the farmer's pocket.

The most important reason why New Zealand dairying has been able to stay as the best producer of low-cost milk products, is the continued reliance on cheap pasture as the sole food source. Grass is the cheapest feed source available and I encourage farmers to make the best use of it. ***Use it don't abuse it.*** The tendency is to fully feed the herd sometimes to the detriment of the pastures. It is important to feed the herd well, but at all times there has to be good pasture utilisation. If the pastures are looked after they will look after the cows.

Dairying in New Zealand is about growing plenty of pasture, and making sure most of that pasture is eaten by the herd. Growing pasture is about soil fertility, drainage and maintaining productive pasture species. Pasture utilisation is about ensuring there are enough cows to eat all the available feed by having the right stocking rate.

About 60% of New Zealand pasture production occurs in the 5 months from September to January. This pasture must be fully utilised. New Zealand dairy pastures are made up predominantly of perennial ryegrass.

Ryegrass plants are made up of several tillers consisting of up to three leaves. Ryegrass leaves originate from a growing point near the base of the plant and seldom does this growing point get removed by grazing. The appearance of new and death of existing ryegrass leaves are closely related. Rate of appearance matches pasture growth thus it is fastest in spring (7 days) and slowest in winter (30 days). Due to the close relationship between appearance and death the life of a tiller is approximately 21 days in spring and up to 90 days in winter. Therefore grazing management should be manipulated around ensuring survival of the pasture and maximising utilisation.

The grazing season

There are four important grazing management periods. They are:

1. **Autumn** From the time of drying off the herd through to the start of calving (April to mid July)

2. **Early Spring** From the start of calving to when pasture growth exceeds the herd demand (mid July to about mid September – this latter date is dependent on the stocking rate)

3. **Late Spring** When pasture growth exceeds herd demand. (About mid September – December)

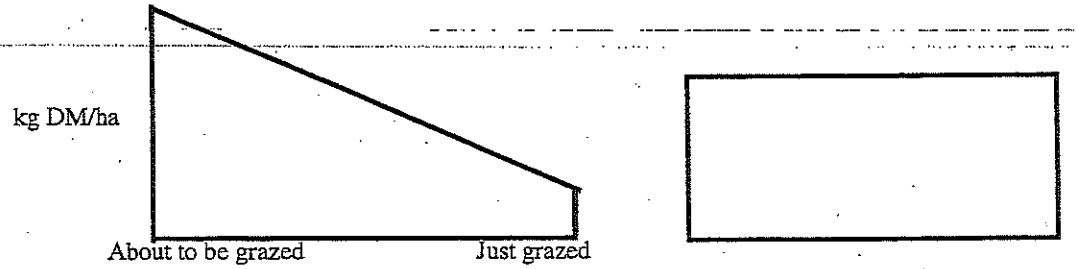
4. **Summer** When pasture growth depends on rainfall (December to late March).

1. April to mid July

The basic aims in this period are:

- To build up and then maintain sufficient pasture cover to feed the herd after calving while ensuring the herd calves at an average condition score (CS) of close to 5.0. Most farms at moderate stocking rates (2.8 to 3.3 cows /hectare) require a farm cover of about 2200 - 2400 kg DM/ha at the start of calving.
- A slow rotation must be established in autumn and then maintained. Pasture damage from pugging during wet periods must be avoided. Cows require at least maintenance feeding during this period ie. a herd at a stocking rate of 2.5 cows/ha requires 15 kg DM/day (2.5 cows/ha x 6 kg DM/cow/day, ie cows fed at 1.5% of 400kg liveweight).
- Pasture cover will drop during winter unless total herd intake is restricted. Herd demand is generally greater than pasture growth.
- To maintain total intake while pasture intakes are restricted, supplements must be used. Alternatively pasture cover can be achieved, and animals properly fed on all pasture if a proportion of the herd is grazed off the milking area, or enough pasture is on the farm at the start of winter to allow cover to drop, yet still achieve target.
- To have a wedge instead of a block (Figure 1) of pasture cover over the farm at the start of calving.

Figure 1. The effect of spread of pasture cover over the farm.



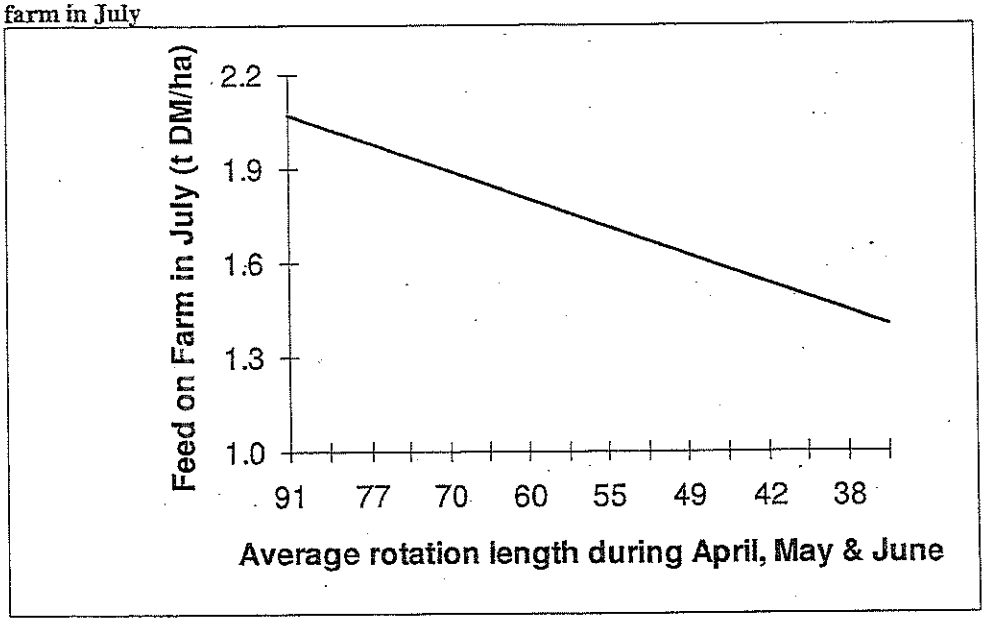
Wedge effect of farm cover **Block effect of farm cover**

When the herd is grazed off the farm over the late-autumn-winter, the pasture available at the start of calving is often over–mature and has a high mass (eg, the block effect in Figure 1). This feed is lower in quality and because it has a high mass there is much dead and decaying material at the base.

The above points are achieved at Dexcel's No. 2 Dairy by establishing a 100 day rotation by early May, and holding it until the start of calving.

Fig. 2 shows what happens to feed on the farm as an increasing proportion of the farm is grazed during April, May and June.

Figure 2: The effect of average rotation length during April, May and June on the amount of feed on the farm in July



These results are from a trial at Dexcel's No. 2 Dairy in the mid 1980's. They show that by restricting pasture intake, the herd that was on a 90-day rotation during the winter had about 2100kg DM/ha farm cover in July. Whereas the herd that was on a faster rotation eg., 40 days, the farm cover dropped to about 1500kg DM/ha, because intakes were not restricted. This shows that the feed on the farm in July is closely related to the number of grazings from 1 April to 30 June.

Conclusion

The earlier you establish the winter rotation in the autumn, and the slower it is, the more feed there will be on the farm at the start of calving.

The effect of intensive grazing of dairy pastures.

Farmer's often debate the benefits of leaving higher post-grazing residuals on subsequent pasture growth rates. In early and late July 1997, cages were placed on the pasture of 2 paddocks so that the cows only had access to grazeable areas for 2, 4, 8 or 24 hours. The effect of differing post-grazing levels on pasture regrowth was measured.

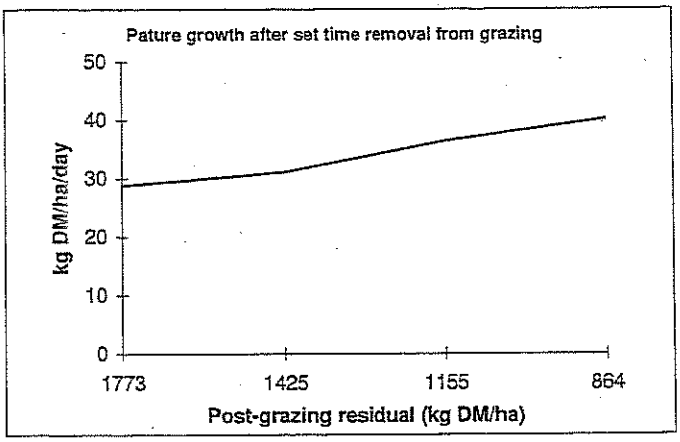
During the week preceding each grazing there was 25 & 2 mm of rainfall respectively. The soil types are Horotiu silt loam and Te Kowhai Clay loam. The pastures were not visibly damaged by pugging following the grazings.

Similar results were obtained from both paddocks. The average post-grazing immediately after and the pre-gazing levels at 52 days later are shown in Table 1. The post-grazing levels ranged from as low as 864 for the area that was not removed from the grazeable area (24 hours) up to 1773 kg DM/ha, on areas cows grazed for only 2 hours.

Table 1: Average pre and post-grazing and accumulated pasture cover (kg DM/ha) for areas grazed for 2, 4, 8 and 24 hours in July.

Hours	2	4	8	24
Post-grazing (July)	1773	1425	1155	864
Pre-grazing (September)	3264	3030	3000	2916
Accumulated growth (52 days)	1491	1605	1845	2052
Net pasture growth (kg DM/ha/day)	29	31	35	39

Figure 3: Average pasture growth 0-52 days post-grazing.



Even though the 24 hour areas were grazed much harder than the 2 hour ones, the accumulated growth after 52 days was 38% higher (Figure 3). The area that had the lightest grazing, subsequently had the **lowest pasture growth** although it maintained the highest pasture cover at the next grazing.

At the end of winter many of the leaves in pastures are reaching the end of their life. If left ungrazed old leaves will not remain until the next grazing. It is likely the rate of appearance of new leaves between the grazing treatments were similar. However some of the new leaves simply replace the loss of old material thus reducing the net accumulation of DM.

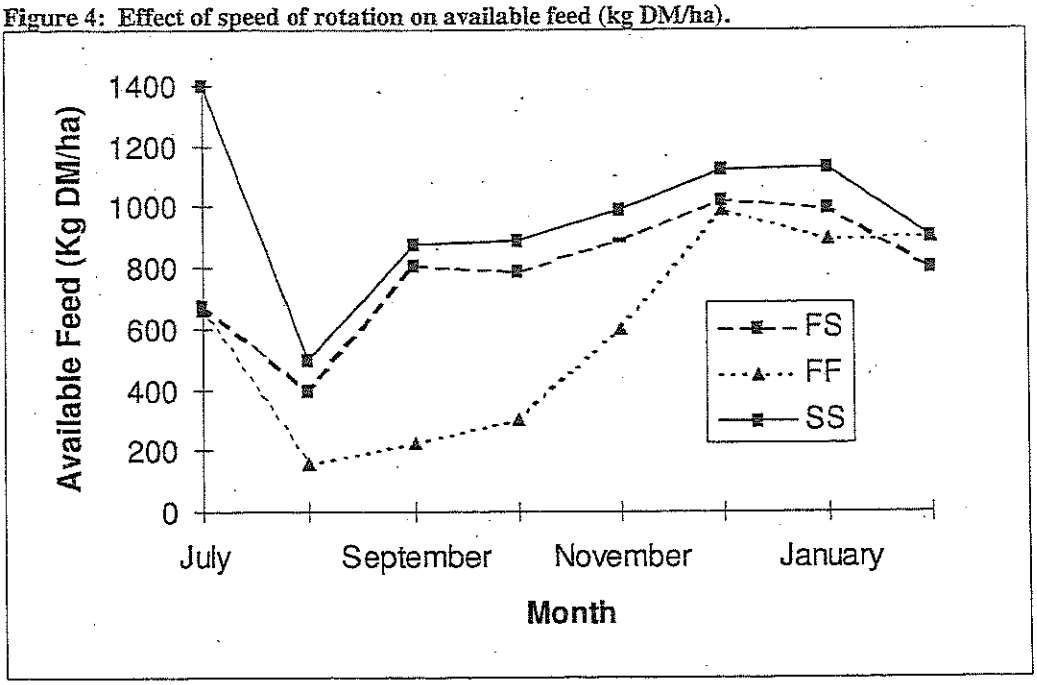
Maintenance of pasture production in late-winter early-spring relies on the herd eating as much of the old pasture as possible. Grass growing grass applies to average farm cover not post-grazing residuals.

2. MID JULY TO MID SEPTEMBER

If the amount of feed on the farm at the start of calving is restricted, and no supplements or N fertiliser can be used during the spring, then the only way the amount of feed on the farm can be increased by mid-September, is to restrict the cow intake from the start of calving to when pasture growth exceeds herd requirements.

In an early 1980's trial at Dexcel's No. 2 Dairy, herds were a on either a slow or fast rotation before and after calving, so there were two levels of farm cover at the start of calving (Figure 4).

Figure 4: Effect of speed of rotation on available feed (kg DM/ha).



As with the previous trial, the slow winter grazing rotation resulted in more feed on the farm in July. The Fast-Slow (FS) and the Fast-Fast (FF) herds had similar available feed in July but a fast rotation after calving quickly dropped feed cover with carry over effects lasting until December. On the other hand a slower rotation after calving meant that the FS herd cover plateaued at a similar level and time as the SS herd.

Conclusion

If short of feed at calving don't go on to a fast rotation in an attempt to fully feed the cows on pasture. Don't panic. All is not lost, by restricting cow pasture intakes and maintaining a slow rotation after calving farm covers will increase.

A trial at Dexcel's No. 2 Dairy in 1989 set out to further examine what happens after calving if groups of cows had differing rotation lengths from mid July to mid September (Table 2). There were eight farmlets involved in this trial with each treatment being replicated twice.

Table 2: Effect of differing rotation lengths on farm cover (kg DM/ha) and subsequent milksolids production

TREATMENT	1	2	3	4
Period	*Rotation length (Days)			
21/7 - 3/8	100	58	41	33
4/8 - 17/8	60	37	26	20
18/8 - 31/8	52	35	21	14
1/9 - 14/9	42	28	14	7
No. of rotations (21/7 - 14/9, 56 days)	1.0	1.5	2.5	4.1
Farm cover at 18 July kg DM/ha	2000	1900	1900	1900
Farm cover at 22 Sept kg DM/ha	1600	1500	1200	1100
MS/cow to 1 October	78	88	83	81
MS/cow to 9 February	248	267	257	246

* A rotation of 100 days means that 1/100 th of the farm was grazed each day.

The area grazed by the Treatment 1 cows was increased slowly (by having a slow rotation length) during the first 8 weeks after calving. For Treatment 4, cows were given a large area (fast rotation) immediately after calving in an attempt to fully feed them in the early post–calving period. Table 2 shows that by late-September

the farm cover had been reduced to a very low level on the faster rotation farmlets, compared with slower rotation herds.

Differences in per cow MS production between the treatment groups, that were evident in October had increased by February.

Figure 5: Average farm cover in spring and the effect on pasture growth (kg DM/ha).

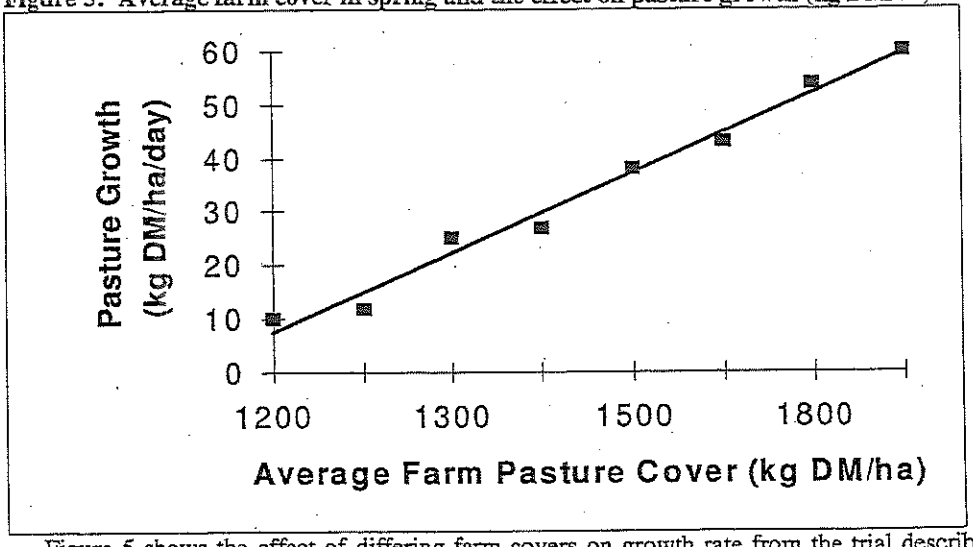


Figure 5 shows the effect of differing farm covers on growth rate from the trial described in Table 2. To make sure that the pasture growth is maintained at a high level in early spring it is necessary to ensure that the farm cover does not get too low (Figure 5). Having a very low pasture cover in the late-winter/early-spring means that it will stay low, similar to the SS herd (Figure 4).

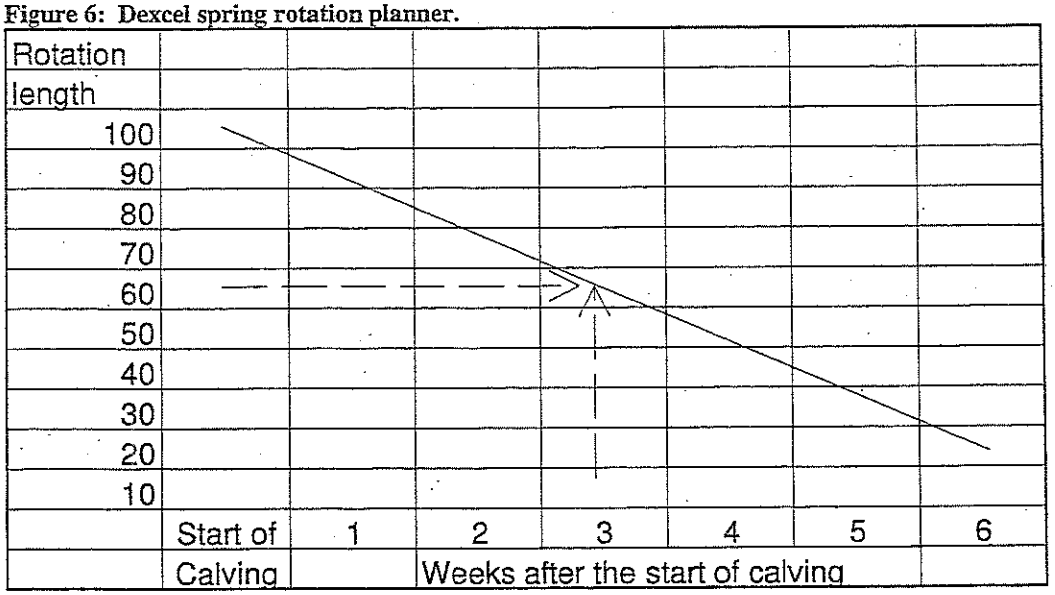
Using a fast rotation immediately after calving will ensure that in this early period the cows are well fed, but they may be fed less over the whole spring. Typically rotations which are too fast immediately after calving result in large September feed deficits. Unfortunately this persists through early October resulting in cows being poorly fed at mating time

Conclusion.

It is essential not to speed up the rotation too quickly after calving. Aim to be on the fastest rotation when pasture growth gets ahead of herd requirements. This is generally about the 10-15th September in central Waikato. The higher the SR the more important this rule is.

From the No. 2 Dairy trial a policy was developed to gradually speed up the rotation length after calving. If the rotation length at the start of calving is 100 days and its thought it should be 20 days, 6 weeks later, then it is necessary to speed up the rotation length by 13 days/week. This is shown in Figure 6 which is the Dexcel Spring Rotation Planner.

Figure 6: Dexcel spring rotation planner.



You can see from Figure 6 that by 3 weeks post-calving, the desired rotation length is 60 days (1/60th of the farm per day). To ensure this occurs, the break size for the dry cows is calculated so that they are receiving the desired level (eg 6kg DM/cow/day) of feed. The remainder is given to the milkers.

Calculations to work out the area to allocate to the herd when on a 60 day rotation, 3 weeks after the start of calving.
60 ha farm
180 cows - 120 cows calved.
3 weeks post-calving.
A 60 day rotation is required.
Therefore, 1 ha/day is required for the whole herd

Still have 60 dry cows that require 6 kg DM/day; (400kg cows fed at 1.5% liveweight)
Pasture cover ahead of dries 3300kg DM/ha;
Grazing down to 900 kg DM/ha,
Therefore consuming 2400kg DM/ha (3300 - 900)

60 cows x 6 = 360 kg DM/day required for the dry herd
360 /2400 = 0.15 ha/day for the dry cows. (1500 m^2)
Therefore the area to give to the milkers is: 1 ha - 0.15 = 0.85 ha. (8500 m^2)

If the pre-grazing cover for the milkers is the same as for the dries (3300 kg DM/ha) but they only graze it down to say 1200 kg DM/ha, then the milkers intake will be about 15 kg DM/cow/day (3300 - 1200 = 2100 x 0.80ha / 120 cows).

Remember that in this example the amount fed to the dries is 1.5% of liveweight. If increased to 2.0% then less will be available to the milkers. In this case the milkers intakes will be approximately 14 kg DM/cow/day.

Overall conclusions

1. The amount of feed on the farm in mid-September was strongly related to the number of rotations from mid-July to mid-September. Increasing the number or rotations reduced mid-September farm cover.

2. The differences in pasture cover in mid-September persisted until November.

3. Where the amount of feed on the farm in mid-September was reduced below about 1800 kg DM/ha by speeding up the rotation too soon or too fast (Treatment 4, Table 2), cows will be underfed during September and October and MS yields will be reduced, and mating performance will be effected.

4. The optimum number of grazings was when 1.5 - 2.5 rotations were completed during the 8 weeks of mid-July to mid September, equivalent to an average of 30-40 days.

5. Where there is a low stocking or very good early spring pasture growth rates then the effects of fast rotations as in FF Treatment & 4 herd (Figure 4 & Table 2) on MS yields, may be beneficial. This is because it will ensure the cows are well fed but more importantly farm cover is least in mid-September. Pastures in late-winter/early-spring are affected more by frequency than intensity of grazing. Thus the aim should be to maintain a moderate rotation length.

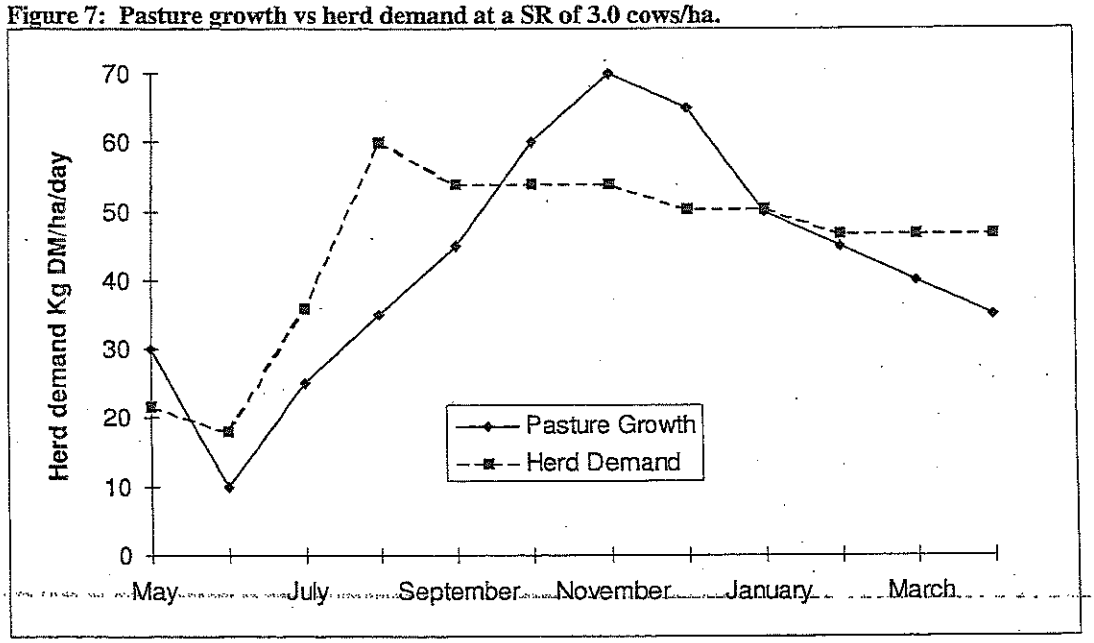
3. FOR THE PERIOD FROM WHEN PASTURE GROWTH EXCEEDS HERD DEMAND (Mid-September to December)

During this period the essential requirement is to provide high quality pasture to the herd. The pasture fed to the herd must be young and leafy. Once the stem-to-leaf ratio increases and seedheads appear, the digestibility and metabolisable energy (ME) content of the feed decreases quickly.

To ensure that pasture quality is maintained it may be necessary to remove pasture not required by the herd. At a stocking rate of 3.0 Friesian cows/ha, the feed demand of the herd in spring will be 54 kg DM/day (3.0 x 18 kg DM/cow/day). Pasture growth will normally exceed this during the months of October, November and December.

At a stocking rate of 3.0 cows/ha there can be long period in the spring when herd demand exceeds pasture growth (Figure 7).

Figure 7: Pasture growth vs herd demand at a SR of 3.0 cows/ha.



The surplus that occurs in October -November must not be wasted, and can be put aside as a deferred area or conserved as silage. Deferring means setting aside areas and not grazing them with the herd in the normal rotation. This is done when pasture growth is higher than herd requirements and the area is grazed when pasture growth has dropped to that lower than the herd requirements (eg. summer). The down side of deferred grazing is that by the time the pasture is fed to the cows it is very poor quality and per cow production is affected.

Management decisions on how much and when to remove areas for conservation are important. If not enough is removed, the cows will undergraze the pasture and quality will decline; if too much is removed then the herd will be underfed. To overcome these problems at Dexcel's No. 2 Dairy a set of decision rules have been established to take account of herd requirements, current farm cover, and predicted pasture growth over the next 2-3 weeks.

Example

If the farm is stocked at 3.0 cows/ha the herd requires 54 kg DM/day (3.0 x 18.0 kg DM/cow/day). When pasture growth is at 70 - 80 kg DM/ha/day then surplus pasture will accumulate quickly and urgent action is necessary. At this time a herd of 240 cows on a 20 day rotation will be grazing 4 ha/day.

This means that at a growth rate of 72 kg DM/ha/day, that approximately 25% of the farm could be closed up for silage. (54/72 x 20/1 = 15 days to fully feed herd).

This is a large area of the farm to close at one time. It is better to watch carefully and act early so that small areas are taken out at a time.

Rule of thumb

A number of people use the rule that if the herd is leaving clumps that cover more than 10% of the paddock then an area should be removed for conservation. Leaving clumps is the first sign that pasture growth has exceeded herd demand. The problem with this method is that it is reactive rather than proactive. If high rates of nitrogen are being used then the growth rate may be as high as 100-120kg DM/ha/day. **Therefore waiting for the clumps to cover 10% of the paddock maybe too late, because at these high growth rates, the feed situation very quickly gets out of control.** In this case the decision to conserve must be best made as soon as the clumps start appearing.

Topping

There has been a lot of discussion on the merits of the benefits of controlling peak spring pasture growth by mowing before or topping after grazing. A trial at No.2 dairy in 1998 showed that mowing before and topping after grazing increased pasture quality and summer MS production. Topping after grazing increased MS production during the trial period (Sept-Feb) by 5%. At the end of the trial period there was a higher herbage mass on the control farmlet and the mowing before farmlet cows weighed more. When an allowance is made for the extra silage that could have been made on the control farm and the extra liveweight the cows on the mowing before farmlet had in February, and if this was converted into MS, then the mowing before and topping after farms produced 14% and 5% less, respectively than the control farmlet.

In summary, although mowing before or topping after grazing can increase the quality of pasture and the yield of MS per cow in summer, the overall benefits for MS production per ha are small or negative.

The focus for dairy farmers should remain on the removal of grazing area for harvest as silage to capture potential pasture production, and to increase grazing pressure to maintain recommended grazing residuals during the late spring.

Silage making

Pasture silage made by NZ dairy farmers is usually of poor quality and does not usually meet the quality requirements of a lactating cow. A LIC survey in 1995 showed that more than 70% of the silage submitted for analysis had an ME of less than 10 MJ ME/kg DM, when it is desirable to be greater than 11. Therefore farmers in NZ have recently been encouraged to increase the quality of pasture silage they harvest.

It is known that as the silage crop matures, yield is increased but the metabolisable energy (MJME/kg DM) decreases. A recent trial at DRC showed that a delay in harvest from 7 to 9 weeks increased yield by 20% but quality declined from 10.8 to 10.3 MJME/kg DM. Therefore, a trade-off exists between dry matter (DM) yield and energy content of that dry matter. Recommendations from recent work is that as long as the post-grazing residual is even, and about 1500-1800 kg DM/ha then closure time should be about 5½ weeks.

The question is often asked "When is a crop ready for harvest?" The answer is generally when 10% of the crop has seed head. The problem with this answer is that between that time 10% seedhead and when the silage is actually harvested can be 1 to 2 weeks, depending on the farmers organisational skills, weather and availability of a contractor. In this time the crop has dropped in quality from being good to marginal. Therefore it is imperative that you are proactive in your decision making on when a crop is to be harvested. If a crop is ready to be harvested it is essential that this can occur. Therefore planning needs to be made well in advance.

Recent silage conserving and feeding trials have demonstrated the importance of offering high quality silage and the balance between yield and quality that allows profitability of a pasture-based dairying system to be maximised. Cows were offered silage of Low, Medium or High ME (8.3, 9.4, or 10.4 MJ ME/kg DM) in the winter, spring, summer and autumn. Milksolids production was increased by 13, 17 and 41% in the spring, summer and autumn respectively when comparing the Low with the High quality silage.

Using this information and combining it with the increase in DM yield from a longer pasture closure period we were able to calculate the value of conserving and then feeding high quality silage to lactating dairy cows. In spring, summer and autumn, we calculated a net return (at $3.50/kg MS) of 6.7, 5.1 & 8.3 cents respectively, per MJME/kg DM increase in silage quality. Therefore it is likely to be more economic to harvest several smaller yields of high quality silage than one large yield of low quality silage.

These trials demonstrate that pasture conservation decisions are important. Making silage is a big cost and if the silage is to be fed to lactating dairy cows and in particular to assist in extending lactation into the autumn, then it is vital that high quality silage is conserved.

4. SUMMER - AUTUMN

Without irrigation this period is highly dependent on summer rainfall. Pasture growth during summer/autumn is very unpredictable and generally the safest management is to maintain the late-spring rotation. If the rotation length is to be altered it should be lengthened rather than shortened.

Two trials at Dexcel have looked at the effects of differing summer rotation lengths on the herd and pastures. The first trial was at No. 2 Dairy after February rain following a dry period in summer. The cows were split into 4 herds and the effect of maintaining a fast rotation or slowing it up was observed (10 versus 40-day rotation). The 40-day group lost production at the start of the trial (when their rotation was slowed initially to 40 days).

Per cow milksolids production was similar for both groups over the trial. However, at the end of the 8-weeks the 40-day group was producing 32% more MS/day than the 10-day group. Their liveweights were similar, and farm cover was about 300 kg DM/ha higher for the 40-day group at the end.

This effect was also shown in a trial at Dexcel's No. 3 Dairy in 1994. Again the slower rotation (40 vs 16) group had higher bodyweight, cow condition and farm cover at the end of autumn. Further, from 15 December to 29 April, an extra 10.5 kg MS/cow (39 kg MS/ha) was produced. These groups were either held at their existing 16 day rotation or slowed down to 40 in early-January.

In the recent work there was an increased pasture cover of over 400 kg DM/ha on the long rotation farmlets, which may have been the result of a sudden increase in grazing pressure when the rotation was extended. Reduced herbage allowance forced the herd to graze a higher proportion of the sward in early summer. This hard grazing removed the majority of the old pasture resulting in only fresh material being carried into the summer.

Both these trials were conducted at high stocking rates. Long summer rotations are probably not appropriate at low stocking rates, in wet summer areas or where irrigation is available. If pasture growth meets the herd requirements for most of the summer, late spring rotations should be maintained until early autumn.

Further reading:

Bryant, A.M. 1984. Feed and management strategies at Ruakura. Proc. Ruakura Farmers Conf. 20-24.

Bryant, A.M. 1990. Optimum Stocking and Feed Management Practices. Proc. Ruakura Farmers Conf. 55-59.

Bryant, A.M. and L'Huillier, P.J. 1986. Better use of pastures. Proc. Ruakura Farmers Conf. 43-51.

Bryant, A.M. and Macdonald, K.A. 1987. Management of the Dairy Herd During a Dry Summer. Proc. Ruakura Farmers Conf. 53-56.

Bryant, A.M., and Macdonald, K.A. 1983. Relationships between amount of feed on the farm, and autumn-winter grazing management and cow performance. *Proceedings of the New Zealand Society of Animal Production 43*: 93-95.

Harris, S.L., Thom, E.R., and Clark, D.A. 1996. Effect of high rates of nitrogen fertiliser on perennial ryegrass growth and morphology in grazed dairy pasture in northern New Zealand. New Zealand Journal of Agricultural Research 39: 159-169.

Howse, S.W., Isherwood, P., Miller, D.B., Wells, J.L., Riddick, C.M., Thomson, N.A., and Clark, D.A. 1996. Pasture silage in New Zealand – targets and current practice. *Proceedings of the New Zealand Grassland Association* **57**: 157-160.

Kolver, E., Penno, J., Macdonald, K., McGrath, J., and Carter, W. 1999. Mowing pasture to improve milk production. *Proceedings of the New Zealand Grassland Association 61*: 139-145.

Macdonald, K.A. 1997. Profitable Dairying. *The Dairyman.* Supplement, occasional publication. September 1997

Macdonald, K.A., and Penno, J.W. 1998. Management decision rules to optimise production on dairy farms. *Proceedings of the New Zealand Society of Animal Production 58*: 132-135.

Macdonald, K. A., 1999. Determining how to make inputs increase your EFS. *Proceeding of the Ruakura Dairy Farmers' Conference 51*: 78-87.

Macdonald, K.A., 1999. Feeding supplements to milkers – South Island systems and costs. *South Island Dairy Event.1:* 135-144

Macdonald, K.A., Nicholas, P.K., Kidd, J.M., Penno. J.W., and Napper, A.R. 2000 The effect of pasture silage quality on milk production and liveweight gain of dairy cows. *Proceedings of the New Zealand Society of Animal Production 60*: 253-255.

McGrath, J.M., Penno, J.W., Davis, K.L., and Wrenn, R. 1998. Effect of date and length of closure and post grazing residual on pasture quality for silage. *Proceedings of the New Zealand Grassland Association.* **60**: 259-264.

Penno, J.W., Bryant, A.M., Carter, W.A., Macdonald, K.A. 1995. Effect of nitrogen fertiliser and summer rotation length on milk production in a dry Waikato summer. *Proceedings of the New Zealand Society of Animal Production 55*: 64-66.

Wrenn, N.R.; Mudford C.R. 1996. Making quality silage. *Proceedings of the Ruakura Dairy Farmers' Conference.* **48**: 50-57.