5. NUTRITION

The nutritional characteristics of pasture and other commonly used feeds and the advantages and disadvantages of their use.

5. NUTRITION

General nutrition

Energy and protein

Energy is the key driver of milk production. In practice high protein pastures meet the protein requirements for high milksolids production. The table below shows levels of production when protein may limit production for cows fed high quality pasture.

Nutrients first – limiting milk production on high quality pasture diets

kg milk/cow/day	Approx. kg MS cow	Nutrient first limiting milk production
20	1.6	Energy (if protein in pasture >18%)
25	2.0	Energy (if protein in pasture > 21%)
30	2.4	Energy and protein
35	2.8	Protein

Fibre

Fibre is the primary source of energy for grazing animals, but is also required to stimulate chewing and saliva production.

Neutral Detergent Fibre (NDF) is the most common measure of fibre used for animal feed analysis. It measures more than 90% of the structural components in plant cells (i.e. lignin, hemicellulose and cellulose).

For cows grazing only high quality pasture the minimum NDF requirements are 27-33%.

Nutritional guidelines for all pasture, pasture + supplement, and total mixed ration (TMR) diets

Protein Good quality all-pasture diets		Protein content of diet required % DM
litres/cow/day	**kg MS/cow/day**	
20	1.6	18
30	2.4	24
Pasture + supplement, TMR		
kg milk/cow/day	**kg MS/cow/day**	
20	1.6	16 (65% degradable, 35% bypass, 32% soluble)
30	2.4	18 (65% degradable, 35% bypass, 32% soluble)

As a general rule for all diets	**Protein content of diet required % DM**
Early lactation	18
Mid lactation	16
Late lactation	14
Dry cow	12

Fibre	(% diet DM)
As a general rule for pasture diets	
Minimum NDF	35
Minimum effective fibre (eNDF)	17
Pasture + supplement, TMR	
Minimum NDF	27-33
Minimum effective fibre (eNDF)	20
Minimum ADF	19-21
Soluble carbohydrate	(% diet DM)
Pasture + supplement, TMR	
Maximum total soluble carbohydrate	38
Maximum starch	25-28
Fat	(% diet DM)
Pasture + supplement, TMR	
Maximum additional unprotected fat	3
Maximum additional protected fat	3
Macro minerals	**Mineral content of diet required (%DM)**
All diets for high production (2 kg MS/cow/day)	
Calcium	0.6-0.8
Phosphorus	0.3-0.35
Magnesium	0.22-0.28
Potassium	1.0+
Sulphur	0.23
Sodium	0.20
Chlorine	0.25

Pasture composition and value

The nutritional value of ryegrass-based pastures as a feed for dairy cows varies seasonally.

Table 1. Effect of season on pasture composition

Season	Pasture composition						
	DM (%)	ME (MJ/kg)	CP (% DM)	NDF (% DM)	SSS (% DM)	Starch (% SSS)	Fat (% DM)
Spring	12-18	11.5-12.5	18-35	35-45	7-25	2-4	3-6
Summer leafy	15-20	10.5-11.5	14-22	42-52	7-25	4-8	4
Summer dry	20-30	9.0-10.0	10-15	50-65	7-10	2-4	2-4
Autumn/winter	13-18	11.0-11.5	15-20	40-47	7-25	2-4	3-5

Grazing management can also influence the nutritional value of pasture.

Table 2. Typical digestibility and ME of pasture.

Component	Green leaf	Soft stem	Hard mature stem	Dead material
Digestibility (%)	70-85	65-75	40-50	40-50
Energy (MJ ME/kg DM)	10.5-12.5	10-11	6.5	6.5

Feed composition

The following definitions apply to the tables on pages 66-71.

DM, dry matter

ME, metabolisable energy

CP, crude protein

NDF, neutral detergent fibre

SSS, soluble sugars and starch

Ca, calcium

P, phosphorus

Mg, magnesium

K, potassium

S, sulphur

Na, sodium

Cl, chloride

FEEDSTUFF	DM (%)	ME (MJ/kg)	CP (% DM)	NDF (% DM)	SSS (% DM)	Starch (% of SSS)	Fat (% DM)
PASTURE							
Spring	12-18	11.5-12.5	18-35	35-45	7-25	2-4	3-6
Summer leafy	15-20	10.5-11.5	14-22	42-52	7-25	4-8	4
Summer dry	20-30	9.0-10.0	10-15	50-65	7-10	2-4	2-4
Autumn/winter	13-18	11.0-11.5	15-20	40-47	7-25	2-4	3-5
SILAGE							
Pasture, good	23-28	10-11	17-18	45	22.0	7	3.0
Pasture, poor	38	9.0	15.0	55	15.0	8	3.1
Barley	33	9.8	11.9	57	19.9	100	2.9
Lucerne	30-40	9.5	20.0	51	16.7	45	3.5
Maize	32-38	10.5-11.5	8.0	32-45	35-47	85	3.1
Pea	33	8.8	13.1	59	18.3	100	3.3
Wheat/oat	36	10.5	13.0	59	16.1	100	3.6
HAY							
Pasture, good	85	9.7	17.0	54	17.7	44	2.6
Pasture, poor	85	7.3	7.0	66	14.6	45	2.6
Barley straw	87	6.5	4.3	80	6.7	100	1.9
Pea straw	85	6.7	6.3-8.0	59	-	-	-
Wheat straw	89	6.3	3.6	79	7.8	100	1.8
CONCENTRATE							
Barley	89	13.0	11.0	21	61.4	90	2.0
Bran	85	9.8	17.1	51	20.6	95	4.4
Canola meal	90	11.5	38	30	-	1.5	3.5
Lupin	89	12.0	34.2	33	22.0	90	5.5
Maize grain	89	13.6	8.0	9	75.1	99	4.3
Oats	89	11.5	13.0	31	47.5	90	4.9

Ash (% DM)	Ca (% DM)	P (% DM)	Mg (% DM)	K (% DM)	S (% DM)	Na (% DM)	Cl (% DM)
10-12	0.2-1.5	0.2-0.6	0.1-0.4	1.5-4.5	0.1-0.6	0.03-0.6	0.03-0.6
7-25	0.2-1.5	0.2-0.6	0.1-0.4	1.5-4.5	0.1-0.6	0.03-0.6	0.1-1.5
8-10	0.2-1.5	0.2-0.6	0.1-0.4	1.5-4.5	0.1-0.6	0.03-0.6	0.1-1.5
-	0.2-1.5	0.2-0.6	0.1-0.4	1.5-4.5	0.1-0.6	0.03-0.6	0.1-1.5
10.0	0.80	0.30	0.21	2.30	0.24	0.10	0.20
9.5	0.55	0.28	0.14	2.0	0.20	0.16	0.19
8.3	0.52	0.29	0.19	2.57	0.24	0.12	0.00
9.5	1.29	0.29	0.25	2.84	0.29	0.05	0.34
4.0	0.25	0.23	0.18	1.20	0.13	0.01	0.00
9.0	0.87	0.34	0.23	3.08	0.25	-	-
8.3	0.57	0.32	0.20	2.85	0.25	0.07	0.07
9.0	0.80	0.40	0.20	2.32	0.26	0.20	0.62
6.3	0.40	0.30	0.18	1.67	0.20	0.15	0.60
7.1	0.30	0.07	0.23	2.37	0.17	0.14	0.67
-	1.60	0.12	0.39	1.40	0.25	0.01	0.67
7.8	0.18	0.05	0.12	1.42	0.19	0.14	0.32
2.8	0.06	0.44	0.18	0.57	0.17	0.03	0.18
6.9	0.13	1.31	0.60	1.50	0.25	0.04	0.05
7.4	0.75	1.10	0.53	1.41	0.73	0.07	0.04
5.1	0.26	0.44	0.00	0.91	0.00	0.00	0.00
1.6	0.02	0.31	0.12	0.40	0.12	0.003	0.05
3.6	0.10	0.41	0.15	0.53	0.19	0.01	0.11

FEEDSTUFF	DM (%)	ME (MJ/kg)	CP (% DM)	NDF (% DM)	SSS (% DM)	Starch (% of SSS)	Fat (% DM)
Peas	87	13.0	24.0	23	46.2	-	1.8
Soya bean meal	90	12.9	50.0	14	27.3	90	1.4
Soya bean hulls	91	11	11.4	61-67	14.0	1.4	2.5
Tapioca pellets	88	12.5-12.8	3	12	50-65	100	2
Wheat	89	12.6	11.3	14	70.2	90	1.9
Whole cotton seed	88	16.0	23.0	44	3.7	90	18.0
Cotton seed meal	89	12	Min 43	20-23	-	1.5	0.05
CROPS/ROOTS							
Chicory	8-19	12.5-13.0	20-26	30-38	4-9	-	-
Fodder beet	14-20	12.0-12.5	9-14	11-16	60-65	5	-
Kale	11-15	11.0-13.5	12-18	20-35	35-40	-	2.1
Lucerne	24	11.0	30.0	30	-	-	2.5
Oats	11-20	11.5	13.2	30	48	90	4.9
Swedes	9-12	11-13	12-20	16-30	45-50	0.1	-
Triticale	32		13.8	59.7	68	67	-
Turnips	9-11	12.0	12-18	27	17	10	2.0
Plantain	10-20	10-12.5	16-28	30-38	6-17	5-15	2.4-3.8
BY PRODUCTS							
Apple pomace	22	10.4	5.4	41	44.0	100	4.7
Bread	63	14.0	13.0	18	65	90	5.7
Brewers grains	24	10.0	23.0	49	11.2	100	7.3
Cabbage	8	13.2	19.0	29	60.4	-	3.4
Carrots	12	13.2	9.9	9	59.4	-	1.4
Condensed distillers syrup	42-45	15-17	15-17	1	-	-	4-8
Dried distillers grains	90	12-13	25-33	30	7.0	55	3.5
Fishmeal	92	11.7	66.7	1.47	2.0	90	10.5
Kiwifruit (ripe)	14	12-12.5	12-17	20	50	2-4	3
Kiwifruit (hard)	20	12-12.5	6-10	25	30	2	3

Ash (% DM)	Ca (% DM)	P (% DM)	Mg (% DM)	K (% DM)	S (% DM)	Na (% DM)	Cl (% DM)
5.0	0.14	0.43	0.17	1.80	-	0.01	-
7.3	0.30	0.68	0.30	2.12	0.37	0.01	0.08
4.8	0.6	0.18	0.25	1.5	0.12	0.01	0.05
6.2	0.2	-	0.15	1.10	-	-	-
2.6	0.07	0.36	0.13	0.46	0.16	0.01	0.08
4.5	0.16	0.60	0.37	1.20	0.26	0.01	-
6.7	0.20	1.15	0.61	1.64	0.40	0.03	0.03
-	1.49	0.34	0.28	3.64	-	0.21	-
-	-	-	-	-	-	-	-
7.0	-	-	-	-	-	-	-
11.0	1.60	0.30	0.25	2.50	0.30	0.06	0.35
3.3	0.11	0.40	0.16	0.52	0.19	0.03	-
6.0	0.4	-	0.10	0.50		0.20	0.20
9.7	0.57	0.33	0.19	3.01	0.21	0.05	-
-	1.75	0.37	0.23	3.00	0.33	0.28	1.45
10-18	-	-	-	-	-	-	-
5.0	0.23	0.11	0.00	0.53	0.11	0.00	0.00
3.0	0.17	0.15	0.40	0.19	-	0.80	-
4.4	0.30	0.60	0.10	0.10	0.36	0.20	0.17
9.0	0.60	0.30	0.19	3.13	-	0.23	-
8.2	0.40	0.35	0.20	2.80	0.17	1.04	0.50
-	-	-	-	-	-	-	-
4.5	0.18	0.83	0.33	0.10	0.44	0.30	0.26
20.8	5.65	3.16	0.16	0.76	0.49	0.43	0.60
0.64	0.03	0.04	0.03	0.33	0.00	0.05	
-	-	-	-	-	-	-	-

FEEDSTUFF	DM	ME	CP	NDF	SSS	Starch	Fat
	(%)	(MJ/kg)	(% DM)	(% DM)	(% DM)	(% of SSS)	(% DM)
Molasses	75	12.0	4.0	0	82.8	0	0.1
Onion	10	13.0	11.6	18	65.1	100	1.6
Palm kernel extract	90	11	14	70		5	8.0
Potato	23	13.0	10.0	7.6	77.2	100	0.4
Pumpkin	8.4	12.9	16.0	5.9	67.4	100	1.2
Tallow	99	31.0	0.0	0	0.0	0	99.0
Urea	99	0.0	281	0	0	0	0.0

Ash	Ca	P	Mg	K	S	Na	Cl
(% DM)	(% DM)	(% DM)	(% DM)	(% DM)	(% DM)	(% DM)	(% DM)
13.1	1.10	0.09	0.43	3.30	0.47	0.15	3.10
3.7	0.20	0.33	0.10	1.57	0.10	0.03	0.20
6.0	0.25	0.65	0.30	0.80	-	0.02	0.50
4.8	0.04	0.24	0.14	2.17	0.09	0.09	0.28
9.5	0.25	0.52	0.14	4.0	-	0.01	-
1.0	0.57	0.06	0.06	0.32	0.00	0.01	0.00
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Feed characteristics and uses

Feed	Type	Considerations
Apple pomace	By-product	A good source of digestible fibre but low in protein. As a moist product it is around 20% DM, with moderate energy levels. It is highly palatable, but is a low mineral product. Consistency may be variable with different batches.
Barley	Concentrate	High starch and risk of acidosis at high feeding rates and/or quick introduction into the diet. High energy and low protein. Palatable and digestible. Best fed through an in-shed feed system or mixed in a ration on a feed pad.
Barley silage	Silage	
Barley straw	Straw/Hay	Low in energy and protein, high in effective fibre. Not suitable as a milking cow feed unless the diet is short of effective fibre. Can be used as part of a dry cow ration.
Bran	Concentrate	Moderate energy and protein levels. Not recommended to feed ad-lib due to the high palatability.
Bread	By-product	High energy, low protein feed and high starch. Risk of acidosis at high feeding rates and/or quick introduction into the diet. Soft oils in the bread can oxidise, so does not store well and goes off quickly.
Cotton seed meal	Concentrate	Very high levels of by-pass protein, excellent digestible fibre and good energy levels. It has a poorer amino acid profile than soya bean meal.
Dried distillers grain	By-product	High energy, moderate protein, high oil which can affect milk fat if the percentage of total unprotected fat in the diet exceeds 6%. Low in starch from extraction process.

Feed	Type	Considerations
Brewers grains	By-product	Rich in protein with moderate energy levels. High in digestible fibre and low in starch. Nutritional value can vary from source to source with a range in dry matters.
Cabbage	By-product	High energy, moderate protein and high SSS. Low proportion of stem to leaf compared to kale means they are less fibrous. Eaten readily and usually needs feeding immediately after delivery.
Canola meal	Concentrate	Highly digestible, high quality protein source with excellent levels of bypass protein. Best fed through an in-shed feed system or mixed in a ration on a feed pad.
Carrots	By-product	High energy, moderate protein, high SSS feed with risk of acidosis at high feeding rates and/or quick introduction into the diet. They are a good source of beta-carotene; however, prolonged use at high levels can colour milk fat.
Chicory	Crop	Management is similar to turnips with time required to adjust to crop. Ready to graze at 25-35 cm height; graze down to 5-10 cm. Do not graze lower than 5 cm. For more information, refer to DairyNZ Farmfact 1-72 – Chicory.
Condensed distillers syrup	By-product	High energy, and a good source of available crude protein. Very low fibre content and can contain high levels of fat.
Lucerne	Crop	Perennial legume, long tap root making it tolerant to dry conditions. Highly nutritive feed – leaf can contain around 12 MJME, however overall value declines as the season progresses (8.5 MJME) and stem component becomes greater. Sodium levels are low. Should be introduced gradually to avoid bloat.
Lucerne silage	Silage	Lucerne taken for silage should be wilted to 25-30% dry matter. It has higher protein content than grass silage and also results in higher intake levels due to lower cell wall content. High fibre levels may reduce nutrient levels in high yielding rations.

Feed	Type	Considerations
Fish meal	By-product	Quality will vary. Excellent protein source, rich in lysine, sulphur, minerals and vitamins.
Fodder beet	Crop	A potentially high yield of digestible nutrients compared to other forage crops. Cows need to be transitioned carefully over a 10 - 14 day period. Graze roots and crop together. Crop DM measurements need to be accurate. Dry cows are commonly put on fodder beet. It should not exceed 2/3 diet. Transition cows off crop 2-3 weeks prior to calving and supplement with magnesium. Refer to Farmfact 1-73.
Kale	Crop	High protein and calcium levels, good water soluble carbohydrates. Can be ensiled. Need to manage effluent loss. Utilisation 75-80% in ideal conditions; 50-60% in the wet. Can provide 100% of diet but better feed usage if less than 65% with high quality baleage, hay or pasture as the other 35%. SMCO: greatest risk in mature kale crops; use little to no sulphate fertiliser. Nitrate poisoning: excessive fertiliser use and exacerbated by certain weather conditions. High Ca/P ratio can cause milk fever at calving.
Kiwifruit	By-product	Good quality milking feed with high energy content but relatively low protein. Needs to be introduced slowly with controlled intake to individual animals. Ripe fruit contain more soluble sugars and increase acidosis risk. Refer to Farmfact 1-61.
Oats	Concentrate	Poorer energy value than wheat and barley but higher in unsaturated oil. High fibre content.
Oats	Silage	Oats can be used for spring-harvested silage and also following winter grazed kale to reduce N leaching. Quality changes with maturation: protein declines, soluble carbohydrate increases. Requires top management, can get high wastage if poor quality. Oats can be used as a single graze feed for dry cows (usually in the South Island).
Onions	By-product	May cause anaemia, also a choke hazard, and there is a risk of milk taint.

Feed	Type	Considerations
Pasture hay, good	Hay	Suitable feed for dry cows, or to reduce risk of acidosis.
Pasture hay, poor	Hay	Poor quality hay can be 7-8 MJME. Not suitable as milking cow feed.
Lupin	Concentrate	Fresh forage or ensiled with maize/cereals. The thick, juicy stem makes them unsuitable for hay. Seeds can be the concentrated protein feed in the diet. Lupin meal or flakes are the seeds processed to remove the fibrous coat.
Maize grain	Concentrate	High energy and starch but slowly digestible, risk of acidosis less than barley or wheat. The seed is high in starch but low in protein, fibre, and minerals.
Maize silage	Silage	High in starch, low in protein, good dry matter levels. Can feed up to 40% of diet to milking cows and 50% of diet for dry cows if the pasture is 25% crude protein. For short periods (up to a month) can feed up to 80% of diet for dry cows. At high intakes require supplementation with Ca, Mg and Na.
Molasses	By-product	High risk of acidosis. Max intake 1.0-1.5 kg DM/ cow/day (i.e. 2 l /cow). Introduce gradually. High in potassium and salt, known to be a laxative. Stores well for up to a year.
Palm kernel extract	By-product	Can sometimes be an issue with palatability. Ideally no more than 30% of the diet; during severe feed deficits max intake 50% of diet, balanced with forage. Cows need water all day at high intakes and a source of long chopped fibre. No major animal health risks. At high intakes review copper supplementation and limit feeding to springing cows.
Peas	Concentrate	Dried peas usually added to animal feed mixes to improve digestibility. Similar to field beans with marginally lower protein. Can be used to replace soya and other protein sources but slightly lower energy. Peas are high in sugar and starch.

Feed	Type	Considerations
Pea silage	Silage	Whole-crop to provide starch and protein in the diet. Peas are sometimes wilted in the field to 25-30% DM. Delaying harvesting beyond flat pod stage results in reduced digestibility and overall feeding value.
Pea straw	Hay	Not suitable for milking cow feed, low energy 7-8 MJME. Pea straw is usually crop residuals from harvesting field peas; this contains dry stem and leaves.
Potato	By-product	High risk of acidosis. Can be reduced by spreading over paddock. Need to restrict to 3 kg DM/cow/day if fed in bins as risk of acidosis from cows gorging. Limited supply. Need to know ration's ingredients.
Pasture silage, good	Silage	Silage and baleage often not greater than 10.5 MJME and therefore not suitable as milking feed. Suitable feed for dry cows, or if no long-chop feed available for milking cows (to reduce risk of acidosis). Cost varies depending on size of bale, wastage and ME.
Pasture silage, poor	Silage	Silage and baleage closer to 9 MJME.
Soya bean hulls	By-product	Good source of digestible fibre, moderate energy content, and average protein. Suitable supplement with grass.
Soya bean meal	Concentrate	The best quality protein feed, high in by-pass protein. Has a good amino acid profile. High in energy.
Swedes	Crop	Low DM% (11-12) which can limit intake. Good palatability and a high energy value. Cows need to be transitioned well. Bolting or maturing swede crops, e.g. elongated necks or flowering heads, increase the risk of ill- health. Swede crops need to be monitored including the proportion of swede in the diet.

Feed	Type	Considerations
Tapioca	Concentrate	Tapioca is a high energy supplement, with similar starch content to maize grain, but is low in protein and not as palatable. Ideal for cows as starch is slowly degraded and has good energy levels.
Triticale	Crop	High energy, moderate protein grain. Some autumn sown varieties can only be grazed once; others may be grazed twice and cut for silage.
Triticale silage	Silage	High production within a short period compared to other crops grown for silage. Can be harvested at an earlier stage before seed head is present (green chop) giving a silage value similar to high quality grass silage.
Turnips	Crop	Use long narrow breaks. Introduce cows gradually to adjust to crop; offer a maximum of 2 kg DM/cow (approx. 2-3 m2/cow/day) in first five days, increasing over next five days, up to 5 kg DM/cow/day; no more than a third of the daily ration. For more information refer to DairyNZ Farmfact 1-67 – Barkant turnips.
Urea	By-product	Urea is the most concentrated non-protein nitrogen source available at 50% nitrogen. Care should be taken to provide urea in small quantities (< 150g/day) in a safe form as it can produce ammonia toxicity if introduced too quickly or larger amounts are fed.
Wheat	Concentrate	Very high energy with average protein. High in starch, low in fibre, but tends to be low in vitamins. Is useful for increasing milk protein yield and for growth. Approximately 10% of starch is rumen unfermented. The readily fermentable carbohydrates present can cause acidosis when fed at high levels. Higher risk of acidosis than with barley or maize.
Wheat straw	Hay	Lowest quality hay at 6-7 MJME.

Feed	Type	Considerations
Wheat silage	Silage	Like maize, not all regions in NZ are suited to growing quality cereal silage with high ME. Requires top management (small harvesting window). Can get high wastage if poor quality.
Whole cotton seed	Concentrate	Whole cotton seed is high in energy, protein, and fibre. When feeding cotton seed the amount that can be fed will be limited due to: chemical residuals from growing the crop, oil intake and effect on the rumen, and the risks of gossypol toxicity.
Whole crop silage mixes and green - chop silage	Silage	Whole crop silage refers to a number of silages already mentioned: oats, barley, triticale, peas. Whole crop silage cereals are harvested when the grain has reached full size but is still soft. Green-chop cereal silage is harvested at the boot stage and wilted. It has similar properties to pasture silage.

Feeding forage crops: factors to consider

Forage crops	Factors to consider
Cereals	Flexible as can be grazed or ensiled (whole crop silage) Silage quality general lower ME than good quality maize silage but is less risky in cooler regions or exposed locations. In North Island difficult to get good grain fill reducing silage quality.
Triticale	Range of cultivars from single to multiple grazings.
Oats	Best suited to single grazing; or multiple cut and carry where height controlled. Quality changes with maturation, protein declining, soluble carbohydrate increasing. Good catch crop following winter fodder beet or brassicas

Forage crops	Factors to consider
Multiple-graze cereals	Sown in autumn; grazing time in winter not as flexible as Italian ryegrass. e.g. triticale, rye corn, oats
Brassicas	Fall into 2 categories – summer feed or winter feed. All provide high quality feed and bulbing brassicas a source of carbohydrate (stored starch and soluble sugars). Dangers of feeding can be avoided by careful transitioning between diets (at least 10 days) and supplementing with straw and silage to increase gut fill and reduce rate of intake and offering 2-3 smaller breaks during the day. High sugar and low fibre: rumen acidosis. Toxic components SMCO, glucosinolates and high nitrate. SMCO1 – reduced performance 'red water' disease; highest risk mature kale, flowering brassicas and secondary re-growth. Rape scold in second-growth Pasja.
Swedes (approx 12.0 ME)	Low DM% 11-12% which can limit intake.
Kale (approx 12.5 ME)	Medium to high in protein (dependent of N fertiliser input), good levels of soluble carbohydrate and high levels of calcium (7-8 g/kg DM compared to pasture 2-2.4 g/kg DM). Can be ensiled; need to manage effluent loss. Utilisation 75-85% ideal conditions; 50-60% in the wet. Can provide 100% of diet but better feed usage if less than 70% with high quality baleage, hay or pasture as the other 30%. SMCO – greatest risk in mature kale crops; use little to no sulphate fertiliser. Nitrate poisoning: excessive fertiliser use and exacerbated by certain weather conditions. High Ca/P ratio can cause milk fever at calving.

[1] SMCO = amino acid S-methylcysteine sulphoxide

Forage crops	Factors to consider
Turnips	Use long and narrow breaks. Introduce cows gradually to adjust to crop; offer a maximum of 2 kg DM/cow (approximately 2-3 m2/cow/day) in first five days increasing over next five days, up to 5 kg DM/cow/day; no more than a third of the daily ration. For more information refer to DairyNZ Farmfact 1-67 – Barkant turnips: feeding the crop.
Chicory	Management is similar to turnips with time required to adjust to crop. Pre-graze at 25-35 cm height; graze to 5-10 cm. Do not graze lower than 5 cm. For more information refer to DairyNZ Farmfact 1-72b – Chicory.
Fodder Beet	Not the same management as kale and swedes. Need to transition cows onto crop over 10-14 day period. Graze leaf and bulb together. Low phosphorus content. Seek veterinary advice about mineral supplement as cows transition off crop at calving. For more information refer to DairyNZ Farmfact 1-73 – Fodder beet: feeding dairy cows.

Crop area required to feed 100 cows: see www.dairynz.co.nz/feed/crops/

	Daily intake (kg DM/cow)			
Crop Yield	**3.0**	**4.0**	**5.0**	**6.0**
8 t DM/ha	375m²	500m²	625m²	750m²
10 t DM/ha	300m²	400m²	500m²	600m²
12 t DM/ha	250m²	333m²	420m²	500m²
14 t DM/ha	215m²	280m²	360m²	430m²
16 t DM/ha	188m²	250m²	313m²	375m²
18t DM/ha	167m²	222m²	278m²	333m²
20 t DM/ha	150m²	200m²	250m²	300m²
25 t DM/ha	120m²	160m²	200m²	240m²
30 t DM/ha	100m²	133m²	167m²	200m²

Estimating chicory crop yield

The DM% of chicory ranges from 10-15% and therefore yields can vary by up to 50% if DM is over or under estimated. The following outlines the best practise method. For more information refer to DairyNZ Farmfact 1-72 – Chicory.

- Make a 0.25m² quadrant by bending wire into a square 0.5 m x 0.5m
- Take cuttings from 4 randomly chosen sites, cut to grazing height (5cm recommended)
- Bulk the 4 samples together and weigh
- Multiply by 10,000 to get fresh weight (kg/ha)
- Take 200g sample of fresh chicory after thoroughly mixing the sample
- Dry in microwave or oven until the weight doesn't change, re-weigh and record the dry weight OR send sample away for DM analysis in a sealed plastic bag
- Calculate DM% (dry weight / fresh weight)
- Calculate DM/ha (fresh weight/ha x DM%).
- Similar to pasture, the Rising Plate Metre can be used to estimate the yield of first year chicory crops when there is no stem present. Take at least 40-50 readings in a 'W' shape across the paddock and calculate yield using the equation:

Yield (kg DM/ha) = RPM height (clicks) x 86 + 235.

Estimating brassica crop yield

- Collect at least 6-8 quadrat samples that are representative of the paddock. Recommendation of 1 quadrat/ha of crop but the more samples the better
- Sample size minimum of 1m² use a 1m x 1m square quadrant or a circle made with a 3.55 m length of alkathene; or for a 2m² sample use 5.1m length of alkathene to make the circle)
- Harvest all the material within each quadrat and measure its fresh weight after removing any excess soil, especially from the bulbs of swedes and turnips
- For bulb crops weigh the leaf and bulbs separately
- Determine the DM content – take a sub-sample of plants/plant parts (swedes, turnips) and send to the lab for DM analysis. As DM% varies greatly between cultivars and paddocks estimating the DM% will result in under or overestimating the yield
- Average the DM yield for the quadrat samples (fresh weight x DM%) and multiply by 10,000 for a 1m² sample or by 5,000 for a 2m² sample (e.g. 1.44kg DM from a 1m² sample equates to 14,400kg DM/ha or 14.4 tonnes DM/ha).

NB. If swedes are ridged, follow the fodder beet method (refer to page 82)

Estimating fodder beet crop yield

- Determine the row spacing of the crop by measuring across 10 rows of crop from the centre of the first row; divide the distance by 10.
- Collect at least 5 yield samples that are representative of the paddock
- From each yield sample remove all the plants from 4 lineal m of a row (50cm row spacings) or 4.44 lineal m (45cm row spacings). This length provides 2m² of sample.
  (2 and 2.22 m lengths = 1m²)
- Remove any excess soil from the bulbs by scraping with a blade, separate the leaf and bulb by cutting as close to the crown of the bulb as possible and measure the wet weight of leaf and bulb separately.
- Select approximately 300g of leaf from multiple plants and 3-5 bulbs for DM determination. Cut the bulbs in quarters lengthways and place one quarter of each bulb into a plastic bag, seal and send with the leaf to the lab for DM determination. As DM% varies greatly between cultivars and paddocks estimating the DM% will result in under or overestimating the yield

Calculate the DM yield for each sample and plant part (fresh weight x DM%; 30kg bulb x 0.14 DM = 4.2 kg DM; 6 kg leaf x 0.09 DM = 0.54kg DM) and average. Add the average bulb and leaf DM yield together ((4.2+ 0.54) = 4.74kg DM/2m²) and multiply by 5000 to determine the kg DM/ha yield (4.74kg DM/2m2 x 5000 = 23700kg DM/ha or 23.7t DM/ha).

Silage

Area of farm to close for silage or baleage during a pasture surplus

Example calculation:

500 cows on 160ha, stocking rate =3.1 cows/ha, 25 day rotation=160/25=6.4 ha/day

Estimated Pasture intake = 18 Kg DM/cow/day

Feed demand = 3.1 x 18 =56 Kg DM/ha/day

Pasture Growth = 65 Kg DM/ha/day

Area to be in grazing rotation = 56/65 = 86% or 138ha of the farm

Close up 14% of the farm or 22ha.

Check that new rotation length is suitable; 138 ha/6.4ha=21.6 days new rotation length.

Density and storage of silage

Density and DM% of silage and hay

Silage type	DM %	Wet weight silage kg/m³ in stack or hay in bale	DM silage kg/m³ in stack/bale
Direct cut grass	13-18	700-900	120-160
Wilted grass	20-30	600-800	160-180
Baleage	35-40	500	200-220
Hay – small bales	85	18-25	15-20
Hay – round bales	85	180-300	150-250
Maize stack	30-40	500-760	170-250 (average 200)
Maize bunker	30-40	600-900	200-300 (average 220)
Typical density in forage wagons is around 80kg DM/m³ for a range of forages			

Estimate of DM % grass silage

Squeeze test: Break up silage 2-3 cm length and roll into ball size of tennis ball, squeeze in fist for 30 seconds	DM %
Hands dry, sample does not stay in tight ball when stop squeezing	Over 30
Sample stays in ball when stop squeezing, no juice, hands moist	26-30
A little juice runs out with difficulty	21-25
Juice runs out easily	18-20

Storage space required for grass and maize silage

Silage storage	Tonnes DM multiplied by	Example
Maize stack	5.0	e.g. 50 t DM x 5.0 = 250m^3
Maize bunker	4.4*	e.g. 50 t DM x 4.4 = 222m^3
Grass silage	5.7	e.g. 50 t DM x 5.7 = 285m^3

** This figure is used to determine weight of maize silage in the example on page 85*

How much silage is in my stack?

To calculate the weight of silage in storage you need to know (or estimate):

a) storage volume (capacity) in cubic metres (m^3)

b) silage density in kg DM/m^3

c) dry matter %.

The weight of silage in storage is then calculated using the following equation:

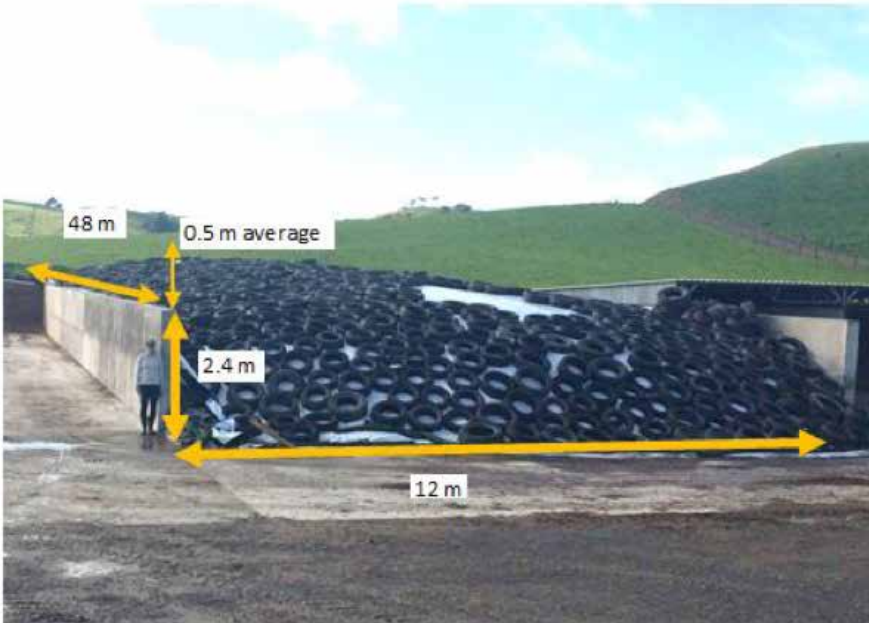
Silage weight (kg DM) = volume of stack or pit (m^3) x silage density (kg wet weight/m^3) x DM %

Estimating stack volume

Volume of the storage can be estimated by multiplying the width by the length by the approximate height of the silage.

In the photo, the dimensions have been estimated at a length of 48 metres, width of 12 metres and height of 2.9 metres (the height at the highest point is about 1 metre above the top of the wall, so about 0.5m on average). The volume of the silage in the bunker is therefore:

48 x 12 x 2.9 = 1670m^3



Using the table on page 84 for storage space for silage as a guide for our example bunker storage in the photo:

Maize silage weight = 1670m^3 ÷ 4.4 = 380 tonne DM*

Density and storage of other feeds

	Density (kg/m³)	Storage (m³/tonne)
Grains – Barley	630	1.6
Grains – Wheat	760	1.3
PKE	630-750	1.35-1.6
Carrots	630	1.6
Onions (dry)	630-725	1.4-1.6
Potatoes	660	1.5

Maximum silage face area (m²) to achieve min. silage feed out rates

On average a 20cm daily progression of the silage face is required across the whole silage face for better silage stability (preventing heating). A slow rate of silage feedout increases losses.

Silage feed out t DM/day	Silage density kg DM/m³	Max. silage face area (m²)	Silage face dimension Example height x width
1	200	5	e.g. 1.5 x 3.3m =5m²
2	200	10	e.g. 1.8 x 5.5m = 9.9m²
3	200	15	e.g. 2 x 7.5m = 15m²
4	200	20	e.g. 2.5 x 8.0m =20m²

Interpreting pasture silage analysis

Factors measured	Typical range	Interpretation
pH	4.3-4.7	A low pH prevents unwanted butyric fermentation. Higher pH (>5.0) may be due to butyric fermentation or to silage being high in DM (>45%) restricting fermentation
Ammonia N (% of total N)	8-12	Low values indicate minimal breakdown of protein in silage usually due to rapid fall in pH to a low level in the silage.
Lactic acid (% of DM)	6-10	High concentrations indicate well preserved silage.
Butyric acid (%of DM)	0.1-0.5	High concentrations indicate poorly preserved silage.

Interpreting maize silage analysis

Factors	Quality of fermentation typical range	Interpretation
pH	3.7-4.2	pH higher than 4.0 may be due to the silage being very high DM (>42%) or the silage has had considerable aerobic exposure.
Ammonia N (% total N)	5-7	High value (>12%) is the result of high protein breakdown. Note: maize silage has low crude protein (8%) i.e. less crude protein available to be degraded.
Lactic acid (% DM)	4-7	High concentrations indicate well preserved silage. Low values may indicate restricted fermentation due to high DM or after considerable aerobic exposure lactic acid was degraded.
Acetic acid (% DM)	1-3	High concentrations are often found with very wet silage (<25% DM) or due to loose packing. Silage treated with inoculant containing L. buchneri show higher levels of acetic acid; this should not be mistaken for a poorly preserved silage.

Time to ensile

Time to ensile (days to when silage can be fed out)

		Days to ensile	
Silage type	**% DM**	**with inoculant**	**without inoculant**
Grass	20	4-7	8-14
	30	4-10	14-21
	40	4-10	20+
	50	Up to 14	Up to 30+
Whole crop cereal	32-45	3-4	7
Maize	30-40	3-4	7

Note: Need to use proven inoculant. The lower the DM the quicker to ensile but more risk of low quality silage (butyric i.e. bad smell). The higher the sugar content the quicker to ensile.

Mineral additives to maize silage

Mineral additives to maize silage (when maize silage 25-40% of DM intake). Contact an animal nutritionist to get recommendations when maize is more than 40% of the diet. Amount of each mineral supplement (g/cow/day) to include when feeding different amounts of maize silage.

Maize eaten – kg DM	**Limeflour**	**Magnesium Oxide**	**AgSalt**	**Dicalcium Phosphate**
	g/cow/day			
Lactating cow				
Less than 3kg	60	40	15	20
3-5kg	70	45	25	35
5-8kg	80	45	40	55
Dry cow (last 3 weeks)				
Less than 3kg	0	60	0	0
3-5kg	0	60	15	0

For more information refer to DairyNZ Farmfact 1-60 – Mineral supplementation for maize silage.

Costing feeds:

Costing per kg DM eaten and per MJ ME eaten

Dry Matter (DM)	= wet weight x DM%
Cost/kg DM eaten	= price per tonne feed ÷ kg DM ÷ Utilisation
Cost/MJ ME eaten	= cents/kg DM eaten ÷ MJ ME/kg DM
Example: Grass silage costs $80/tonne; 35% DM; 10 MJ ME/kg DM Utilisation of 80% (10% wastage storage + 10% wastage feeding out)	
DM	= 1000kg x 35% DM = 350 kg DM
Cost/kg DM eaten	$= \frac{\$80/\text{tonne}}{350\text{kg DM/tonne}}$ x 100 = 23 cents/kg DM offered $= \frac{23 \text{ cents}}{0.80}$ = 29 cents/kg DM eaten
Cost/MJ ME eaten	$= \frac{29 \text{ cents/kg DM}}{10 \text{ MJ ME/kg DM}}$ = 2.9 cents/MJ ME eaten