PASTURE PRODUCTION UTILISATION GUIDE

INTERNATIONAL

GROW WITH CONFIDENCE

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PASTURE PRODUCTION UTILISATION

INTRODUCTION

No matter what type of stock you are running, you need pastures that will deliver. With the right pasture for your situation, you can meet the needs of your livestock in a profitable and sustainable way. This will enable you to keep your options open and concentrate on making every stock unit count and maximise your profits. Whether you are growing winter lambs, dairy cows, prime beef or perhaps all three, with the right pasture for your enterprise, you can grow with confidence using the tools in this guide.

CONTENTS

GRAZING MANAGEMENT AND UTILISATION

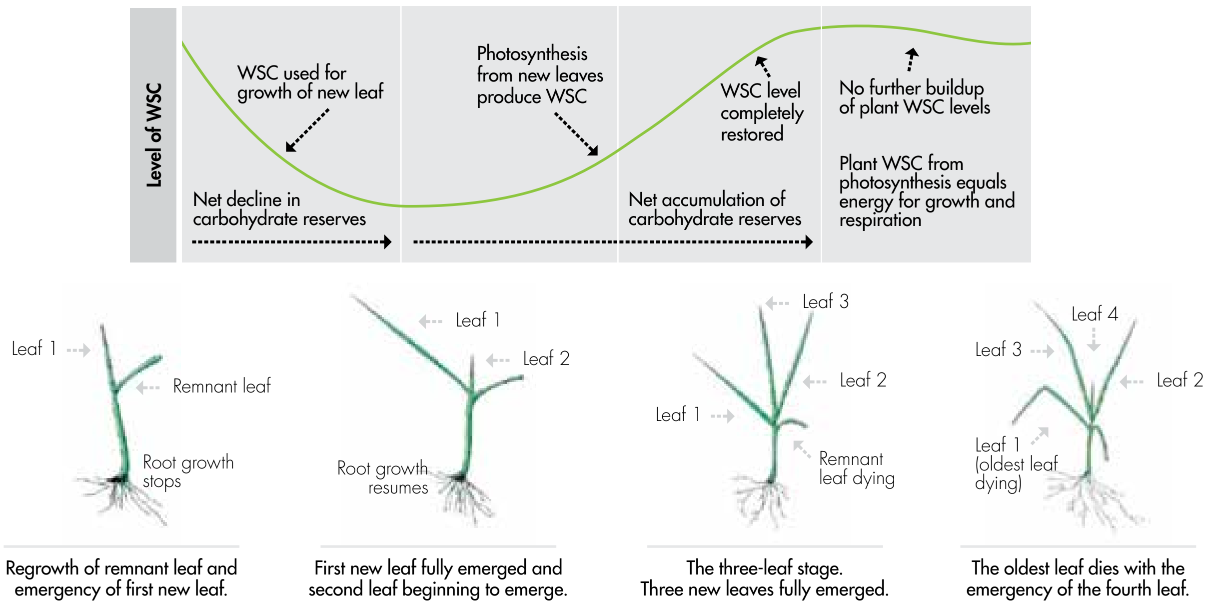
Rest periods and plant physiology

In order to reach full potential, all pastures require a rest period in order to maximise growth and maintain persistence. Rest periods allow plant species to replenish soluble carbohydrate stores, which are depleted in the grazing process. Grazing once these reserves have been replenished and prior to leaf senescence, provides optimal quality for grazing and maximises production per hectare.

Once plant species are grazed, carbohydrate reserves in the plant's roots and base are used to initiate growth, before the plant has enough leaf area to undertake photosynthesis and accumulate photosynthates. Grazing during the regrowth phase can severely affect the plant's persistence, regrowth and production. The cause of this is due to the depletion of a plant's soluble carbohydrate stores before it has enough time to replenish stores that were used for initial regrowth.

For ryegrass (Lolium spp.), it is not until the second leaf has emerged that soluble carbohydrate levels have been replenished enough for grazing to recommence (see figure below). It is therefore recommended that grazing be undertaken, not before the second leaf, but prior to the fourth leaf or leaf senescence. The optimal time for grazing is the three leaf stage. Grazing ryegrass at a three leaf stage, results in more tillers per plant, more roots per plant and better plant survival. This ultimately reduces the amount of invasive summer and winter weeds.

Figure 1: Plant soluble carbohydrate and starch reserves of ryegrass following grazing.



Source: Grass Based Health.

Rotational grazing is recommended as it allows for adequate rest periods and ultimately leads to increased plant persistence, pasture utilisation and regrowth.

Continuous grazing fails to provide sufficient time for replenishment of carbohydrate stores and does not allow pasture growth to be maximised. Additionally, pasture utilisation generally ranges from 40-80% and can influence the potential returns per hectare. Strip grazing and high stocking rates on small areas can assist with increasing pasture utilisation, while large open paddocks, continuous grazing and low stocking rates result in under-utilised pasture.

Grazing duration is also important. The time spent grazing in an individual area should be short to avoid the grazing of regrowth. Therefore it should be no longer than 1-3 days. Reductions in dry matter production of up to 40% have been reported in studies from Tasmania when pasture was grazed for 6 days when compared with 1-3 days (Michell and Franks 1993).

In general, within a regrowth phase each new leaf is approximately 1.5 times greater than the previous leaf (i.e. leaf 2 vs. leaf 3) and therefore grazing at 3 leaf stage maximises production.

Table 1: Leaf appearance and subsequent grazing rotation length (based on 3 leaves) for ryegrass at varying soil temperature.

Soil temperature	Days for leaf emergence	Grazing rotation (3 leaves)
18-25° C	5-7 days	15-21 days
7-9° C	17-20 days	50-60 days

Common grazing intervals and growth stages

While we have focused mainly on ryegrass grazing management, the basic principles of grazing apply to all species. There is however variances in optimal growth stages and intervals when different species should be grazed. Outlined below is a summary of the pre and post grazing residuals and approximate grazing intervals for different times of the year.

Table 2: Summary of the grazing residual and intervals for a range of commonly used species.

				Grazing interval (days)			
Soil temperature	Time to first grazing	Pre-grazing residual	Post grazing residual	*Autumn*	*Winter*	*Spring*	*Summer*
Lolium spp.	42 - 56 days	2 1/2 - 3 leaf canopy closure	3-4 cm 60-70% utilisation	21-35	45-60	15-21	35-45
Phalaris*	8 - 12 months	4 leaf (7 - 10cm)	3-4 cm 60-70% utilisation	21-35	45-60	21-28*	45-60
Continental tall fescue	56 - 70 days 15 cm	8 - 12cm	4-5 cm	21-28	50-70	14-21	21-28
Chicory	42 - 56 days 7 leaves	3-4 leaves 20 cm height	2-3 cm 90% utilisation	21-35	35-60	14-21	21-35
Forage brassica** rape	56 - 84 days crop maturity	crop maturity	5 cm 60-80% utilisation	28-35***	N/A	28-35	28-35
Forage cereals	42 - 56 days secondary root formation	10 - 15cm duration GS21 - GS30	5 cm	21-35	35-45	N/A	N/A

** Phalaris requires seed set in late spring so that the formation of rhizome in the base of the plant can take place. The rhizome is important for drought survival and regrowth in autumn.*

*** Forage brassicas often have a ripening requirement (maturity) before they can be grazed. Maturity is evident by the bronzing of the tips and margins of the plant. If grazed prior to maturity, yield potential isn't reached and photosensitivity can occur due to photosynthates reacting with UV light in the blood stream of the grazing animal.*

**** Regrowth only occurs when planted in early autumn (March).*

Pasture utilisation

Utilisation is the measure of the amount of feed on offer (FOO) that is consumed by grazing stock and not wasted through activities such as trampling of feed, under grazed pasture and plant desiccation. It is usually referred to as a percentage (%). Small paddock size, high stocking rates and rotational grazing favour increased utilisation.

Table 3: Estimate of utilisation of feed on offer (FOO) for different grazing techniques.

Grazing technique	Estimated utilisation range (% of FOO)
Set stocked (small paddocks < 20ha; moderate stocking rate)	30-50%
Set stocked (larger paddocks > 20 ha; low stocking rate)	20-40%
Rotational grazing (simple 4 paddock)	40-60%
Intensive rotational grazing (moved every 1-3 days)	60-75%

Benefit of legumes in pasture

Legumes are often sown with grass species as part of a mix. The benefit that legumes provide is improved feed quality, particularly when grass has gone reproductive, along with providing a source of nitrogen to the pasture. Legumes form a symbiotic relationship with rhizobia which in turn fixes atmospheric nitrogen and makes it available to the legume plant. Through the process of grazing (faeces and urine recycling) and mineralisation of old legume roots and shoots, the nitrogen is then provided to the grass pasture and promotes growth. Legumes can readily supply 16-18kg of fixed N/tonne of DM produced which is the equivalent of 150-200 units of N/ha/year or approximately 300-400kg/ha of urea.

Including a legume with a grass based pasture therefore reduces the need for N fertiliser and has shown to increase total forage yield, seasonal growth and quality. The legumes selected depend on the use and environment.

Table 4: Summary of different pastures and recommended legume component.

Pasture type	Common legume additions
Cool temperate perennial pasture (irrigated)	White clover, red clover, strawberry clover
Cool temperate perennial pasture (high rainfall > 650 mm/yr.)	White clover, red clover, sub-clover, strawberry clover
Mediterranean perennial pasture (< 650 mm/yr.)	Sub-clover, arrowleaf clover, medic, balansa clover, Persian (resupinatum)
Annual pasture	Sub-clover, arrowleaf clover, Persian (majus), Persian (resupinatum), balansa clover, berseem clover
Sub-tropical pasture	Medic, Persian (resupinatum), early sub-clover

All legumes can be slower to establish than some more vigorous grass species, such as ryegrass. It is important, in the establishment stage, to maintain light into the canopy and avoid 'canopy closure' by the grass species. Therefore a light early grazing, to aid light penetration into canopy is recommended. As clovers are sensitive to soil temperature, sowing early, while soil temperatures are > 12°C (53°F) will also greatly assist establishment.

As annual legumes rely on seed set in order to survive, allowing adequate rest periods around flowering stage can assist in seed set and regeneration.

Table 5: Summary of duration and stage of rest periods to aid regeneration of some common legumes.

Legume	Type of legume	Rest duration to aid seed set
White clover	Perennial clover	Not required – but can regenerate from seed if allowed.
Strawberry clover		
Red clover	Perennial clover	Not required.
Sub-clover	Annual – seed burial	Reduce canopy prior to flowering to aid the number of flowers that will go onto form seed. It is not that necessary, especially after first year of seed set to rest the pasture during flowering but avoiding overgrazing during flowering will assist seed yield.
Persian (majus)	Annual – aerial soft seed	Not required. No regeneration.
Persian (resupinatum)	Annual – aerial seeder	20-30 days from flowering to physiological maturity will aid seed set and regeneration for the following year.
Balansa clover		
Medic		
Arrowleaf clover	Annual – aerial seeder	30-40 days from flowering to physiological maturity will aid seed set and regeneration for the following year.

The aim of a mixed grass and legume sward is to maintain around 30% legume ground cover throughout the year, once established. The sowing rate of the clover will vary depending on seed size, so there is no set rule, however the table below demonstrates some typical mixed sowing rates for grass/legume pastures. In lower rainfall environments a lower plant population is required.

Table 6: An example of 3 different legume and grass mixes for varying rainfall zones.

	Lower rainfall/extensive		Medium rainfall/mixed		Higher rainfall/intensive	
Grass	Lower rates, smaller seeds		Intermediate rates		Higher rates, ryegrass, fescue	
	Hardy, drought tolerant		Production and some hardiness		Production main focus	
	Usually cocksfoot, phalaris		Many types and most species		Usually ryegrass, fescue	
Legumes	Often larger seed, higher rates		Intermediate rates		Often smaller seed, so lower rate	
	Regenerating annuals		Production and some hardiness		Perennials, summer active	
	Mostly sub-clover based		White, sub, annuals		White clover, red clover	
Examples	Phalaris	4 kg/ha	Ryegrass	12 kg/ha	Ryegrass (1)	12.5 kg/ha
	Cocksfoot	2 kg/ha	Cocksfoot	2.5 kg/ha	Ryegrass (2)	8.5 kg/ha
	Sub-clover (1)	4 kg/ha	White clover	2 kg/ha	White clover (1)	2 kg/ha
	Sub-clover (2)	4 kg/ha	Sub-clover	4 kg/ha	White clover (2)	2 kg/ha
			Balansa clover	1.5 kg/ha		
Total kg/ha	14 (Legume % = 57% wt)		22 (Legume % = 34% wt)		25 (Legume % = 16% wt)	

FEED BUDGETING AND ANIMAL PRODUCTIVITY

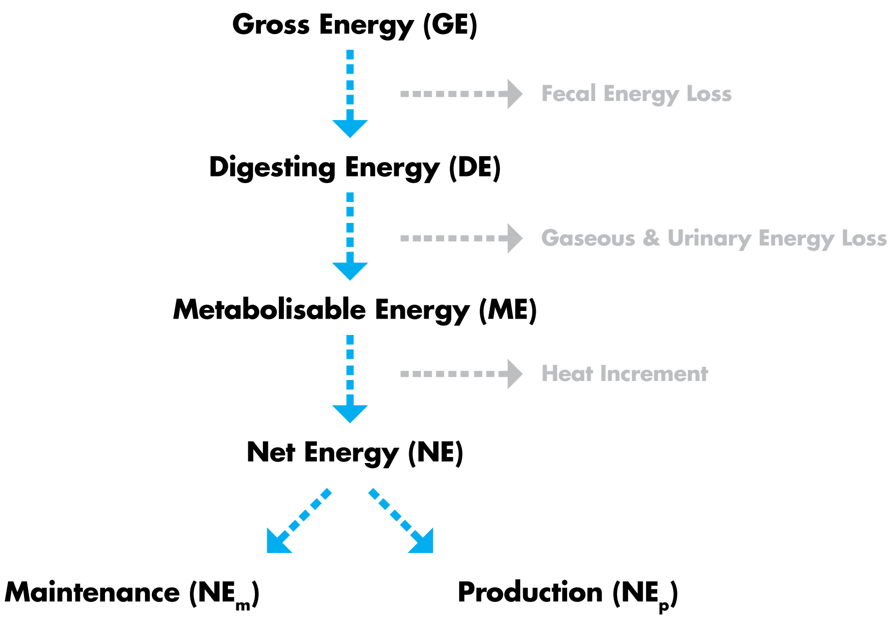
All animals require the following in order to survive and meet our production demands:

1. **Energy** – Energy is required for maintenance, activity, pregnancy, milk production, liveweight gain and wool production
2. **Protein** – Required by the animal as they form the basis of many body structures such as hair, muscle and skin as well as enzymes and hormones
3. **Fibre** - Ensures proper rumen function, however limits dry matter intake
4. **Vitamins and minerals** – Necessary for achieving desired production levels.

It is important to have a strong understanding of an animal's requirements and what forages will meet their demands. The following section provides information and a number of tools to assist in feed budgeting for animal production.

Understanding energy losses

Pasture feed quality is measured in metabolisable energy (MJ ME/kg DM) or commonly referred to as ME, which is a measure of the energy remaining after losses of energy through faeces, urine and methane (gases) are taken into account. The picture below demonstrates the losses as we move from gross energy of a feed source to net energy. Net energy is the energy remaining for maintenance (NEm) (day to day bodily functions) and for production (NEp) (meat, milk and wool).



Note: It is often the case that animals are being offered various different feed types through the course of a daily feed allowance. As such, estimates of feed quality and utilisation will need to be weighted accordingly, depending on the proportions of various feed offered. It may also be the case that some animals in a mob may avoid or consume various feed types preferentially, which may need to be taken into account or managed appropriately.

Energy requirements of different stock classes

All animals require metabolisable energy (ME) to meet their production needs. The following will have a positive effect on the ME requirement of an animal:

- Stage of reproduction (animals that are pregnant have a higher energy demand)
- Animal production for meat, wool and milk (the greater the production, the greater the requirement)
- Level of activity (more walking and running increases requirement).

Understanding the energy requirement of your stock class enables you to provide the energy to meet their needs. The following sections of feed budgeting demonstrate the energy demand of different stock classes and how feed quality influences performance.

DSE requirement of different stock classes

Dry sheep equivalents (DSE) are a measure to compare different stock classes and animal requirements. A DSE refers to a 50 kg dry sheep with no weight gain and is equivalent to 8.3 MJ ME/day. The table below demonstrates how the demand of the animal changes. As a general rule 1 DSE is equivalent to 1 kg DM/hd./day. This means a steer rated 10 DSE would require approximately 10 kg DM/day.

Table 7: Sheep and cattle DSE ratings.

	Breeding stock maintaining condition: body weight (kg)							
	40	45	50	55	60	65	70	100
Ewes dry/first 3 months preg	0.8	0.9	1.0	1.1	1.2	1.2	1.3	
Ewes last 2 months preg - Singles	1.1	1.2	1.3	1.4	1.5	1.6	1.7	
Ewes last 2 months preg - Twins	1.2	1.4	1.5	1.6	1.7	1.8	1.9	
Ewes lactating - Singles	1.6	1.7	1.9	2.1	2.2	2.4	2.5	
Ewes lactating - Twins	1.9	2.1	2.3	2.5	2.7	2.9	3.0	
Wethers	0.8	0.9	1.0	1.1	1.2	1.2	1.3	
Rams								2.2

	Weaners: body weight (kg)		
	20-30	30-40	40-50
Weaners gaining 50g/hd/d	0.8	1.1	1.3
Weaners gaining 100g/hd/d	1.1	1.4	1.6
Weaners gaining 150g/hd/d	1.4	1.7	1.9

	Cattle DSE table: body weight (kg)							
	200	300	400	450	500	550	600	700+
Heifer last 3 months preg			9.0	10.1	10.8	11.4	12.2	
Cows dry/1st 6 months preg			6.4	6.9	7.3	7.8	8.2	
Cows last 3 months preg			8.2	9.2	10.1	11.0	11.9	
Cows first 3 months lactating			12.8	14.7	16.5	18.3	20.1	
Cows late lactation			18.3	19.9	21.5	23.1	24.7	
Dry heifer/steer - maintenance	3.0	4.2	5.4	6.0	6.6	7.2	7.8	
Dry heifer/steer - gaining 500g/hd/d	5.1	6.7	8.7	9.6	9.9	10.8	11.7	
Dry heifer/steer - gaining 1kg/hd/d	6.6	8.9	11.4	12.7	13.3	14.5	15.7	
Bulls - Maintenance								10.2

ME requirements of beef cattle and sheep

Table 8: The energy requirements of sheep classes and production levels for feed budgeting purposes.

ME requirements for wether and ram lambs (MJ ME/lamb/day):

	Liveweight (kg)				
Liveweight gain (g/d)	20	25	30	35	40
0	4.5	5.5	6.5	7.5	8.0
50	6.0	7.0	8.0	9.0	10.0
100	7.5	8.5	10.0	11.0	12.0
150	9.0	10.0	11.5	12.5	13.5
200	10.5	11.5	13.0	14.5	15.5
250	12.0	13.0	14.5	16.0	17.5
300	13.5	14.5	16.5	18.0	19.5

ME requirements for ewe hoggets (MJ ME/hogget/day):

	Liveweight (kg)					
Liveweight gain (g/d)	20	25	30	35	40	50
0	4.0	4.5	6.0	7.5	7.0	8.5
50	6.0	6.5	8.5	10.0	9.5	11.5
100	8.0	8.5	10.5	12.5	12.5	14.5
150	10.0	10.5	13.0	15.0	15.0	17.0
200	12.0	12.5	15.0	17.5	17.5	20.0

ME requirements for maintenance and liveweight gain of mature ewes:

	Liveweight (kg)					
Liveweight gain (g/d)	45	50	55	60	65	70
0 (maintenance)	7.0	8.0	9.0	10.0	10.5	11.0
50	10.0	11.0	12.0	13.0	13.5	14.0
100	12.5	13.5	14.5	15.5	16.0	16.5
150	15.5	16.5	17.5	18.5	19.0	19.5

Additional ME requirement of pregnant ewes (MJ ME/ewe/day):

	Weeks prior to lambing			
	-6	-4	-2	0
Single (5kg)	2.5	3.5	5.0	7.0
Twins (4kg)	4.0	6.0	8.0	12.0
Triplets (3kg)	4.5	6.0	9.0	13.5

Add to ewe maintenance

ME requirements of ewes (MJ ME/d) during different stages of lactation:

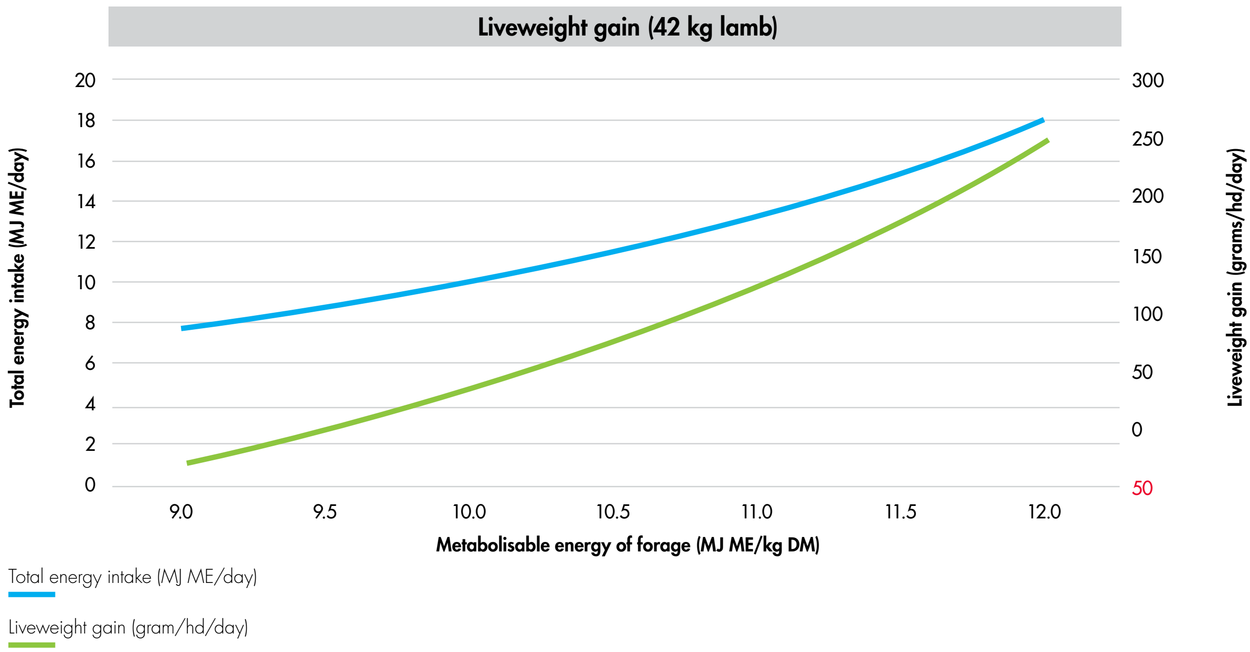
	Singles suckling week				Twins suckling week			
Ewe (kg)	1	3	6	9	1	3	6	9
40	12.0	23.0	20.0	18.5	23.0	26.0	23.0	20.0
45	21.0	24.0	21.0	19.5	24.0	27.0	24.0	21.0
50	24.5	28.5	24.5	20.5	28.5	32.0	28.5	22.0
55	25.0	29.0	25.0	21.5	29.0	33.0	29.0	23.0
60	26.0	30.0	26.0	22.0	30.0	34.0	30.0	24.0
65	27.0	31.0	27.0	23.0	31.0	35.0	31.0	25.0
70	28.0	32.0	28.0	24.0	32.0	36.0	32.0	26.0
Lamb pasture requirement	-	3.0	5.0	9.0	-	2.0	4.0	8.0

Notes:

Each kg of ewe liveweight lost is equivalent to 17MJ ME while each kg of ewe liveweight gained requires an additional 65 MJ ME.

For triplets or quads add 1.0, 2.0 and 4.0 MJ ME/d for weeks 3, 6 and 9 respectively.

Figure 2: Liveweight gain of a 42 kg lamb and 300 kg steer on pasture of varying metabolisable energy (MJ ME/kg DM). The higher quality forage exponentially influences animal performance as there is a daily maintenance energy (MJ ME/day) requirement before energy is available for production.
Total energy intake is located on left hand side axis and *liveweight gain* on right hand side axis.



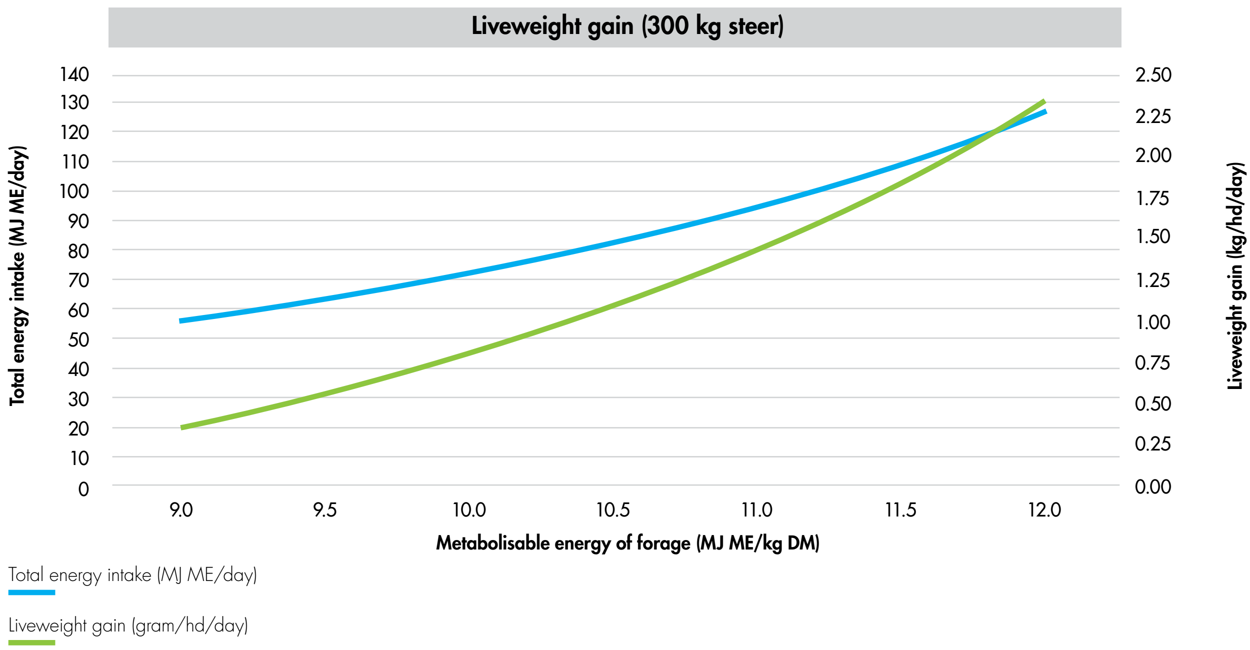


Table 9: The energy requirements of cattle classes and production levels for feed budgeting purposes.

ME requirements for maintenance and growth in cattle (MJ ME/d):

		Liveweight gain (kg/hd/d)					
Liveweight gain (g/d)	Maintenance	0.25	0.5	0.8	1.0	1.3	1.5
100	14	23	28	32	37	41	46
150	21	31	37	43	49	55	61
200	28	39	47	54	62	69	77
250	35	46	55	64	72	81	90
300	40	53	63	73	84	94	104
350	45	59	71	82	94	105	116
400	49	66	78	81	103	116	129
450	54	72	86	99	113	127	141
500	58	78	93	108	123	138	152

Notes:

Add 5% to values for heifers and deduct 5% for bulls

Add 5-10% for small breeds and deduct 4-8% for large breeds.

ME requirements (MJ ME/d) of beef cows during lactation:

	Month of lactation		
Liveweight (kg)	1	3	5
350	74	80	75
400	79	85	80
450	85	91	86
500	90	96	91
Calf pasture requirements	-	10	30

Notes:

Each kg of liveweight lost is equivalent to 28 MJ ME

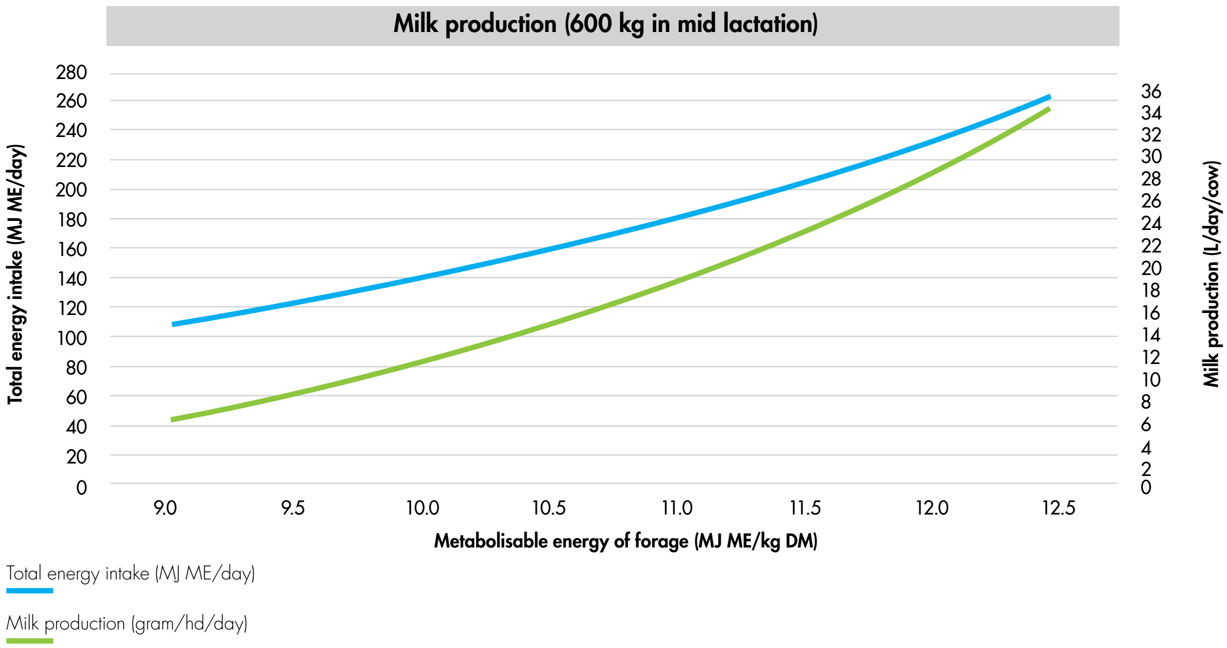
Each kg liveweight gained requires an additional 70 MJ ME

Increase values by 35% for dairy-beef cows with higher milk

ME requirements of dairy cows

Figure 3: Milk production (L/day) of a 600 kg dairy cow on pasture of varying metabolisable energy (MJ ME/kg DM). The higher quality forage exponentially influences animal performance as there is a daily maintenance energy (MJ ME/day) requirement before energy is available for production.

Total energy intake is located on left hand side axis and *milk production (L/day/cow)* on right hand side axis.



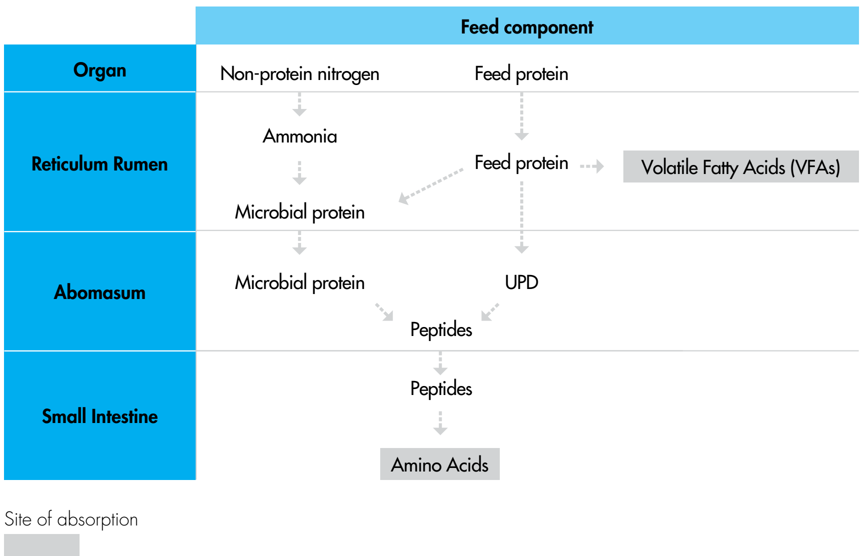
Understanding crude protein

Protein is a material that builds and repairs body tissue (muscle, skin and organs) and repairs hormones and enzymes.

Protein is made up of amino acids which are required by animals. Amino acids are the building blocks of muscle, milk protein and a foetus during pregnancy. In total there are 25 amino acids required by an animal, of which 10 are essential. Essential amino acids can't be produced by the animal and must be provided in the diet.

In ruminants some protein is supplied by the forage as undegradable dietary protein (UDP), however a large percentage (approximately 80%) is provided by microbial crude protein (MCP). This reason MCP is the main source of protein in ruminants is due to proteins being broken down to ammonia in the rumen. Microbes within the rumen then feed on this ammonia and available volatile fatty acids (VFAs) and grow. The flushing of these microbes from the rumen into the abomasum of the animal is the main source of dietary protein. Figure 4 below demonstrates this process within a ruminant.

Figure 4: Protein digestion and absorption in the rumen.



Source: MLA

Table 10: As the energy of the diet increases so does the ability of an animal to utilise a higher protein source. If energy is limiting, the crude protein of the feed will be broken down to ammonia and then excreted from the animal as urea.

Ratio	Lamb live weight			
	20 kg	30 kg	40 kg	50 kg
Energy (ME/day)	Crude protein %			
13	18.2	17.5	16.8	15.5
12	16.5	15.8	13.8	12.6
11	14.5	13.5	11.0	10.0
10	12.8	11.8	9.2	8.6

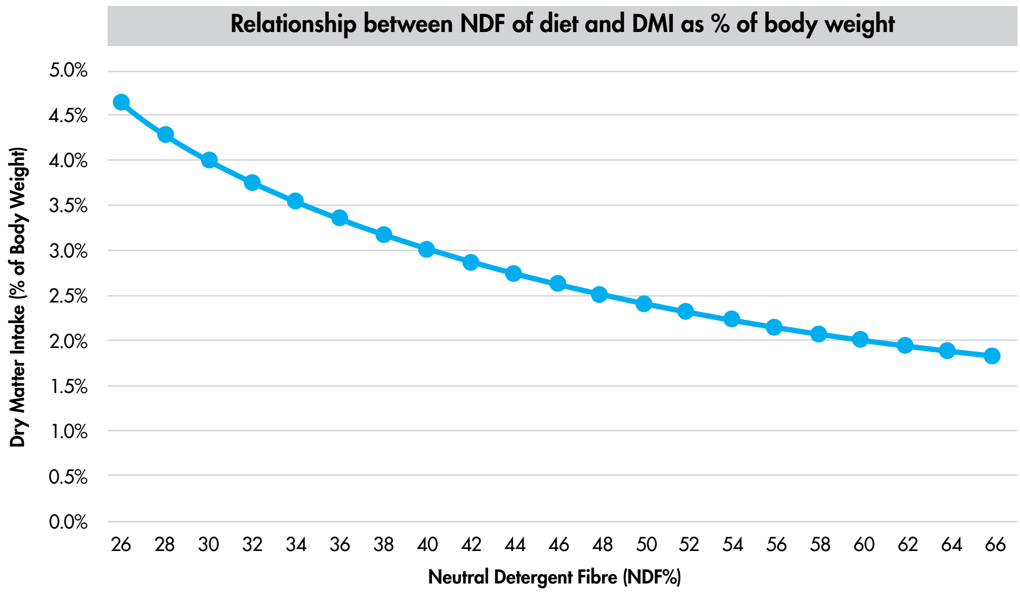
Source: Grazfeed

Understanding digestibility and fibre

Fibre is important for efficient rumen function. It is important in ruminant nutrition that a cow chews its cud promoting saliva. Saliva creates bicarbonates which helps to buffer the rumen pH against increasing acidity.

Too much fibre on the other hand does restrict feed intake and can adversely affect animal performance. It is important, if wanting to maximise production that the fibre is kept to a minimum critical level (around 35% NDF). This allows efficient rumen function and maximum feed intake.

Figure 5: Relationship between neutral detergent fibre (NDF) and dry matter intake (DMI) as a % of body weight. As fibre decreases, DMI increases due to quicker rumen passage leading to better animal performance. Please note that NDF of the diet shouldn't get below 32-35% NDF, otherwise rumen acidosis can be an issue due to a lack of bicarbonates which buffer rumen pH.



Feed values

Table 11: Below are typical feed values of common green feed and conserved forages used in temperate agriculture.

Indicative feed values for green feeds, pasture/forage types:

Green feeds	Dry matter (%)	Metabolisable energy (MJ/kgDM)	Crude protein (%)	Neutral detergent fibre (%)
Ryegrass/clover pasture				
Spring, immature	14	12.0	25	35
Late spring, leafy	18	11.0	20	45
Summer, leafy	20	10.0	18	50
Summer, dry and stalky	25	9.0	14	60
Annual ryegrass, leafy	15	12.0	21	37
Chicory, leafy	16	11.7	12	17
Cocksfoot - young	23	11.0	12	-
Fescue - young	21	10 (8.5-11.5)	15 (7.5-25)	-
Kale	14	11.8	16	26
Kikuyu, leafy	17	9.8	16	48
Lucerne, leafy	24	11.0	30	30
Maize, greenfeed	22	10.3	9	45

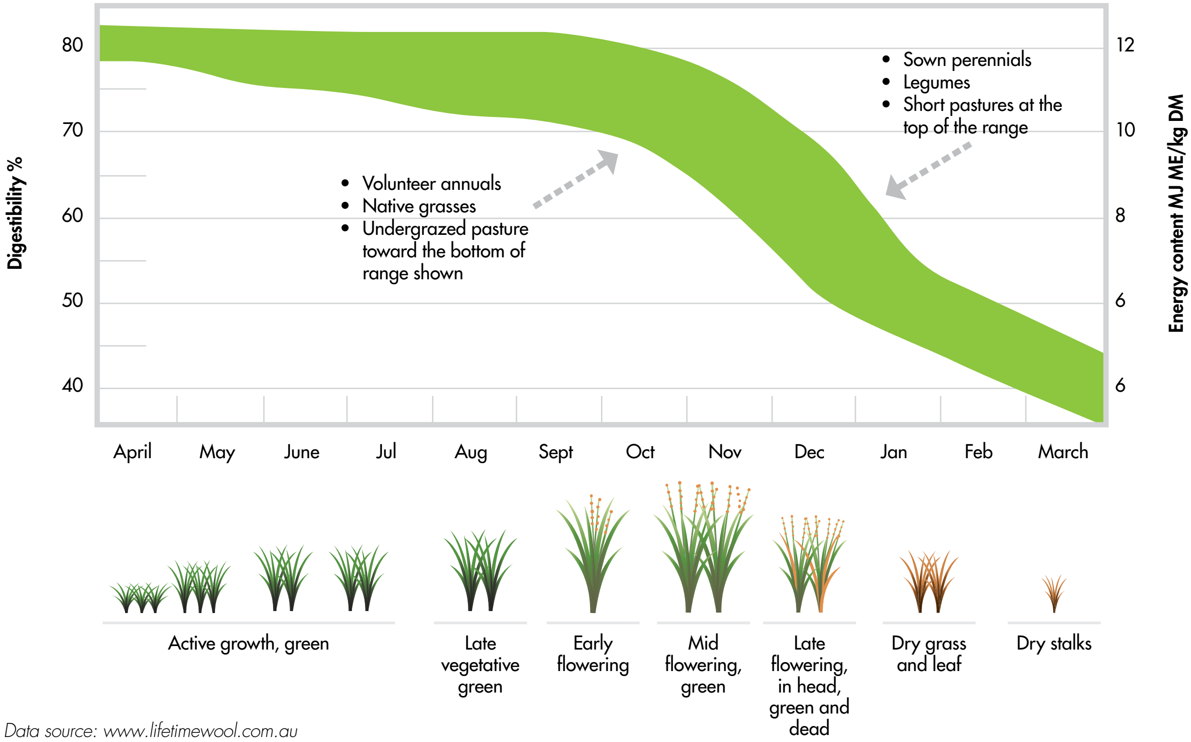
Green feeds	Dry matter (%)	Metabolisable energy (MJ/kgDM)	Crude protein (%)	Neutral detergent fibre (%)
Millet, boot - early flower	20	9.2 (7-10)	10 (6-17)	64 (46-76)
Oats, green feed	18	12.0	18	53
Paspalum, leafy	31	9.8	14	58
Phalaris - young	20	11 (10-12)	17 (19-20)	50-55
Rape	14	11.5	17	25
Sub-clover/medic	15	11.0 (10.5-11.5)	22 (18-25)	25-35
Red clover	15	12.0	27	34
Ryegrass - young	18	12 (11-12.5)	20 (18-22)	50-55
Sorghum, hybrid	20	10.0	18	55
Turnips - whole crop	10	12.5	13	29
White clover	15	12.0	27	26

Consider these values as a guide under reasonable-good management. Factors such as diseases, pests, fertility, seasonality and grazing management will cause significant variation. Adapted from various sources incl: Milk Production from Pasture, 2007; Holmes et al, Heritage Seeds Research, DPI Vic.

Fodders	Dry matter (%)		Metabolisable energy (MJ/kgDM)		Crude protein (%)		Neutral detergent fibre (%)	
Supplement Type	Average	Range	Average	Range	Average	Range	Average	Range
Barley silage	39	(20.9 -64.3)	9.1	(5.5 -11.5)	10.7	(5.5 -22.9)	60.8	(44.5 -68.9)
Barley hay	87	(66.1 -93.7)	8.8	(4.2 -11.2)	8.2	(1.2 -14.6)	57.8	(42.0 -86.6)
Barley straw	89.3	(73.4 -93.6)	6.5	(2.2 -8.5)	2.8	(0.2 -28.8)	76.5	(54.7 -87.3)
Clover silage	41.9	(20.9 -79.5)	9.6	(8.1 -10.6)	19.3	(12.4 -27.2)	46.3	(38.6 -56.1)
Clover hay	86.6	(61.3 -93.2)	8.9	(6.2 -11.2)	17.6	(6.3 -26.1)	46.9	(33.2 -72.2)
Grass silage	43.2	(17.1 -89.3)	9.3	(4.8 -12.0)	13.2	(5.1 -26.6)	58.5	(39.7 -77.8)
Grass hay	86.3	(51.9 -94.0)	8	(4.9 -10.5)	8	(0.7 -17.7)	66.7	(43.3 -83.2)
Legume + grass silage	42.1	(13.7 -68.3)	9.4	(5.9 -11.4)	16	(7.3 -28.6)	50.8	(28.6 -76.2)
Legume + grass hay	86.4	(45.2 -95.9)	8.8	(5.2 -11.4)	14.5	(4.1 -25.4)	53.6	(30.4 -78.4)
Lucerne silage	49.5	(15.8 -87.7)	9.4	(4.8 -10.9)	20	(5.3 -32.1)	45.5	(27.3 -63.7)
Lucerne hay	87.8	(36.0 -96.1)	9.3	(5.3 -11.3)	18.9	(5.7 -29.7)	44.7	(30.9 -67.0)
Lucerne straw	86.1	(68.2 -93.4)	5.7	(4.3 -6.8)	8.9	(5.9 -14.1)	66.5	(64.7 -68.0)
Maize silage	30.9	(9.2 -84.5)	10.6	(5.0 -13.0)	7.7	(3.4 -17.1)	48.2	(36.4 -67.1)
Millet hay	90.1	(89.6-90.6)	7.1	(6.3 -9.2)	9.6	(6.6-10.9)	74	(66.5-76.0)
Oaten silage	40.9	(18.1 -82.2)	8.7	(5.9 -11.2)	9.8	(3.8 -19.4)	59.9	(39.5 -75.3)
Oaten hay	88.9	(40.2 -96.4)	8.4	(4.5 -11.3)	6.9	(1.1 -16.3)	59.3	(41.1 -83.6)
Oaten straw	89.4	(80.2 -93.8)	6.2	(4.3 -10.0)	2.8	(0.1 -11.9)	73.3	(54.5 -78.8)
Pasture silage	43.1	(10.9 -87.6)	9.4	(2.2 -11.8)	14.1	(3.2 -27.3)	56.5	(31.8 -79.5)
Pasture hay	86.2	(48.6 -95.5)	8.4	(5.3 -11.2)	10.8	(1.7 -30.0)	63	(36.8 -81.7)
Persian clover silage	42.9	(23.7 -81.9)	9.9	(8.2 -11.2)	17.6	(8.0 -23.4)	47.6	(34.7 -60.0)
Persian clover hay	85.6	(67.8 -93.5)	9.6	(7.0 -11.7)	16.2	(5.3 -23.3)	43.4	(32.6 -66.8)
Rice straw	85.2	(52.2 -93.5)	6.7	(5.3 -8.9)	4	(1.9 -5.0)	63.4	(53.4 -68.5)
Sub-clover silage	37.1	(20.6 -59.9)	9.5	(5.2 -10.5)	18.8	(12.6 -26.9)	45.6	(30.6 -59.2)
Sub-clover hay	86.8	(71.7 -93.9)	8.8	(6.5 -10.6)	17.2	(7.7 -25.7)	47.3	(33.1 -71.0)
Triticale silage	42.9	(20.1 -71.0)	9.1	(7.1 -11.2)	10.8	(4.0 -24.0)	57.9	(41.4 -70.2)
Triticale hay	86.6	(54.3 -93.9)	8.6	(4.8 -10.7)	7.3	(1.3 -16.2)	55.7	(40.5 -73.0)
Triticale straw	89.8	(62.7 -95.7)	6.2	(4.1 -9.0)	2.8	(0.7 -6.7)	67.3	(50.1 -86.5)
Wheat silage	44.9	(27.5 -69.1)	8.8	(4.6 -10.7)	10	(6.5 -16.0)	55.5	(47.7 -63.4)
Wheat hay	87.9	(46.8 -95.1)	8.7	(4.9 -11.0)	8.2	(0.1 -17.4)	52.8	(37.3 -79.4)
Wheat straw	92.4	(64.7 -96.7)	5.1	(3.8 -9.3)	2.8	(0.2 -8.8)	73	(53.6 -86.2)

Data sourced from Jacobs et al. 2001, Australian Journal of Experimental Agriculture 41, 743-751, via DPI Vic

Figure 6: The changes in digestibility and metabolisable energy (ME) of forages over the season for a temperate species in southern hemisphere. While plants are young and green, digestibility and ME is high, however as the season progresses and plants become reproductive (increasing and stem) the quality of the forage declines.



Data source: www.lifetimewool.com.au

Calculating animal production and dry matter intake

Feed values:

$$\text{Expected dry matter (DM) intake} = \frac{(1.2 \times \text{Liveweight})}{(\text{NDF }\%)}$$

Maintenance energy requirement of animals:

$$\text{Maintenance energy requirement (cattle and sheep)} = \text{LWT}^{0.75} \times 0.60$$

$$\text{Maintenance energy requirement (young lambs)} = \text{LWT}^{0.72} \times 0.60$$

Calculating liveweight gains:

$$\text{Expected liveweight gain (kg)} = \frac{(\text{Total ME.day - Maintenance ME.day})}{36}$$

$$\text{Calculating milk production}^{*} \text{ (L)} = \frac{(\text{Total ME.day - Maintenance ME.day})}{6}$$

*Assumes a milk protein of 3.6% and butterfat of 4.4. To calculate milk solids multiply litres x 8%

An Example:
Calculating liveweight gain of a 300 kg steer eating a ryegrass based pasture (11 ME and 40% NDF).

1. $$\text{DMI} = \frac{(1.2 \times 300)}{40} = 9 \text{ kg DM/hd/day}$$

2. Energy Intake = 9 kg DMI/day x 11 ME = 99 MJ ME/day

3. Maintenance ME = $300^{0.75}$ x 0.60 = 43 MJ ME/day

4. $$\text{Expected liveweight gain} = \frac{(99 \text{ MJ ME} - 43 \text{ MJ ME})}{36} = \mathbf{1.55\ kg} \text{ liveweight gain per day.}$$

Table 12: A rule of thumb guide for feed conversion efficiency (FCE) from kilograms of dry matter consumed to either liveweight gain (kg LWT) or milk production (litres).

Forage quality	Kg DM consumed/kg LWT gain	Kg DM consumed/L of milk
High quality (11 ME+)	6	0.8
Moderate - high quality (10 ME)	8	1.0
Low quality (9 ME)	12	1.2
Very low quality (8 ME or less)	14-25+	2.0+

Terminology for feed budgeting and pasture assessment

DM = Dry matter

FOO = Feed on offer, often referred as ‘feed available’ or ‘grazing mass’ as kg of DM/ha

Residual = DM left in the pasture after grazing

Utilisation = an estimate or a measurement of the % FOO consumed

Feed Consumed = FOO - Residual

LWT = Liveweight in kg

ME = Metabolisable energy in MJ/kg of DM

NDF = Neutral detergent fibre (indigestible part of feed) as % of DM

CP = Crude protein as a % of DM

DSE = dry sheep equivalent, which allocated a definitive measure of grazing intake by class of stock. (See tables).

DMI = Dry matter intake (kg/head/day)

Grazing Interval = Rest phase between grazings

Grazing duration = period of time stock are on the paddock, often number of days

Concurrent growth = amount of growth whilst the stock are grazing it. Applies to lower stock densities mostly.

RETURN ON INVESTMENT

Principles of return on investment

Understanding the benefits that improved cultivars provide will help promote the overall value to the end user. The key objective of any breeding program is to provide a product with an end user benefit. This benefit can often lead to an additional end product (i.e. milk, meat or wool) or provide some form of cost saving.

Some of the benefits that an improved cultivar may provide include:

- Increased total yield
- Increased seasonal yield
- Increased persistence
- Increased N fixation
- Improved feed quality
- Reduced input requirement (i.e. insecticide or lime).

There are also benefits derived from a 'systems' approach to a product including:

- The use of lucerne in a farming system to reduce supplementary feeding
- Using a better quality forage option in a Kikuyu based pasture
- A renovation versus a 'do nothing' approach
- Seed coating and its benefit of stress shield and early sowing.

Any of the above benefits, be it cultivar versus cultivar, or system versus system, can be converted to an end product, then shown as a value to the end user. It is often quite easy to demonstrate a net benefit to the end user, as seed is only a marginal part of the total cost.

The figure below demonstrates that basic process of taking a benefit, converting to an output and then calculating the net benefit that offers to the end user.

STEP 1
What is your DM yield benefit?
i.e. 8% or + 700 kg/DM/ha

STEP 2
Convert total DM to utilised DM
i.e. 60% (range 30% - 75%)

STEP 3
Convert your utilised DM to a final product (meat or milk) or Dry Sheep Equivalent (DSE/ha)

STEP 4
Convert production benefit to **$**

STEP 5
Add or deduct the difference in costs
i.e. Increased fertiliser - Increased seed costs etc.

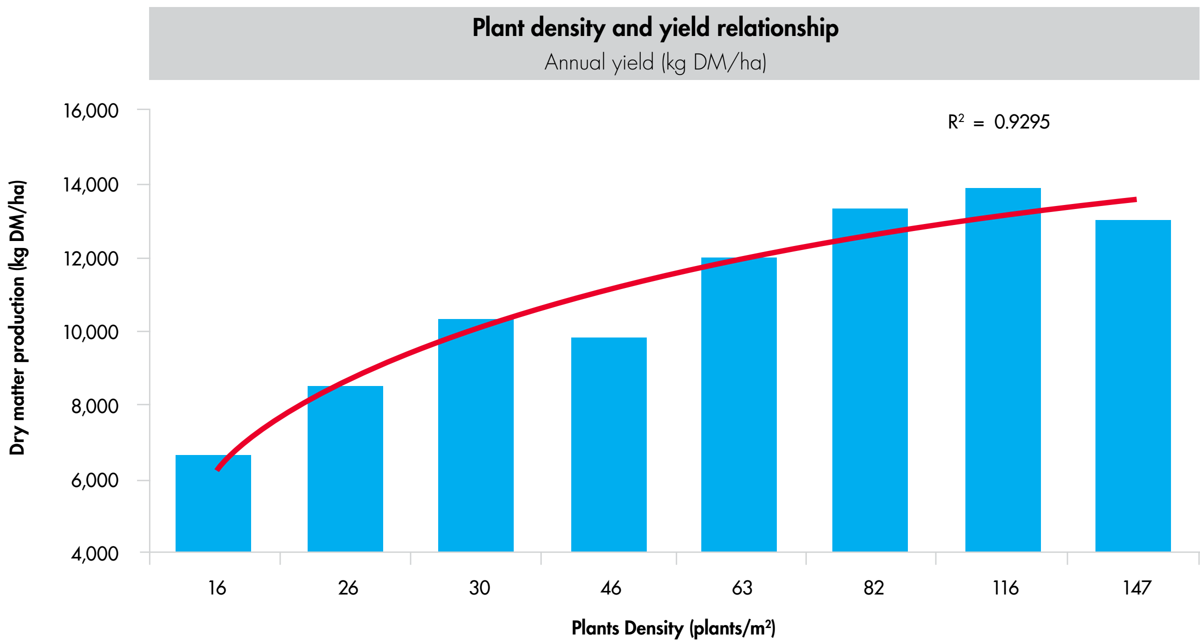
STEP 6
What is the net **$** benefit?

Examples of a return on investment benefit

We have a lucerne cultivar that has demonstrated improved persistence due to pest and disease tolerance, and as such has been able to maintain greater plant density in the final years before termination of the stand. We estimate that based on the plant density in the final year the improved cultivar has produced an additional **1,500 kg DM/ha** over an older, less persistent cultivar. The lucerne stand is used largely for cattle under a cut and carry system and the additional production provided by the improved cultivar goes to liveweight gain. Given our understanding of feed conversion on lucerne we estimate that for every **6 kg of DM consumed*** we will produce a kilogram of liveweight gain. We estimate a utilisation of 80% in this system. Current prices are at **$2.80/kg**. The improved lucerne cultivar is **$100/ha** more than the older variety.

*From Table 12, page 17.

Figure 7: The effect of plant density on lucerne forage yield at Howlong Research Station in 2015 and 2016 as average annual yield.



Calculating total DM consumed:

1,500 kg of DM x 80% utilisation = 1,200 kg of DM consumed.

Converting to lamb liveweight gain:

1,200 kg consumed/6 kg of DM for every 1 kg of gain = 200 kg/ha of LWT benefit.

Converting LWT gain to income:

200 kg/ha of LWT x $2.80/kg = $560 /ha total income benefit.

Calculating the net benefit to the grower:

$560 /ha benefit - $100/ha additional cost = **$460/ha.**

So for an additional seed cost of **$100/ha** the improved cultivar has provided an additional gross margin of **$460/ha.**

Cost-benefit: sub-clover sowing rates

Howlong sub-clover sowing rate trial

Mean annual rainfall 540mm, soil: alluvial silt-loam, pH $CaCl_2$ 5.4

Sown Autumn 2013, self-regenerated 2014, continues 2015

Cultivar: Mintaro, mid season brachy. Trial is being grazed by sheep, yield measurement cuts taken prior to grazing.

Assumptions:

Seed price AgriCote:	$8.50	
Value/kg DM supplement:	$0.28	$250/t @ 88%DM, (legume hay):
Lamb feed conversion rate:	5.00	kg DM eaten per kg LWG, range 4.0 - 6.0 +
Lamb LWT $/kg:	$2.20	
Feed utilisation rate:	60%	
Nitrogen fixation:	17	kg N fixed per tonne DM harvested.

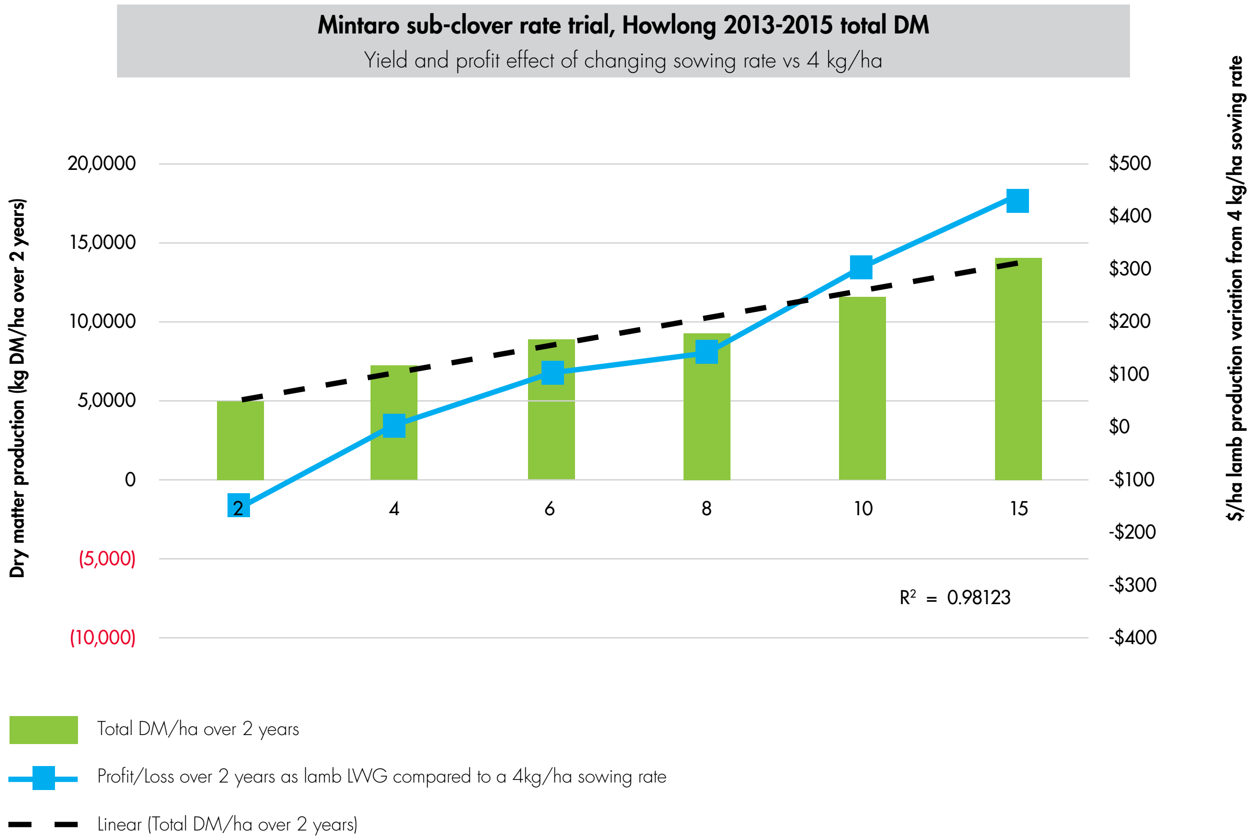
Table 13: Trial data (after 2 years).

	Sowing rate kg/ha	Seed cost / ha	2013 DM/ha	2014 DM/ha	Total DM/ha	Buried seed kg/ha @25mm Feb 2015	Nitrogen fixed (est.) kg/ha
"Cost-saving" sowing rate:	2	$17	1197	3616	4813	402	82
Typical rate in industry:	4	$34	2020	4968	6988	632	119
Minimum rate recommended:	6	$51	2988	5602	8590	583	146
Good sowing rate:	8	$68	4508	4808	9316	791	158
Top producers' sowing rate:	10	$85	5228	6352	11580	446	197
	15	$128	6607	7327	13934	871	237

Table 14: Variation of sowing rate from 4 kg/ha and effects on potential profit as lamb LWT.

	Sowing rate kg/ha	Extra DM kg/ha	Benefit $ as DM/ha vs good hay	Benefit kg lamb LWT/ ha, 60% utilis.	Benefit potential income lamb $/ha	Profit / Loss over 2 years as lamb LWG $/ha	% ROI as lamb LWG
"Cost-saving" sowing rate:	2	-2175	-$618	-74	-$163	-$146	-859%
Typical rate in industry:	4	0	$0	0	$0	$0	0%
Minimum rate recommended:	6	1602	$455	55	$120	$103	202%
Good sowing rate:	8	2328	$661	79	$175	$141	207%
Top producers' sowing rate	10	4592	$1304	157	$344	$293	345%
	15	6946	$1973	237	$521	$427	335%

Figure 8: The effect of sowing rate of Mintaro sub-clover on dry matter yield (LHS axis) and profitability of a lamb grazing operation over 2 years, when compared with typical 4 kg/ha sowing rate (RHS axis).



Take home messages:

Lower sowing rates are not a cost saving, and impact on yield, nitrogen fixation, seed-set and lost potential profitability.

Lower sowing rates have lower percentage ground cover for first 2-3 years, and likely more prone to weed competition.

This trial is an environment without grass component, so lower sowing rates likely to be even more challenged in a mixed sward.

Sub-clover sowing rates should be upwards of 6kg/ha, preferably 8 at least.

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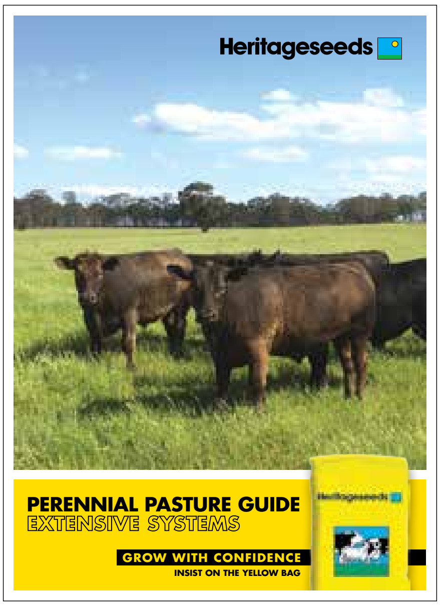

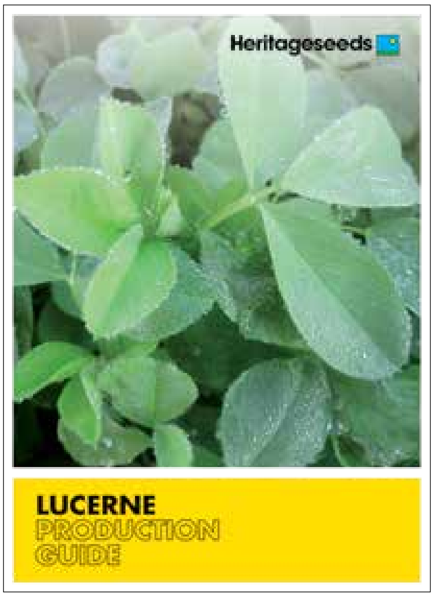

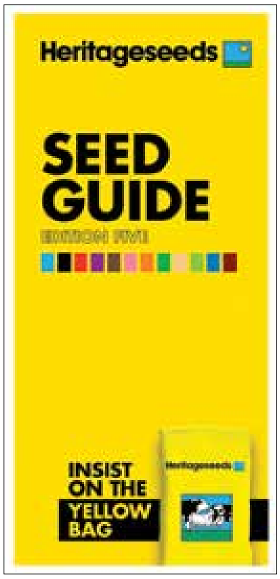

NOTES

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