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Ryegrasses and their use in Irish Agriculture

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An area of approximately 300,000 acres is sown to grass each year in Ireland. Ryegrasses are by far the most important herbage grass sown and they are the mainstay of reseeded Irish pastures. Perennial ryegrass is undoubtedly the predominant species and in 1973 accounted for 62.0% of the total seed used. Italian and hybrid ryegrasses are also used to quite a large extent and their seed tonnage reached about 25% of the total sown in 1973. Table 1 shows the amounts of seed of grass and legume herbage species used in 1973.

Table 1: Seed of grass and legume herbage species consumed in 1973 in the Republic of Ireland

	Home Produced (tons)	Imported (tons)	Total (tons)
Perennial ryegrass	900	1,850	2,750
Italian & Hybrid ryegrass	100	1,000	1,100
Timothy	-	330	330
Cocksfoot	-	84	84
Meadow fescue	-	160	160
Tall fescue	-	15	15
White clover	-	200	200
Red clover	-	75	75

In 1973 the amount of home produced seed of perennial ryegrass was only half that of 1971. This is a consequence of Ireland's entry to the E.E.C. and indicates that farmers prefer the more sophisticated varieties bred in other countries.

PERENNIAL RYEGRASS

The varieties of perennial ryegrass presently grown in this country are divided into three groups according to time of heading (Tables 2, 3 and 4). Some varieties were recently re-named and the old names are given in brackets. All varieties with (T) are tetraploids.

Table 2: Early and medium early varieties (Heading before May 20)

Aberystwyth S.24	Oriel
Cropper	Premo
Grasslands Ruanui (New Zealand Perennial)	Tailteann
Gremie	Barvestra (T)
Melino (R.V.P. hay-pasture)	Reveille (T)
Oakpark	

The varieties in Table 2 produce more herbage in spring than those in the other Tables but are normally less persistent. The old varieties Aberystwyth S.24 and Grasslands Ruanui have a relatively good persistence. The new medium early varieties Cropper and Premo although producing less spring growth than S.24 and Ruanui are more persistent and give higher total yields under a frequent defoliation regime. Our new variety Oakpark is also a medium early type and performed as well as Premo in trials conducted at Loughgall. The varieties in this group are suitable for leys of medium duration where early growth is required. They also give a good first silage cut about the third week in May.

Table 3: Medium late varieties (Heading between May 20 and June 5)

Aberystwyth S.101	Talbot
Barlenna	Agresso (T)
Combi	Barlatra (T)
Glasnevin Leafy	Taptoe (T)
Kent Indigenous	Terhoy (T)
Scotia	

The varieties in this group are in general more persistent than those of the early group. Some of them such as, Combi, Glasnevin Leafy, Scotia, Talbot and Taptoe combine a good persistence with an erect growth habit which makes them suitable for conservation.

Table 4: Late varieties (Heading after June 5)

Aberystwyth S.23	Semperweide (Sceempter pasture)
Barenza pasture	Spirit (Sceempter hay)
Compas (Combi pasture)	Vigor (Melle pasture)
Endura	Barpastra (T)
Fingal	Fortis (T)
Lamora	Petra (T)
Pelo	Terpas (T)
Perma	

Late heading is normally associated with late spring growth, prostrate growth habit, leafiness in summer grazing and high level of persistence. These varieties are more suited to long term leys. Variety Spirit with a more erect growth habit than most late flowering perennial ryegrasses is particularly suitable for conservation. This variety has performed extremely well in large scale experiments conducted at Oakpark as will be mentioned later. The late types are more resistant to poaching than those in the other groups and therefore are recommended in areas of high rainfall and difficult soil conditions such as the Drumlin regions.

Figures 1 and 2 show the difference between the patterns of growth of the early and late groups.

The tetraploid varieties mentioned were all bred in the Netherlands. They are 1-2% lower in dry matter content and have a slower rate of drying than the diploids. They have a consistently higher soluble carbohydrate content and are slightly more digestible. These varieties are a little later in spring growth than their diploid counterparts and are generally less persistent under grazing in pure stands but compete well with other grasses in mixtures. The tetraploids are more palatable to stock, particularly in summer and autumn. Their seeds are larger than those of diploids.

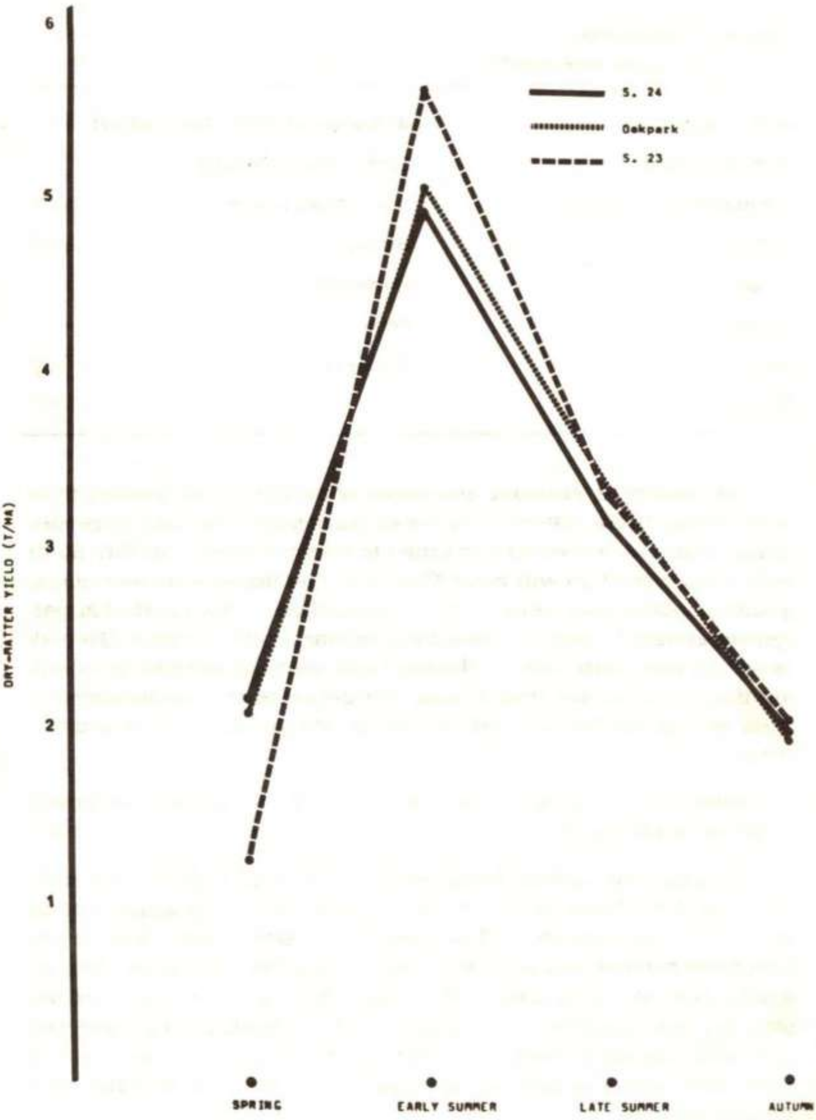

Fig. 1:

Seasonal distribution of DM yield of single swards of early and late varieties submitted to eight defoliations per annum (1971/72 means).

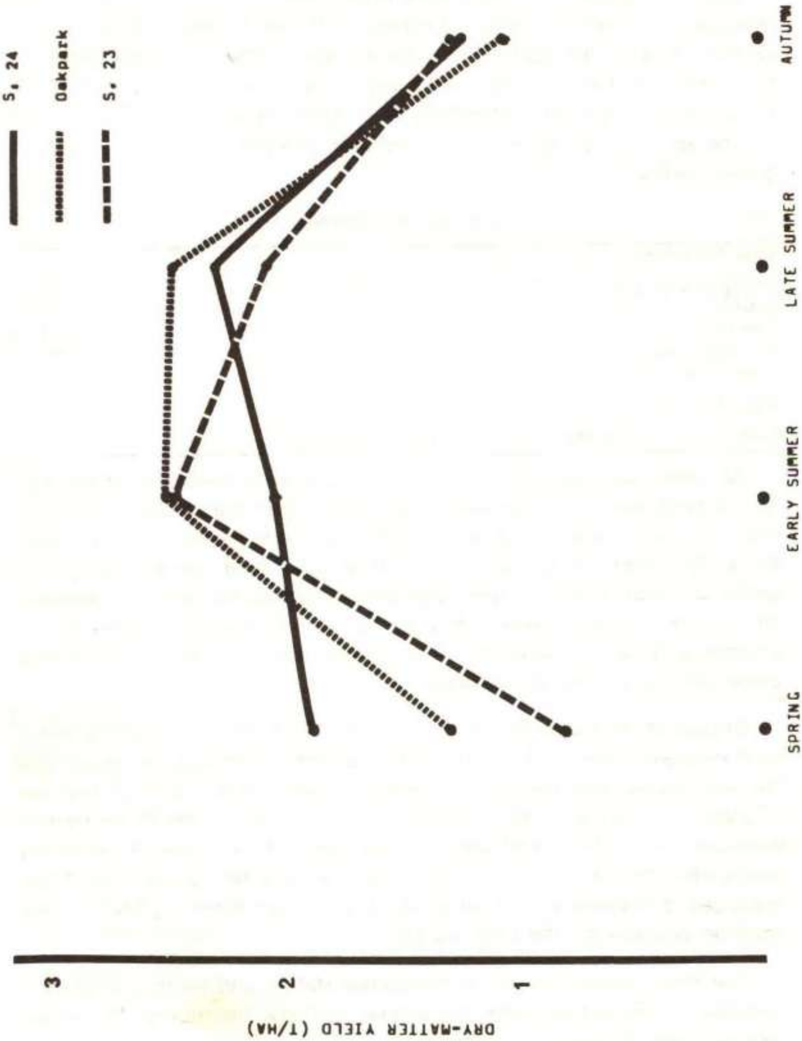

Fig. 2:

Seasonal distribution of DM yield of grass + clover swards including early and late varieties of perennial ryegrass respectively. Means of 1971/72 and defoliation regime as in Fig. 1.

ITALIAN AND HYBRID RYEGRASSES

Italian ryegrass is a short-lived grass used in short leys, or in seed mixtures for leys of longer duration. It has a long growing season combined with the ability to produce good crops of silage and hay. Output in the first harvest year is normally unsurpassed by any of the other ryegrass species particularly when sown in autumn. The varieties of Italian ryegrass sown in Ireland are divided into two groups, as shown below.

ITALIAN RYEGRASS

Low Persistency		
Aberystwyth S.22		Lomi trifolium
Celtic		Milamo
Combita		Prima roskilde
EF 486 Dasas		Vejrup MB
Leda Daehnfeldt		Tetila (T)
High Persistency		
Lema	Lemtal (R.V.P. Italian) Optima	

All these varieties are earlier in spring growth than any of the perennial ryegrasses and head about two weeks later than S.24. They provide an "early bite" of great value to the dairy farmer. Thus, under the Irish conditions an early bite in February/March can produce an increase of ¾ to1 gallon of milk/cow/day. Among the varieties mentioned, Lemtal, better known as R.V.P. Italian, excels all the others in persistence and winter hardiness. This variety is able to survive for at least three years as will be shown later.

Grasslands Manawa (formerly named H.1) is the only variety of hybrid ryegrass sown in Ireland. It is a hybrid between perennial and Italian ryegrass and was bred in New Zealand. It has some of the out-of-season growth of Italian ryegrass combined with some of the persistence and sward density of perennial ryegrass. This variety is extremely susceptible to winter kill in cold areas. A new tetraploid hybrid ryegrass called Sabrina, produced by the Welsh Plant Breeding Station, will soon be available on the Irish market.

The main characteristics of tetraploid Italian and hybrid ryegrass in relation to diploid varieties are similar to those mentioned for tetraploid varieties of perennial ryegrass.

SEED MIXTURES

Ryegrasses are sown in seeds mixtures which normally include a herbage legume. In Ireland white clover is an inseparable companion of ryegrass in the great majority of mixtures sown. Seeds mixtures would certainly give a subject for another lecture. However, I wish to refer briefly to them. Grass breeders are more and more tailoring their varieties to specific objectives and managements such as:

1. Grazing under high stocking rates and high levels of soil fertility
2. Production of high yields of conserved grass of good quality in 2-3 cuts
3. Increase of early spring growth

Consequently, the old complex mixtures such as the well known Cockle Park mixture, based on a combination of a number of different grass and legume herbage species, are rapidly being replaced by much simpler mixtures more suitable to be exploited under the new and sophisticated systems of management. A few examples of mixtures adapted to particular systems of management and suitable to be sown by Irish farmers will now be presented.

1. Early Grazing + 2/3 cuts silage (18 to 24 months)	
Celtic	12 lb
Lema	8 lb
Tetila (T)	8 lb
Blanca/Kersey/Sabeda	2 lb
2. Silage only (2 years)	
Lemtal	18 lb
Tetraploid red clover	12 lb
3. Early grazing + 2/3 cuts silage	
Lemtal	25 lb
Blanca/Kersey/Sabeda	3 lb
4. Grazing + silage (Leys of medium duration)	
Lemtal	6 lb
S.24	8 lb
Spirit	14 lb
Blanca/Kersey/Sabeda	2 lb
5. Grazing + silage (Leys of medium duration)	
Lemtal	6 lb
Spirit	14 lb
Reveille (T)	8 lb
Blanca/Kersey/Sabeda	2 lb

The use in a mixture of ryegrass varieties of the same heading group facilitates the management of a sward and therefore the replacement of mixtures 4 and 5 by one of the two following mixtures is recommendable.

6. Grazing + early silage
(Leys of medium duration)

Lemtal	6 lb
S.24	14 lb
Reveille (T)	8 lb
Blanca/Kersey/Sabeda	2 lb

7. Grazing + late silage
(Leys of medium duration)

Lemtal	6 lb
Spirit	14 lb
Taptoe (T)	8 lb
Blanca/Kersey/Sabeda	2 lb

8. Grazing
(long term)

Victor (Melle)	16 lb
Combi	6 lb
Petra (T)	6 lb
Blanca/Kersey/Sabeda/Grasslands "Huia"	2 lb

ASSESSMENT OF RYEGRASS SILAGE IN TERMS OF ANIMAL PRODUCTIVITY

Grass breeders are often criticised because they normally evaluate their varieties on the basis of cutting experiments and not on animal productivity. Therefore, I am briefly reporting the evaluation of three ryegrass varieties in terms of beef production.

Varieties Spirit (Sceempter Hay) and Oriel of perennial ryegrass and Lemtal (R.V.P.) of Italian ryegrass were undersown with barley in March 1970 in large scale plots (1 ac) and have been compared under a 3 - cut silage management. The main objective of this experiment is to guide the plant breeder in the way to produce ryegrass varieties suitable for silage conservation. The swards received 439 kg/ha (3½ cwt/ac) of 0:10:20 fertiliser at the end of December or early in January and a total of 280 kg/ha (250 lb/ac) of N was applied in 1971 and 358 kg/ha (319 lb/ac) in 1972 and 1973. The first nitrogen dressing was applied in the middle of March and consisted of 439 kg/ha (3½ cwt/ac) of C.A.N. (26%) and the other two applications were carried out after the first and second cuts respectively. The first cut was made when the herbage had a D-value not lower than 63, i.e. ten days to two weeks after mean ear emergence for Oriel and around mean ear emergence for Lemtal and Spirit. Second and third harvests were made 6 to 7 weeks after the first and second cuts respectively.

Total yields of herbage dry matter produced by 3 - silage cuts in 1971, 1972 and 1973 are shown in Fig. 3.

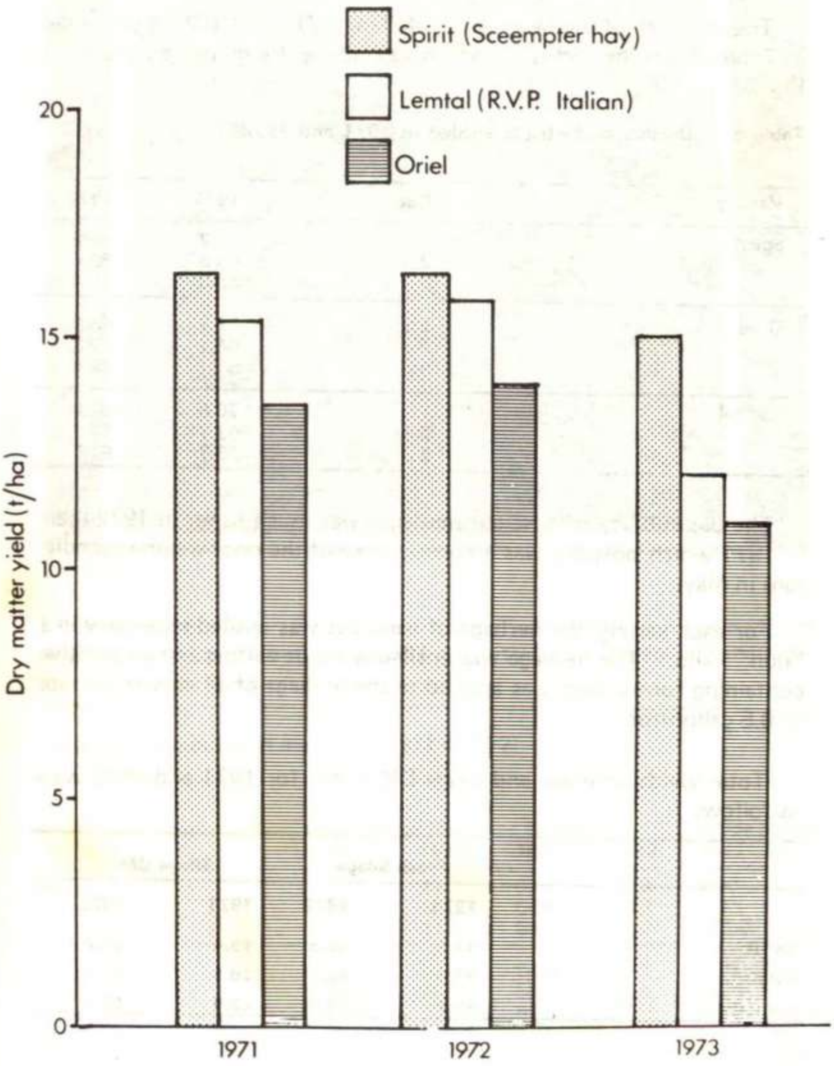

Fig. 3: Total yields of dry-matter (kg/ha) produced by 3-silage cuts.

The depressive effect of this type of management reported by Green & Eyles (1960) and Ribeiro (1970) in varieties with low persistence is particularly evident in the 1973 data for Oriel and Lemtal. Figure 4 illustrates the effect of this management in variety S.321 of perennial ryegrass.

The D-values of the herbages ensiled in 1971 and 1972 are presented in Table 5 and the yields of digestible organic dry matter are shown in Fig. 5.

Table 5: D-value of herbages ensiled in 1971 and 1972

Variety	Cut	1971	1972
Spirit	1	73.7	65.9
	2	68.6	66.4
	3	66.0	69.4
Oriel	1	72.7	63.3
	2	64.1	62.3
	3	61.7	68.4
Lemtal	1	70.6	63.9
	2	62.7	54.7
	3	53.7	62.7

The digestibility of first cut herbages was much lower in 1972 than in 1971 which possibly was a consequence of the poor weather conditions in May.

For each variety the herbage of each cut was ensiled separately in a "bun" - silo. The herbage was ensiled without wilting and an additive containing formic acid was applied to the herbage of all cuts at the rate of 0.5 gallon/ton.

Total yields of silage and silage DM (t/ha) for 1971 and 1972 were as follows:

	Fresh Silage		Silage DM	
	1971	1972	1971	1972
Spirit	54.5	60.5	13.4	13.7
Oriel	47.0	48.7	10.5	11.8
Lemtal	49.2	55.7	12.9	12.8

All silages were well preserved with the exception of first cut Oriel in 1972 which had a 4.5 pH and 1.4% decomposed protein.

The composition of the silages is given in Table 6.

Fig. 4: Aspect of a sward of S.321 submitted to a 3-silage cut management for 4 years.

Table 6: Compositon of the silages (1971 & 1972)

	Cut	DM of silage (%)		D-value		Crude protein	
		1971	1972	1971	1972	1971	1972
Spirit	1	24.6	21.2	68.0	60.8	9.00	8.50
	2	27.7	19.0	64.8	66.3	10.70	13.50
	3	22.3	31.3	66.6	71.9	12.90	13.50
Oriel	1	20.8	22.3	64.8	59.2	9.30	9.00
	2	27.0	26.1	59.8	60.1	10.20	11.50
	3	20.9	27.5	62.9	70.9	14.80	16.30
Lemtal	1	24.1	17.3	64.2	58.4	8.50	8.40
	2	29.9	29.3	58.3	56.5	8.70	9.70
	3	26.8	33.0	54.8	61.5	13.09	12.60

The cost of a tonne of fresh silage and silage dry matter is presented in Table 7.

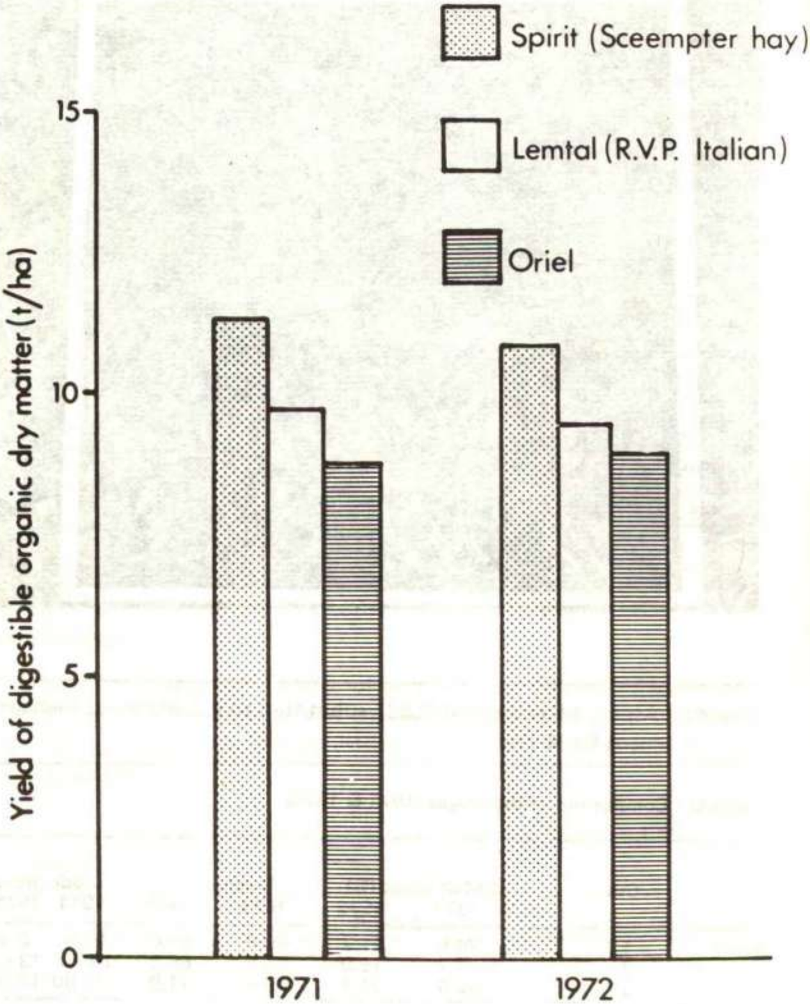

Fig. 5: Total yields of digestible organic matter (t/ha) produced by 3-silage cuts.

Table 7: Cost of t silage and silage DM

	Fresh silage	Silage DM
	£	£
Spirit	2.64	11.78
Oriel	2.87	11.88
Lemtal	2.71	11.82

The different expenses involved in the production of one tonne of dry-matter of Spirit expressed as a percentage of the total cost were as follows:

Seed & sowing	2.8%
Fertilisers	36.7%
Fertilisers distribution	3.1%
Formic Acid	15.5%
Harvesting & ensiling	41.9%

The assessment of the silages in terms of beef production was conducted for the first time in 1972. A feeding experiment was carried out in winter 1972-'73 in which 30 Friesian bullocks with an average liveweight of 447 kg (8½ cwt) were fed **ad libitum** for 105 days with ryegrass silage without supplementation but with access to a salt lick. The animals were randomised and divided into three groups of 10 and fed as follows:

Group 1.	Spirit silage
Group 2.	Oriel silage
Group 3.	Lemtal silage

In the first 45 days the animals were fed first cut silages. They were then fed second cut silages for 32 days and in the last 28 days of the experiment they were fed third cut silages. The mean intakes of silage and dry matter were:

Mean intake/head/day

	Fresh Silage	Silage DM
Spirit	43.4 Kg.	10.0 kg
Oriel	40.8 Kg.	10.2 kg
Lemtal	36.3 Kg.	9.0 kg

The mean liveweight gain per animal per day and the mean liveweight gain per unit of area obtained from the three silages were:

	L.w.g./head/day	L.w.g./ha (105 days)
Spirit	0.880kg (1.94 lb)	1201kg (1059 lb/ac)
Oriel	0.544kg (1.20 lb)	628kg (567 lb/ac)
Lemtal	0.549kg (1.21 lb)	784kg (669 lb/ac)

The mean efficiency of feed conversion, measured as the kg live-weight gain produced by an intake of 100 kg of silage dry matter, was calculated and the following values were obtained:

L.w.g. (kg)/100 kg silage DM intake

Spirit = 8.80 kg
Oriel = 5.34 kg
Lemtal = 6.13 kg

Finally the number of animals fed with the silage produced in 1 ac or 1 ha was estimated and is given in Table 8.

Table 8: Number of animals fed for 105 days.

	Acre	Hectare
Spirit	5.2	13.0
Oriel	4.5	11.0
Lemtal	5.5	13.6

In conclusion, the results of the feeding experiment show that under the 1972 conditions, the animals fed with Spirit silage performed significantly better than those fed with silages of the other two ryegrass varieties.

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Some aspects of Silage Making and Feeding

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Our livestock industry is going through a period of tremendous growth and expansion. Increase in output will improve the nation's balance of payments and should increase farmers' profits provided that the rate of increase in costs is kept lower than the rate of increase in output.

Let us consider briefly the trends in costs and returns in intensive winter beef production over the past three years. The costings published by I.M.P. in 1970 are taken as a base and compared with costings for 1973 calculated in exactly the same way except for the substitution of 1973 values for 1970 values. The result of this exercise is summarised in Table 1.

Table 1. Costs and returns (£) per animal for an intensive system of winter beef production in 1970 and in 1973.

	1970	1973	% change
Total variable costs	100.05	179.80	+ 79.7
Total overheads	7.75	13.85	+ 78.7
Interest on working capital	4.10	9.88	+ 141.0
Sales	120.75	210.00	+ 73.9
Gross output	44.75	66.00	+ 47.5
Gross margin	20.70	30.20	+ 45.9
Nett margin	12.95	16.34	+ 26.2
Nett margin less interest	8.85	6.46	- 27.0

While total variable costs, total overheads and sales have increased by over 70% the gross output and gross margin have increased by less than 50% and the nett margin has increased by only 26%. Furthermore interest on working capital has more than doubled and after allowing for interest the nett margin per animal has actually declined by 27%.

These calculations are of little relevance if no expansion is planned but they are very relevant to farmers who are commencing intensive winter beef production or who are expanding existing wintering enterprises.

Against this background of rather low nett margins per animal in intensive winter beef production it is necessary to consider the more important aspects of silage making and feeding. Results of feeding trials are quoted and interpreted on an economic basis. The main economic criterion is "feed cost per cwt. liveweight produced". This feed cost includes the cost of fertilizers and of harvesting, the cost of silage additive and of concentrate supplement where either are used but do not include rent, rates, storage or feeding costs.

The major aspects to be discussed are:

1. Yield
2. Quality and supplementation
3. Preservation (additives)
4. Efficiency of conservation (losses)
5. Wilting and fine chopping

1. YIELD

Higher yield is desirable in its own right because of the desirability of optimising output per unit area of land. Associated with it is the important side effect that it spreads harvesting costs. Table 2 shows how increasing yield from 4,000 to 4,700 lb. D.M./acre by using 92 rather than 46 units of N. reduces the harvesting costs per ton of D.M. ensiled, without significantly increasing the total cost of feed per cwt. liveweight gain. Because of the higher output the margin per acre over feed cost is substantially increased by the higher yield.

Table 2. Effect of increasing yield on the costs and returns from silage

	Yield: lb D.M./ acre	
	4000	**4700**
Harvesting cost per ton D.M. (£7.50 per acre)	£4.20	£3.60
Feed cost per cwt liveweight gain	£5.10	£5.20
Margin per acre over feed cost (liveweight @ £18 per cwt)	£39.20	£46.60

2. QUALITY

We know from several sources, e.g. the Department of Agriculture and Fisheries data (2), that most silage still has a low feeding value.

The making of low quality silage incurs roughly the same fertilizer and harvesting costs as high quality silage. Yet, more low quality material is required to put on a unit of weight gain, and furthermore low quality material sets a low ceiling to the attainable rate of gain in the absence of supplementation. Table 3 shows how feed quality expressed as growth promoting potential for stores influences the feed cost per cwt. liveweight produced. Likewise nett margins per acre are in favour of higher quality silage even when the higher stock-carrying capacity and a price rise is taken into account as shown in Table 4.

Table 3. Effect of silage quality on feed cost per cwt liveweight gain. (store cattle)

Feed Quality Liveweight gain (lb/day)	Conversion rate Lb feed D.M./lb liveweight gain	Feed cost per cwt liveweight gain
1.5	10	£5.20
0.7	18	£7.50

Table 4. Effect of silage quality on the nett margin per acre with and without price rise

	Leafy	Stemmy
Daily liveweight gain	1.5	0.7
Profit margin/acre No price rise	£17.20	- £7.75 (loss)
Profit margin/acre £1.50/cwt price rise	£39.85	£25.60

(Selling @ £18.00 per cwt)

Concentrates may be used to make up for poorer quality silage but barley is at least four times as expensive as good silage. Thus, feeding any barley increases the feed cost per cwt. liveweight produced. Table 5 shows how the feeding of barley to raise the growth rate of store cattle to 2.0 lb. per day increases the feed cost per cwt. liveweight gain.

Table 5. Effect of feeding barley (at £50 per ton) with good and average silages on the feed cost per cwt liveweight gain

	Lb barley	Liveweight gain lb/day	Feed cost per cwt liveweight gain
Good silage	0	1.5	£ 5.20
	4	2.0	£ 8.55
Average silage	0	0.7	£ 7.50
	4	1.3	£11.75
	10	2.0	£14.50

Feed cost per cwt. liveweight gain is increased substantially by feeding high levels of barley, but it is only one element of the total cost involved in wintering. Profit in barley feeding depends mainly on being paid more for the extra product than what is paid for the barley. When fed at a rate of about 4 - 5 lb. per day with good quality silage to 8 cwt. cattle every 8 lb. barley fed produces about 1 lb. extra liveweight. Every 12 lb. barley produces about 1 lb. carcase under the same circumstances. With poorer quality silage the response to barley feeding should be somewhat better. Table 6 shows the break-even selling prices for beef at different cost prices for barley fed at about 4 lb. per day with good and average quality silages.

Table 6. Break-even selling prices for beef at different cost prices for barley fed with good and average quality silages.

	With good (1.5 lb/day) silage		With average (0.7 lb/day) silage
Barley cost (£ per ton)	**Liveweight (£/cwt)**	**Carcase (p/lb)**	**Liveweight (£/cwt)**
46	18.40	25	16.20
50	20.00	27	17.50
54	21.60	29	19.00
58	23.10	31	20.30
Conversion rate	8 : 1	12 : 1	7 : 1

If barley costing £50 per ton is fed at 4 lb./day with good leafy silage to finishing cattle then selling price must be at least £20 per cwt. liveweight or 27p per lb. carcase in order to break-even. If it is fed with average silage the minimum sale price to break-even is £17.50 per cwt. liveweight.

3. PRESERVATION - ADDITIVES

Preservation of silage is important chiefly because it influences intake and, consequently, production. Table 7 shows intakes and performance of cattle on well preserved and badly preserved September silages. In this case the difference in preservation was due solely to the use of ½ gal formic acid 85% per ton as an additive. Additive use improved preservation, intake, weight gain, carcase weight and feed conversion. After allowing for the cost of the additive the cost of feed per cwt. liveweight gain was reduced by additive use.

Table 7. Effect of preservation on intake of silage and growth rate of cattle (8 cwt)

Preservation	Good	Poor
Intake Lb D.M./day	18.9	13.8
Liveweight gain Lb/day	1.9	1.0
Carcase weight Lb	566	537
Lb D.M. per lb liveweight gain	9.8	13.3
Feed cost per cwt liveweight gain	£6.50	£7.15

However, a response to the use of an additive is not always obtained. Table 8 shows a case where an additive was used on late May grass but was not required to give a good preservation. Intake, liveweight gain, carcase weight and feed conversion did not differ between treatments. Feed cost per cwt. liveweight gain was increased in this case by additive use and no return was obtained on the use of additive. Instead the cost of the additive resulted in money being wasted.

Table 8. Effect of additive when used on grass not requiring additive

Additive	½ gal 85% formic/ton	None
Preservation	Good	Good
Intake Lb D.M./day	17.3	16.3
Liveweight gain Lb/day	1.6	1.4
Carcase weight Lb	554	560
Lb D.M. per lb liveweight gain	10.9	11.3
Feed cost per cwt liveweight gain	£5.75	£4.75

Because of this possibility it is very important to distinguish between the need for additive and the waste of additive.

An effective additive is required only on lush leafy grass ensiled in wet conditions, particularly if grown with high nitrogen. Stemmy grass should not be treated.

Where an additive is considered necessary the only additive confidently recommended at the present time is 85% formic acid. All of the other available additives are being tested.

4. EFFICIENCY OF CONSERVATION

This is very much dependent on the over-all standard of management, particularly on the attention given to covering the silo. If the silage is covered so that air is completely excluded losses in the silo will be quite low, 10% or less. As the standard of covering deteriorates, more air penetrates and more silage rots on the surface of the silo. The quantity which rots can be as low as nil or as high as 50%. In good farm practice and with good covering total loss can be kept as low as 15% but in many cases particularly in outdoor clamps with badly covered sides the loss is often over 30%. Table 9 shows the influence of this avoidable extra 15% loss on the feed cost per cwt. liveweight gain and on a calculated profit per acre from a good crop of leafy silage. In addition to the effect on feed cost it also reduces total output by 15%. Of course, these considerations should stress the desirability of efficient conservation.

Table 9. Effect of loss in the silo on feed cost per cwt liveweight gain (£)

	Loss of D.M. in silo	
	15%	30%
Feed cost/cwt liveweight gain	5.20	6.26
Profit/acre. No price rise	22.95	16.70
With £1.50/cwt rise	44.50	34.35

5. WILTING

The wilting of grass for silage is becoming popular in recent years. The main reason is that cutting and wilting to some extent is an integral part of a harvesting system using a fine chop harvester. Wilting has several points in its favour.

(a) It reduces the load to be carried from the field and reduces or eliminates effluent. If a leafy crop is being cut at 17% D.M. and wilted to 25% the weight to be carried is reduced by 32%. Effluent will be reduced by about 30 gal per ton. However, when an average stemmy crop is cut at 20% D.M. and wilted to 25% D.M. weight to be carried is reduced by only 20% and effluent is reduced by about 15 gallons per ton.

(b) Wilting to 25% dry matter means that the quality of the preservation will be good in nearly all crops without additive use. The most likely exception would be a crop which is very wet and low in sugar prior to cutting (e.g. Autumn grass). Theoretically wilting to 25% D.M. can be regarded as an alternative to using an additive but this substitution applies only to grass which needs an additive to preserve well without wilting. As was the case when considering additives, the preservation of stemmy crops generally will not be improved by wilting. Unaided they preserve well.

(c) Wilting will increase the amount of feed that will fit in a silo of fixed volume by up to 40%. This can be a considerable advantage in circumstances where extra silo capacity independent of animal accommodation is required by an expansion programme.

In terms of animal production responses to wilting are not conclusive. Sometimes, trials in which intake was increased by wilting showed no increase in production. Table 10 shows the averaged results of many trials conducted in several centres, including Grange, in which wilted and unwilted silages were compared. Because both milk and beef animals were used in those trials responses are given as a percentage increase over the unwilted control.

Table 10. Animal production response to wilting

Cattle	pH of unwilted silage	Increase due to wilting
Mature	4.1	-2.6%
Mature	5.0	29.8%
Weanlings	4.0	44.7%

Generally, it appears that many of the recorded increases due to wilting in production by mature animals were obtained in trials in which the unwilted silage was badly preserved. Most trials carried out with cows and heavier cattle in which the unwilted silage was well preserved did not show a response to wilting. In contrast, there were several trials in which response to wilting were obtained with weanling cattle even when the unwilted silage was well preserved and this is shown in the third line of Table 10. The response of 44% is inflated by two rather high responses. The average response obtained in most of the Grange trials with weanlings was under 20%.

While better performance on wilted silage has always been attributed to the higher dry matter content it can, in many cases, be just as validly attributed to better preservation. Of course, these two are related in that drier grass is more likely to preserve well but they are not inseparably linked. It is important to distinguish between the effect of dry matter content **per se** and the effect of preservation **per se**. It appears that when preservation is good (low NH_3-N, low butyric acid low pH) dry matter content has relatively little influence on intake and performance by mature animals over the range of D.M. content usually encountered. But when low dry matter content is accompanied by poor preservation, intake and performance is depressed. This latter situation is more likely to arise when a leafy wet crop is ensiled. Preservation of stemmy grass is less likely to be influenced by dry matter content and, consequently, performance on this material is not likely to be influenced by wilting. This point has been borne out by Department of Agriculture farm weighings over the past few years in which the average performance of cattle fed on direct cut and wilted silages has been similar.

In summary, the wilting of wet leafy grass which may not preserve well if ensiled direct should ensure good preservation and good performance. But wilting the great bulk of the grass ensiled in this country cannot be expected to improve performance.

Difficulties associated with wilting are its dependence on good drying weather and the involvement of expensive complex machinery which may increase the harvesting cost to the farmer. A good measure of the drying power of the atmosphere is Potential Evaporation (PE) as measured by evaporation of water from an open pan (Class A pan). It combines the effects of temperature, humidity, wind and sunshine in one single measurement.

In an efficient high speed system of making wilted silage the ideal wilting period should be about 24 hours. Some preliminary records at Grange show that to raise the dry matter content of a 10 ton leafy crop containing 17% D.M. at cutting to about 25% (to ensure satisfactory preservation) requires weather conditions to evaporate about 2.5 mm water from the open pan. Evaporation from an open pan of water in a 24 hour period can vary from nil to over 7 mm. There are many days during the silage making season during which evaporation is less than 2.5 mm and, consequently, many days during which a satisfactory degree of wilting in a leafy crop will not take place.

Table 11 shows the average number of years out of 10 in which you can expect a series of 1, 2 or 4 consecutive days to have a PE of 2.5 or more at Lullymore in late May, June/July, August and September. It shows clearly that wilting conditions are worst in late May, August and September when wilting is most needed from the preservation viewpoint. A farmer with one days silage work on a particular date in late May is likely to succeed in six years out of 10. However, the farmer who wants two consecutive good days will succeed only 3 - 4 years in 10. This has serious implications for the consistent making of wilted leafy silage by contract. Success in wilting stemmy crops will be much more frequent partly because stemmy crops wilt easier and partly because wilting condions are better in mid summer when stemmy crops are being harvested.

Table 11. Number of years in 10 in which a series of 1, 2 or 4 consecutive days through the silage season will have a PE over 2.5 mm

	No. of days in series		
Month	**1**	**2**	**4**
Late May	6.0	3.6	1.3
June/July	7.5	5.6	3.2
August	6.0	3.6	1.3
September	3.0	0.1	-

Problems with the cost and operation of machinery for wilting are for the contractor rather than the farmer. However, the harvesting cost per acre or per ton for wilted silage relative to direct cut silage is a figure which is of relevence to the farmer. If there is no difference in cost/acre between single or double chop direct cut and precision chopped wilted silage then clearly the farmer ought to choose to wilt for the advantages in confers in terms of effluent control and increased silo capacity. But if wilting costs more than direct cutting then extra cost must be offset against the value of the advantages. This value will vary widely from one farm situation to another. In one situation the saving on additive costs and the reduction of effluent and increase in silo capacity could postpone the construction of a new silo. In other situations, however, none of these points may have any value. Table 12 shows how contract harvesting cost per acre, yield and feeding value influence a calculated feed cost per cwt. liveweight gain. As shown in earlier tables yield and feeding value are very important determinants of feed cost. This table shows the contract harvesting charge to be equally important particularly if the yield and the feeding value of the grass being ensiled is low.

Table 12. **Effect of yield, quality and contract cost per acre on the feed cost per cwt liveweight gain**

Quality Lb/day Liveweight gain	D'M. Yield Lb/acre	Contract Charge per acre £6.0	£9.0	Difference
		£	£	£
0.7	3,000	9.5	11.9	2.4
	4,000	8.3	10.1	1.8
	5,000	7.6	9.0	1.4
1.5	3,000	5.3	6.6	1.3
	4,000	4.6	5.6	1.0
	5,000	4.2	5.0	0.8

SUMMARY AND CONCLUSIONS

1. **High Yields** of grass for silage are desirable and are important in keeping feed cost at a reasonable level.

2. **High Quality** is essential to get high performance with low cost.

3. **Good Preservation** is essential to exploit the potential of high quality silage.

4. Avoidable loss increases costs and reduces profits.

5. **Wilting** has many management advantages but does not always increase production.

6. **Weather** conditions make it very difficult to consistently exploit the advantages of wilting, except in the case of the small-scale independent operator.

7. High **Harvesting** costs can be borne only by high yields of high quality grass.

Fertilizing Grassland for Beef Production

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Introduction

In 1972 Irish farmers spent £30.8 million on fertilizers which was the second largest input after purchased feeding stuffs (£65.3 million) into agriculture (1). With an overall increase of 28% in sales from 1971-72 to 1972-73 (2), it is estimated that farmers spent £39.4 million on fertilizers last year. These figures reflect a big expansion in fertilizer use over the years (Table 1) rather than an increase in prices (table 2).

Table 1. Fertilizer usage and livestock numbers in Ireland

Year	Fertilizers (1,000 tons)			Livestock (millions)	
	N	P	K	Cows	Total
1952-53	11.2	18.5	25.4	1.17	4.4
1962-63	33.0	48.0	74.0	1.27	4.3
1972-73	129.5	90.3	153.6	2.10	7.0

From 1953 to 1973 nitorgen usage has increased almost twelve fold, phosphorus five fold and potassium by six fold. There was a steady rise in the use of N.P.K. in the period 1953-66 but it was in 1967-68 that dramatic increases in sales occurred, especially in nitrogen. Trends in the livestock numbers were somewhat similar. There was only a marginal increase for the period 1953-63 but since the introduction of the heifer subsidy in 1964 there has been a big rise in numbers. Obviously the increased use of fertilizers followed the rise in the feed demands of stock.

Table 2. Consumer, Fertilizer and Livestock Price Indexes in Ireland, 1953, 1963 and 1973*

	Price Indexes		
Year	Consumer	Fertilizer	Livestock
1953	100.0	100.0	100.0
1963	127.7	67.4	102.8
1973	242.6	100.0	282.1

* Irish Statistical Bulletin 1953, 1963 and 1973

For 20 years, 1953-1973, overall prices of fertilizers did not increase. In fact prices decreased during the late fifties and early sixties with the introduction of subsidies for phosphorus and potassium and the establishment of Nitrogen Eireann Teo. In 1954 one ton of sulphate of amonia cost £22.50 and in 1973 it cost £24.14 (2). Potassium cost £20.50/ton in 1954, £13.50/ton in 1963 and £23 in 1972. Phosphorus which cost £12/ton in 1953 cost £12.53 in 1972-73. In the same period the purchasing power of the £ declined to 40 per cent of its 1953 value.

The Livestock Price Index has lagged behind the Consumer Price Index for most of the 20 years. For ten years, 1953-63, it showed little or no change but since 1968 the gap between the indexes has narrowed and in 1973, when cattle prices were at a peak, the Livestock Price Index was 40 points ahead of the Consumer Price Index.

WHERE FERTILIZERS ARE USED

In 1972 the Fertilizer Use Survey showed that three-quarters of the total N and P and two-thirds of K fertilizers purchased were spread on grassland (3). It is estimated that grassland farmers spent £22 million on fertilizers in that year compared to an estimated £13.6 million on purchased feeding stuffs for cows (£6.7m) and cattle (£6.8m). Fertilizers are, therefore, the biggest single input by most farmers into their enterprises. There is little doubt that in the past fertilizers have been cheap. The new prices projected for 1974 i.e. £41-42/ton of N (26%), £32-33/ton of P (8%) and £37-38/ton of K (50%) could however revert the ratio of the Fertilizer Price Index and the Livestock Price Index to the relationship they had in 1953. This will mean costly fertilizers at a time of reduced prices for cattle and beef. It is a situation where grassland farmers must critically evaluate their fertilizer use and try to achieve more efficiency both with it and animal manures.

In grassland fertilizing there are three distinct situations:

(a) grass swards which are cut for silage
(b) grass swards which are grazed
(c) grass swards which are cut once for either hay or silage and then grazed.

This paper deals mainly with swards which are either always cut or always grazed.

FERTILIZING GRASSLAND FOR SILAGE

In recent years it has been standard practice to fertilize almost all areas cut for silage and in 1972 the average application rate/acre was was 84 lb N, 32 lb. P and 64 lb. K (3). More phosphorus and potassium are used per acre here than in the United Kingdom (4). Compared with the Netherlands, where phosphorus use has remained static for 18 years, the relative position of Ireland has changed from 23% to 83% of their rates of P application/acre in the period 1953/73. We apply approximately 60% of the Netherlands rates of K/acre but there the use of potassium has declined (4).

SOIL FERTILITY

The increased use of fertilizer is reflected in increased soil fertility. In 1954 77% of soil samples analysed at Johnstown Castle were low in phosphorus (below 0.5 ppm) and there were no samples in the medium to high range (above 3.1 ppm) but by 1970 there were no samples in the low range while 37% were in the high category (4). The trend for potassium levels was similar. About 66% of soil samples were very low in K (below 24 ppm) in 1954 but there was only 2% in this category in 1970 while 36% were in the high bracket (above 100 ppm). The low phosphorus soils were mainly in the south east and the low potassium soils in the midlands. There were widespread deficiencies of P and K in Ireland during the immediate post war years and even until the late fifties. This is not so today.

SOIL PRODUCTIVITY

In a Productivity Experiment conducted for four years (1967-71) at 27 sites in Ireland (5) the inherent fertility of the soils had a marked influence on the herbage yields of the grassland (Table 3). In the fourth year of the experiment, the mean response to phosphorus was 37% although the responses ranged from 21 to 100%. With potassium there was a mean response of 47% and a range from 18 to 161%. Generally there were very poor responses to liming while nitrogen increased yield by an average of 65%.

Table 3. Variability of grassland production (100 lb D.M./acre)*

Plant Nutrient		No Fertilizer	Adequate Fertilizer
	mean	61.50	102.0
Nitrogen	range	42 - 83	76 - 128
Phosphorus	mean	64.5	88.5
	range	32 - 93	64 - 113
Potassium	mean	60.5	89
	range	24.5 - 96.5	64 - 114
Lime	mean	45	48
	range	30 - 60	31 - 65

*Ryan, M., Research Report, Soil Div., An Foras Taluntais, 1970

DRY VERSUS WET GRASSLAND

Besides the inherent fertility of the soil the factor of wetness or dryness plays a major role in the productivity of grassland. Gleeson (7) showed that well fertilized dry grassland in Co. Limerick was 26% more productive than similarly fertilized wet grassland while Ryan (5) reported an average 9.7% higher yield on dry as opposed to wet soils from his 27 grassland sites.

PHOSPHORUS FERTILIZING FOR SILAGE

Herbage production from two different sites on a similar soil type at Grange demonstrates the effect of previous fertilizing on phosphorus requirements for silage cutting. Site A had received annual dressings of 3-4 cwt. (8%) phosphorus over many years while site B received only a single dressing of 3 cwt. (8%) P/acre in the previous ten years. Prior to starting the experiment, site A had a soil phosphorus reading of 4 ppm and site B a value of 1-2 ppm, while both sites were grazed swards. During the experiment the swards were cut three times annually for silage. Some results of the experiments are given in Table 4.

Table 4. The long term effect of phosphorus fertilizing on grass yields (100 lb D.M./acre)

Phosphorus (8%) cwt/acre/year	Site A Total Yield 6th year	Site B Total Yield 5th year
0	106.7	72.5
1	111.5	83.4
2	114.5	87.7
4	121.9	87.1

At site A there was almost no response to phosphorus until the fourth year but at site B there was a response of 11% in the first year. This response increased to 15% in the fifth year and the accumulated application of half a ton of phosphorus (8%) increased production by 21% on site B. At site A, however, in the sixth year the responses due to phosphorus were small and insignificant although there was a steady upward increase in yields as the quantity of applied P accumulated. Soil phosphorus at site A declined to 2 ppm in the control but it increased to 5-6 ppm with the accumulated application of 24 cwt (8%) P/acre.

It is evident from these results that farms which have a high soil phosphorus level either through fertilizing or natural fertility can achieve high grassland production when only small rates of phosphorus or no phosphorus is applied for a few years. In other words farmers can cash in the legacy of built-up phosphorus fertility. Naturally, care must be exercised in case deficiency arises sooner than expected.

PHOSPHORUS AND SLURRY

Winter housing of livestock, especially in large numbers, creates a problem in the collection and storage of animal dung and urine. A mature bullock can produce 6-7 gallons of dung and urine per day and should any dilution occur with rain-water the figure could rise to 8-9 gallons/day. Cattle dung contains all of the phosphorus excreted by animals while as much as 8 lb is contained in 1,000 gallons of cattle slurry. Higher amounts of phosphorus do occur in slurries collected from animals fed large amounts of meals e.g. pig slurry contains 20-25 lb P/1,000 gallons.

Since land spreading of the enormous amounts of slurry produced by housed cattle is the only practical method of disposal, it is of interest to understand the usefulness of animal slurries as sources of phosphorus for grass production (Table 5).

Table 5. **Effect of cattle and pig slurry with four rates of phosphorus /acre on grass production (100 lb D.M./acre)**

Phosphorus (8%) cwt/ acre/year	Control	Type and Rate of Slurry gals/acre/year			
		Cattle		Pigs	
	0	2500	5000	2500	5000
0	69.2	81.9	92.1	89.9	96.1
1	74.9	86.8	94.9	89.2	100.8
2	76.9	86.4	95.6	91.0	101.0
4	81.3	87.1	97.3	90.3	101.9

The mean results over five years showed that a response of 17.5% was obtained with 4 cwt. phosphorus (8%)/acre/year in the presence of adequate nitrogen and potassium. With the application of slurry there were little or no responses with phosphorus. When it is considered that 2,500 gallons/acre of cattle slurry supplies as much as 2½ cwt. of phosphorus (8%) and the soil contributes an extra 1 cwt. of P/acre, then it is understandable that very poor responses are achieved with fertilizer phosphorus. In the case of pig slurry, excess amounts of phosphorus are supplied even with 2,500 gallons/acre. Farmers who have both cattle and pig slurry should alternate the use of them on areas treated with slurry. This allows for better use to be made of the phosphorus in the pig slurry while at the same time better use is made of the potassium in the cattle slurry (Table 6).

POTASSIUM AND SLURRY

The responses achieved with potassium fertilizing in the presence of animal slurries are shown in Table 6.

Table 6. **The effect of three rates of potassium with two rates of cattle and pig slurries on grass yields (100 lb. D.M./acre)**

Potassium (50% K) cwt/acre/year	Type and Rate of Slurry gals/acre/year				
	Control	Cattle		Pigs	
	O	2500	5000	2500	5000
0	70.0	85.7	96.7	83.3	96.5
2	78.9	86.2	90.3	94.0	102.4
4	83.5	89.8	92.9	92.8	101.0

There was a mean response over five years of 19% with 4 cwt. potassium/acre/year and in the fifth year the response was 42%. By the application of cattle slurry there was no response with potassium and in fact with 5,000 gallons/acre plus applied potassium there was a reduction in herbage yields due to excess nutrient. There is little doubt therefore that dressings of 5000 gallons/acre/year of cattle slurry can maintain the potassium demands of intensive silage cutting.

In the case of pig slurry however responses were achieved with dressings of fertilizer potassium. An annual application of 2 cwt K/acre/year produced responses of 11.4% with 2500 gallons/acre of pig slurry and a smaller response of 5-8% with 5000 gallons/acre. Pig slurry is generally low in potassium, 10-12 lb K/1000 gallons and must therefore receive some supplementation with fertilizer potassium. This contrasts with cattle slurry which contains 40-45 lb K/1000 gallons and needs little or no supplementation.

Nitrogen Fertilizing for Silage

Areas cut for silage receive 30% of all the fertilizer nitrogen used nationally (3). This must be a sector in which more efficient usage and better returns are possible if farmers are to overcome increasing costs. Some details are given in Table 7 on the herbage production and responses achieved over four years with fertilizer nitrogen for silage.

The most salient feature of the results was the response to nitrogen at the first cut. In all years it was far in excess of what was achieved with a mid-season or autumn cut. The natural growth of grass is always greatest in April, May and early June and moisture supply is rarely limiting in this period. Consequently, herbage responses to nitrogen are high. Growth of grass in the June to August period is often restricted because of partial drought which can also effect autumn silage cuts. Secondly, the daily rate of grass growth declines quite rapidly from mid July onwards.

Table 7. Effect of incremental dressings of nitrogen on herbage yields (100 lb D.M./acre) and responses (lb D.M./lb N)

Nitorgen lb/acre/cut	First Cut		Second Cut		Third Cut	
	Yield	Response	Yield	Response	Yield	Response
0	31.5	–	26.5	–	17.7	–
37	43.2	32.0	32.2	15.4	20.2	7.0
75	48.0	22.0	35.7	12.2	22.5	6.4
112	53.0	19.0	38.0	10.0	23.7	5.3

Our results suggest that a declining rate of application from the first to the third cut gives the most efficient return per unit of N. For example, when 75 lb N was applied/acre/cut the response declined from 22.0 lb D.M./lb N at the first cut to 12.2 lb D.M./lb N at the second and 6.4 lb D.M./lb N at the third cut. When the 75 lb N/acre was increased to 112 lb N/acre for the first cut, the response to the extra application was 13.3 lb D.M./lb N. This was intermediate to responses recorded with 37 and 75 lb N/acre in the second cut and far exceeded any of the responses in the autumn.

Therefore for a three cut silage system fertilizer nitrogen should be applied at the following rates: 3½ cwt (26% N) for the first cut, 2½ cwt for the second and 2 cwt for the third. What is probably more practical, especially with high cutting charges/acre, is to aim at maximum yields in the first two cuts and forget about the autumn silage cut.

Where slurry is applied to silage areas the rates of nitrogen can be reduced (Table 8). Cattle slurry alone increased grass yields by 1,150 lb D.M. with 2500 gals/acre and by 1,900 lb with 5000 gals/acre, while pig slurry increased production by 2,000 and 3,000 lb/acre, respectively. Comparisons of herbage responses with the slurries to those achieved with fertilizer nitrogen showed that 1000 gallons of cattle slurry had a value equivalent to 34 lb N while 1000 gallons of pig slurry was equivalent to 40 lb N. It was still beneficial to apply some nitrogen with cattle slurry to achieve optimum yields.

Table 8. **The Influence of slurry and three levels of nitrogen on grass production (100 lb D.M./acre)**

Nitrogen lb/acre/ cut	Type of Slurry (gals/acre)				
	Control	Cattle		Pigs	
	0	2500	5000	2500	5000
0	62.4	73.9	81.8	82.5	92.3
112	78.4	88.3	98.5	91.4	101.0
225	85.0	95.1	105.8	97.2	106.0

THE GRAZED SWARD

As the grazing animal returns considerable quantities of dung and urine back onto grazed pasture, it is natural to expect that the fertilizing of those areas should be different to swards cut for silage. Mature cattle excrete 10-12 times per day and urinate 5-6 times, producing, in the process, an average of 45-50 lb dung and 25-30 lb urine. In a grazing season of 200 days this amounts to 4.5 tons of dung and 2.75 tons of urine or 1,600 gallons of excreta. This excreta contains approximately 80 lb N, 14 lb P and 90 lb K. Since the total area covered by daily dung droppings is only 6-8 sq. ft. and by urinations 15-18 sq. ft., the distribution of the nutrients in cattle excrements can be very uneven.

PHOSPHORUS FERTILIZING FOR GRAZING

Some five years ago we selected two sites to investigate the effect of phosphorus fertilizing under an all grazing system of management. At Grange the experimental site was on a Brown Earth type soil of high clay content, with an available soil P level of 4-5 ppm and a history of annual phosphorus fertilizing for 20 years. At Johnstown Castle the soil was a Grey Brown Podzolic, consisting of a loam overlying a sandy clay loam, with an available P level of 3-4 ppm and was annually fertilized with P for 20 years also.

Three levels of phosphorus; 0, 1.5 and 3.0 (8% P) cwt per acre were compared at two stocking rates of 3.75 and 2.5 cattle/acre. The stocking rates were reduced to 2.66 and 2.0 animals/acre in July. Results for the fifth year of the experiment are given in Table 9. Because there were no differences between the 1.5 and 3.0 cwt P/acre, only the mean figure for those treatments are given.

Table 9. Effect of 5 years phosphorus fertilizing of pasture on liveweight productions per acre (lb)

No. of animals per acre	Phosphorus (8%) cwt/acre/year			
	Grange		Johnstown Castle	
	0	1½-3	0	1½-3
3.75 - 2.63	842	804	708	841
2.50 - 2.00	644	670	582	657

At Grange there was no response to phosphorus even though the control had received no P for five years. The soil at this site represents 35% of the grasslands in the country and making allowance for past P fertilizer dressings, the findings are very significant to many grassland farmers.

At Johnstown Castle however in the fifth year there was a 19% increase in liveweight/acre with 1.5 cwt P/acre at the high stocking rate. At the low stocking rate the response was 13%. This site is only representative of sandy loams which have poor natural reserves of nutrients. The lack of responses with more than 1.5 cwt. (8%) P/acre on a phosphorus responsive site, such as Johnstown Castle, illustrates that for grazing situations only low rates of P are required to maintain high animal output.

POTASSIUM FERTILIZING FOR GRAZING

In a mixed grazing experiment at Grange over six seasons (8) there was a significant increase in the herbage potassium levels from an average of 3.0% in the first year to over 4.0% in the sixth year. There was therefore an effective recirculation of the herbage potassium. An annual maintenance application of 1 cwt (50%) potassium was used, but this obviously only caused luxury uptake of the nutrient. In a completely grazing situation there is a virtually closed potassium cycle, so that the requirements for fertilizer potassium are negligible.

NITROGEN FOR SPRING GRAZING

Table 10. Effect of spring nitrogen application on liveweight gains of grazing cattle (lb)

	Nitrogen (26%) cwt/acre	
	0	2
Cattle liveweights (lb)		
mid April	654	641
late July	794	846
liveweight gain/head	140	205
Responses to N		
/animal	-	65
/acre	-	214

Fertilizer nitrogen for spring grazing has been investigated and recommended on the basis of cutting experiments. In the last two years the effect of a single application of nitrogen for spring grass on liveweight performance of store cattle has been studied at Grange. The sward was completely grass dominant and it was stocked with 3.3 animals per acre. Some mean results for 1973 are given in Table 10.

An interesting finding was that February applied nitrogen had a residual effect until July. This is rarely found in a cutting experiment with small dressings of nitrogen such as 2 cwt/acre. It is suggested that re-circulation of the extra nitrogen content in the treated sward by the grazing cattle contributed somewhat to this result. Work elsewhere has shown that returns of dung and urine are most effective on all grass swards and can amount to 140 lb N/acre/year (9).

The spring nitrogen increased liveweight performance by 46% per animal or 65 lb/head. This showed a return of almost 2 cwt. liveweight gain/acre for an input of 2 cwt of (26%) nitrogen, which was a very worthwhile expenditure by any standards of costing.

NITROGEN FOR GRAZING

Usage of nitrogen throughout the grazing season is possibly a more leading question at the moment for dry stock farmers than is its use in spring. Since 1971 three rates of nitrogen/acre at three stocking rates have been investigated at Grange using a grass/clover sward. Each season the stocking rate was reduced by 25% in late July or early August. In the first year of the experiment the swards had clover contents of 30-35% but last year there was only 10-11% clover in the low nitrogen plots and 2-3% clover in the high nitrogen treatments. The mean results for the three years are given in Table 11.

Nitrogen at 8 cwt/acre increased liveweight gain by 19% over 2 cwt N/acre and the increase was highest at the higher stocking rate. The response with four animals/acre was 22.6% versus 15% with three animals/acre. There was little or no response with the 16 cwt (26%) N/acre.

Table 11. Effect of fertilizer nitrogen and stocking rate on liveweight gain per acre (lb)

	Nitrogen cwt (26% N) acre		
No. Animals/acre	2	8	16
3	854	982	-
4	910	1116	1190
5	-	-	1153

Stocking rate showed a positive interaction with nitrogen. The liveweight gain with four animals/acre was 6.5% higher than with three animals/acre, when using 2 cwt N/acre but it was 13.6% higher with 8 cwt N/acre. This indicates that high stocking rates are needed to ensure the greatest return from using nitrogen throughout the grazing season.

DISCUSSION

Rising prices for livestock products and the relatively cheap supply of plant nutrients in the last few years encouraged increased and widespread usage of fertilizers. If similar amounts are used in 1974 as in 1973 the higher prices will make the national fertilizer bill £65-70 million annually or a total of £500 million in the next eight years. This is a very high input into agriculture and it could also be the watershed in in future expansion of fertilizer sales.

Farm livestock retain only small quantities of major mineral nutrients - N,P,K. - which are present in the food they eat. Plant nutrients are brought onto farms in fertilizers, feeding stuffs and biological nitrogen fixation. They are removed in crop and livestock products and in drainage water. In continuous grazing situations the leak of nutrients from the system is very small and insignificant. We have shown that on grazed swards the responses with P and K may be small, or a number of years in developing, due to a build up in nutrients and that fertilizer nitrogen may be the only nutrient giving worthwhile responses in such cases.

In herbage conservation there is a large removal of nutrients in hay and silage but if the animal manures are collected properly and are returned to the same areas there could be an accumulation of nutrients in the soil. Feeding stuffs bought and fed on livestock farms will enrich the animal slurries with N, P and K. Where pigs are fed on farms the quantities of fertilizers bought in the form of meals can be enormous and certainly reduces the dependance on manufactured fertilizers for grassland.

We have shown that the response to N, P and K in the presence of slurries are negligible or reduced. With the proper cycling of nutrients there is no reason why farmers cannot reduce their dependance on fertilizers for plant nutrients. The time has arrived when nutrient balance sheets must be developed for farms in order to achieve more efficient use of nutrients. Excess nutrients in the form of slurry on a farm should be transported and used elsewhere.

In the last 20 years fertilizer use has markedly improved the fertility of our soils. The time is now at hand when farmers should cash some of this legacy. At the same time they must be ever watchful that deficiencies do not arise. Just as in other spheres of our economy, where it appears that the 'throw away' age is at an end, we must endeavour to collect animal manures and wastes more efficiently and make better use of them.

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Calf Rearing Principals and Practices of Early Weaning

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INTRODUCTION

Any system of calf rearing, if it is to command wide acceptance, should satisfy the following criteria:

1. must ensure the survival of a high per centage of calves;
2. must be reasonable well defined and simple to implement;
3. must ensure adequate performance for the particular system of production envisaged;
4. must be viable in economic terms.

Nature's way - single suckling - usually satisfies the first three criteria but is not always economically viable. Single suckling is, of course, unsuited to raising calves from the dairy herd which are the main source of calves for beef production in Ireland. Traditionally in Ireland pail feeding of milk for a protracted period has been the method most commonly employed. The present paper discusses the early weaning of calves which is essentially concerned with replacing liquid feeding by the feeding of feed in a solid form at an early age. However, before discussing early weaning a few comments on the basic principles of calf rearing - which must be respected regardless of the method of rearing employed - may be useful.

THE NEWBORN CALF

The cow usually gives birth to a healthy calf - even if she has to do so at the expense of her own tissues - so that the survival and performance of the calf usually depends on what happens after birth. Although the calf is usually healthy at birth, it is extremely vulnerable to infection and very limited in the range of foods which it can digest.

Colostrum: The new born calf acquires passive immunity by the ingestion of colostrum, the antibodies of which are abosrbed intact during the first 24-36 hours of life. As the absorption of antibodies declines (some reports indicate that absorption may be limited to the first six hours under certain circumstances) it is important that colostrum be ingested within a few hours of birth. Normally, leaving the cow and calf together is the most satisfactory way of ensuring adequate intake of colostrum but the stockman should be on hand to ensure that suckling takes place. When calves are allowed to suckle their dams, intake of colostrum is of the order of 1½ gallons in the first day, increasing to 2½ gallons by the fourth day. Although smaller quantities are effective in preventing septicaemia, liberal quantities may be required to prevent localised intestinal infections and diseases such as pneumonia. Should bucket feeding of colostrum be practised, it is important that adequate quantities should be fed undiluted, at body temperature and at frequent intervals.

In addition to antibodies, which are the main protection against infection in the newborn, colostrum is a better source of most nutrients than ordinary milk and probably contains factors which allow the calf to withstand cold environmental temperatures. Colostrum contains five-times more protein, ten-times more Vitamin A and considerably more trace elements than ordinary milk. In the case of vitamin A (adequacy of which is considered by some to be important in reducing the incidence of scours and pneumonia) there is little placental transfer to the foetus and colostrum is nature's way of ensuring that the needs of the newborn are satisfied.

Digestion: The abomasum or true stomach is the only functional part of the ruminant stomach in the newborn calf and liquids pass directly into the abomasum. The calf at this stage is very limited in his capacity to digest materials, other than the constituents of milk. Of the commonly available materials, eggs and glucose are the only materials which the baby calf can efficiently utilize. Materials such as sucrose is an invitation for scour if mixed with the milk for the calf.

Recently, there has been considerable interest in replacing whole milk by milk replacers. Milk replacers intended for feeding from the first week onwards should consist essentially of high quality skim milk powder suitably supplemented with homogenised fat and vitamins. One of the characteristics of 'high quality skim milk powder' is that the whey proteins should not be excessively denatured during processing or storage (Roy, 1971; Rolls & Porter, 1973). High quality milk replacers can completely replace whole milk and may have advantages from the point of view of cost and flexibility. Recent developments (e.g. soy flour in milk replacer - Colvin & Ramsey, 1968) have pointed to the possibility of replacing milk proteins by other proteins. Although this research field offers interesting possibilities, further research and development are required before these milk replacers can be recommended for feeding from the post colostrum period onwards. As the calf gets older its ability to digest materials other than the constituents of milk increases and, therefore, the specifications for milk replacers for older calves are not so strigent. While the use of 'follow-on' milk replacers may have a place in systems of rearing such as veal production, the use of a single high-quality milk replacer coupled with early weaning onto solid food seems to be preferable in most rearing situations. Table 1 gives the results of a recent experiment (Murphy **et al**, 1970) in which four milk replacers, commercially available on Irish market, were compared with whole milk (WM) in an early weaning system of calf rearing.

Table 1. Performance of Calves on Whole Milk and Milk Replacers

	Whole Milk	Milk Replacers*			
		1	2	3	4
Initial Weight (lb)	99	93	94	95	97
4 Week Weight	133	128	137	134	126
12 Week Weight	232	228	234	239	225

* reconstituted to contain 12.5% dry matter at feeding.

Under the conditions of this study, the milk replacers supported the same performance as whole milk when fed at equal volumes.

Whereas liquid food passes directly into the abomasum, solid food passes directly into the rumen and rumen development takes place early provided the stimulus of solid food is given. A four-week old calf that has been accustomed to solid food can digest most ingredients as efficiently as an adult ruminant (Preston, 1963). However, the capacity of the rumen, relative to requirements, is low at this stage and if maximum performance is to be achieved liberal quantities of whole milk must be fed. This raises the question of 'adequate performance for the particular system of production'. In animals intended for slaughter as finished beef at 15-24 months or for first calving at around 2 years of age, daily liveweight gains in the order of 1½ lb. over the first few months should be 'adequate': a performance consistent with weaning onto a solid diet at the 4-week stage. However, in systems such as veal production where daily gains of 2½ - 3 lb. are demanded of the young calf, liberal quantities of milk must be fed.

EARLY WEANING

Early weaning, which in the present context means replacing the liquid diet by a solid diet at an early stage, is achieved by

(a) restricting milk intake;

(b) providing a suitable concentrate mixture;

(c) providing adequate roughage either as a component of the concentrate mixture or as long roughage;

and

(d) having fresh water freely available.

Milk Restriction: The object here is to provide sufficient milk (or milk replacer) to enable the calf to make moderate weight gains without completely satisfying its appetite for food. In this way intake of concentrates is stimulated. The optimum level of milk feeding has not been established but the following levels have proved satisfactory in a number of investigations and are suggested here:

Birth Weight of Calf (lb.)	Whole Milk (pints/day)
60	5
80	6
100	7

Higher levels of milk feeding than those recommended can be used but they will have the effect of reducing concentrate intake and, perhaps, causing a set-back at weaning if weaning takes place at a predetermined age rather than a predetermined intake of concentrates. Levels substantially lower than the ones recommended are unlikely to give satisfactory performance (Roy **et al** 1958).

High quality milk replacers may replace whole milk. Opinions differ as to the optimum concentrations at which the milk replacer should be reconstituted but there seems to be little to be gained from deviating from the concentration of cow's milk i.e. about 12.5% dry matter or 1.25 lb. of milk powder made up to a gallon by the addition of water. In once-a-day feeding, higher concentrations are sometimes used to ensure that the calf consumes all the milk offered. Whatever concentration is used it is important to ensure that the milk replacer be adequately mixed. With many milk replacers this requires the use of a mechanical mixer and adherence to the manufacturer's instructions.

The distribution of the milk during the milk-feeding stage is another aspect which requires comment. Feeding the same daily level of milk throughout and weaning abruptly gives satisfactory results and has much to recommend it in the interests of simplicity. There is nothing wrong with gradually weaning the calf off milk provided the regime can be implemented. The question of twice-a-day as opposed to once-a-day feeding has received considerable attention over the past few years. In general, once-a-day feeding can be safely introduced from about the ten-day stage onwards. The time saved as a result of once-a-day feeding should be used for inspection of the calves, otherwise it may be desirable to persist with twice-a-day feeding which ensures a "built-in" inspection twice a day.

Suitable Concentrate: The general recommendations for early weaning concentrates are that they should

(a) be palatable

(b) contain 16-20% crude protein;

(c) contain 5-10% crude fibre.

While these recommendations appear suitable they give little information which is helpful in the actual formulation of rations. Traditionally, early weaning mixtures tended to be complex - some containing up to 20 ingredients. However, most research reports (e.g. Caffrey & McAleese; 1964, Hardy, 1972; Milligan & Grieve, 1970) indicate that simple mixtures are equally effective. Table 2 gives the composition of an early weaning mixture which has proved satisfactory over a number of years at University College, Dublin.

Table 2. Early Weaning Concentrate Mixture

	%
Barley	73
Soyabeans	24
Minerals	3
Vit. A i.u./ton	9 million
Vit. D i.u./ton	2 million

Barley in the above mixture can be replaced by other cereals or by beet pulp (Connolly **et al**, 1967) and the soyabeans can be replaced by other protein sources (Hardy, 1972). There is some evidence (Atai & Harshbarger, 1965) that the addition of a sweetening agent such as brown brown sugar or molasses may be desirable. However, Murphy **et al.**, 1970, found no advantage from the inclusion of brown sugar. What is probably more important than a sweetening agent is that the mixture should be fed fresh daily and refusals discarded or fed to other cattle. Another important consideration is the physical form in which the concentrate is fed. In general, coarsely textured mixtures are desirable, or perhaps essential if long roughage is not freely available. This usually means that the cereal is coarsely ground or rolled with a moisture content of about 18% in the grain. Rolling of dry barley (less than 14% moisture) gives a product of variable texture which in the author's experience is not desirable in early weaning mixtures. Opinions differ as to whether pelleting improves the palatability of the diet. The size and hardness of the pellets have probably contributed to variation in responses which have been reported (Bartley, 1973). When fibre is limiting in the diet, pelleting may have the effect of reducing performance (Warner **et al.**, 1973).

Roughage: The need for long roughage in the diet of the early-weaned calf depends to a large extent on the composition and physical form of the concentrate mixture. While there are a number of reports where calves have been successfully reared without the provision of long roughage (e.g. Warner, 1973), the majority of reports indicate long roughage is desirable from the point of view of ensuring adequate concentrate intake and control of bloat and other digestive upsets (Preston, 1963; Preston, 1967; Kellaway **et al.**, 1973 a,b). Kellaway **et al.** (1973a) found that calves with access to roughage had a growth rate 50% greater than a control group with no roughage provided. It should be emphasised, however, that roughages are usually provided to ensure normal functioning of the digestive tract of the young calf rather than to meet nutrient requirements. As the calf gets older, it can rely to a greater extent on roughages as a source of nutrients and from the 12-week stage onwards a daily intake of 3 lb. of concentrates plus good quality hay ad libitum should be capable of ensuring a daily gain of about 1.5 lb.

Hay is the roughage of choice for young calves but silage may be fed provided the material is fed fresh daily and free from moulds. The results of a trial comparing hay and silage in an early weaning system are presented in Table 3 (Curran **et al.**, 1973). The increased performance ance of the silage-fed calves accrued from the higher digestibility of the silage.

Table 3. Comparison of Hay and Silage in an Early Weaning System

Diet:	**Hay**	**Silage**
Roughage	ad lib.	ad lib.
Concentrates (hd./day)	3 lb.*	3 lb.*
Performance:		
Initial Weight (lb.)	102	97
12 wk. Weight (lb.)	235	240
28 wk. Weight (lb.)	395	423

*4lb. to 12 weeks, 2lb. after 12 weeks.

EARLY WEANING ROUTINE

The early weaning procedures which have been successfully implemented at Lyons over a number of years are depicted in Table 4.

Table 4. Early Weaning Routine Practised at Lyons*

DAY	1	2		3–9		10 to Weaning**
Liquid Diet:	**P.M.**	**A.M.**	**P.M.**	**A.M.**	**P.M.**	**A.M.**
Glucose (oz.)	3	3	1½	0	0	0
Milk Replacer (oz.)	0	0	3½	7½	7½	15
Liquid Feed (pints)	3	3	3	3	3	6
No. feeds per day	1	2		2		1
Solid Food:						
Concentrates***				ad libitum		
Hay				ad libitum		
Water				ad libitum		

* Refers to bought in Friesian calves but home produced calves are treated similarly except that glucose feeding is omitted.

** Weaned abruptly when daily intake of concentrates has reached 500 g. (18 oz.) on 3 consecutive days.

*** See Table 2 for composition.

On the evening of arrival each calf receives 3 pints of a 5% glucose solution (1 oz. /pint). Milk replacer is gradually introduced on the second day and from the third day until weaning 15 oz. of milk replacer reconstituted to six pints of fluid are fed daily. Recently, we have changed to once-a-day feeding from the ten-day stage without any ill-effects. Weaning takes place when a calf is consistently eating (i.e. for three consecutive days) 500 g. of concentrate daily. In addition to the procedures outlined on Table 4, each calf usually receives on arrival a vitamin injection containing 250,000 i.u. Vitamin A and 150,000 i.u. Vitamin D and for the first eight days 250 mg. aureomycin per day. There is no reason to believe that either of these procedures is essential to the successful operation of the rearing system. We are currently investigating the influence of the antibiotic feeding on the development of drug resistance.

Food Intake: The fact that the calves are penned individually facilitates weaning at a pre-determined concentrate intake, in this case 500 g. (18 oz.)/day. The total milk intake (from colostrum stage) is about 20 gallons (25 lb. milk powder) per calf and the average age at weaning is about four weeks. When calves are group-fed, it is probably desirable to delay weaning until the average intake is 1½ lb. concentrates per day to ensure that the poorer calves in the group have attained a satisfactory level of intake. If satisfactory intake of concentrates is to be achieved at an early age, it is essential that the concentrates are fresh at all times and that hay and clean water are freely available.

Concentrate intake increases rapidly after weaning reaching about 4 lb. per day at 7-8 weeks. There may be a tendency for the faeces to become semi-fluid in the week immediately after weaning but this should not cause alarm as the calf usually remains healthy. Early weaned calves may continue to be fed concentrates **ad libitum** after weaning until slaughter, as in 'barley-beef' production, or more generally restricted to a level of 3-4 lb. per calf after the 12-week stage with roughages ad libitum.

In the case of spring born calves weaning should take place at least two weeks before turning out to pasture. The reason for delaying turn-out are:

(a) it enables the stockman to ensure that the calves have been satisfactorily weaned;

(b) it is difficult to wean onto concentrates when grass is simultaneously available to the calf;

(c) some calves may be reluctant to eat concentrates at pasture unless they have acquired a taste for them prior to turn-out and in general a certain amount of concentrate supplementation at pasture is necessary until calves are at least 12 weeks old.

APPLICATION OF EARLY WEANING

Despite the advantages of early weaning with respect to reduced scouring and reduced feed costs, there is often a reluctance on the part of producers to adopt this system of rearing. Numerous reports (e.g. Harte & Curran, 1964) have, however, shown that early weaning compares favourably with the more traditional methods of rearing. A recent experiment at Lyons (Brophy & Caffrey, 1973) has confirmed that the early weaned calf is at no permanent disadvantage provided the deficit in milk intake is made good by an equivalent amount of concentrates. Three groups of calves were involved in the study:

(i) Control - early weaned as outlined in Table 4 and fed concentrates to a maximum of 4.4 lb. (2 Kg) per day;

(ii) High concentrates - as 'control' but with maximum concentrate intake at 5.5 lb. (2.5 Kg) per day;

(iii) High milk - milk feeding prolonged for 4 weeks beyond the 'control' weaning stage and maximum concentrate intake maintained at 4.4 lb per day. Hay was available ad libitum to all groups.

Intake and performance data are presented in Table 5.

Table 5. Effect of level of milk and level of concentrate on calf performance

	Treatments*		
	Control	**High Concentrates**	**High Milk**
Performance:			
Initial Wt. (lb.)	107	106	108
7 weeks (lb.)	168	168	178
12 weeks (lb.)	221	236	234
Intake:			
Milk Replacer (gallons)	14	14	34
Concentrates (lb.)	264	300	248

* see text for details of treatments.

Hay intake was low (about ½ cwt. per calf) and not greatly influenced by treatment and is, therefore, ignored in the present discussion. As expected, calves on the 'High Milk' treatment were heavier at 7-week stage than the other calves. However, the 'High Concentrate' group had made up the deficit by the 12-week stage. When we compare the relative intakes on the 'High Concentrate' and the 'High Milk' treatments, it appears that 20 gallons of milk replacer (25 lb. milk powder) is equivalent to 52 lb. of concentrate. From an economic viewpoint it appears that early weaning is justified unless the cost (on a unit weight basis) of milk powder is less than twice the cost of concentrates - a situation which rarely if ever obtains.

It is also clear from Table 5 that when calves are early weaned concentrates must be fed to make up the milk deficit. For example, it would take 5 lb. of concentrates to replace 2 gal. of milk in the diet of a 12-week old calf. Failure to recognise this will obviously give disappointing results if early weaning is adopted.

As mentioned in the introduction, the system of calf rearing adopted must be suited to the system of production envisaged. Over the past few years we have been using early weaning in two systems of beef production at Lyons:

(1) September-born calves intended for slaughter at 18 months,

weighing 9½ cwt.:

(2) March-born calves intended for slaughter at 2 years, weighing 10½ cwt.

In the case of the September-born calves, it is important that the calf should be at least 400 lb. by time of turn-out to grass in April while the March calf should reach 400 lb. by mid-October. To achieve these targets the September calves are early weaned and subsequently fed concentrates to maximum of 2 kg and hay **ad lib.** up to turn-out in early April. The March calves are bought in early March, weaned by the end of March and fed concentrates and hay **ad lib.** until turn-out to pasture in mid-April. At pasture the March calves are fed concentrates at rate of 1 kg per head daily until mid-June when they are changed onto aftergrass. From mid-June onwards no concentrates are fed. Table 6 gives the feed requirements for the September - and March-born calves up to the 400 lb. stage, when the calves are approximately 7 months old.

Table 6. Feed Requirements for September and March Born Calves - Birth to 7 months

	Month of Birth	
	March	**September**
Milk Replacer (gallons)	20	20
Concentrates	2 cwt.	7 cwt.
Hay	½ cwt.	5 - 6 cwt.
Grass	Apr - Oct	None

Since grass grazed **in situ** is the cheapest feed available to the Irish producer, it is obvious from Table 6 that efficient use of grass greatly reduces the cost of rearing spring calves. Grazing management is described elsewhere in this Journal. It is sufficient to say here that early-weaning can be incorporated into a system of production which makes efficient utilization of grassland.

CONCLUSIONS

As with all systems of production, attention to detail is the key to successful calf rearing. In the present paper some of the more important principles and practices in the successful execution of early weaning have been emphasised.

The particular rearing system adopted by the individual producer will depend on the alternatives available as well as the expertise and likes and dislikes of the feeder. With increasing intensification, ease of operation and economics are likely to be major considerations in the selection of a rearing system. In the author's view, early weaning is an economic and relatively simple system to operate which should be adaptable to most situations. It should give adequate performance for most situations and the specialised calf-rearer should be able to keep mortality to less than 2%.

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Major Progress towards Destrus Synchronisation in Cattle

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INTRODUCTION

Methods of oestrus induction and synchronisation in sheep have been practised on Irish farms for a number of years. Successful oestrus control in the sheep by intravaginal application of progestagens was first reported ten years ago. (Robinson, 1964). Subsequently, many studies have been carried out on various aspects of reproduction in the ewe both within the breeding season and in the anoestrus or out-of-season period. Because of the greater facilities required and the greater costs involved methods of oestrous cycle control in cattle have not been as intensively studied.

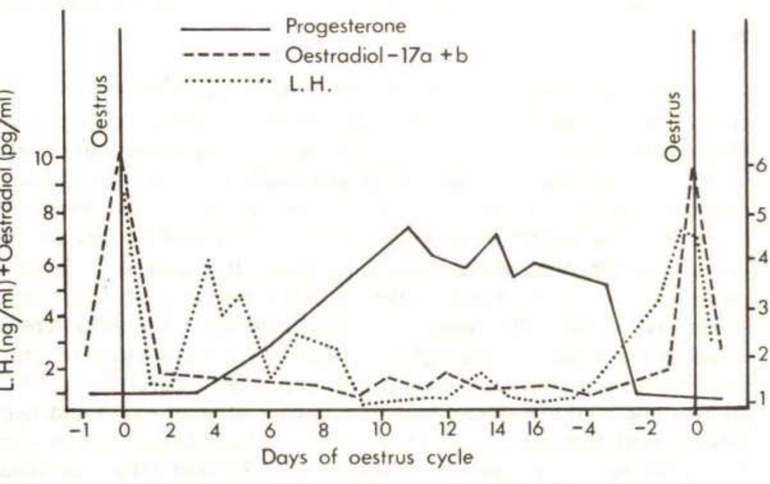
For the calf producer, however, successful methods of oestrous cycle control would have many advantages both in economic return and efficient management. Firstly, controlled breeding techniques in cattle would facilitate the introduction of genetically superior bulls from the artificial insemination service into the suckler herd. At present because of the problems of oestrus detection in the suckler cow and also because of the high labour costs that would be involved in detecting oestrus in individual animals under natural conditions, artificial insemination is not normally practised in suckler herds. The advantage of breeding from some of the high performance A.I. bulls would of course take the form of increased weight gain in the calf. Secondly, controlled breeding methods would lead to a shorter calving season and batch calving, thus allowing proper planning of feed and labour requirements during the various phases of the operation. Further efficiency would be gained by using a successful technique for synchronising ovulation as well as oestrus thus eliminating the need for oestrus detection and allowing insemination to be carried out on groups of treated animals at a predetermined time. This would mean a single visit from the inseminator to cover 20-30 animals and would be of benefit to both the farm and A.I. manager alike.

The aim of the present studies being carried out at the Agricultural Institute on oestrus and ovulation control in cattle is to develop methods that would be practical under Irish farming conditions. Elsewhere in this Journal Dr. J. Roche has referred to the Agricultural Institute's oestrus synchronisation work being carried out at Grange. This paper describes the research work undertaken at the Institute's Western Research Centre at Belclare. These studies include research on various methods of induction and synchronisation of oestrus and ovulation in heifers and cows, both cyclic and inactive, and take account of both the beef and dairy situations.

OESTROUS CYCLE CONTROL

The normal cyclic activity in the cow or heifer is based on the production and interaction of a complicated series of endocrine hormones. In recent years much research has been devoted to the identification and measurement of many of these compounds which are involved in the normal ovarian cycle. In Fig. 1 three of the most important of these hormones are shown during the normal cvcle.

Fig. 1

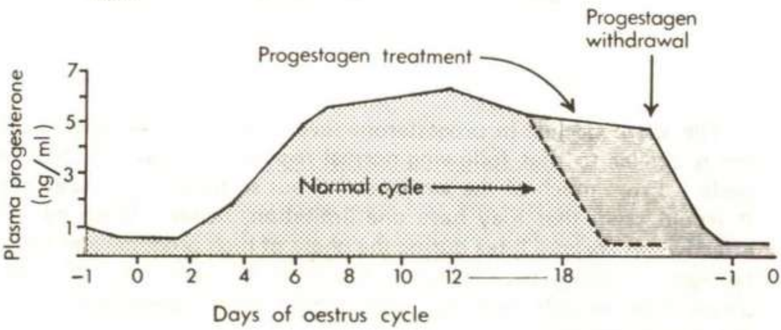


HANSEL & ECHTERNKAMP (1972)

In order to control oestrus or ovulation it is necessary to temporarily alter the levels and timing of production of some of these hormones. In so far as gaining control over the ovarian cycle is concerned probably the most useful indicator of events is the level of progesterone. Following oestrus and ovulation a corpus luteum is formed which produces progesterone at an increasing rate until midcycle; the level then remains fairly constant until regression of the corpus luteum which occurs fairly rapidly around day 17-18 of the cycle. Regression of the corpus luteum means a sharp decline in the level of progesterone and this, associated with other events, means the occurrence of oestrus within about three days. Essentially there are two main methods of synchronising oestrus in cyclic animals.

1 The first method depends on simulating the action of the cyclic corpus luteum. This is achieved by introducing a progestagen hormone which acts like a corpus luteum and prolongs the luteal phase of the cycle until the corpora lutea of all animals have regressed; following withdrawal of the progestagen a similar series of events takes place as in the normal cycle. In other words following the decline of progesterone level a high proportion of animals will be in oestrus within 2-4 days (Hansel, 1961; Lamond, 1964; Jochle, 1972). This manipulation of the progesterone level is shown diagrammatically in Fig. 2.

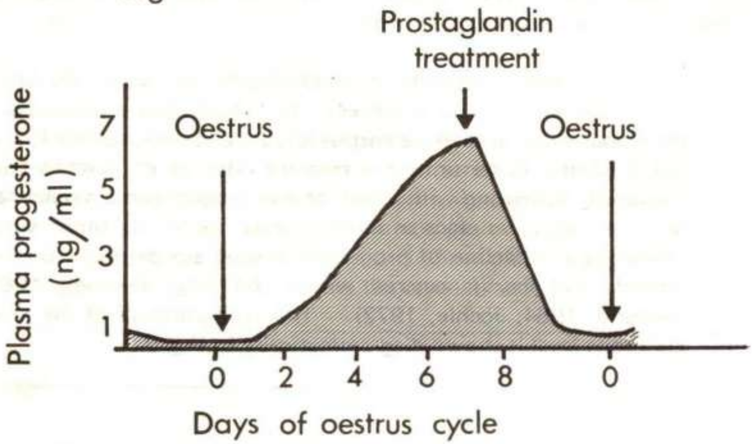
Fig. 2



2. The second method of synchronising oestrus in cyclic animals is by administration of compounds which will themselves cause premature regression of the corpus luteum with the consequent decline in progesterone level. Some of the compounds used in early studies such as oxytocin (Armstrong & Hansel, 1969) and oestradiol (Wiltbank, 1966) were effective in causing corpus luteum regression but were not satisfactory as regards fertility. More recently however a new series of compounds have been examined. These are termed prostaglandins and have shown some promise both in synchronisation of oestrus and in subsequent fertility levels. The prostaglandins are naturally occurring in the tissues and are already involved in normal cycle regulation. They can now be synthetically produced on a large scale. The

action of the prostaglandins in causing corpus luteum regression is shown diagrammatically in Fig. 3.

Fig. 3



The sharp decline in progesterone level following their administration is similar to that following normal regression at day 17-18 of the cycle. From much of the work carried out so far with prostaglandins it would seem that they have one limitation, namely, they are only effective on corpora lutea during the phase of high progesterone output i.e. approximately between days 5 and 16 of the cycle. This also means that animals must be cyclic before any prostaglandin routine would be successful.

The post-partum suckler cow is one category of animal which presents a relatively greater problem in cycle control studies because of a period of anoestrus. Following calving, a period of lactation anoesttrus occurs and is confounded with nutrition effects at this time. Therefore control of the cycle in this group really means both induction and synchronisation of oestrus.

A series of studies involving mainly progestagen treatments administered in different ways and prostaglandin analogues administered intramuscularly were carried out on cyclic heifers at the Agricultural Institute, Belclare, and on heifers and suckler cows on farms in co-operation with farmers, the advisory service and artificial insemination station managers.

METHODS OF TREATMENT USED

In attempting to control the bovine cycle by administration of progestagens, one problem which has been encountered by many workers is a method of hormone administration that will release the right amount at the right rate. Many reports have dealt with daily intramuscular injections (Trimberger & Hansel, 1955; Ulberg & Lindley, 1960) or incorporation in the feed (Zimbelman, 1963). Neither of these methods would be practical under Irish farming conditions. A few authors have examined the use of intravaginal sponge pessaries. However all report high sponge losses and therefore reduced treatment responses in cattle (Wishart & Hoskins, 1968; Hale & Symington, 1969; Hignett et al. 1970). But because the intravaginal sponge technique has been widely adopted for use in sheep, it was decided to examine its possible use in cattle and a number of factors affecting sponge retention in heifers and cows were studied (Sreenan, 1970). Data on the effect of hormone compound on retention are shown in Table 1.

Table 1. Effect of Hormone Compound on Pessary Retention

	Heifers			Cows		
Hormone Compound	Number inserted	% retained	Duration (days)	Number inserted	% retained	Duration (days)
Progesterone	117	82.1	17-20	143	57.3	17-20
Cronolone	75	98.6	17-20	91	73.6	17-20
Total	192	90.4		234	65.6	

Sponges containing progesterone were lost more often than those with cronolone. However it seems more probable that the effect was one of density rather than hormone compound per se. However hormone compound may for other reasons have an effect on retention and Australian workers (Moore & Robinson 1967) have reported a high sponge loss when they used progesterone. Having selected one polyurethane sponge type, it was then included in a study of a number of possible methods of progestagen administration and these are outlined in Table 2.

Table 2. Methods of Progestagen Administration

Treatments	Dose Level	Duration
Progesterone Sponge	3.000 gm	20 days (A) 10 days (B)
Cronolone Sponge	0.150 gm	20 days
Progesterone Implant	3.000 gm	20 days
Cronolone Implant	0.200 gm	20 days
Cronolone Intramuscular	0.0024 gm/day	20 days
SC21009 Implant plus Intramuscular injection	0.006 gm	10 days (B)
Prostaglandin analogue Intramuscular	500-900 u.g. (Luteal phase)	1-2 days

Progesterone was administered either by intravaginal polyurethane sponge or subcutaneous silastic rubber implants. Cronolone was administered in a similar manner and also by daily intramuscular (i/m) injections. The progestagen SC-21009 was administered by very small hydron implants inserted into the animals ear, combined with oestradiol valerate and SC-21009 i/m at the same time.

OESTRUS RESPONSE FOLLOWING ALL TREATMENTS

The relative merits of all treatments in inducing oestrus in this trial are shown in Table 3. All animals used were cyclic Hereford cross heifers.

Table 3. Heat response following different methods of progestagen administration

Treatments	No. of Animals	% Heat Response
Progesterone Sponge (A)	46	91.3
Cronolone Sponge	33	87.8
Progesterone Implant	21	57.1
Cronolone Implant	15	26.7
Cronolone Intramuscular	16	93.7
SC2 1009 Implant plus Intramuscular injection	25	96.0
Prostaglandin analogue Intramuscular	10	90.0

Progesterone sponges inserted for 17-20 days (A) effected a very high oestrus response. Of 46 animals ten lost sponges towards the end of the treatment period but seven of these ten showed oestrus. It may be that they lost sponges because they came into oestrus and not that they showed oestrus as a result of sponge loss. However the oestrus response of all animals of this group retaining their treatments was 35/36 or 97.2%. Progesterone implants and cronolone sponges had much poorer oestrus response, mainly because many of the heifers had shown oestrus at their normal time with the treatments still in place. The other progestagens (SC-21009 hydron implants) were similar to the progesterone sponges in effecting a high oestrus response following withdrawal as was cronolone i/m. The other type of treatment, the prostaglandin analogue, was very effective in inducing oestrus by causing rapid regression of the corpus luteum but all of the animals in this group were selected between day 6 and 16 of the cycle.

Thus it is possible to achieve high heat responses and many other authors report similar data (Review, Hansel, 1972 and Jochle, 1972). However unless the heat response is over a reasonably confined period of time it is of little value.

The degree of synchronisation of oestrus for the best of the treatments is shown in Table 4.

Table 4. Degree of Heat Synchronisation in response to different methods of Progestagen Administration

Treatments	% Heat response	Heat spread from end of treatment (hrs)				
		24	48	72	96	>96
Progesterone Sponge (A)	91.3	30.4	52.2	6.5	2.1	8.7
Cronolone Sponge	87.8	24.2	51.5	3.0	9.0	12.1
Cronolone Intramuscular	93.7	56.3	37.5	-	-	6.3
SC21009 Implant plus injection	96.0	73.3	20.0	6.7	-	-
Prostaglandin analogue intramuscular	90.0	-	21.4	28.5	39.5	10.7

Little or no oestrous response occurred within the 24 hours after treatment removal. The heat spread periods in Table 4 start 24 hours after treatment removal. The progesterone sponge (A) had a fairly high degree of synchronisation with over 80 per cent of heats occurring over a 48 hour period. Cronolone i/m had an equally high degree of synchronisation but obviously this is not a practical treatment as animals have to be treated daily over a full cycle. The SC-21009 implants had the highest degree of synchronisation with 93.8 per cent of heats occurring over a 48 hour period. The prostaglandin treatment had the greatest spread with only about 50 per cent of heats occurring over a 2-day period.

It is clear therefore that treatments are available which can effect a high oestrous response with high degree of synchronisation. It was necessary then to determine the fertility of animals at this induced heat after treatment. This was carried out by breeding animals either to bulls or A.I. and slaughtering them between 50-60 days from breeding or else allowing them to calve down on the farm.

FERTILITY LEVELS FOLLOWING TREATMENT

Information on pregnancy rates from the various groups are given in Table 5.

Table 5. Effect of methods of progestagen administration on fertility

Treatments	Service	Conception Rate (%)		
		1st	2nd	1st + 2nd
Progesterone Sponge (A)	Bull	52.5	68.4	85.0
Cronolone Sponge	Bull	44.8	75.0	86.2
Cronolone Intramuscular	Bull	62.5	66.6	86.6
SC21009 Implant plus Intramuscular injection	A.I.	44.0	64.2	80.0
Prostaglandin analogue Intramuscular	A.I.	70.0	66.6	90.0

Progesterone (A) sponges have a pregnancy rate of 52.5 per cent which is approx. 10-15 per cent below normal first service conception for heifers (Laing, 1970; Boyd & Reed, 1971). Similarly cronolone sponges showed a reduced level of fertility and this figure of 44 per cent would be in agreement with the data of Wishart & Hoskins (1968). Cronolone i/m has a normal fertility level and similar to that achieved by Wishart (1973) in Friesian heifers. SC-21009 implant while having the highest degree of synchronisation had a reduced level of fertility at the controlled heat. However subsequent work here and data from other authors shows that this level is probably below normal experience. The French worker Mauleon (1974) has produced data showing that the fertility data for SC-21009 varies between cows and heifers and also between particular breeds of heifers.

Lastly fertility following the prostaglandin analogue would seem to be about normal. There are only ten animals involved here but the indications are good and are in agreement with similar work elsewhere. The second service conception rates of all groups do not differ from each other or from control or normal conception rate and indeed the combined first and second conception rates are all eighty per cent or over.

Because in the earlier studies some of the treatment groups were bred to bulls it was then necessary to determine whether in fact these fertility levels would still hold following artificial insemination. One treatment was selected [progesterone over 20 days (A)]and at the induced oestrus heifers were bred either to the bull or A.I. The results are shown in Table 6.

Table 6. Effect of method of breeding on fertility

Treatments	No. of Animals	Service	Conception Rate		
			1st	2nd	1st + 2nd
Progesterone sponge (A)	32	Bull	53.1	73.3	87.5
Progesterone sponge (A)	32	A.I.	56.2	71.4	87.5

Again there were sponge losses but at a similar level (10%) in each group. All animals were bred as they came in oestrus and pregnancy rates are shown to be almost equal, and differ little from that in the earlier trial. Following both first and second service combined, 87.5 per cent of all treated animals had conceived. It would seem that, provided animals are inseminated at about mid-heat or 6 hours from the start, there is no difference between natural mating or artificial insemination in terms of pregnancy rate following this treatment.

It has been mentioned earlier that there are two main methods of synchronisation, based on either simulation or regression of the corpus luteum. More recently, however, some reports have appeared combining these two methods and as a result shortening the treatment period by half. This means injection of a compound capable of causing corpus luteum regression and at the same time administration of a progestagen for a short period (9-10 days). This combination would have advantages for the sponge as little loss should occur before 9-10 days. The effect of shortening the treatment and adding in both oestradiol and progesterone intramuscularly was compared with the standard progesterone (A) 20 day sponge. The pregnancy rates following breeding by either A.I. or natural mating are given in Table 7.

Table 7. Effect of treatment duration on fertility

Treatment	Duration (days)	Service	Conception Rate 1st	2nd	1st + 2nd
Progesterone sponge (A)	20	Bull	51.4	64.7	82.8
Progesterone sponge + i/m* injection (B)	10	Bull	60.0	100.0	100.0
Progesterone sponge (A)	20	A.I.	53.8	66.6	84.6
Progesterone sponge + i/m* injection (B)	10	A.I.	63.6	50.0	81.8

*Intramuscular

Again, fertility levels following the long term progesterone sponge are about 50 per cent while pregnancy rates following the shortened (10 day) treatment are approximately 10 per cent higher for each group. While numbers involved here are small, present work indicates that it is possible to achieve approximately 60 per cent pregnancy rate following the short term treatment. Another advantage with the sponge would be the high retention rate over a 9-10 day period. In this trial retention rate over a 10 day period was 96 per cent in heifers.

All of this work was carried out on cyclic heifers at Belclare and is a different situation to that found at farm level.

FARM TRIAL SERIES

In treating animals at farm level information such as cyclic activity, stage of cycle, etc. will not be available. However unless treatments are successful at farm level they are of little value. In order to test some of the best treatments a series of farm trials were arranged with co-operation from the Advisory Service. Breeding in most cases was by A.I. through the A.I. Station Managers.

Preliminary results are given in Table 8.

Table 8. Synchronisation trials on farms - Spring 1973

No. of farms 16; No of heifers 203; No. of cows 234.

Treatments	% Heat Response	% Non-Return (60 days)	Cows/Heifers
Progesterone Sponge (A)	76.5	61.5	Cows
Cronolone Sponge	70.1	59.1	Cows
Progesterone Sponge (A)	73.1	67.3	Heifers
Cronolone Sponge	83.7	43.7	Heifers

The trials involved a total of 437 animals and heat responses and non-return rates are given separately for heifers and cows. The cows were all beef suckler cows with calves at foot. While non-return rates are not a good indicator of pregnancy, especially in the suckler cow, pregnancy diagnoisis by palpitation in a number of these farms would indicate a pregnancy rate to the induced heat of approximately 45-55 per cent. Overt heat response was lower than that recorded at Belclare but all animals were covered by A.I. on fixed days following treatment removal.

A further series of trials were conducted during the autumn in which the short duration treatments only were applied (Table 9). Heat response was much higher than previously, with over 80 per cent of animals showing oestrus following treatment. Only non-return (60 day) rate is as yet available for these animals but indications are that it is somewhat better than the early long term treatment. One factor that would seem to have a large effect on treatment outcome is the nutritional status of the animals at treatment.

Table 9. Synchronisation trials on farms - Autumn 1973

No. of farms 6; No. of heifers 71; No. of cows 85.

Treatments	Duration (days)	% Heat Response	% Non-Return (60 days)
Progesterone Sponge (B) + intramuscular injection	10	84.2	75.0
SC21009 Implants + intramuscular injection	10	89.3	67.5

SUMMARY

From these studies on induction and synchronisation of oestrus in beef heifers and suckler cows encouraging results have been obtained following the administration of some of the treatments. The short-term progestagen treatments have shown pregnancy rates to the synchronised oestrus in the region of 60 per cent. The simple intramuscular prostaglandin treatment has resulted in a pregnancy rate of 70 per cent. Initial farm trials have shown that pregnancy rates of approximately 45-55 per cent are possible and later trials indicate that this may be in the region of 55-60 per cent following modification of some of the treatments.

While this is only the beginning of a large area of work it now seems possible that in the near future practical treatments for the induction and synchronisation of oestrus will be available to farmers. Before this is achieved, full scale field testing will be required and this will have to be organised in co-operation with the artificial insemination service because the greatest advantage would be the introduction of A.I. into the beef herds.

ACKNOWLEDGEMENTS

The cronolone and prostaglandin used in these studies were kindly donated by G.D. Searle and ICI Ltd. respectively. The author wishes to acknowledge the expert technical assistance of Mr. T. McDonagh in all of this work, also the excellent co-operation of farmers, advisory service and A.I. station managers, in particular the North Western Cattle Breeding Society (Sligo).

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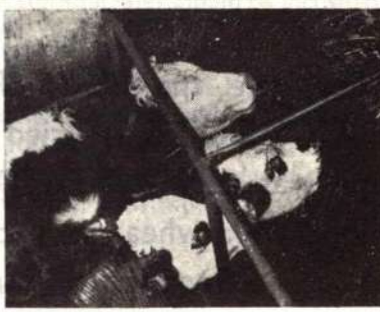

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Grazing Management for Dairy Calves and Heifers

J. D. Leaver
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INTRODUCTION

As herds increase in size the number of young stock reared as replacements increases and it becomes more important to develop specialised systems of rearing which are simple and economic. The young stock enterprise on the dairy farm usually suffers from a lack of imposed management and as a result of poor growth rates heifers often calve for the first time at a late age and in the process require a large agreage of land for feeding purposes. It is therefore advisable to organise rearing so that heifers are calved at about two years of age because this has the additional advantage of fitting in with the one season calving pattern practised on many farms. Also, stocking rates should be increased to comparable levels in the dairy herd.

It is important that the heifers are large enough at first calving in order to minimise management problems and the aim should be to achieve a pre-calving liveweight of 1100 lb. This represents an average liveweight gain of about 1.5 lb/day during the rearing period and as grass is by far the cheapest food available, growth during the grazing season should be optimised.

The objectives in grazing management are to achieve high liveweight gains per animal but at the same time to efficiently utilise the grass available. Such an achievement is somewhat difficult at high stocking rates due to problems with young calves. Firstly, they graze for fewer hours per day and also graze more selectively than older cattle, and consequently if they are forced to utilise most of the grass in a paddock before being moved to a new paddock, resulting liveweight gains are poor. Secondly, if the same area of land is used for a number of years to intensively graze young calves, stomach worms become a major problem. These normally occur from July onwards.

Experiments at NIRD have aimed at overcoming these two problems by grazing management.

A LEADER-FOLLOWER SYSTEM OF GRAZING

In 1968/9 a comparison was made using 184 mainly autumn-born young stock between a conventional system in which calves and older heifers rotationally grazed in completely separate paddock systems, and an experimental system in which calves rotationally grazed immediately in front of older heifers

Half of the calves on each system were regularly drenched with an anthelmintic from July onwards. All calves were given an oral vaccine against husk. The results of this comparison given in Table 1 show that the liveweight gain of calves on the conventional system responded to drenching. Thus a substantial worm burden was present, but on the leader-follower system there was no response signifying the absence of a large worm burden. A comparison of the drenched calves on the two systems also shows an advantage for the leader-follower system due to the calves being allowed to graze selectively. The liveweight gains of the heifers, although slightly lower on the leader-follower system, were adequate on both systems.

Table 1. A comparison of two grazing systems for calves and heifers

	Conventional System		Leader-follower system	
Calves	**Drenched**	**Not Drenched**	**Drenched**	**Not Drenched**
Initial liveweight (lb)	385	380	381	380
Liveweight gain (lb/day)	1.40	1.06	1.74	1.75
Heifers				
Initial liveweight (lb)	836		839	
Liveweight gain (lb/day)	1.86		1.75	

The results from the leader-follower system were very encouraging and this was then adopted at NIRD as the standard grazing system. A study was then made of the effect of stocking rate. An increase in stocking rate was shown to depress the liveweight gain of the calves as well as the heifers, as indicated in Table 2, and this again illustrates the sensitivity of calves to changes in grass supply. Stocking rate also affected the production and utilisation of grass dry matter. A decrease in acreage from 0.8 to 0.6 acres per replacement unit (a replacement unit = 1 calf + 1 heifer) reduced total grass dry matter production by 7% and increased total utilisation by 9%. The high levels of utilisation emphasise the high efficiency of grazing cattle in harvesting grass. The levels of grass production were generally low due to low rainfall on the valley gravel type of soil.

Table 2. The effect of stocking rate on liveweight gains and production and utilisation of grass on a leader-follower grazing system

Acres per replacement unit	0.8	0.7	0.6
Liveweight gain (lb/day), Calves	1.65	1.54	1.36
Heifers	1.54	1.36	1.06
Grass D.M. production (lb/acre)	6070	5830	5650
% total utilisation	88	92	96

The length of the grazing rotation does not appear to be an important factor affecting liveweight gains. Recent experiments at NIRD have shown only small differences between 21 and 35 day rotations.

The size of animal at turnout is an important factor affecting liveweight gains, as shown in Table 3. Older and larger calves and heifers grow faster than younger, smaller cattle. Spring born animals will therefore always have lower growth rates than autumn born.

Table 3. Size of animal at turnout and liveweight gains at grass (NIRD 1972/73)

	Initial liveweight (lb)		Liveweight gain (lb/day)	
Calves	over 400		1.85	over 168 days
	300-400		1.74	
	200-300		1.65	
	under 200		1.45	
Heifers	over 900	Pregnant	1.94	over 112 days
	800-900		2.00	
	700-800	non-pregnant	1.78	
	under 700		1.72	

ORGANISATION OF A LEADER-FOLLOWER GRAZING SYSTEM

The first decision must be to optimise the production of grass. Although critical comparisons have not been carried out, this grazing system has been successfully tested on both permanent and temporary grass, and despite the rise in fertilizer costs, economic responses in grass dry matter production up to 200 units/acre of nitrogen are likely to occur under most conditions.

The most difficult decision concerns the choice of the optimum stocking rate which will depend on (a) the level of grass production, (b) how much silage or hay is to be taken from the area, and (c) the size of the animals (spring or autumn born). A guide to this choice taking into account these factors is given in Table 4.

Table 4. **Guide to stocking rate (acres per replacement unit) for dairy replacements**

Grass D.M. production (lb/acre)	Autumn-born			Spring-born		
	Grazing	Conservation	Total	Grazing	Conservation	Total
6,000	0.9	0.6	1.5	0.7	0.7	1.4
8,000	0.7	0.4	1.1	0.5	0.5	1.0
10,000	0.6	0.3	0.9	0.4	0.4	0.8
12,000	0.5	0.3	0.8	0.4	0.3	0.7

The area for grazing must then be subdivided into paddocks, the number depending on the amount of silage or hay to be removed. In a totally integrated system where all the conservation is taken from the paddock area, 10-12 will be necessary in order to give flexibility during cutting. The required quantity of conservation can be attained by cutting each paddock once e.g. in a 10 paddock system, 6 paddocks for the first and 4 for the second cut.

In a two sward system where no conservation is taken from the paddocks, 6-8 paddocks are adequate and management can be simplified by having a fixed grazing cycle with a rigid twice weekly movement of animals.

Supplementary feeding of concentrates at grass for most of the season is unnecessary. At turnout concentrate feeding need only be continued for the first week except for spring born calves, which must continue on concentrates up to 3 months of age. At the end of the season it is often beneficial to feed 3-4 lb/day of barley for the last 6 weeks at grass.

CONCLUSIONS

Most of the progress to be made in the dairy replacement enterprise is during the grazing season. Stocking rates will have to be increased if similar levels of grazing efficiency to the dairy herd are to be achieved. This will involve the imposition of specialised grazing management.

Many of the problems associated with intensive grazing with young cattle appear to be overcome by the use of a leader-follower grazing system. This enables the calves to graze selectively giving high growth rates, controls the build-up of stomach worms in calves, gives adequate growth rates in the following heifers and high levels of grass utilisation. The objectives of high liveweight gains in cattle maintained at high stocking rates therefore can be achieved. The system is now being used successfully on many commercial farms.


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Reproduction in Spring Calving Dairy Cows

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INTRODUCTION

A concentrated calving pattern within six weeks prior to the cows going out to grass has a major influence on efficient herd management. The aim should be to calve 90% of the herd within an eight week period.

Although a concentrated calving pattern may not be immediately attainable particularly in herds which presently have a very prolonged calving pattern, the calving season can be shortened considerably by shortening the breeding period and by culling or carrying over the barren cows.

The more important factors affecting compact calving and reproductive performance which have been examined at Moorepark are:

1. Heat Detection
2. Conception Rate and Submission Rate
3. Time of Insemination
4. Nutrition
5. Artificial Insemination and Natural Service

1. HEAT DETECTION

This is perhaps the single most important factor. There are three methods of heat detection:

(a) Observation

(b) Observation with Heat Mount Detectors (Kamar)

(c) Vasectomised or Teaser Bulls fitted with a chin ball mating device.

OBSERVATION

This is the most common method of heat detection. But it can be unreliable. Research (1) shows that where heat detection is carried out by the milker in addition to his other chores up to 12% of animals presented for insemination are not in heat. This error is increased to 36% when heat checks are made as the animals are driven to and from the milking shed. Table 1 shows the times of onset of heat in a spring calving herd.

Table 1. Times of onset of heat in spring calving herd (400 heats observed)

Observation Time	% Detected
6 am	30.7
10 am	17.1
2 pm	20.7
6 pm	9.2
10 pm	13.1
2 am	9.2

By 10 am up to 50% of heats which are to occur on the particular day are recorded. Two further checks, one at 2 pm and another after evening milking should result in over 80% of heats being detected. It is important to remember that while the average length of heat is 17 hours some may be as short as four hours. Thus the more frequent the observations the more heats will be detached.

OBSERVATION PLUS HEAT MOUNT DETECTORS (KAMARS)

These detectors are glued to the back of the cow or heifer between the hip bones. Pressure from the brisket of the mounting animal triggers the detector which then changes colour to red. Over 90% efficiency has been claimed for these detectors as a means of heat detection. Results from trials at Moorepark show that they are far from satisfactory. Table 2 shows that only 47% were retained before or at heat. The low retention rate is due to the fact that spring calving cows "mount" and lose their hair at breeding time. Costing 30p each they are a poor investment.

Table 2. The efficiency of Kamar Heat Detectors

Initial No. of Detectors	No. Red Plus Heat	No. Red Minus Heat	No. Lost During Heat
135	64 (47%)	3 (2.2%)	29 (45%)

VASECTOMISED OR TEASER BULLS

These bulls are fitted with a chin ball mating device. This method has been shown to be 90% efficient in heat detection. Research (2) indicates that they reduce the incidence of "silent" heats by one third. They also reduce the labour and time involved in heat detection. However teaser bulls are expensive to maintain. They also pose managerial problems particularly around the dairy or parlour. False mountings may occur and the bull may disrupt milking routine. It is advisable therefore that the bull be removed from the herd before milking.

If a teaser bull is run with more than 40 animals a significant number of heats may be missed as "harem" formation tends to occur. In such circumstances it is advisable to use a second teaser bull.

The best system for dairy herds in my opinion is frequent and timely observations during the day. Results are as good as any of the other methods. However teaser bulls have a definite place particularly with replacement heifers which are to be artificially bred.

Whatever form of heat detection is used proper animal identification is essential. At Moorepark neck bands, medallions, freeze brands and/or plastic ear tags are used. One of these alternatives is recommended.

The ultimate answer to heat detection is synchronisation and insemination without reference to heat. This development will emerge in the near future.

2. CONCEPTION RATE

The interval from calving to service has a direct effect on conception rate. Table 3 shows this effect.

Table 3 Effect of service Interval on Conception Rate

Calving to Service Interval (days)	11-31	32-52	53-73	74-94
1st Service C.R.%	35	54	60	68

The longer the calving service interval the higher the conception rate. However, if one is to achieve some form of compact calving some animals will have to be served before the recommended 50-60 day calving to service interval. Submission rate, a relatively new term, plays an important role in compact calving. It is defined as the percentage of cows correctly detected in heat and inseminated during the first four weeks of mating. Table 4 shows the interaction of conception rate and submission rate on the percentage of animals calving in a four week period.

Table 4. Interaction of Conception Rate and Submission Rate on four week Calving Pattern

Case	C.R.%	S.R.%	% calving in 4 weeks
1	68	50	34
2	54	85	45
3	68	85	55

In this situation a farmer decides for example that from mid-April all animals that come on heat will be served. Case 1 shows that the advantages of a high conception rate are offset by a low submission rate e.g. the farmer allows all animals irrespective of calving date 60-70 days from calving to service. Case 2 shows that although the conception rate is low the overall percentage calving in four weeks is higher due to a high submission rate. This is achieved by inseminating all animals that come on heat irrespective of calving service interval after the beginning of the breeding season. Case 3 is the ideal situation and in New Zealand some farmers have reached a level of 72% of their herd calving in four weeks. If heifer matings are added to Case 2 there is no reason why 90% should not be in calf within 8 weeks of the beginning of mating.

3. TIME OF INSEMINATION

One of the factors affecting conception rate is time of insemination. For optimum fertility the time relationship between oestrus/ovulation and insemination is important. The ova survive for about six hours and the sperm for about 36 hours. Information on the optimum time for insemination varies greatly (3,4,5). The range varies from three to 25 hours after heat onset. In 1971 a trial was carried out at Moorepark to determine the optimum time insemination. The results (Table 5) show that the conception rates achieved during the first 12 hours of the heat period are significantly ($P > 0.05$) lower than for the 12 to 24 hour period.

Table 5 Effect of Time of Insemination on Conception Rate

Time (hrs)	0-6	6-12	12-18	18-24
C.R.%	48	40	59	65

However recent evidence (6) from New Zealand indicates that time of insemination is not as important for bulls which have above average fertility as for those with average or below average. Sperm from the latter have a shorter "in vivo" life span and die before ovulation. Hence the lower conception rates. MacMillan concludes that "in vivo" sperm liability is therefore a major factor influencing a sire's fertility, as suggested by the large differences in conception rate due to the effect of time of insemination.

Additives to semen diluents such as amylase and B glucuronidase tend to accellerate sperm capacitation time. From the above evidence it would appear that a strong case can be made for the development and addition of certain diluents which would reduce capacitation time and thereby increase fertility.

4. NUTRITION

The existence of a positive relationship between plane of nutrition and/or liveweight change and fertility in the cow has been widely accepted. Whilst some good evidence exists to support the case there is equally some evidence which does not do so (7,8,9,10). Another report (11) demonstrated that pre and post calving plane of nutrition have a cumulative effect on fertility. The effect of a low post calving feeding level is increased when preceeded by a low pre calving plane of nutrition.

Pre and post calving plane of nutrition was examined in Moorepark over two years. Animals were fed on a high or a low plane of nutrition for eight weeks pre and eight weeks post calving according to treatment. The high plane before and the high plane (H-H) after calving consisted of 2.4 lbs of D.M. per 100 lb bodyweight from silage and eight lb of meals before calving and 2.8 lb of D.M. per 100 lb bodyweight plus 16 lb of meals after calving. The low plane pre and post calving (L-L) consisted of 1.5 lb of D.M. from silage alone pre calving and 2.0 lb of D.M. from silage plus 4 lb of meals after calving. The results (Table 6) show that animals on a high-low plane of nutrition (H-L) and losing 3.2 lb per day post calving (16%) had a calving to conception interval (C.C.I.) of 80 days and a conception rate to first service natural service of 75%. This does not concur with other work (9) on the subject. All groups even those on the Low-Low plane of nutrition had a calving conception interval of less than 85 days, thereby allowing a calving to calving interval of 365 days. It should be mentioned that all groups gained or maintained weight before calving and all lost weight to varying degrees post calving.

Table 6. The Effects of Pre and Post Calving Plane of Nutrition on Cow Fertility

Treatment Pre - Post	C.O.I[1]	C.C.I.[2]	Conception Rate %	Lbs.Lost/day Post Calving	% Loss in 8 weeks
H - H	37	67	71	1.4	7
H - L	35	80	75	3.2	16
L - H	42	65	80	1.1	5
L - L	48	76	74	2.1	12

[1]C.O.I. - Calving to oestrous interval (days)

[2]C.C.I. - Calving to Conception interval (days)

The conclusion to be drawn from this trial is that good silage "ad lib" before calving and silage plus 4-8 lb of meals after calving until animals go to grass are sufficient. It can also be concluded that either nutritional stress is not an important factor in the fertility of spring calving cows or that bodyweight changes are a poor measure of this stress.

5. ARTIFICIAL INSEMINATION AND NATURAL SERVICE

The Conception Rates achieved by Artificial Insemination are generally lower than those from natural service (12,13). Some sources (13) found the differences to be as great as 15% in favour of Natural Service.

The reasons why A.I may have lower conception rates than natural service are many. These include:

1. Accuracy of heat detection
2. Individual A.I. operators
3. Time of Insemination
4. Calving service interval
5. The use of fresh or frozen semen. It is reported that conception rates with deep frozen semen are 5 to 10% lower than with fresh semen used on the same day (15,16).
6. The number of times a bull serves a cow during heat can influence the conception rate.
7. Data on natural service may include animals first bred to A.I. but then bred to the bull and included as a first service to the bull. This would lengthen the Calving Service Interval and increase conception rate.

A.I. and natural service were compared in a trial conducted at Moorepark under controlled conditions. The frozen semen used was taken from the bulls to be used for natural service. Animals were allocated to treatments on the basis of similarity in lactation number and calving date. All animals were allowed 50 days after calving before service. Animals for A.I. in heat in the morning were served that afternoon and animals in heat in the afternoon were served the following morning. Heat observations were carried out five times daily. Animals for natural service were served once when they were in heat.

The results of this experiment (Table 7) indicate that A.I. is as good as natural service under these conditions. It is perhaps important to note that only one A.I. operator was used. The animals assigned to natural service in Hard 1 had a shorter calving service interval as some animals were served on the first heat post calving.

Table 7. Comparisons between A.I. and Natural Service

Herd	No. of Animals	A.I.	C.R.%	C.S.I.	No. of Animals	Natural Service	C.R.%	C.S.I.
1	76	50	65.7	77	71	45	63.3	59
11	33	22	66.6	76	34	19	55.8	76
111	57	39	68.4	71	53	34	64.2	72
Total	166	111	66.8	74	158	98	62.0	69

C.R.% - Conception rate
C.S.I. - Calving service interval (days).

NUMBER OF SERVICES PER BULL PER DAY AND PER WEEK

Roberts (19) reports that services per bull per week varies from four to 12. At Moorepark a trial was conducted in which records were kept on the number of cows served per day by each bull and the resulting conceptions. The cows were "hand mated" and served only once by the bull. When the bulls were in daily use two cows were usually the maximum number that conceived in one day even though four may have been served. However one bull after a four day rest served five and four conceived. From this it would appear that frequent short periods of rest are desirable.

The number of animals involved in the trial was small. Table 8 gives the number of services per bull per week. Seven conceptions were the maximum achieved by any of the four bulls per week.

Table 8. Services per Bull per Week

Bull	No. Served	No. Conceived	Once Only Repeats	C.R.%
W.C.F.	16	7	6	43
G.W.T.	10	7	3	70
A.F.T.	13	7	4	53
"	11	7	2	64
"	8	6	2	75
C.V.R.	12	7	1	58
"	6	4	1	66

Some farmers with bulls at free range are achieving better results. However it is important to remember that there is a limit to a bull's performance, if one is to achieve a compact calving season. Therefore in a herd with 70 cows calved, the number of cows that can come on heat in any one day is 70/21 or 3.3. In this case a bull may have to serve over three cows per day. A second bull should be used on an alternate day basis in order to obtain maximum fertility.

Semen was collected from two of the bulls used in this experiment on the same rota as they had mated cows. Twelve ejaculates were taken from bull A.F.T. The average volume of semen was 3.5 cc (table 9) containing an average of 0.17 billion (10^9) spermatazoa per cc. The number of spermatazoa required for fertilization is five to ten million per cc using fresh semen. Thus it would seem that numbers of sperm were not responsible for only seven animals conceiving. However, the volume per ejaculate is small and this may have some effect on sperm transport and conception rate.

SEMEN COLLECTION FREQUENCY

In most Irish A.I. Stations semen is collected from bulls once or twice per week. The total number of inseminations per bull in this country is less than half the New Zealand figure (16). The conception rate for first inseminations with liquid semen was 66.9% and 62% for deep frozen semen. Each dose of 0.5 ml contained 2.5 million sperm. This is about one tenth of the dose needed for deep frozen semen.

It is thought however that frequent collection from bulls has adverse effect on both bulls and semen. However Hafs (17) has shown that daily ejaculation of aged bulls for as long as eight months is not harmful either to the bulls or to the quality of semen.

The increasing demands for sperm from genetically superior bulls will not be met by once or twice weekly collection and the use of frozen semen also limits the numbers inseminated as the sperm requirements can be ten times that of fresh semen.

The total number of sperm collected from one bull (Bull A.F.T. Table 8) in one week was as follows:

Table 9. Semen Examination in one bull

Frequency of Ejaculate Collection	Vol. of Semen per Ejac. (ml)	Sperm Conc. (10^9)/ml	Total Sperm per week (billion)
Daily (7 days) (12 Ejacs.)	3.5	0.17	44.20

Taking the average of 70% motility 30.94 billion sperm per week were produced. This represents a potential 100,000 breedings per bull per year using 10 million motile sperm per insemination.

It would appear that daily collection and the use of a fresh semen service during the peak breeding months would maximise the use of our best bulls. Semen collected in excess of the daily requirements could be deep frozen.

INFERTILE AND REPEAT BREEDER COWS

Reproductive disorders account for 22% of cows culled. In order to ascertain why animals are infertile, a post mortem examination was carried out on the uteri and ovaries of infertile and repeat breeders culled from the Moorepark herds. Table 10 shows that even though all animals were examined before being culled four (7%) were in fact pregnant. It is probably much greater in commercial herds where pregnancy diagnosis is not carried out as a routine. All the other animals except one had a history of regularly repeating to services. Some had been served by bull and A.I. up to nine times. The main feature to be noted is that only 14 (27%) had any macroscopic abnormalities which would interfere with fertility. Only one animal had inactive ovaries. A recent abbatoir survey (18) showed that 52% of ovaries examined were inactive.

Table 10 Reproductive Tract Examinations in Moorepark herds

Total No. of cows examined		52
Pregnant		4
Uterus	Inflamed	4
	Infected	3
Ovary	Adhesions	4
	Cysts	1
	Inactive	1
Fallopian Tube	Pyogenic Cyst	1
	Hydrosalpinx	1
Gas in Broad Ligament		5
Number with abnormalities		14
% Abnormalities		27

It would be concluded that the 73% which had no abnormalities would eventually go in calf if left long enough in the herd. However, information on the hormone status of these animals would add a desirable dimension to our knowledge and possibly lead to the development of therapy which would get them in calf earlier.

SUMMARY

Farmers should strive for a compact calving system in their herds by (1) accurate heat detection; (2) submitting as many animals as possible for insemination during the first few weeks of the breeding season and (3) by culling or carrying over late calvers or animals difficult to get in calf. Pregnancy diagnosis should be carried out before culling. Proper animal identification is also very desirable.

Cows should be fed good quality silage "ad lib" before calving and the silage should be supplemented with 4-8 lb of meals after calving until they are transferred to spring grass. The genetic merit of the herd is improved by using the best bulls from the A.I. stations but this depends on their availability.

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Control of Brucellosis in Intensive Farming

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For many years Brucellosis was known under the name of Contagious Abortion and about the only two things that one can say with unqualified certainty are:

1. That it is very contagious

2. That the only clinical symptom in cattle is abortion.

It would be readily manageable if exposure to infection led to (a) prompt abortion within a few days or weeks

or (b) the early development of positive blood titres

or (c) a positive reaction to some other type of test such as the tuberculin reaction in Tuberculosis.

Unfortunately none of these things happen with any degree of regularity. In fact they are often the exception rather than the rule.

NATURE OF THE DISEASE

Whilst most infected cows abort only once the disease becomes chronic and such animals become symptomless carriers. Even when subsequent pregnancies in such cows run full term the foetal tissues and fluids may be grossly infected and cause fresh dangerous spread of the disease.

Worst still, some apparently non-infected (serologically negative) heifers or cows may carry full term, spread gross infection and be recognised as being infected only some weeks later. When this happens in a herd the results can be quite disastrous as precautions taken at a "normal" calving are often minimal. The sequel is often the commencement of a serious abortion storm some two months after the event in the in-contact gravid animals. (This is becuase the minimum incubation period is about 40-50 days).

SEROLOGICAL TESTS

As far as serological tests are concerned they basically identify animals which are receiving sufficient antigenic stimulus to produce antibodies, but all infected animals do not fall into this category. Some of the exceptions are:

1. The incubation period of the disease in pregnancy can vary from one to nine months so that animals exposed up to nine months previously may not yet react to tests, may calve normally and spread infection.

2. Quite apart from the long incubation period there is also the phenomenon of latency - whereby an animal may carry infection from its early youth, pass all routine serological tests and then abort during its first pregnancy.

3. Some cows effect a recovery from infection in as much as blood titres may fall to negative levels over a few years. Unfortunately many such apparently negative animals shed small numbers of organisms and may be the cause of a future breakdown when the herd has been clear of brucIllosis sometimes for years.

4. Vaccination can produce some confusing blood pictures, the interpretation of which requires a high degree of skill. Despite these exceptions brucellosis can be eradicated.

Let us examine some salient features of the disease and from these try to plan a campaign to suit our particular circumstances.

CLASSICAL PATTERN

The exposure of unprotected pregnant heifers or cows almost certainly leads to abortion. The incubation period may be from one to nine months and some blood titres may become positive only after abortion. The usual mode of infection is by ingestion but there may not be sufficient organisms to set up either infection or antibody protection in the dams tissues. Thus, serological tests may remain negative. However a very small number of organisms migrating to the uterus during pregnancy is quite sufficient to set up an infection there. The target site is the foetal placenta in which infection causes necrosis of the cotyledons. Secondly, a small number of organisms can set up infection in the udder. In the milking cow a positive milk ring test may then be the first indication of infection. At parturition leakage of large numbers of organisms from the uterus occurs across the cotyledons into the bloodstream and causes bacteraemia. It may then take up to 19 days for the animal to give a positive serological test. The bacteraemia may also cause gross infection of the udder, and in fact it has been found that about 90% of infected cows are infected in the udder. For this reason the milk ring test is highly efficient in detecting the infected cow.

EXPOSURE OF THE NON-PREGNANT HEIFER

This usually leads to, at most, temporarily positive blood titres. The infection is rapidly overcome and titres usually fall to negative levels over a period of months. It is the exception and not the rule for the non-pregnant heifer to develop persisting positive titres. Exposure of non-pregnant heifers can lead to one or two things

(a) Natural immunity in over 90% of heifers and

(b) Latency in something less than 10%.

The important of these two effects is quite different when we are attempting to control the disease as opposed to their importance in the final stages of eradication.

VACCINATION

Whether S19 or K45/20 is used, one gets approximately the same degree of protection which is "about 70% against a reasonable level of challenge". This is not as good as we would like and there seems to be not much hope of producing a better vaccine. It is an unfortunate fact that it is very difficult to produce a good vaccine from any gram-negative organism. (E.coli, Vibrio Cholera, Salmonella, etc.). Thus the protection afforded bv vaccination will be as good as the chance we give it and it will not stand up to massive challange. However, vaccination can be a very big help in controlling the disease.

SOME BASIC CONSIDERATIONS IN TRYING TO CONTROL THE DISEASE

So far we can see that:

1. The pregnant animal is highly susceptible to infection
2. The non-pregnant animal is highly resistant
3. We can supply a modicum of protection by vaccination

Under normal management conditions the young stock are reared apart so that even in heavily infected herds they usually test out well. In the initial stages of control they can be vaccinated and left so until they are served. The first step in controlling the disease must be to protect pregnant animals against exposure. Basically this means that no female is allowed to calve or abort in the presence of other pregnant females, because the foetal fluids and placenta carry enormous numbers of bacteria.

Another piece of information which can be applied is:

(a) Heifers exposed in the first third of pregnancy tend to carry nearly or to full term.

(b) Heifers exposed in mid-term tend to abort 40-50 days later

(c) Heifers exposed in late term tend to carry to full term but are usually then found to be infected.

Even if one cannot isolate each animal for parturition one should segregate pregnant animals in groups according to their stage of pregnancy and remember that economically at least the ones in the 4-6 months range are the most vulnerable. This is a rational approach to limiting spread of infection. There should always be some isolation boxes on a farm - one should aim that all parturitions take place in them and that they are cleansed and disinfected after each event. Almost any disinfectant is effective against Brucella abortus as long as the organism is not protected by dirt or organic matter - so cleansing is also important.

The bulk of infection is in the foetal membranes and fluids. These are normally passed within a few hours of parturition. Involution takes place within a few days after the expulsion of placenta. After this, the rate of excretion is not great and should not unduly affect vaccinated animals. Thus it is better to have all females in for the act of calving rather than keep in a few for three weeks. It is most important that all females are effectively vaccinated.

THE MILK RING TEST

The MRT does not suffer from the same deficiencies as serological tests in the vaccinated herd. It is uninfluenced by K45/20A vaccination and this was one of the reasons why:

(a) In 1967 it was decided to ban S19 and use K45/20A vaccine

(b) Conversely, that the MRT was chosen as the best method of diagnosis of the disease in the heavily infected areas.

The MRT has the following advantages:

(a) It is cheap, rapid and easy to perform.

(b) It detects only antibodies in the milk - so that it will detect 90% of infected cows (and these are the dangerous 90%).

(c) It avoids "overkilling" in a vaccinated or infected population.

The Pre-Intensive Scheme is an excellent Scheme designed to eliminate the dangerous infected animals. It is not an eradication scheme but if successful will have two great benefits to the farmer:

1. It will make eradication possible more quickly and

2. Because the farmer is not obliged to dispose of reactors immediately (as is required under the Blood Test and Slaughter Scheme) it will allow him to retain an optimal level of production as he controls the disease. In doing so is less likely that farmers who avail of the scheme will be subjected to severe financial stress when the Blood Test and Slaughter methods are introduced.

SOME DIFFICULTIES

1. **Intensification leads to greater contact and to more rapid** spread of a contageous disease (Contageous Abortion). In fact under some intensive systems control may be extremely difficult.
2. Good management is essential for progress in any herd, whether dairy or beef.
3. It is easier to get rid of the disease in spring-calving milk-producing herds than in those supplying liquid milk the year round. The synchronisation of calving assists in this as one has a period of six months or more to carry out tests when no animal can abort to upset the validity of the tests.
4. In single suckled herds with calvings synchronised over a short period the same remarks apply. **But** if one is thinking about the state of affairs where the bull runs loose the year round with a large number of females (a system of nil-management) - one must think seriously and decide whether one is in farming as a business or merely as an idle hobby.

CONCLUSIONS

The total eradication of brucellosis is a rational National objective which will primarily be of benefit to the farmer, and to a lesser extent to the community.

Compensation and support for the eradication of the disease is provided out of public funds to which we all contribute. It should be a matter of concern and conscience to all that the aim should be to deplete the national herd as little as possible and to avoid undue hardship on the individual farmer. These are difficult objectives to contend with when dealing with this type of disease. But all these factors have been considered in deciding to tackle the problem in the Southern Counties on a two stage basis.

Stage 1. is the Pre-Intensive Control Scheme and

Stage 2. will be the familiar Test and Slaughter policy of Eradication.

The Pre-Intensive Scheme is strongly recommended. It offers a way of virtually eliminating the disease whilst still maintaining maximum production. It may suffer from some defects, but is not a final statement. Some amendments will inevitably be made, and with frankness in discussion and due consideration of difficulties it may be possible to improve it. Control of brucellosis is not easy and demands hard work from both farmers and vets.

Basically it is the job of the Veterinary profession to assist farmers by studying this particular problem - conditions vary from farm to farm - carrying out and interpreting appropriate tests, formulating a workable plan of campaign and then monitoring progress in regular consultation with farmers. As progress is made tactics may also need to be changed, as also will the severity of interpretation of supplementary tests.

Nevertheless **nobody but the farmer can control brucellosis in his herd.** It must be tackled methodically, and it entails many things which may be simply expressed as good management. Some necessary details are:

1. Accurate records (Date of birth, tag number, service dates, calving dates, identity of calf, vaccination dates, etc.)
2. Provision for isolation at parturition
3. Cleansing and disinfection of any housing and potentially dangerous materials before removing for safe disposal (foetuses, placentae, foetal fluids).
4. Provision for group isolation during pregnancy and a watchful eye on all pregnant animals for any sign of impending parturition.
5. Keep boundaries and internal fencing in good repair.

To these I would add:

(a) Do not buy in female replacements - particularly pregnant ones and

(b) Love thy neighbour as thyself

Farming and County organisations have a part to play and they should encourage their farmers to go ahead with control where possible on an area basis and they should bring pressure to bear on both offenders and stragglers.

To meet the requirements of E.E.C. directives we must be free of Brucellosis by 1978 - otherwise we will have serious difficulties not alone in external trade but also in the traditional internal movement patterns of the cattle trade.

THE GREAT ALL·ROUNDER

DEVELOPMENT OF BEEF AND DAIRY BUILDINGS IN NORTHERN IRELAND AND SOME OF THE PROBLEMS

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There has been a dramatic expansion in the number of suckler cows in Northern Ireland while dairy cow numbers continue to increase steadily. The current annual expenditure in farm buildings is about £8 million of which more than half is spent on buildings for cattle. Herds of 100 to 200 cows or beef units of 500 to 1,000 cows are not uncommon.

The quantity of silage conserved has trebled during the last six years. Self feeding was the most common method of feeding silage but easy feeding associated with open silos has now become popular particularly in beef fattening units. Open silos are not popular with self feeding because of the increased volume of slurry to be collected and stored.

Cubicle and slatted floor housing systems have allowed farmers to house cattle in larger numbers. Sufficient straw for bedding is no longer available. Slatted floors are installed between rows of cubicles to eliminate the daily chore of scraping yards.

Although three months storage of slurry is accepted practice, an increasing number of farmers are expanding storage capacity to cater for the entire winter period. Storage of slurry is expensive but is accepted in the interests of the environment. Storage methods vary from below ground tanks to above ground tanks.

Buildings tend to be steel framed Dutch barns with lean-to's. Although timber buildings of the kennel type were popular a few years ago the cost differential between these and the more conventional buildings has been reduced due to increasing prices of timber. Proprietary buildings for cattle are used very little compared with the pig and poultry industry. The exception to this is the Masstock building. This development arose from well tried slatted floor systems established here for some years.

Problems which will affect building developments in future are:

1. Labour Costs
2. Cost of borrowing money
3. Increased building costs
4. Level of grant

5. Pollution control
6. Planning controls on farm buildings and amenity considerations.

Farm labour is becoming scarce and expensive. Improved efficiency through the further use of buildings is therefore required. With cost of borrowing money at a record level and building costs rising at 20% to 30% per annum farmers are being forced to consider cheaper systems of housing animals. Cheap housing systems must have a low labour requirement and must satisfy pollution and other amenity considerations. It is doubtful if a really cheap system can satisfy all these requirements. Grants under the Farm Capital Grant Scheme have been reduced from 40% to 20% for farm buildings. Under the new EEC Scheme the grant rate will be 25% but will apply less widely.

The Water Act was introduced in 1972 for the purpose of conserving water resources and promoting water cleanliness. It means that cases of pollution of watercourses by animal waste or silage effluent are liable to prosecution. In this regard silage effluent presents a major problem.

Planning controls for farm buildings have also been introduced. Only buildings outside the confines of the principal farmyard, close to houses and roads, over 12 metres in height and more than 300 sq. metres in area require planning permission. It is anticipated that this will not unduly affect the development of farm buildings.

THE RELATIVE ECONOMICS OF SPRING AND AUTUMN MILK PRODUCTION

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A three year experiment with six autumn and two spring calving herds was undertaken to study the relative costs of autumn and spring milk production. Each herd consisted of 21 cows in a self contained farmlet which provided grazing and silage for winter feed. The autumn calving herds were arranged in a factorial arrangement of three feeding levels during the winter period as follows: 1.8 kg, 3.6 kg, and 5.4 kg of concentrates per head per day and each feeding level was stocked at either 2.84 cows/hectare or 3.53 cows/hectare. The spring calving herds were fed 3.6 kg of concentrates per day from the time of calving until they went to grass in mid-March and were stocked at either 2.84 cows per hectare or 3.53 cows per hectare. The autumn calving herds calved over a three month period with a mean calving date of 14 September, and the mean calving date for the spring herds was 14 March. All other management practices were similar except greater quantities of silage were cut for the autumn calving herds.

The land acreage required to carry both spring and autumn herds was found to be similar. Milk yields were increased as level of concentrate feeding increased for the autumn calving herds. Milk production per cow was depressed due to increased stocking rate but output per hectare was increased at the higher stocking rates. The autumn calving herds produced more milk than the spring calving herds. The production data obtained were used to determine the relative costs of milk production under both systems.

PROTEIN SUPPLEMENTATION OF GRASS SILAGE FOR DAIRY COWS

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Ninety Friesian cows in early lactation were used in an experiment to study the effects of varying the protein content of the concentrate used to supplement grass silage. Concentrate rations based on barley and soyabean meal were formulated to contain 12, 15 and 18% crude protein. Each of these concentrates was fed at 3.0, 5.5 and 8.0 kg per day to 10 lactating cows for eight weeks. The animals were individually fed grass silage ad libitum.

The protein content of the concentrate ration did not affect silage dry matter intake. At the lower and intermediate levels of feeding, increasing the protein content of the concentrate tended to reduce bodyweight loss. At the higher level of feeding, the animals on the three protein levels gained bodyweight during the experimental period.

Increasing the concentrate protein from 12 to 15% resulted in increased milk production at the three levels of feeding while elevating the protein from 15 to 18% increased milk production only at the higher level of feeding. The protein content of the concentrate had no consistent effect on milk fat or protein content.

EFFECTS OF CROSSING FINNISH LANDRACE AND GALWAY SHEEP

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Ewes producing twins are biologically more efficient than ewes producing singles. Since the frequency of twinning is low in the Galway breed the most important goal in breed improvement is higher litter size. The results of Fingalway evaluation (½ Finn x ½ Galway) show that the most immediate way to improve Galway sheep is through the introduction of Finn genes. Data were summarised for the years 1971-'73. The average litter size for Fingalway ewes was 2.0 compared with 1.4 for Galway ewes. In addition significantly fewer Fingalway ewes were barren.

The number of lambs weaned per ewe per year were measured in two flocks of ewes over a period of three years. The ewes were born in 1968 and 1969 and in total represented 75 Fingalway and 283 Galway ewes. The Fingalway ewes weaned on average of 1.70 lambs/ewe/year. The corresponding figure for Galway ewes was 1.23. Data from 14 breeders flocks wherein Galway and Fingalway hoggets produced lambs supported these results with an extra 0.50 lambs weaned per ewe. While lambs weaned per ewe per year is the most important trait, lamb growth is also important. A progeny test of Galway and Fingalway rams yielded average weaning weights of 28.9 and 28.8 kg for Galway and Fingalway sires, respectively. Analysis of lamb mortality data has shown no significant differences between mortality of Galway and Fingalway lambs born to Galway ewes. Similarly, there was no difference between the mortality rates of twin lambs born to Galway and Fingalway ewes. Significantly more ¼ Finn x ¾ Galway ewe lambs produced lambs in their first year than did Galway ewe lambs (57 vs 26%).

The fleece weights of Galway and Fingalway hoggets averaged 2.9 and 2.7 kg, respectively. The results quoted show that the Finn sheep population is a very useful source of genetic material for improving the Galway sheep breed.

CONTROL OF THE OESTRUS CYCLE OF THE BOVINE

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Effective synchronisation of the oestrus cycle in the bovine necessitates control of the functional life span of the corpus luteum (a). Two approaches towards the control of the corpus luteum were studied.

Firstly, progesterone was administered by silastic implant for 18 days and effective synchronisation was obtained. However, fertility to natural mating irrespective of time and number was low with 50% of heifers conceiving. Reducing the period of progesterone administration from 18 to 9 days resulted in normal fertility, based on slaughter and calving data, but lower oestrus response was obtained. The oestrus response was dependent on the stage of the cycle at which treatment was initiated. Heifers implanted in the luteal phase all responded, while those implanted shortly after ovulation or during the follicular phase had a much lower synchronising response. Incorporating different ratios of oestrogen and progesterone and increasing the treatment period from 9 to 12 days, increased the oestrus response up to 80% without reducing fertility. The mode of administration of progesterone was studied and a new technique based on a silastic intravaginal device has been developed. Retention rate in both cows and heifers is high and effective synchronisation with progesterone has also been obtained.

The second approach involved the intramuscular injection of prostaglandin F2 alpha after the fifth day of the oestrus cycle. One injection of either 20 or 30 mg PGF2 alpha was used. Neither the dose of PGF2 or the stage of cycle affected the high heat response obtained with this injection. Fertility following one insemination of frozen semen was the same in PGF2 alpha treated heifers and non-treated control heifers.

COMPARISON OF NORTH AMERICAN HOLSTEIN AND EUROPEAN FRIESIAN DAIRY CATTLE

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Over the past 25 years, Irish dairy farmers have gradually changed from Shorthorn to Friesian cows and obtained about a 20% increase in output per cow as a result. Can this kind of gain be made again? The evidence on the merit of Holsteins suggests that it can. The average recorded yields of Holsteins in the U.S.A. are about 140% above that of Friesian cows in Ireland. Most of this difference is due to feeding but there is evidence that there is a genetic difference amounting to 20% to 30%. This evidence comes from several European countries and is of three kinds

1. Comparisons of daughters of Holstein bulls tested in Europe with normal European Friesians
2. Comparisons of progeny tests of Holstein bulls tested in the U.S. and in Europe.
3. Comparisons of imported pure Holsteins and local European Friesians

The general indication from 12 such published reports is that compared to European Friesians the Holsteins are 20% to 30% more productive in milk, about the same for fat and protein %, at least as good in growth and feed efficiency, but perhaps poorer in beef conformation. Data on Canadian bulls tested in the U.S.A. suggest that the U.S. Holstein population is about 6% better for milk production than the Canadian.