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Pasture Plants

Pastures

Telford

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Learning outcomes

Pasture plants are fundamental to farming in New Zealand. Identifying the plants present in a pasture and understanding their growth characteristics is essential to optimising animal performance.

During this course you will learn about the most commonly used pasture plants; ryegrass, white clover and other legumes. You will learn how to identify these pasture plants, establish them and understand how their growth and quality varies with season and location. You will also learn about pasture conservation methods.

At the end of this course you will be able to:

- identify the main species of ryegrass and legumes used in pasture in terms of their characteristics, palatability, physiology and habit
- describe growth of grass including seasonal and regional variations
- describe pasture quality and palatability in terms of seasonal variations
- describe pasture establishment processes
- explain the benefits of conserving pasture and processes involved, including deferred grazing
- calculate volumes and weight of available dry matter of conserved pasture
- describe a method for determining pasture quality and strategies used to manage pasture quality

With the information learnt during this course you will gain a greater understanding of the driving force behind New Zealand farming – pasture plants.

Source: Lee Clift

Pasture

Pasture is the basis of New Zealand's ruminant farming systems. Pasture is a group of plants, usually grasses, legumes and herbs, which are suitable forage for grazing ruminant animals. These plants, along with specialised bacteria such as rhizobia that fix nitrogen and others that break down dead material, endophytes that protect grass plants from being eaten, insects, earthworms and other flora and fauna, form a pastoral ecosystem.

Although pasture is a mix of plant species, the predominant species in sown pastures are ryegrass and clover. Other grasses and herbs are increasingly being used in pasture mixes or as special purpose crops but ryegrass and clover still provide a reliable source of quality animal feed for most regions during most seasons.

The advantages of a perennial ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*) pasture include:

- high dry matter production in many locations
- fast and reliable establishment in a range of soil and climatic conditions
- good persistence if basic fertility and pest control are met
- flexibility in grazing management options for sheep, cattle, deer and goats

Identifying ryegrass types and legumes, and their characteristics is essential to managing pastures to optimise animal performance. Sometimes there is conflict between what is best for the pasture and what is best for the animals. For example, at times animals may need to graze pasture shorter than is best for the pasture due to feed shortages brought on by drought or flooding. The goals of the farm enterprise and the farmer will determine the priority of pasture and animal needs during these times.

Long summer pasture showing grass, and red and white clover seedheads.

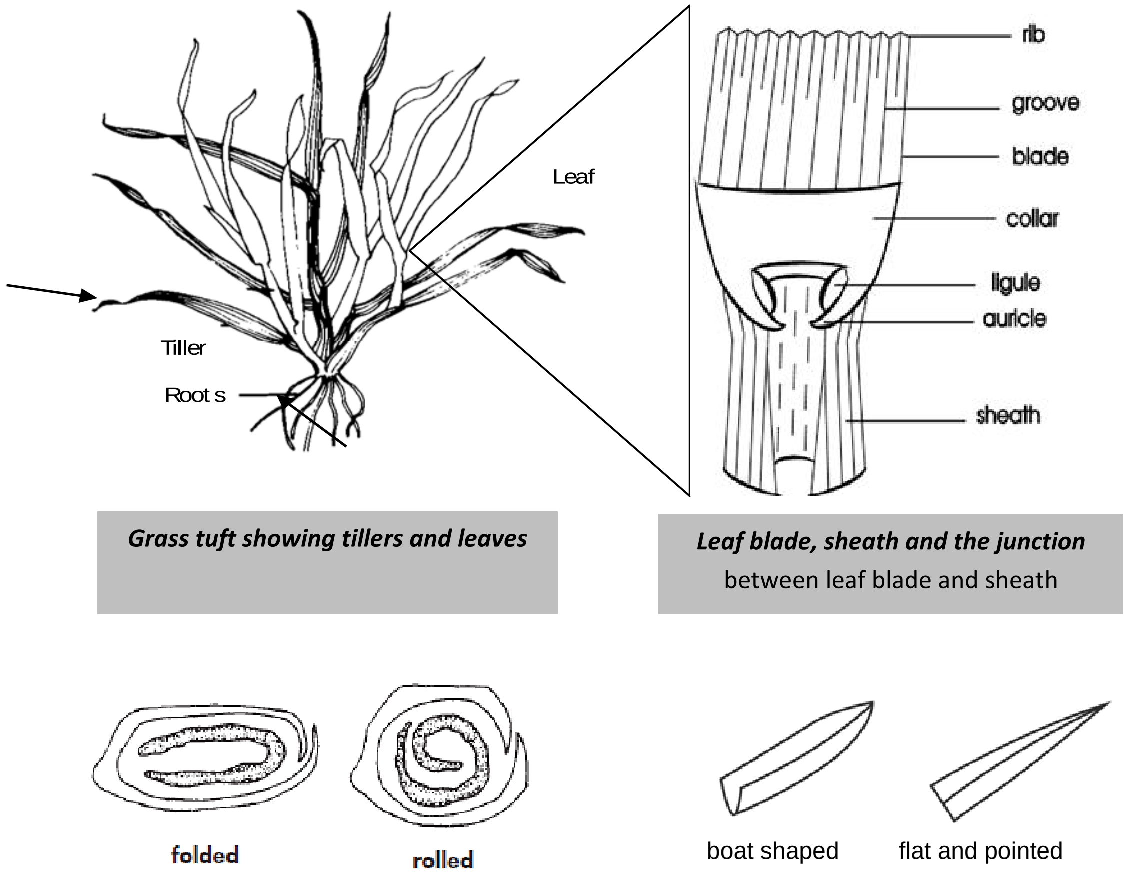
Source: Lee Clift

Pasture Species

Identification of ryegrasses in their vegetative state

To identify different species of ryegrass in their vegetative state (when they are not flowering) you need to observe their growth habit and structure of their tillers and leaves. Figure 1 shows the plant parts you will need to observe to identify the differences between perennial, annual and short rotation ryegrass.

Figure 1: Vegetative parts of ryegrass plants



Grass tuft showing tillers and leaves

Leaf blade, sheath and the junction between leaf blade and sheath

Emerging leaf in cross section

Leaf blade tip

Source: www.omafra.gov.on.ca

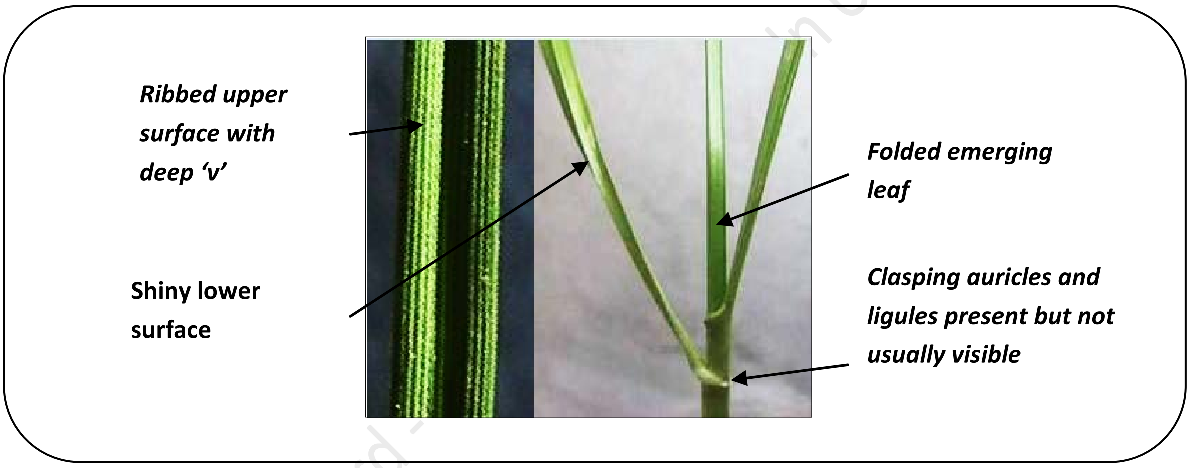
Lolium perenne – Perennial ryegrass

Lolium perenne is the main ryegrass species used in pasture mixes sown in most areas of New Zealand. The grass most people call ryegrass is usually perennial ryegrass but may be perennial, Italian/annual or hybrid ryegrass. There are differences between these types of ryegrasses although they are often subtle. As a farmer, or if you are involved in pasture management, you need to be able to identify the different species because they have varying persistence, livestock palatability and management needs.

> *Lolium perenne* was introduced to New Zealand in the mid-1800s. It is native to Europe, temperate Asia and northern Africa. Due to its value as a livestock feed and a hardy turf plant it is now found in temperate climates throughout the world.

The following identifying features are a guide only. Ryegrass that has become naturalised in pastures over many years may have adapted to a particular grazing system, soil, aspect and climatic conditions and vary compared to the original sown cultivar. Features in bold type indicate main differences between perennial and Italian/annual ryegrass.

Identifying physical features



Source (image): pastureinfo.massey.ac.nz

Leaves

- **blade width typically up to 7mm and length up to about 30cm**
- **blade with a flat pointed tip**
- vary from lime to deep green colour depending on nutritional status of soil and stage of growth (In spring, perennial ryegrass paddocks are often lime green whereas in mid-winter the same paddock is likely to be a deep green colour)
- ribbed on the upper surface
- a deep 'v' shaped groove at the midrib
- shiny lower surface
- **emerging leaf is folded** (may appear rolled in young plants)
- **auricles are present and clasping**
- no ligule visible (very small and narrow)
- the base of the sheath is usually dark red to purple in colour (may be hidden by outer dead leaves)

Growth habit

- Perennial ryegrass grows in **dense tufts**. These are more obvious when grown as spaced individual plants than when within a pasture.

Characteristics

Perennial ryegrass requires moist, fertile soil conditions and performs poorly during hot, dry conditions mainly due to its shallow rooting system. However it is able to withstand treading and hard grazing and persists well when grown under ideal conditions. Individual plants can live for many years through vegetative reproduction of tillers.

Seasonal growth of perennial ryegrass largely determines the production of a ryegrass dominated pasture. Newer varieties (e.g. Bealey) have better winter growth than older varieties (e.g. Ruanui) but cold temperatures typically mean slower growth over winter. Growth rate begins to speed up in early spring (August – September) with peak growth rates for most varieties occurring from mid to late spring (October – November). Seedheads start to form in late spring through summer resulting in lower pasture quality although pasture mass may be high due to higher dry matter content of the seed heads and stems. Some varieties head later than others allowing a longer period of leafy grass before poorer quality stems and seedheads form. In autumn (March, April, May) there is a lift in leaf and tiller production as seedheads die off and temperatures drop.

Perennial ryegrass is naturally a diploid plant, meaning it has two sets of chromosomes. Tetraploid cultivars have been artificially developed by plant breeders to have four sets of chromosomes. Tetraploid cultivars are generally larger plants with bigger cells and higher water content giving them a more succulent appearance than diploid ryegrass. They also tend to have a lower tiller density (i.e. less tillers per plant) although newer more dense varieties have been developed. Tetraploid ryegrass is generally more palatable to livestock than diploid varieties.

Grassland's Halo tetraploid perennial ryegrass

Source: agricom.co.nz

Perennial ryegrass commonly contains endophytes, a type of fungus that helps protect the plant against insect attack. The fungal strands grow between the plant cells, and transmit themselves to the next grass generation by growing into the developing seed head and then growing into the subsequent grass seedling.

Some endophytes can cause health problems for livestock but new 'novel' endophytes have been developed that are less harmful to stock but still protect plants from insects.

There are many different cultivars or varieties of perennial ryegrass with varying production characteristics. It is important to consider what you need from your grass in terms of yield, patterns of growth, endophyte, ploidy and heading dates before choosing a variety to sow.

Lolium multiflorum – Italian or annual ryegrass

Lolium multiflorum is called both Italian ryegrass and annual ryegrass. It has relatively short persistence in pastures compared to perennial ryegrass. *L. multiflorum* cultivars that persist for between one and three years are generally called Italian ryegrass.

L. multiflorum cultivars that persist up to one year are generally called annual ryegrass or Westerwolds ryegrass (reflecting its origins in the Westerwolde area in the province of Groningen, Netherlands[1]). Annual ryegrass is typically sown as a specialist pasture of eight to ten months duration. It can be sown after crops such as maize or cereals have been harvested to provide winter feed prior to sowing a summer crop.

> *Lolium multiflorum* was selected from *Lolium perenne* and became established as a species distinct from perennial ryegrass. The first reported cultivation of *L. multiflorum* was grown in northern Italy, hence its common name today, Italian ryegrass.

The identifying physical features of Italian ryegrass and annual ryegrass are basically the same, remembering that there is a wide natural variation within the *L. multiflorum* species. Some cultivars may have wider leaves than others and some may be more or less erect in habit, etc. but these variations generally fall within the identifying features of the grass.

Identifying physical features

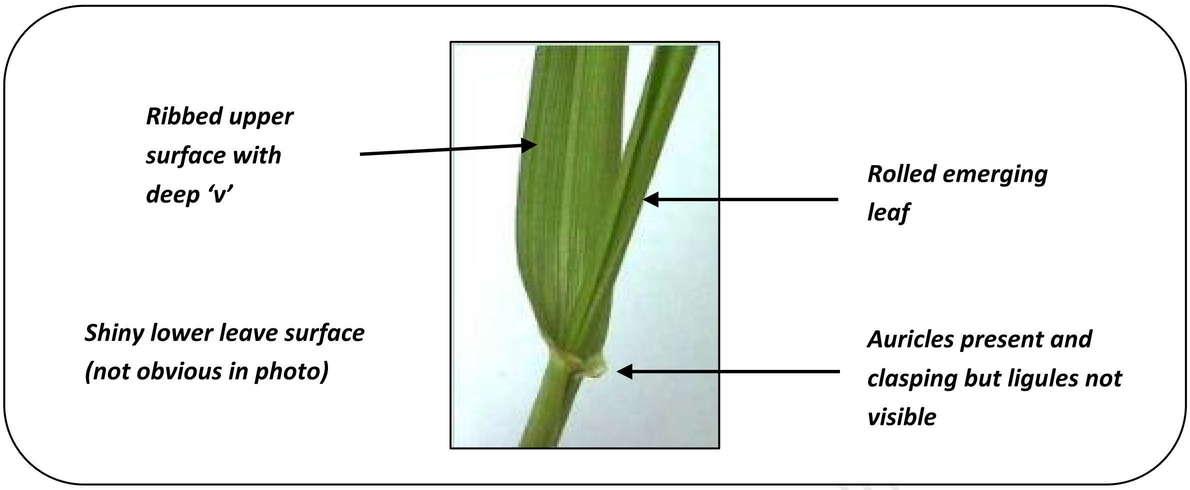
Leaves

- **blade width about 5 – 12mm and length up to about 40cm**
- **blade with a flat pointed tip**
- varies from lime to deep green colour depending on nutritional status of soil and stage of growth but generally a little yellower than perennial ryegrass
- ribbed on the upper surface
- a deep 'v' shaped groove at the midrib
- shiny lower surface
- **emerging leaf is rolled**
- **auricles are present and clasping**
- ligules not visible
- the base of the sheath is usually red to purple in colour (may be hidden by outer dead leaves)

[1] Extension publication AGR-179, Annual Ryegrass, University of Kentucky, College of Agriculture, www.ca.uky.edu

Growth habit

- Italian ryegrass grows as tufts that are typically **not as dense (larger and fewer tillers) than perennial ryegrass**.
- It usually has a **more erect** growth habit than perennial ryegrass.
- At the 2 – 3 leaf stage, annual ryegrass usually pulls out more easily than perennial.



Source (image): pastureinfo.massey.ac.nz

Characteristics

Annual ryegrass produces well over winter but typically develops seedheads quickly if sown in spring. Italian ryegrass can persist through moist summers to provide feed the following winter and spring. Italian ryegrass does not contain the endophyte present in perennial ryegrass but can contain an endophyte associated with annual ryegrass (*Neotyphodium occultans*) that does not cause any animal health issues.

As with perennial ryegrass, *L. multiflorum* is naturally a diploid plant but plant breeders have developed tetraploid cultivars that are generally larger and more palatable plants than the diploid types. They are best grown under fertile, moist conditions with care taken not to over graze them – being more palatable stock tend selectively graze them.

Lolium x boucheanum Knuth. (syn. L. hybridum) - Hybrid ryegrass

Hybrid ryegrasses have been bred from crosses between perennial (*L. perenne*) and Italian/annual (*L. multiflorum*) ryegrass. They are also commonly referred to as short or long rotation ryegrass. As expected, hybrids vary in features between perennial and Italian ryegrass depending on the aims of the plant breeder. Some hybrids are much like perennial ryegrass but with improved winter production and reduced persistence while others are more like Italian ryegrass but with enhanced persistence. In some cases there may be other species of grass included in the breeding, such as meadow fescue in the cultivar Matrix.

Two botanical names are used to describe hybrid ryegrass; *Lolium x boucheanum* and *Lolium hybridum* depending on the classification system followed.

Identifying physical features

Similar to perennial or annual ryegrass (depending on breeding) with the following exception

Leaves

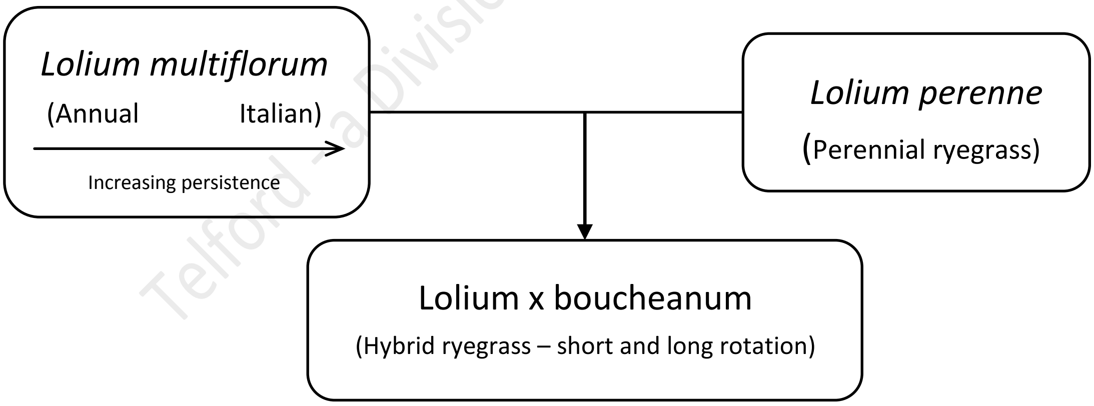
- **leaf blades have a boat shaped tip**
- leaves look shiny, narrow and are partly folded in a v shape but may be larger and appear more succulent than perennial ryegrass
- may look less dense than perennial ryegrass

Characteristics

The long rotation hybrids tend to be longer living than Italian ryegrass and with higher yields. They may live up to 10 years under good conditions. Most short rotation hybrids are free of endophyte whereas long rotation hybrids typically have the same endophytes as perennial ryegrass. The growth characteristics of hybrid ryegrasses depend on their parentage; short rotation hybrids are more like Italian or annual ryegrass, and long rotation hybrids more like perennial ryegrass.

Figure 2 shows the relationship between the different types of ryegrass. Remember that Italian and annual (Westerwolde) ryegrass are just variations of *Lolium multiflorum*. To confuse matters further *L. multiflorum* is also often called short rotation ryegrass.

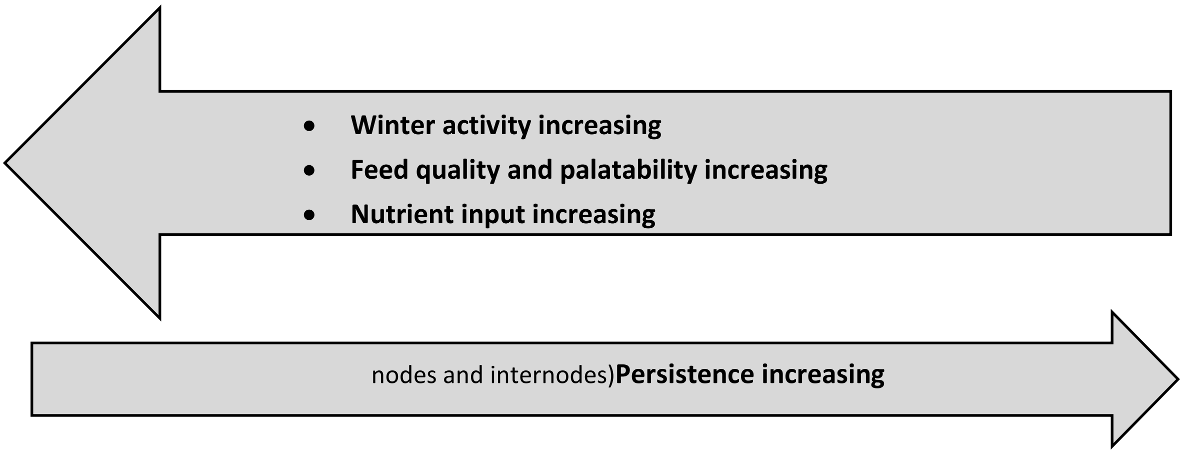
Figure 2: Relationships between the different types of ryegrass



The variations between different ryegrass species and cultivars provide different options to meet a farm's environmental and animal systems. Figure 3 compares the main characteristics of the different ryegrass types.

Figure 3: Ryegrass types and typical characteristics

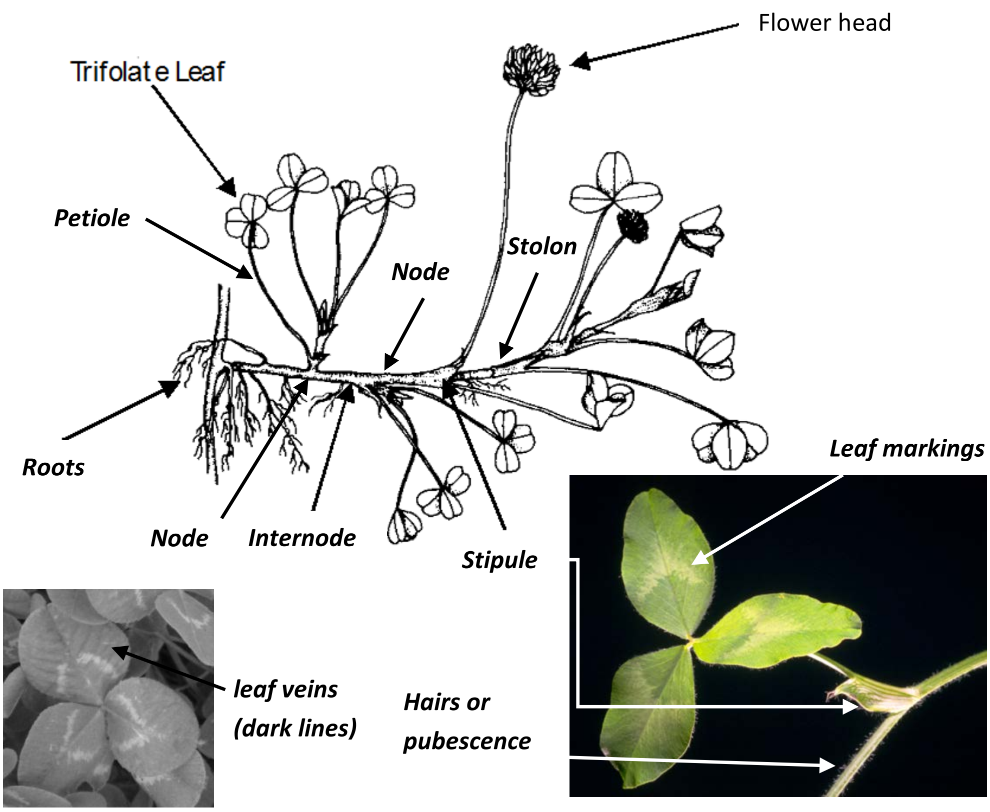
Annual	Italian and hybrid			Perennial		
	Short term	Medium term	Long term	Large leaved	Medium leaved	Fine leaved



Identification of common pasture legumes

To identify different species of clover you need to observe their growth habit and plant structures. Figure 4 show the basic plant parts you will need to observe to identify the differences between clover species. Table 1 describes the various parts of clover plants.

Figure 2: Clover plant parts



Source: Lee Clift

Table 1: Parts of the clover plant

Plant part	Description
Flower head	A dense inflorescence of flowers without stems.
Inflorescence	The arrangement of flowers on the floral axis.
Internode	Area of the stem between the nodes.
Node	The point on the stem where leaves are attached.
Petiole	The stalk of a leaf which connects the leaf to the stem.
Pubescence	Small hairs on the surface of leaves and stems.
Rhizome*	An underground stem which is capable of producing new plants at the nodes.
Stipule	Small, pointed, leaf-like structures at the base of the petiole.
Stolon	A prostrate above-ground stem which is capable of producing new plants at nodes.
Trifoliate leaves	Leaves consist of three leaflets at the end of a petiole
Veins on leaves	Vascular structures that show as dark lines on the leaves

** Not shown in above diagram*

Most clover plants have a stem (called a stolon) that grows across the top of the ground. Roots form at many of the stem nodes. The leaves on a clover plant grow out alternately (one leaf from one side of the stem, the next leaf from the other side). Where the stalk (petiole) of the leaf joins the stem, a pair of structures called stipules grows. These are useful aids for identifying clover species.

White clover - *Trifolium repens*

White clover is the predominant clover species grown in New Zealand pastures. Its persistence, palatability, feed quality and ability to fix nitrogen has ensured its continued use since European farmers first introduced it in the 1800s. However in recent years the establishment of clover root weevil threatens white clover's predominance unless resistant cultivars are developed.

Identifying physical features

Source: Lee Clift

Leaves

- trifoliate
- hairless
- round to oval in shape
- moderate branching of leaflet veins at ends
- stipules scale like, hairless, small and pointed
- typically mid-green in colour but can vary from light to dark green depending on growing conditions
- usually have a whitish 'v' or crescent-shaped '∪' mark and occasionally red flecks

Source: Lee Clift

Growth habit

- prostrate, branched, creeping stolons
- roots at the nodes

Flowers

- forms a head of florets
- white to pale pinkish florets turn brown after flowering

There is wide variation in the above features within white clover populations and three distinct types have also been identified. They are classified by leaf size. These are summarized in Table 2.

Table 2: White clover types based on leave size

White clover type	Characteristics	Use
Large leaved (Also called Ladino)	• grow tall and upright • thick stolons • robust roots • fewer stolons • lower persistence	More suited to dairy rotationally grazed systems.
Medium leaved	• intermediate between large and small leaved types	Widespread use in general purpose pastures. Performs well under a range of grazing management, except under very close continuous grazing or very lax grazing.
Small leaved	• low growing • many leaves • many thin, multi-branched stolons	Their low-growing habit and high stolon density make it hard for stock to remove stolons. They are best used under close, continuous grazing, particularly by sheep.

Characteristics

White clover performs well in moderate to high fertility soils but may not perform well in dry situations. Plants with a high density of stolons persist best. This is because the central tap root dies after a year or two but the roots developed at the nodes of stolons enable continued plant growth and survival. So the more stolons there are, the more roots there are, and the greater the chance of plant persistence.

White clover has higher temperature requirements than ryegrass for optimum growth; 20°C – 25°C compared to 15°C – 20°C. It has relatively poor winter/spring growth compared to ryegrass. Its production peaks in summer and then tails off again as temperatures cool off in autumn. Seedheads are also formed in summer but the quality of clover does not decline as significantly as ryegrass does during flower and seedhead formation and can provide quality feed at a time when ryegrass is typically low in quality.

White clover is highly digestible because of its lower fibre content than grasses and faster rate of passage through the animal's gut. Other legumes such as red clover and subterranean clover also offer good quality feed but need careful management to prevent overgrazing and increase persistence.

White clover can be attacked by clover flea and slugs but it is clover root weevil that has caused the greatest loss of plants in recent years, particularly in the North Island. Resistant cultivars are being developed but in the meantime farmers may need to consider alternative legumes or high quality herbs in areas with high populations of clover root weevil. Nitrogen fertiliser may also need to be applied to pastures to replace the nitrogen normally fixed by white clover.

Red clover – *Trifolium pratense*

Red clover plants (*Trifolium pratense*) have a tap root and increase in size by producing new leaves from the original root. They are a much more upright plant than white clover (*Trifolium repens*). Red clover performs well in moderate to high fertility soils, even in dry conditions due to its tap root's ability to extract water from deeper in the soil profile than white clover.

Identifying physical features

Leaves

- trifoliate
- hairy particularly on the back of leaflets, petioles also hairy
- round to oval in shape but tend to be more oval than white clover
- leaflet veins much branched toward the edge
- stipules very obvious and attached to the stem for most of their length, noticeably veined
- typically a darker green than white clover but can vary from light to dark green depending on growing conditions
- a whitish 'v' mark on leaflets
- tend to be larger than white clover, around 15 – 40mm long

Growth habit

- forms distinct branching plants rather than spreading with stolons (Note: There are new cultivars that do spread to some extent)
- plant erect, sometimes approaching 1m in height

Flowers

- forms a large oval to rounded head of florets up to about 3cm in diameter
- pink to reddish purple florets turn brown after flowering
- pair of short leaves just below each head

Source: Lee Clift

Red clover flower heads change from oval to round in shape as the florets open as shown in the image above. Note the hairy stems, the leaves just below the flower head and the difference in size between white and red clover flowerheads. (See colour version of this image on attached colour pages)

Characteristics

Red clover typically persists for two to four years in pastures but may last up to seven years under favourable conditions. A new spreading variety, Broadway, has the potential to persist for longer because it has a more prostrate growth habit and horizontal stems that root when the nodes touch the soil. Rooting occurs mainly in autumn and only when the soil surface is moist.

Red clover grows well in summer, generally flowers later than white clover and conserves well as hay. It has poor winter growth. Cultivars are usually divided into early and late flowering types. Early flowering types have better early spring growth than late flowering types. Tetraploid varieties are also available with larger leaves, flowers and plants.

Red clover appears to be more tolerant of clover root weevil than white clover. It can however contain oestrogenic compounds that may reduce ewe fertility if used to flush ewes prior to mating. New varieties have been developed that are lower than some older varieties.

Subterranean clover – *Trifolium subterraneum*

Subterranean clover is an annual species. On drier sites (sunny hill faces, stony soils) most perennial legumes, with the exception of lucerne, are unproductive during dry summers and some may not survive summer drought (e.g. white clover). Annual clovers can survive from year to year as they set large amounts of seed before dying, ensuring a seedbank and rapid regeneration of seedlings with autumn rains.

Source: pastureinfo.massey.ac.nz

Identifying physical features

Leaves

- trifoliate
- hairy
- heart-shaped
- few leaflet veins and branched slightly toward edges
- stiplules broad, veined and pointed for half their length
- typically a darker green than white clover and often have small black spots
- some cultivars have distinct leaf marks

Growth habit

- grows from rosettes to produce long, horizontal stems
- seedheads bend down and the burrs are pushed into the soil surface after flowering

Flowers

- forms small head with around 3 – 6 florets
- whitish coloured florets

Source: informedfarmers.com

Characteristics

Subterranean clover is named for its ability to bury its seeds. The seed heads bend down and force the burrs (the seed case) into the soil. In this way the seeds survive the summer underground and germinate in autumn. It grows from rosettes to produce long, horizontal stems during late winter and spring, providing good quality feed at a time when other clovers are typically not performing well.

Subterranean clover has a lower optimum temperature for germination and growth (10-15ºC) than perennial legumes such as white clover (20-25ºC). It starts rapid growth at least a month earlier than lucerne, and white and Caucasian clovers.

The earliest flowering cultivars are suited to areas with low rainfall (<500 mm) while later flowering cultivars are adapted to higher rainfall (>700 mm). Moisture is required for ten weeks from the start of flowering for good seed yields. To maximise seed set grazing at flowering should be minimised. Careful management in autumn is also necessary to encourage seedling survival. Most seed available in New Zealand is imported from Australia.

Subspecies and varieties

Sub clover has been divided into three subspecies, each of which is best suited to particular soil and environmental conditions:

1. *Trifolium subterraneum* subsp. *subterraneum*, the most commonly used species (described above), does best on well-drained, slightly acid soils.
2. *Trifolium subterraneum* subsp. *yanninicum*, does well on poorly drained land and areas subject to intermittent waterlogging. The seed of T. yanninicum varieties is a characteristic cream to light brown colour. Unlike many T. subterraneum varieties, the plant is not hairy, and the calyx lobes (bracts at base of flower) are elongated.
3. *Trifolium subterraneum* subsp. *brachycalycinum*, the third subspecies. This type is best adapted to neutral to alkaline but will grow on mildly acidic soils. Unlike other sub clovers, *T. brachycalycinum* has little ability to bury its seed, but its long, twining peduncle (flower stalk) seeks out cracks in the soil and hides the burr in these.

The considerable variation within the three subspecies largely accounts for the wide distribution of sub clover. Hundreds of strains have been collected in Australia and overseas, but only a handful of these have been used commercially.

Strawberry clover – *Trifolium fragiferum*

Strawberry clover leaves and growth habit are much like white clover and they can be mistaken for each other in their vegetative state in pasture. The florets, however, are usually pinker than white clover florets and, as the seeds develop, the flower head takes on a strawberry-like appearance.

Identifying physical features

Leaves

- trifoliate
- hairless

- similar to white clover but more slender and pointed
- leaf veins meet the margin at an angle
- leaf surface between veins is smooth and velvety compared to undulating in white clover
- stipules scale like, hairless, small and pointed
- typically mid-green in colour but can vary from light to dark green depending on growing conditions
- doesn't usually have white mark on leaves

Source: pastureinfo.massey.ac.nz

Growth habit

- prostrate, branched, creeping stolons

Flowers

- similar to white clover in size and shape
- pink coloured florets
- head forms a strawberry-like appearance after flowering

Characteristics

Strawberry clover grows well on saline soils (soils with a high salt content) usually close to the sea or river estuaries. It is also more tolerant of wet and infertile soils than white clover. Of even greater importance for the future, strawberry clover has greater drought tolerance than white clover. As climate warms, the frequency and intensity of drought periods is likely to increase, requiring the need for a more drought tolerant clover species than white clover. Strawberry clover may meet this need. Although little emphasis has been placed on Strawberry clover by plant breeders in New Zealand to date, interest in the potential of this species is starting to develop.

Caucasian clover – *Trifolium ambiguum*

Caucasian clover originates from temperate areas in southern Russia, Romania, eastern Turkey, Iran and Iraq. It is slow to establish but, once established, it is persistent and can produce more dry matter than white clover.

Source: informedfarmers.com

Identifying physical features

Leaves

- trifoliate
- hairless
- oval but longer and more pointed than white clover (often twice as long)
- distinct whitish 'v' shaped mark on leaflets

- stipules membranous, pointed but not obvious
- blue-green

Growth habit

- more erect than white clover
- growing points emerge from the soil surface
- spread by creeping rhizomes, no stolons

Flowers

- heads typically larger than white clover (similar to red clover in size)
- pinkish coloured florets that turn brown after flowering

Characteristics

Caucasian clover produces a large perennial taproot (at least 1.4m deep in silt/clay loam). In contrast, the smaller white clover taproot dies at between 12 and 18 months, leaving only shallow roots that need frequent rain or irrigation to survive.

Rhizomes (underground stems) of Caucasian clover avoid and survive the high (40+°C) surface soil temperatures experienced on dryland farms in summer. Compared with white clover, Caucasian clover has greater drought and extreme temperature tolerances (hot and cold), survives in infertile soils and tolerates some insect and nematode pests and viruses better than white clover. It can also tolerate close grazing once established because the vegetative growing points of are underground.

Caucasian clover has a 20% faster leaf photosynthesis rate than white clover at all temperatures within the 7°C to 30°C range. Like all temperate perennial herbage legumes, Caucasian clover has an optimum temperature range for growth of 20-25°C. Caucasian clover has also shown a 20% faster leaf photosynthesis rate than white clover when water is freely available and over 30% faster rate when soil moisture content was only 50% of soil water holding capacity. This helps Caucasian clover produce more than white clover at all stages of water stress.

Caucasian clover requires a specific rhizobium strain to form effective nitrogen-fixing root nodules that are not present in New Zealand soils. Therefore, all seed must be freshly inoculated shortly before sowing with the correct strain of Caucasian clover rhizobia.

Caucasian clover has the same rapid rate of germination, emergence and primary shoot development seen in most clover species. However, the thermal time required to start production of the secondary growing points, which are required to rapidly produce a canopy of leaves, is much longer for Caucasian clover than perennial ryegrass or white clover.

For example, ryegrass begins tillering after 400°Cd. Degree day (°Cd) measurement is simply the amount of accumulated heat over time. The amount of 'heat' each day is calculated by adding together the daily minimum and maximum temperatures and dividing it by two and subtracting from this average temperature value the base temperature at which no growth occurs. White clover grows stolons after 430°Cd but Caucasian clover takes 1200°Cd for its first additional crown shoots and about 1600°Cd (most of a growing season) for secondary shoot production from rhizomes. For example, in a North Canterbury

climate, it would take about one to two months for white clover to grow stolons but about six months for Caucasian clover to grow crown shoots.
Because young plants are slow to develop secondary shoots Caucasian clover seedlings are poor competitors and do not produce enough leaves to compete for light against most other weed and sown species. Establishment practices need to take this into account. Spring sowing is essential, particularly in cool environments. A common saying about Caucasian clover is that "It sleeps in the first year, creeps in the second year and leaps in the third year".

Lotus – *Lotus uliginosus syn. L. pedunculatus*

Lotus uliginosus is also known by its former botanical name Lotus major. In New Zealand it is commonly called lotus. It is a perennial legume native to Europe, eastern Russia and northern Africa. It can be confused with Birdsfoot trefoil (see page 21) but is less erect in growth habit.

Identifying physical features


Source: en.wikipedia.org

Leaves
- trifoliate but may appear to have five leaflets at first glance - the two extra 'leaflets' at the petiole are actually leaf-like stipules
- range from almost hairless to obviously hairy
- oval, slightly pointed at tip
- few leaflet veins
- stipules leaf-like but smaller and more rounded than true leaflets
- typically mid-green in colour

Growth habit
- spreads by creeping rhizomes, no stolons
- many slender stems, which are often hollow
- stems not able to support their own weight, at first growing upright, then if not grazed, sprawling loosely on the ground in an interwoven mat

Flowers
- gorse-like yellow florets often tinged with red
- each flower head has 3-15 florets (usually 6-8)
- develop slender seedpods that look a little like a birdsfoot

Characteristics

Lotus has good tolerance of acidic and infertile soils and can cope with being waterlogged. It produces a tap-root and spread by rhizomes. Many of the stems are hollow, which assists oxygen transfer under waterlogged conditions. It is an ideal legume for areas not suited to white clover or other moderate to high fertility requiring clovers. It stores carbohydrate in its rhizomes in autumn for over-wintering so is useful in cold climates such as the South Island high country. It is often grown under trees in agroforestry in New Zealand because it tolerates shade and needle litter better than clovers.

The feed quality of lotus is similar to lucerne, but with the added advantage of condensed tannins. At low levels (lotus levels are typically 2 – 8%), tannins prevent bloat in ruminants while also protecting plant proteins from being degraded to ammonium in the rumen — enabling more protein to be absorbed in the small intestine.

Lotus prefers mild to warm conditions (optimum temperature for growth 24°C), so it makes little growth in winter, but can have reasonable autumn and spring production and good summer growth if moisture is available. It flowers in late spring to early summer, but requires a day length of more than 16 hours to flower profusely. Stand persistence relies to a large extent on regrowth from the rhizomes.

Rhizome development, shoot growth and long-term stand persistence are favoured by a lax form of rotational grazing, particularly during peak rhizome expansion in summer to early autumn. Grazing management must be lax (leave about 7 – 10cm stem and leaf) because recovery depends on secondary regrowth from lateral buds on the shoot stumps left behind after grazing.

Birdsfoot trefoil – *Lotus corniculatus*

Birdsfoot trefoil is a perennial legume native to the Mediterranean basin, Europe and parts of Eurasia and Africa.

Identifying physical features

Leaves

- trifoliate but may appear to have five leaflets at first glance - the two extra ‘leaflets’ at the petiole are actually leaf-like stipules
- range from almost hairless to obviously hairy
- oval, slightly pointed at tip
- stipules leaf-like but smaller and more rounded than true leaflets
- typically light to mid green in colour, usually paler than lotus maor

Growth habit

- erect growing (similar to lucerne), 0.3-0.6 m high with many slender stems
- has a tap root, no rhizomes or stolons
- initial stem development is from the crown with regrowth often from nodes

Source: www.msuturfweeds.net

Flowers

- gorse-like yellow florets often tinged with red
- can have from 1-10 (usually 4-6) yellow florets
- develop slender seedpods that look a little like a birdsfoot

As with lotus, birdsfoot trefoil is tolerant of acid and infertile soils but tends to be shorter lived than lotus. It is more like lucerne in its use and management but requires less fertiliser than lucerne to maintain good growth.

The rhizobia strain associated with birdsfoot trefoil does not persist in New Zealand soils so birdsfoot trefoil has not naturalised (as lotus has). It is usually sown as a special purpose legume pasture, similar to lucerne, in drought prone, infertile areas. As with lotus, birdsfoot trefoil contains condensed tannins and requires a lax grazing regime to ensure persistence.

Test Yourself # 1

1. Collect from the field and correctly identify two ryegrass species and three clover species.

2. Describe, in words, the relationship between perennial, Italian, annual, short rotation and long rotation ryegrasses.

3. Describe two differences between the leaves of *Lolium perenne* and *L. multiflorum*.

4. Describe two situations where growing annual ryegrass would be advantageous.

5. When describing legumes, what is:
   a) a petiole
   b) a node
   c) an inflorescence
   d) an internode
   e) a stipule

6. From the selection of legumes described in the section on common pasture legumes, what clover are you likely to have if the leaves are hairy with a 'v' marking and the plant has an upright growth habit with no stolons.

7. At what time of the year does subterranean clover typically perform better than white clover.

8. List three clovers that are more suited to dry summer conditions than white clover.

9. Describe the main physical differences between *Lotus uliginosus* and *L. corniculatus.*

Pasture Growth

Perennial grasses live for more than a single growing season and reproduce vegetatively, by tillering, as well as by seed. Most *annual* plants complete their growth cycle in one season and reproduce only by seed, however, common annual pasture grasses reproduce vegetatively as well as by seed. Most pasture grasses, and ryegrass in particular, have a low growing point that escapes damage from grazing animals. These two factors, vegetative reproduction and a low growing point, combine to produce an ideal growth form for grazing livestock year round.

Pasture grasses spread vegetatively by three main growth habits:

1. tufted (bunch or tussock-forming)
2. stoloniferous
3. rhizomatous

Tuft of ryegrass among clover

Source: Lee Clift

Tufted grasses, such as ryegrass, form tufts of grass that typically only spread a relatively short distance by vegetative means. In some cases tillers can become separated from the tuft, by hoof damage for instance, and grow new roots to form a new tuft away from the original plant. However, tufted grasses mainly spread by seed production.

A stolon, is a prostrate, above-ground stem that forms from the parent plant and develops nodes from which leaves and roots grow. If the new growth at the node becomes separated from the parent plant (i.e. the stolon is broken) it can survive to produce a new plant. Carpet grass (*Axonopus affinis*) has a stoloniferous growth habit.

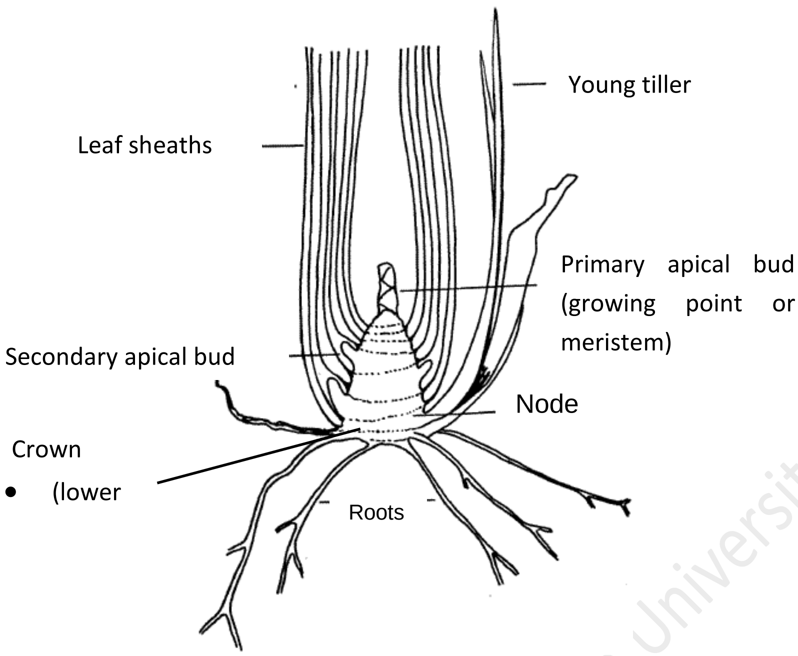
A rhizome is much the same as a stolon but it grows underground instead of on the surface. Kentucky bluegrass (*Poa pratensis*) and paspalum (*Paspalum dilatatum*) are rhizomatous grasses.

Both stoloniferous and rhizomatous plants can spread relatively large distances from the original parent plant. Kikuyu grass (*Pennisetum clandestinum*), Mercer grass (*Paspalum distichum*) and browntop (*Agrostis capillaris*) produce both stolons and rhizomes and can spread more quickly than ryegrass when conditions favour their growth.

All three types of growth are dependent on the development of tillers to capture sunlight for photosynthesis[2] to create plant nutrients. Tillers grow from apical buds between leaf sheaths (see Figure 5 next page) and develop their own root system. The lower nodes, internodes and dormant buds, together with related tillers, form the crown of the plant. In tufted grasses the tillers grow vertically from the crown, whereas with stoloniferous and rhizomatous grasses tillers grow out from nodes horizontally.

[2] Photosynthesis is the synthesis of complex organic material from carbon dioxide, water, inorganic salts, and light energy (from sunlight).

Figure 3: Cross section of the base of a ryegrass plant



Source: Adapted from www.fog.org.au/grasses_of_nsw

Stages of grass growth

There are three main stages of grass growth

1. vegetative – germination, leaf growth and tillering
2. reproductive – elongation, seedhead and seed formation
3. senescence

Given its importance to New Zealand agriculture, we will concentrate on examining how perennial ryegrass grows.

Vegetative stage

Germination

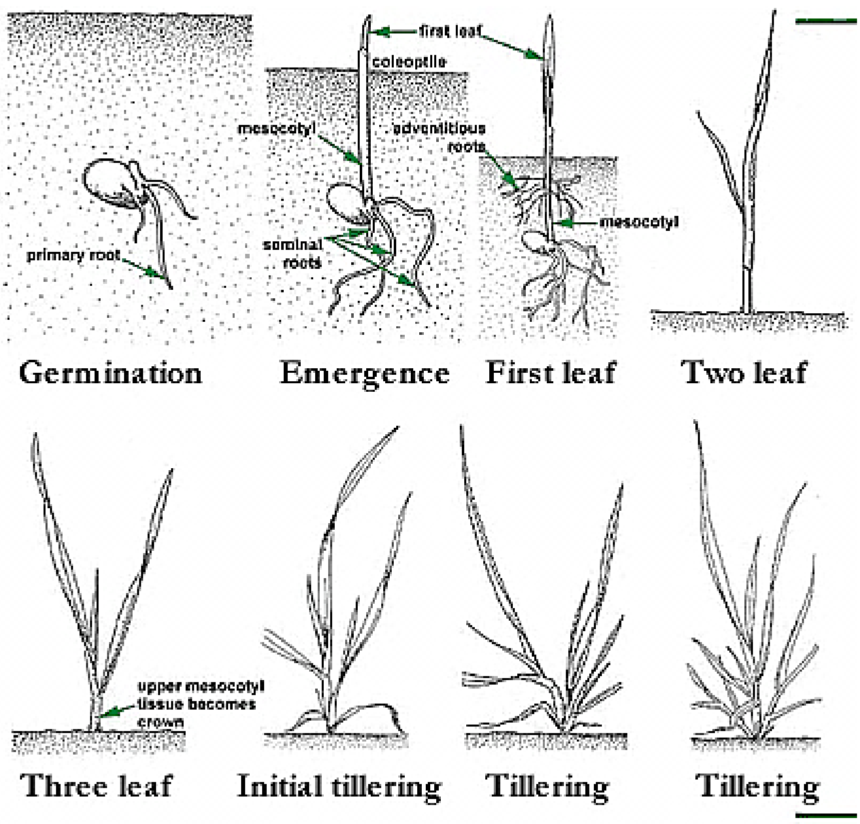
Ryegrass seeds are pale brown, flat, awnless (no spike at the tip) and are approximately 6mm long. For diploid varieties there are about 520,000seeds/kg. Tetraploid varieties have larger seeds with around 350,000seeds/kg.

After sowing and coming into contact with moisture, the seed begins to swell. After 3 to 5 days the root emerges from the end of the seed that was attached to the seed head, just before the emergence of the coleoptile (see Figure 6). After it has grown 5 – 10mm, the coleoptile splits at the top allowing the emergence of the first leaf.

Perennial ryegrass germinates reasonably easily over a wide range of temperatures and moisture conditions. Experiments have shown that it will germinate in temperatures ranging from 5 to 30°C. A study by G. M. Lodge (see Reference section) reported that maximum germination occurred under a regime of 12 hours at 30°C followed by 12 hours at 10°C.

Early growth rates of seedlings depend on seed reserves, which are indicated by seed weight; heavier seeds typically having greater seed reserves.

Figure 4: Vegetative stages of grass growth



Source: Oregon State University www.fsl.orst.edu/forages/projects/regrowth/print.cfm?PageID=32

Leaf growth and tillering

After the first leaf emerges, subsequent new leaves grow up encircled by the last one. The oldest leaf is always on the outside and the youngest expanding leaf in the centre. Leaves are made up of a blade and sheath (see Figure 1, page 5). Sheathes of older leaves can give the appearance of a stem but it is not the true stem. In grasses such as ryegrass the true stem is at the very base of the plant at ground level where grazing animals cannot damage it. It stays dormant until the plant enters the reproductive phase.

Each new leaf continues to grow from tissue at the base. Leaves can continue to grow rapidly even after the tips have been removed by grazing or cutting. Ryegrass plants produce three live leaves on the main shoot and each tiller. As each new leaf emerges the oldest one dies. When the tiller has three leaves it doesn't stop growing. A fourth (new) leaf is produced, and the first (oldest) leaf starts to die. Then a fifth leaf is produced, and so on. If the pasture isn't grazed, dead matter (of little feed value) builds up in the base of the pasture.

The rate of leaf appearance varies with the season. In mid-spring a new ryegrass leaf may appear every 5 days and in mid-winter it may take as long as 17 days. So in mid-spring each leaf lives about 15 days. A leaf produced in mid-winter will live about 50 days or until it is consumed or until temperatures start to rise in spring and leaf emergence speeds up resulting in death of the older leaf.

A tiller forms from a secondary apical bud (see Figure 5) and has its own apical meristem or growing point. Ryegrass plants begin tillering after 400°Cd (degree days). (Degree day (°Cd) measurement, as noted in the section on Caucasian Clover, is the amount of accumulated heat over time. The amount of 'heat' each day is calculated by adding together the daily minimum and maximum temperatures and dividing it by two and subtracting from this average temperature value the base temperature at which no growth occurs.)

Plants continue to produce tillers until they reach other plants. Once all the gaps between plants have been filled competition for resources such as soil nutrients and light reduce the rate of tiller development. Each tiller usually lives for about one year.

The size and density of tillers varies depending on management. A ryegrass pasture grazed infrequently e.g. rotational dairy system, may have about 5000 large tillers/m^2 but a pasture intensively grazed by sheep under set stocking may have twice as many. Although the structure of these two swards may be different the total dry matter production could be similar because plants at lower density tend to be larger than those at higher density so overall leaf mass could be the same.

Factors affecting leaf and tiller production
There are four main factors that affect leaf and tiller production:

1. Temperature
   Ryegrass normally grows between 5°C and 25°C. As the temperature increases toward 25°C, the rate of leaf appearance and leaf extension increases. Optimum growth for leaves and tillers is achieved between 20-25°C with night time temperatures equal or only slightly lower (typically November to January depending on region). At the same temperature, leaves grow faster in spring than in autumn. Sustained periods of higher temperatures (particularly over 30°C) eventually decrease growth rates.

2. Light
   Light is essential for providing energy through photosynthesis and enables the plant to grow. During short periods of poor light and reduced levels of photosynthesis, such as when leaves are shaded by other plants, the plant uses reserves stored in the leaves and base to buffer growth.

3. Water
   Plants need water to maintain strength and for the process of photosynthesis. Lack of water causes reduced growth rates and may cause wilting or even death. Water stress occurs when the evaporation of water through the leaves is faster than the rate of uptake from the soil. Leaf expansion is first restricted during day time hours when the evaporative demand is at its highest. During a dry period, plant cells continue to be formed, but they need water to expand. When rain finally arrives these cells expand quickly, so growth after drought appears to be relatively fast. In cases of too much water, death of plant roots can occur leading to leaf die back.

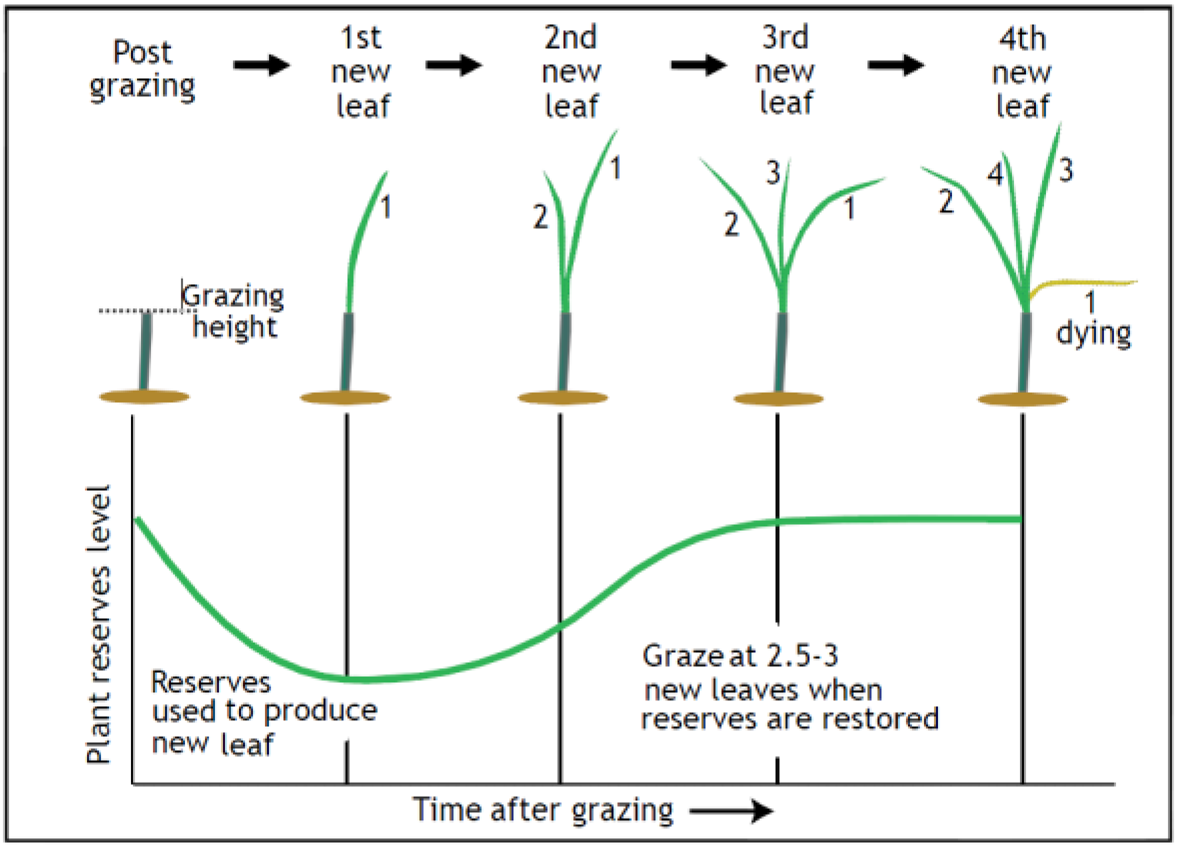
4. Nutrients

   Adequate amounts of plant-available nutrients need to be present in the soil to maximise grass growth. Nitrogen is often a limiting nutrient so inputs of nitrogen usually result in increased rates of leaf and tiller growth.

Grazing and vegetative growth

Understanding how ryegrass plants grow is essential for estimating the ideal grazing time and ensuring pasture persistence. Grass plants store energy as carbohydrate. This is used to initiate growth of new leaves after grazing. The new leaves then build up more reserves by photosynthesis.

Figure 5: Ryegrass growth and plant reserve levels



Source: www.agriseeds.co.nz

After grazing, grass growth is slow. A large amount of leaf area has been eaten therefore photosynthesis is low. It takes a long time to get a small amount of growth. Growth rate increases as the second and third leaf emerge because leaf area is increasing. With the emergence and expansion of the third leaf, maximum leaf area occurs ensuring that most of the sunlight is utilised for photosynthesis.

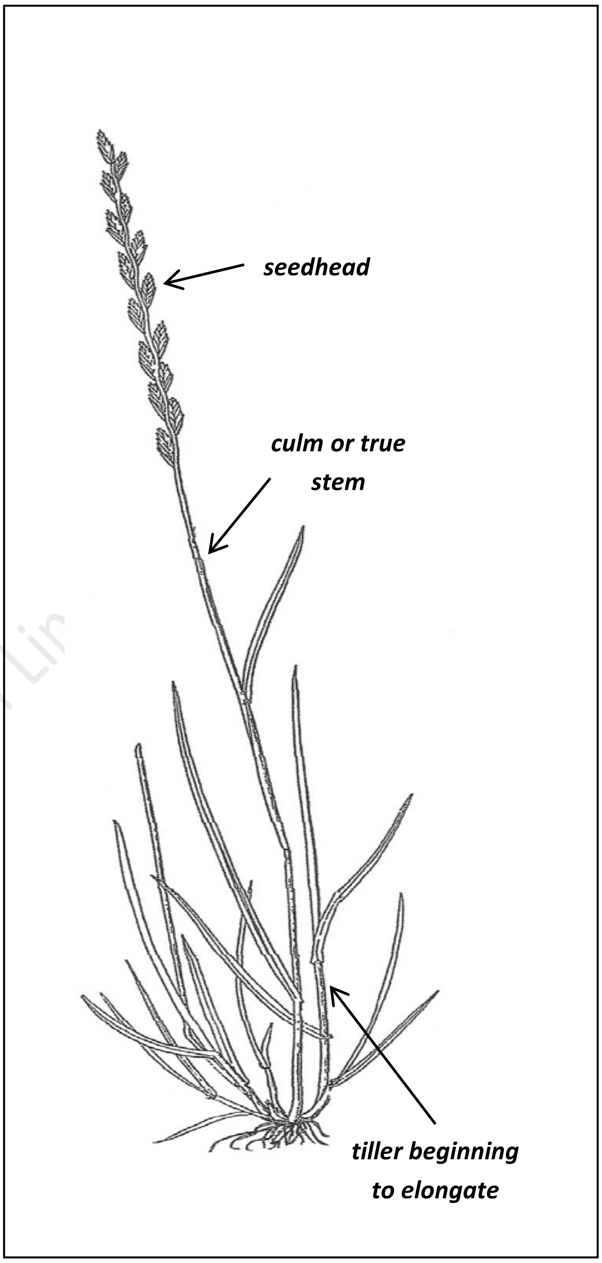
As the fourth and fifth leaves emerge the pasture starts to get longer and rank, shading of grass leaves and clover occurs and growth slows. The older leaves of the plant are dying, reducing feed quality.

Grazing should occur when tillers show an average of 2.5 – 3 tillers per plant (see Figure 7). At this stage many plants will have their third leaf (on some tillers it will be small, on others fully developed) and plant reserves will have recovered enough to graze.

Grazing before the second new leaf appears doesn't allow the plant reserves to be fully restored. Repeatedly grazing before the second leaf appears decreases yield and persistence. This is particularly important following drought, when plants are under stress. Grazing the first new growth after rain, before tillers have 2.5 new leaves, can kill plants.

Reproductive stage

Reproductive stage of grass plant



Elongation refers to the initial stages of reproduction when the tiller begins to produce a flower rather than a leaf. This process happens during late spring. Most grasses must experience winter conditions of low temperatures and short day lengths to trigger elongation and reproduction. Early flowering ryegrasses are sensitive to March/April temperatures and late heading varieties to April/May temperatures.

The node at the top, or apex, of the stem is the location of the shoot's apical meristem (see Figure 5), an area of new cell formation. The cells in this area can develop into either leaf buds or flower buds, depending on the stage of the shoot.

In late spring, a shoot within each tiller rapidly elongates at the upper internodes. The elongation becomes the true stem or culm. The lower internodes do not elongate and remain at the base of the plant.

Stems contain lignin for strength which is not easily digested by ruminants. The grass in the elongation or reproductive stage therefore has a lower feed value. A flower emerges from within the top leaf sheath. Pollination occurs and then seeds form and mature.

Once mature, seeds fall to the soil or are spread by the wind. Cattle and sheep can also disperse seed as seeds are capable of germination after passing through their digestive tracts. Sheep wool may also act as a method of dispersal as seeds get lodged in the fleece then fall out later usually at another location.

Senescence

Once a tiller has reproduced it dies. This does not mean the whole plant dies. Tillers that did not form a seedhead continue to produce leaves and the lower nodes continue to produce tillers. In this way ryegrass plants can continue to live for many years.

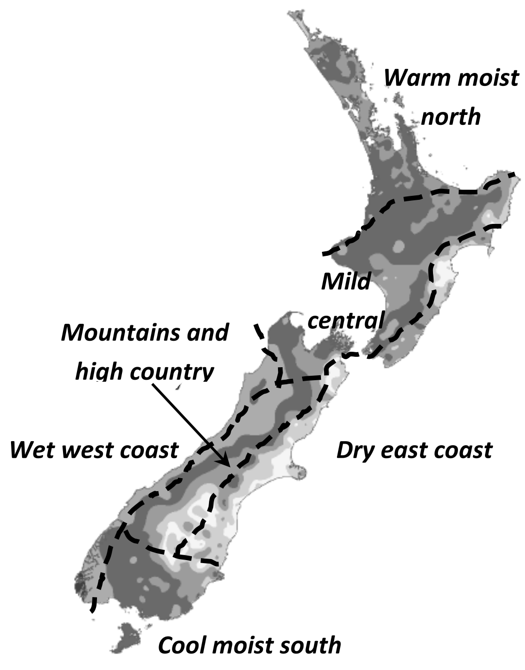
One of the main determinants of the quality of a pasture is the amount of dead material from dead leaves, stems and seedheads. Lignification (the development of the fibre lignin) increases as grass plants age and reproduce. When grass dies the lignin breaks down relatively slowly, particularly in cool conditions. Pasture grazing management that minimises the production of old leaves and reproductive tillers will help maintain good plant quality. We look at this in more detail in the section on pasture quality, page 48.

Seasonal and regional variations in pasture growth

Climate

New Zealand lies between latitudes 34º and 47º south and is considered to have a temperate climate, with warm summers and moderately cold winters. Warm oceanic currents and mountainous topography lead to distinct climate regions. The surrounding oceans help to prevent large temperature extremes of over much of the land but rainfall is reasonably plentiful because of oceanic evaporation and frequent depressions. The presence of the mountains, stretching from southwest to northeast, in the path of eastward moving air masses has a pronounced effect on regional climates, with differences in rainfall and temperature often greater east to west than north to south. The country can be roughly divided in six pasture growth regions. These regions are shown in Figure 8.

Figure 6: Pasture growth regions based on rainfall and temperature

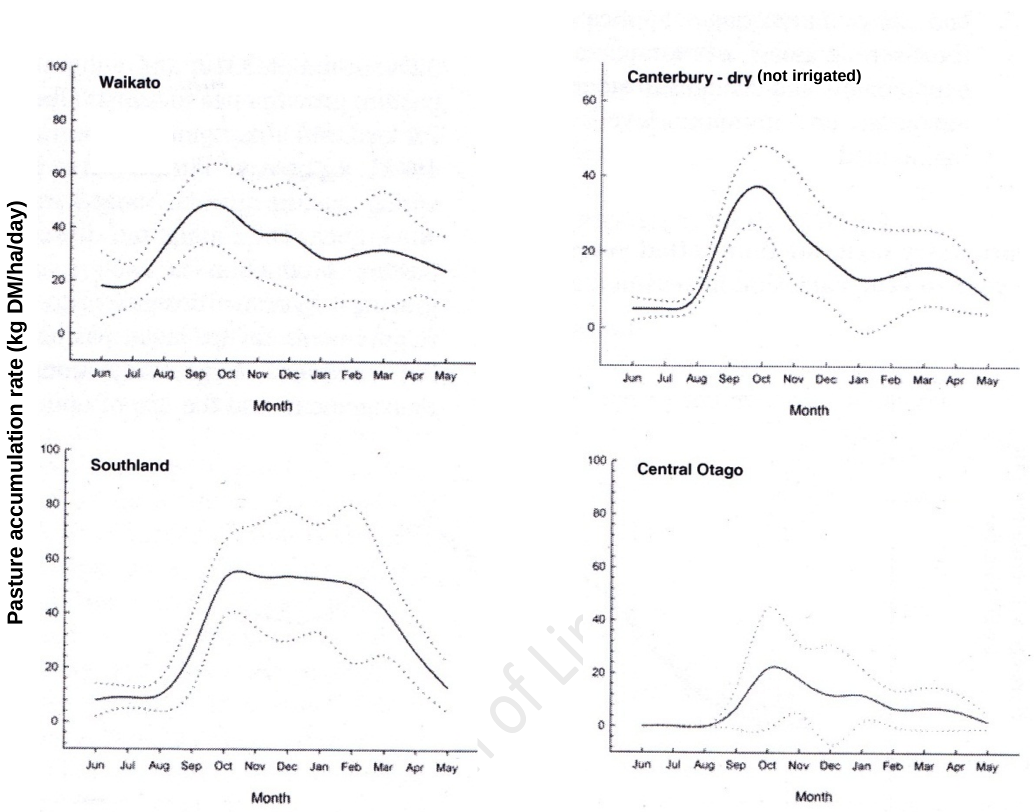


There is no clear cut boundary between regions however each region typically has similar seasonal variations in pasture growth and species grown.

Climate change and resulting changes in weather patterns are likely to alter pasture growth patterns in these regions over the coming decades. More severe droughts in areas that don't normally suffer much from droughts, unseasonal snow falls and increased high rainfall events may change pasture growth patterns in the future.

These differences in climate create differences in seasonal pasture production patterns some of which are illustrated by the following graphs.

Figure 7: Typical seasonal patterns of pasture production in Waikato, Canterbury (not irrigated), Southland and Central Otago, showing the daily pasture accumulation rates (kgDM/ha/d).



Note: Dark lines indicates the mean daily pasture accumulation rate. The pale dotted lines show the variation around the mean values.

Source: Adapted from 'Pasture and Supplements for Grazing Animals'

The four growth patterns above mainly reflect the regulating effects of temperature and moisture stress on radiation driven plant growth. From the graphs, it is obvious that, in general, a farm in Southland is naturally able to produce more pasture over a year than a dryland farm in Canterbury. Canterbury farmers may be able to boost their production by artificial means such as irrigation but without irrigation they have to accept that the natural upper limits of pasture production are inherently lower than their Southland counterparts due largely to climatic factors.

There are three main climate factors that affect pasture growth:

- solar radiation
- temperature
- rainfall

Solar radiation

Solar radiation, through photosynthesis, provides the material and energy to build new pasture growth. The amount of radiation (light), on a weekly basis, varies little from year to year with the supply of energy highest in late December and lowest in late June. However, even in late June, chemical analysis of plant tissues indicate that low radiation does not appear to limit growth as there are almost always high levels of sugars from photosynthesis present in leave and stems. It is likely that low temperatures limit conversion of this sugar into new growth during winter, not lack of light.

Temperature

Temperature regulates the rate of metabolic processes. Temperature:

- directly affects the ability of plants to convert sugars into growth
- indirectly affects growth by changing the rate that soil micro-organisms make nutrients and nitrogen in particular available for plant uptake (mineralisation)

In most cases little can be done to alter temperature so farmers need to manage their pastures within the limits set by the local temperature patterns. Providing shade (trees or artificial materials) is one of the few ways that farmers can have any direct influence over temperature.

However, differences in pasture growth do occur as a result of different pasture species responses to temperature. Grasses generally have greater pasture growth than clovers during winter. Pasture production generally declines over summer at higher temperatures due to reduced grass growth although this can also be due to lack of moisture.

Ryegrass has an optimum growing temperature of near 18ºC, clovers 20-25 ºC and tropical grasses, like paspalum and kikuyu, nearer 30 ºC. Annual ryegrass usually grows better in winter and early spring than perennial ryegrass. Prairie grass also has good winter growth. Subterranean clover has a lower optimum temperature and better winter growth than white clover. These are just some of the species differences that can be exploited by farmers to match pasture species to temperature patterns.

Temperature also indirectly affects the pattern of grass growth and, to a lesser extent, clover growth by affecting nitrogen availability. In cold humid climates such as Southland, soil organisms are inactive over winter allowing nitrogen-rich material (dead clover roots and uneaten leaves) to accumulate. When soil temperatures rise above 6 ºC in spring, microbial activity increases and these organic materials are broken down, releasing nitrogen and creating a surge of pasture growth.

This effect is illustrated in Figure 9. Compare the steep slope of the pasture curves around August/September for Southland compared to the gentler slope for the Waikato. In the warmer, more humid climate of the Waikato, where microbial activity and mineralisation continue during winter, there is a more gradual increase in spring growth. In general, the colder the winter, whether from seasonal effects, greater altitude or higher latitude, the lower the winter growth rates and the greater the spring ‘flush’ of growth.

Rainfall

Rainfall and its effects on soil moisture can be a major limitation to pasture growth in many areas of New Zealand. Many regions experience soil moisture deficits (where evaporation is greater than rainfall) during summer and often into early autumn. Summer dry periods tend to be longer and more severe in eastern regions such as Hawkes Bay, Canterbury and Otago. Lack of soil moisture has a significant effect on pasture growth and if severe can cause plant death. Although too much water can also result in plant death this is less of a problem for most parts of the country other than perhaps Westland.

These general trends may however be changing as global climate changes. In recent years areas such as the Waikato that are not normally badly affected by moisture deficits over summer have suffered severe drought with consequent poor (or no) pasture growth. Northland has swung from excessive moisture to drought, both having a major effect on pasture production.

Lack of rainfall can be overcome where irrigation is an option. The ability to apply sufficient quantities of water to overcome plant stress enables farmers to artificially maintain pasture growth. Although irrigation can significantly improve annual pasture production there are issues with water availability and taking of water from rivers and aquifers that need to be addressed to ensure the sustainability of irrigation practices. In the long term, learning to farm without irrigation, by planting appropriate pasture species and using a low farm input system, may be more sustainable.

Each farm also has its own microclimate, which can either exacerbate or improve the macroclimate of the location. Features such as hill ranges, forests (either native or plantation), lakes and the sea can influence the local climate. For example, proximity to the sea tends to reduce extremes of temperature, including the incidence of frosts, whereas proximity to large forested areas may result in a higher rainfall relative to a region in general.

Source: Lee Clift

The differences in microclimate within a farm also need to be taken into account. For example a large farm with, say, the eastern end bordering the sea and the western end rising inland to a height of 250m is likely to have a range of microclimates that influence plant growth. Another example would be a hill country farm with some flats (relatively cool but damp on the valley floor) and north (warm but dry) and south (cold but damper) hill slopes.

Soil

Another factor that varies between farms and regions is soil type. Soils vary in their chemical, biological and physical properties. These all influence the pasture species that grow and their rate of growth.

Maps showing the main soil types and their distribution are shown on the attached additional colour pages and are also available on line at www.mfe.govt.nz . Detailed information on each soil type or order is available on the Land Care website soils.landcareresearch.co.nz .
New Zealand soils are naturally acidic with low levels of nitrogen, phosphorus, and sulphur. Many, particularly in higher rainfall areas, are also low in potassium (K). Consequently, to grow ryegrass dominant pastures (derived from European soils and climates) New Zealand soils need to be developed and maintained with nitrogen-fixing plants (such as clover), fertilisers and, often, lime to sustain high-yield plant growth.

In general, North Island soils are strongly influenced by volcanic ash, with many areas naturally low in minerals such as magnesium, copper, iron, cobalt, and boron. In the South Island, most arable soils come from parent material carried down from mountains and foothills by rivers and wind, aided by glacial action. Mineral deficiencies in South Island soils follow rainfall patterns – in general, the wetter the area, the greater the potential for minerals to be leached out.

Soil type and climate interact to affect pasture production. For example, areas of the Bay of Plenty may have similar climate but one may have pumice soils and the other recent soils which have different fertility and physical characteristics, hence pasture growth rates. Conversely, some areas have similar soils but a different climate resulting in different pasture growth rates. For example, areas of Northland and Westland have similar podzol soils but different climates resulting in quite different pasture species and growth rates.

Table 3 shows the fifteen soil orders that cover New Zealand. Soil types are classified using the NZ Soil Classification introduced in 1992 to replace the older NZ Genetic Soil Classification.

Table 3: New Zealand's 15 soil orders and their predominant land uses

Soil order	Region of New Zealand	% cover	Predominant land use
Allophanic	Central North Island	5	Pastoral farming, cropping, and horticulture
Anthropic	Central Ōtago, Westland	<1	Modified soils – extensive in urban areas and areas that have been mined
Brown	East Taranaki, Wanganui–Rangitīkei, east coast of North Island, Wellington, Marlborough, Nelson–Buller, Southland, and South Island high country	43	Intensive pastoral farming and forestry
Gley	Wetlands – low parts of the landscape prone to water logging	3	High-producing dairy farms (with drainage systems)
Granular	Northland, South Auckland, Waikato, and some areas in Wanganui	1	Pastoral farming, cropping, and forestry; horticulture in some areas
Melanic	Lowland plains on east coast of South Island (some in Northland)	1	Pastoral farming, mixed cropping, and market gardening
Organic	Lowlands of Waikato and Bay of Plenty wetlands	1	Vegetable growing and horticulture
Oxidic	Northland, Banks Peninsula, and Ōtago Peninsula	<1	Pastoral farming, forestry, and native bush

Pallic	East coast of North Island and Manawatū	12	Pastoral farming and mixed cropping
Podzols	Northland and Westland	13	Agriculture and forestry
Pumice	Central North Island, Hawke's Bay, and Bay of Plenty	7	Pastoral farming, forestry, and native bush
Raw	Central North Island, Hawke's Bay, and Bay of Plenty	3	Pastoral farming, forestry, and native bush
Recent (alluvial and coastal)	All districts (floodplains, lower terraces of rivers, and coastal areas)	6	Alluvial: dairy farming, arable crops, market gardening, horticulture, and sports fields Coastal: pastoral and exotic forestry
Semi-arid	Central Ōtago	1	Pastoral farming, pipfruit, tussock land, and mountains
Ultic	Northland/Auckland	3	Urban, pastoral farming, and native vegetation

One of the main differences between soil and climate effects on pasture growth is that soils can be modified through fertiliser application, drainage, physical intervention (e.g. cultivating) and biological means (e.g. introducing earthworms and spreading compost to improve organic matter levels). The use of these modifications has enabled farmers throughout New Zealand to successfully grow ryegrass/clover pastures even though the unmodified soils may not have supported this type of pasture. Whether these modifications are sustainable is debatable and farmers may need to look at using a more diverse range of pasture species or varieties to maintain pasture production with less reliance on modifying soil characteristics.

Understanding the macroclimate, microclimate, and soil type of the land being farmed provides a better understanding of pasture production limitations and potential. It enables farmers to customise their animal systems and management to match their pasture systems. Tables in the Appendix list average pasture production for various locations in New Zealand that reflect the climate and, to a lesser extent, soil type of the region.

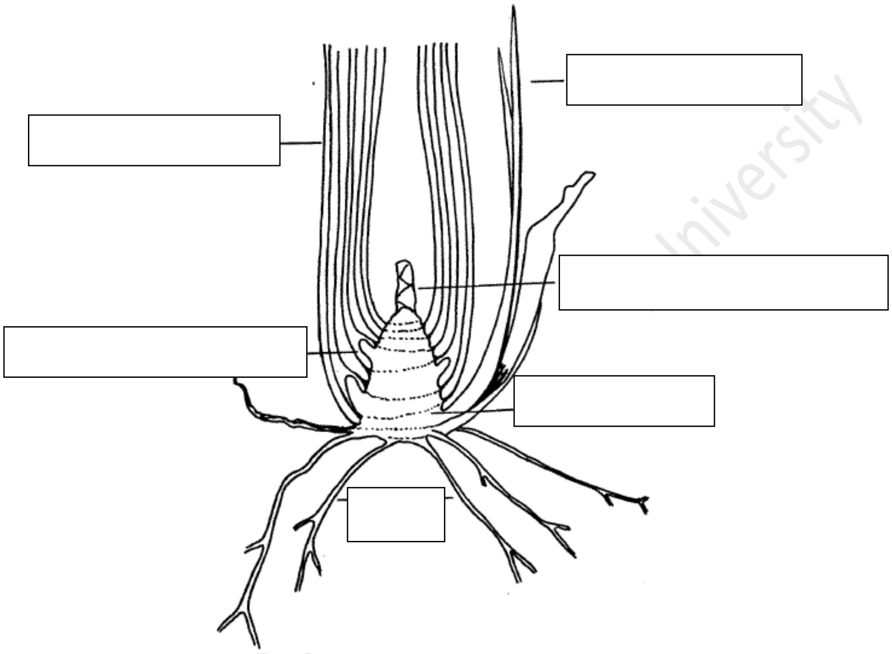
Test Yourself #2

1. Explain what a ryegrass tiller is and its role in terms of plant growth and reproduction.

2. Describe the way in which leaves grow on a ryegrass plant.

3. How long do ryegrass leaves live for?

4. Label the grass parts indicated by the empty boxes in the following diagram.



5. At what leaf stage is it best to graze ryegrass? Explain why.

6. Describe three ways in which ryegrass seed can spread naturally.

7. Explain the reason for the rapid increase in the rate of pasture growth in spring in cool climates such as Southland.

8. Describe how climate would influence what clover species you would grow in your region.

9. Name the main soil order(s) in your region and briefly describe its characteristics. Explain what modification the soil would need to make it suitable to successfully grow perennial ryegrass/white clover pasture. [The following websites may be of help to answer this question: www.mfe.govt.nz/publications/ser/enz07-dec07/html/chapter9-land/page1.html#figure92 and soils.landcareresearch.co.nz .]

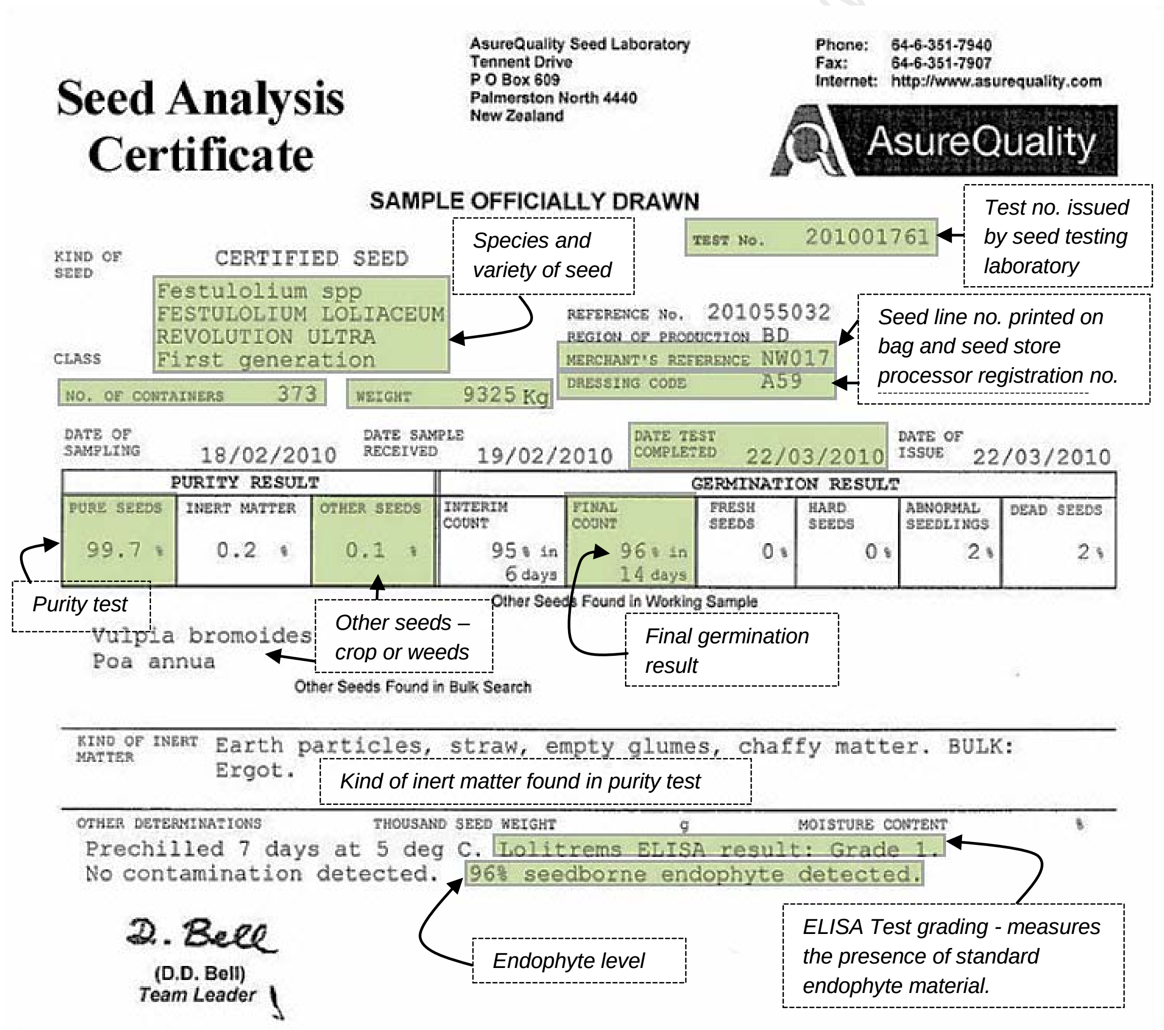
Pasture establishment processes

Good pasture establishment techniques lead to good pasture persistence. With spring sowing, the aim is to get big, healthy ryegrass and clover plants established before dry conditions potentially take hold in summer. If autumn is also dry then good establishment technique becomes even more critical.

Use quality seed

Once you have decided on the most appropriate species to sow, the next step is to purchase good quality seed. Buying Certified Seed is recommended. This is seed produced under the NZ Seed Certification scheme run by AssureQuality that guarantees that you are buying the cultivar stated and it has minimal contamination of other seeds, including weeds. The seed should have no contamination from noxious weeds. Major seed retailers stock certified seed. An example of a seed certificate is shown below.

Figure 8: Example of a seed certificate



Source: Figure adapted from www.cropmark.co.nz

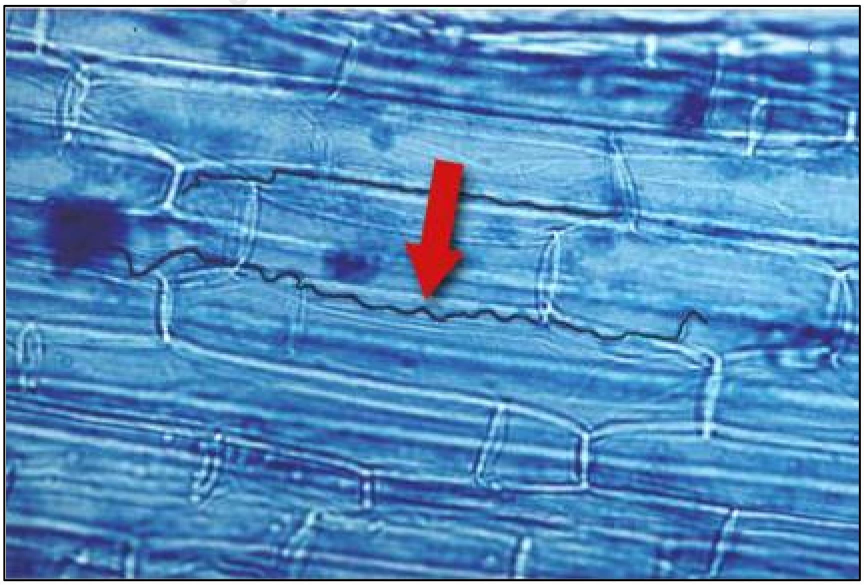
Germination, purity and endophyte information should be available, on request, to check seed quality. The germination should be 90% or greater, seed purity 99% or greater and perennial ryegrass with endophyte should have 70% or greater endophyte. Endophyte level declines over time, so it is best not to sow seed that is left-over from last year’s sowing. Use seed harvested in the year of sowing for best endophyte viability.

Ideally buy seed that has been treated (coated) with fungicides and/or insecticides. This gives seeds and seedlings some protection during the germination and emergence phase against pests such as Argentine stem weevil, black beetle and grass grub and various fungi. Note that endophyte in ryegrass seed is not active against insects during the first few weeks after germination, so the use of treated seed is essential in insect-prone areas. Clover seed can be treated with a systemic nematicide (chemicals that control nematodes), nitrogen-fixing rhizobia and even trace elements. This can improve establishment, nodulation and root growth.

Tetraploid cultivars require higher seeding rates (kg/ha) than diploid cultivars because their seeds are larger and heavier. Always check the seed weight before working out suitable seeding rates as species and cultivars do vary.

Endophyte selection

Most perennial ryegrass plants in New Zealand pastures contain a fungus called endophyte that grows inside the plant and protects it from insect attack but can also cause animal health problems. New or “novel” endophytes have been selected to reduce animal health problems associated with ryegrass infected with the old “wild” endophyte (ryegrass staggers and overheating), while maintaining positive protective features. Few varieties are now available with the old wild (also called Standard or High) endophyte.



Arrow points to endophyte growing between the cells of a leaf.

Source: www.aboutrtf.com/endophyte_leaf.html

When used appropriately novel endophytes can improve animal performance and improve grass yield and persistence.

Choosing the right endophyte for your area will determine pasture persistence and animal productivity (e.g. AR1, AR37, Endo5 and NEA2). In areas with cooler summers and good rainfall or irrigation, cultivars without endophyte, or with low levels of standard endophyte can be used (Westland, Southland, parts of Otago and some irrigated land in Canterbury). Such pastures are not usually under significant stress from insect attack. However, endophyte-infected cultivars are needed for all of the North Island.

'Novel' endophytes vary in their level of plant protection and animal health risks.

- Ryegrass with AR1 endophyte
    - Provides a safer pasture (than 'old' endophyte) with low animal health risks while providing a moderate range of insect protection. Care is needed in areas with high black beetle numbers (northern North Island) as AR1 only gives moderate resistance to this pest.
- Ryegrass with Endo5 endophyte
    - Endo5 pastures (as with AR1) contain no Lolitrem B, the main cause of ryegrass staggers, but provide good control of adult black beetle, Argentine stem weevil and pasture mealy bug. Endo5 pastures should persist better than AR1 pastures in areas with black beetle.
- Ryegrass with NEA2 endophyte
    - Thought to provide insect protection similar to Endo5.
- Ryegrass with AR37 endophyte
    - Provides greater insect control than any other commercially available endophyte, providing protection against Argentine stem weevil, pasture mealy bug, root aphid and adult black beetle. Has excellent low risk of ryegrass staggers.

Endophyte is a living organism, and has a limited life span in stored seed. Therefore pastures sown from old or poorly stored seed may have reduced endophyte levels. Alternatively, seed can be bought without endophyte, for use in areas where there is little or no pest pressure on pastures.

Methods of establishing pastures

The four main methods for establishing pasture are:

1. Oversowing existing pasture
2. Undersowing into existing pasture
3. Spray and direct drilling – pasture to pasture
4. Full cultivation – pasture to pasture, and pasture to crop to pasture

Timing of pasture establishment is important to its success. In warmer winter regions sow seed just before or at the start of autumn rain. Sowing early, as a general rule by mid-April in the North Island, and by the end of March in the South Island, prevents cold temperatures slowing establishment speed. Slow establishment results in a late first grazing and plant size (which is critical for future persistence) will suffer. In colder winter regions, sow seed in the spring.

Oversowing existing pasture

Many hill country areas are too steep or rough to cultivate or direct drill so broadcasting or oversowing seed is the only option to introduce improved pasture species and varieties. In most cases white and subterranean clovers are oversown to improve pasture quality directly and to improve general pasture production by fixing nitrogen (which becomes available to other pasture plants when clovers die and decompose).

Areas to be oversown need to subdivided to enable the use of high stocking rates (at least 200 stock units per hectare – SU/ha). Subdivided areas should be of similar aspect, steepness and altitude to minimise stock camping and fertility transfer.

Oversown areas also need to have adequate fertility, especially phosphate, to successfully establish and grow oversown clover. If phosphate levels are inadequate low fertility species such as browntop will soon out-compete the newly established clover plants.

Advantages	Disadvantages
• Relatively simple	• Only a short term solution
• Minimal loss of production from existing pasture	• Not successful if existing pastures are dense
• Improved pasture quality if clovers oversown	• Need appropriate subdivision which may be expensive
• Pasture plant density increased	• Need relatively high soil phosphate levels for successful clover establishment and persistence
	• Less opportunity to correct soil problems compared to full cultivation methods

Before seeding, aim to remove most of the resident vegetation to increase the chances of sown seeds reaching the soil surface where they can establish. To do this, paddocks should be grazed with sheep or cattle at 200+ stock units/ha for two to four days on a regular basis. Immediately before oversowing further treading with up to 900 ewes/ha four at least four hours will open up existing cover. Ideally this should be done after rain. In some cases a light herbicide application of glyphosate type herbicide can supress existing pasture species without killing them but give new seedlings time to establish without too much competition.

In areas being oversown from recently cleared virgin native species, tussock, or into paddocks sown in maize for 10 years or more then legume seed should be inoculated with appropriate nitrogen-fixing rhizobia. Inoculated seed may also be needed for areas that have had a continued low presence of clover for many years with resultant low levels of soil rhizobia. Otherwise recent research suggests that inoculating clover seed is not likely to improve clover establishment. Rhizobia are now widespread throughout New Zealand and existing soil rhizobia are likely to be better suited to the local conditions than any introduced strains.

Coating clover seed for pest protection (insecticide/nematicide), disease protection (fungicide) and increased availability of nutrients, such as lime and molybdenum, is still advisable to help improve chances of successful establishment.

Undersowing into existing pasture

Undersowing is a no-till, i.e. no cultivation, method of pasture renewal. It involves direct drilling seed into existing pasture without applying herbicide. Undersowing provides a short-term solution to improving pasture production under certain situations.

Before undersowing, hard graze the existing pasture and drill into the thin (open) pasture. Direct drills use a coulter, disc or chisel to cut a slot in the soil where the seed is deposited and the slot then closes naturally, to some extent, to cover the seed. Rollers or chain harrows can then be used to ensure good seed coverage and consolidate the soil.

Advantages	Disadvantages
• Simple, with little preparation required • Minimal loss of production from existing pasture • Winter and spring growth increased if using annual or Italian ryegrass cultivars • Pasture plant density increased	• Only a short term solution • Not successful if existing pastures are dense • Less opportunity to correct soil problems compared to full cultivation methods • May reduce clover content • Annuals & Italian ryegrasses will not persist long, may attract insects (as most do not contain an endophyte) and result in open weedy pastures once they have died out

Soil tests will indicate what fertilisers may be needed and these can be applied at the same time that seed is drilled (not directly in contact with the seed but next to it). Lack of moisture is the most important factor determining whether fertiliser will damage germinating seeds. In dry conditions sowing should be delayed until sufficient rain falls or if it is not possible to wait, application rates should be reduced and, ammonium based fertilisers should be switched to Superphosphate based materials.

Seed and fertiliser contact can be reduced by using drills that place seed and fertiliser apart or by broadcasting fertiliser. To avoid damage to germinating seeds use very low rates of nitrogen fertiliser in direct drills, e.g. below 15kgN/ha (and not as urea) with new pasture.

In general, small seed are more predisposed to germination damage from fertiliser than large seeds, and clover seeds are typically more susceptible than ryegrass seeds. Fertilisers that contain, or quickly generate, ammonium nitrogen can be particularly damaging to germinating seeds. Germination risk increases with increasing fertiliser application rate.

After seedlings emerge, graze lightly and frequently to minimise shading of new seedlings by existing plants. Do not pug the pasture in winter to prevent damage to new plants.

Spray and direct drilling – pasture to pasture

Spraying and direct drilling is a no-till method of pasture renewal. Pastures dominated by unsown and undesirable grasses (such as paspalum, Yorkshire fog, browntop, Kikuyu and wild fescue) or weeds are sprayed with an appropriate herbicide (usually a glyphosate based herbicide such as Roundup) before seed of desirable pasture species are direct drilled.

Spraying eliminates competition between new seedlings and established plants, resulting in improved seedling growth and survival. For summer-dry farms best results are achieved by spraying in the autumn. For South Island farms under irrigation and farms that are not under moisture stress, new pasture can be sown in spring or autumn. Spring is often the preferred time as paddocks can be renovated when there is surplus feed so animal production is not compromised.

Advantages	Disadvantages
• Good control of competition through herbicide	• Less opportunity to correct soil problems compared to full cultivation method
• Less time until first grazing compared to full cultivation or sowing after a crop	• Pasture may not persist if soil problems were the initial cause of poor persistence
• Better soil moisture retention than full cultivation	• Perennial weeds could return quickly
• Reduced potential for erosion compared to full cultivation	

Preparing for successful direct drilling with herbicide (no tillage)

Hard graze the paddock to about 3.5cm to remove excess plant material. After one to two weeks or up to 5-6 cm plant growth, spray the paddock with glyphosate type herbicide following recommended spraying rates. Allowing some regrowth means the plants are actively growing and readily take up the herbicide.

Graze the pasture between three to seven days after spraying (depending on glyphosate formulation) before the pasture browns off. One spray may be sufficient for a good kill but the presence of hard to kill perennial weeds, for instance Californian thistle, Kikuyu, dock, browntop, Poa pratensis, may mean the existing pasture requires more than one spray.

For good Kikuyu control, Kikuyu pastures can be mechanically mulched to remove stolons and produce a leafy pasture before spraying in autumn. After mulching, the pasture should not be grazed, particularly by cattle or cows, until after glyphosate herbicide has been applied to ensure no Kikuyu is covered by dung (and misses being sprayed).

Drilling

Ryegrass should be sown *no deeper* than 2cm using appropriate equipment. The seed should be covered using a press wheel on the drill or by dragging a chain or brush harrow. For good clover establishment *do not* drill clover seed in the same rows and at the same depth as ryegrass seed, as this reduces clover establishment because ryegrass will always out-compete the white clover. This means you need to purchase clover seed separate to ryegrass rather than buying a mix of clovers and grasses.

***Direct drilling a sprayed paddock*.**

Source: www.nzffa.org.nz

One method of establishment is to use a direct drill with a separate box on the front that can sow the clover in front of the drills sowing the ryegrass. A bar or brush harrow can be used to cover the clover seed. Cross drilling at half the desired seeding rate each way may appear to give the best result but may be less economic than a single pass at the full rate. Cross drilling gives faster canopy development, resulting in less weed pressure.

It is recommended using drills with 10 or 7.5 cm drill spacing (rather than the traditional 15 cm spacing). This gives better ground coverage by ryegrass and better long-term weed control.

Common seeding rates are:

- 16-25 kg/ha ryegrass
- 3-4 kg/ha white clover
- 3-4 kg chicory – optional
- 3-4 kg/ha red clover – optional

The above rates are dependent on:

- a good, firm seedbed
- seed being drilled evenly (tractor speed slow)
- a drill with good depth control
- adequate moisture after sowing

With excellent seedbed preparation it is suggested that rates as low as 10 kg ryegrass/ha are adequate. Using higher than recommended seeding rates typically results in many weak plants that don't compete well and die during the first summer, particularly if it is drier than normal.

With attention to detail, excellent seedbed preparation and good sowing technique (not too deep, not sown too fast) the cost of establishment can be considerably less as a lower seeding rate can be used.

Slugs are a major cause of pasture renewal failure when spray/drilling because the decaying vegetation is a perfect habitat for slugs. Monitor slug numbers by putting wet sacks out overnight. If, in the morning, there are six or more slugs in or under each sack seek advice on slug bait control. If in doubt apply slug bait.

Full cultivation – pasture to pasture, and pasture to crop to pasture

Full cultivation is typically more expensive than direct drilling but may be necessary where there is a major problem with the current pasture species, weed infestation or wanting to establish a new endophyte. Growing at least one crop between cultivation of old pasture and sowing of new pasture will allow time to control persistent weeds and high pest infestations. Difficult to control grass species such as Kikuyu may require 18 months of cropping before establishing permanent ryegrass and clover pastures.

Full cultivation for perennial pasture – *pasture to pasture*

Advantages	Disadvantages
• Better establishment of clovers than direct drilling	• Slower to first grazing than direct drilling
• Improved weed control compared to direct drilling, particularly undersowing	• Release of carbon from soil
• Paddock can be levelled, contoured, and/or have drains or reticulated irrigation installed before sowing	• Potentially poorer soil moisture retention
• Lime can be incorporated to reduce soil pH to improve nutrient release for plant uptake	• Potential risk of soil erosion from wind and water
• Reduces soil compaction	• Poorer weed and pest control than full cultivation and growing a crop before resowing

Full cultivation for perennial pasture – *crop to pasture*

Advantages	Disadvantages
• Best option to establish new cultivars if done well	• Expensive if crop grown prior to sowing pasture yields poorly
• Reduces soil and plant pests	• Requires good planning to fit crop and pasture renewal into farm system without compromising animal production
• Best weed control	• Crop and, then pasture establishment requires good planning, timing of operations and attention to detail
	• Release of carbon from soil
	• Potentially poorer soil moisture retention
	• Potenial risk of soil erosion from wind and water

Preparing for successful drilling with herbicide and cultivation

Where full cultivation is required three main steps are required for good weed- and pest-free establishment of pastures:

1. spraying
2. cultivating (tilling)
3. sowing

Spraying

Spray the old pasture in autumn with a glyphosate based herbicide before sowing a winter ryegrass. This is a more effective at killing perennial weeds than spraying in spring.

In spring, in regions with mild climates, a second glyphosate spray is applied in preparation for a summer crop. In cooler South Island climates a second glyphosate spray is applied and the new pasture sown. Alternatively, the paddock could be cropped through to the following spring before the new pasture is sown. In mild climate regions, the autumn after the summer crop a third and final glyphosate spray is applied to ensure all unwanted persistent plant species, such as Kikuyu, are completely killed and the new pasture is sown.

Between spraying and cultivating, graze heavily to speed up death and decomposition of the old pasture.

Cultivating

Cultivation or tillage involves ploughing or rotovating, discing, harrowing, rolling or some combination of these methods.

Tillage can be 'minimal' or 'full'. With minimal tillage the pasture is broken up with disc harrows or grubber. It may look uneven and lumpy before drilling. The drill acts as a further cultivation before a final light harrowing and rolling. Full tillage involves ploughing or rotovating, followed by other cultivation methods to form a fine, smooth seedbed.

Note: The term 'cultivation' can mean tillage or the entire process of growing a crop. Tillage refers to the tilling or physical breaking up of soil in preparation for sowing seeds or planting plants.

A fine, firm, warm, moist and clod-free seedbed will provide new pasture seeds with the best opportunity for long-term establishment. However, in very dry seasons or regions, or where soil erosion from wind or water is likely then minimum tillage or direct drilling may be more successful methods of establishing new pasture. Breaking up soil results in moisture loss during dry conditions and directly exposes soil particles to wind and rain resulting in soil movement and removal to waterways and other areas

Rolling to consolidate seedbed

Source: www.bentaitcontracting.co.nz

It is important to roll the seedbed before and after sowing. This consolidates the seedbed and helps conserve soil moisture around the seed. A rule of thumb is that if you walk on your seedbed and your boot prints sink 1 cm or more into the soil, it's not firm enough.

Incorporating lime into the soil at cultivation is typically beneficial, particularly if you are likely to use high rates of nitrogen fertiliser once pasture is established and have a low soil pH. If applying urea, 1.5 kg lime is required to be applied annually per kg urea to adjust for soil acidification from the urea. For example if you apply 400 kg urea/ha/year (184 kgN/ha), you will need to apply 600 kg lime/ha/year to maintain the original pH of the soil. If using DAP, apply twice this rate, i.e. 3.0 kg lime per kg DAP/annum. Other types of fertiliser are usually incorporated when drilling seed.

Drilling

Seed drilling requirements are the same as noted in the section on drilling after spraying (page 42).

Managing newly established pastures

Renewing pastures costs money and you need to protect your investment by managing the new pasture to maximise the potential production of the pasture.

Spray weeds post emergence. Weed problems are much worse in dry autumns. Ryegrass and clover establish more slowly, but some weeds germinate and grow with almost no moisture. Monitor newly sown paddocks closely, and spray appropriate herbicides as recommended, while weeds are still small.

Apply nitrogen (rate depends on soil tests but typically 25 – 50kg/ha) two to four weeks after seedling emergence to stimulate growth (tillering) as nitrogen fixed by clover will not contribute to soil nitrogen status for over 12 months.

The first grazing is the most critical. New pasture should be grazed as soon as plants snap off and don't pull out of the ground when plucked by hand. This promotes tillering and growth. If you delay this grazing, you can slow establishment and reduce overall yield. Aim to nip off the top 2 – 3 cm of the new plants.

To prolong the life of your pasture:

- Use adequate fertiliser, especially nitrogen considering the extra production from the new pasture. It takes 12-18 months for nitrogen from clover to become available.
- Do not allow new pastures to become pugged as this will harm or destroy new plants.
- Do not overgraze the pasture during its first summer. Instead use supplements or alternative grazing to leave adequate residuals.
- Do not cut for silage or hay in the first spring after sowing.

Test Yourself #3

1. Describe two situations which would require pasture to be established by oversowing.

2. Describe the benefits of using ryegrass infected with novel endophytes.

3. Provide examples of situations where you would each of the following methods of pasture establishment:
   a) Oversowing existing pasture
   b) Undersowing into existing pasture
   c) Spray and direct drilling – pasture to pasture
   d) Full cultivation – crop to pasture

4. Explain why it is important to use good quality seed when establishing pastures.

5. Describe the role of herbicide when establishing pasture.

Pasture quality and palatability

Farmers are recognising more than ever that pasture quality is as important as pasture quantity when trying to achieve animal liveweight targets. A high quality pasture at a specific mass will typically result in better animal performance than a poor quality pasture of the same mass. Understanding what pasture quality is and how it changes with the seasons allows management decisions to be made to help grow high quality pastures.

What is pasture quality?

Pasture quality is a measure of the nutritive value of a pasture. One of the main measures of nutritive value is metabolisable energy (ME). The unit of measurement used is MJME/kgDM. High quality usually refers to pasture and forage species with an ME of at least 11 MJME/kgDM. In pastoral systems energy is usually the limiting factor of production. The energy available for ruminants depends on the energy value of feed and the rumen digestion rate. The rumen digestion rate depends on the levels of protein, soluble carbohydrate and fibre content of the pasture.

Crude protein (CP) percentage is the unit of measurement of protein in forage. Most pasture plants contain between 12 to 25% CP. Rumen microbes need a minimum of 9 – 12% CP to function effectively. They breakdown plant proteins to yield amino acids which are either incorporated into microbial protein or degraded further to ammonia which is also used to synthesise microbial protein or is absorbed into the ruminants blood and excreted as urea in the urine. The dead rumen microbes that flow into the small intestine are the main source of protein for a ruminant.

Rumen outflow is normally 13-14% protein. A high-energy, easily digested diet with adequate buffering (not too acid) allows more microbial protein to flow out of the rumen and therefore more protein available to the animal. Increasing the amount of protein entering the small intestine can improve muscle growth and overall growth rates of young ruminants. Milk, which is high in energy and protein, is the ideal food for young growing ruminants as the milk bypasses the rumen and the protein stays intact. Tannin-containing forages like lotus can be useful bypass proteins for weaned and older animals but can have flavour issues when condensed tannin levels are high. Rapidly digested, high ME forages like clover, rape and chicory are the feeds most likely to give a protein response in New Zealand finishing systems. In general, protein is less likely to limit production than energy intake.

Plants with too much protein (25 – 30%) at low to moderate energy levels (6 – 9 MJME/kgDM) can have a negative effect on growth rates as energy is required to excrete urea making less available for growth. High protein levels can also cause high rumen acidity (because microbes can't use all the protein) resulting in acidosis, which, if severe, can lead to death.

Soluble carbohydrates or sugars in plants are quickly digested by ruminants making room for more feed and potentially higher energy intake. They may also increase protein absorption as rapid movement of plant material through the gut allows less time for microbes to breakdown the protein. For plants with the same total carbohydrate levels, indicated by a similar ME, those with lower soluble carbohydrates are likely to have lower digestibility because more carbohydrate is made up of harder to digest cell wall materials (cellulose and hemicellulose).

Ruminants must also eat enough fibre for the rumen to work effectively. Fibre refers to cellulose, hemicellulose and lignin that make up the cell walls of plants. It is slow to digest. Ruminants need to stop grazing, regularly sit down and chew their cud (ruminate) to help break down plant material into smaller pieces and to produce saliva. The saliva acts as the buffer in the rumen to balance the acid produced during rumen fermentation. The fibre causes the rumen to move and shift the contents around during rumination and digestion.

Source: Lee Clift

Grazing animals generally select a diet of higher quality than the average of the pasture offered. This is because grazing animals prefer not to eat dead material. In addition dead material is usually found at the base of a pasture so it is less accessible. The diet selected often contains a disproportionately high amount of clover (when compared to a botanical dissection of the pasture). This is partly due to the generally horizontal orientation of clover leaves, their position near the top of the canopy in grazed pastures and to some extent, their preference by livestock. There is some evidence that when clover is lower in the canopy that clover is not preferentially grazed indicating that accessibility is as important as palatability in determining animal intake of plants.

When animals graze a pasture faster than it is growing, their diet quality declines as higher quality components are removed and potential for selection becomes less over time. This reduction in diet quality is coupled with lowered intake due to the lower diet digestibility once the leafy parts have been eaten. Intake is often further reduced due to lowered overall pasture mass, resulting in lowered animal performance.

In summary, pasture quality is mainly a function of its metabolisable energy levels but is also affected by the proportions of crude protein, soluble carbohydrates and fibre. The better the quality the faster the feed is digested and the more the animal can eat. Low quality feed, such as hay, moves through the animal more slowly, restricting intake. In general, clover is considered to be a higher quality feed than ryegrass as indicated by the values in Table 4.

Table 4: Average feed values of perennial ryegrass and white clover*

	Metabolisable energy (MJME/kgDM)	Crude protein (%)	Soluble carbohydrates (%)	Fibre[3] (NDF %)
Perennial ryegrass	11.0	15	9	49
White clover	11.5	27	12	26

These values are annual averages and can vary significantly depending on plant growth stage and weather.

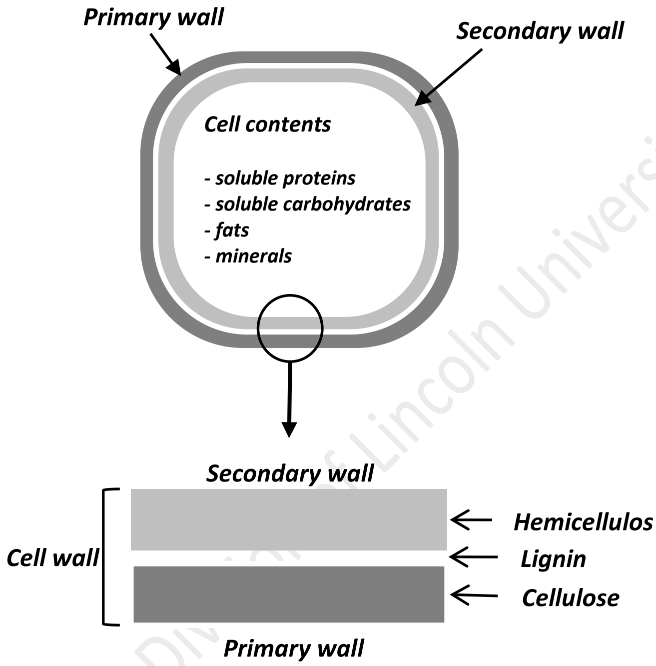
Source: Lincoln Farm Technical Manual

[3] Neutral detergent fibre (NDF) analysis is the way in which fibre is measured.

What is pasture palatability?

Palatability is the preference an animal has for a particular pasture plant or plant part. It is affected by texture, aroma, succulence, hairiness, leaf percentage, fertilisation, sugar content and other unidentified factors. Animals have their favourite foods in the same way that humans do. If you have ready access to a food you like you tend to eat more of it – ruminants are no exception to this rule.

Forage plants have three basic components: water, cell contents (including soluble carbohydrates, soluble proteins and minerals) and structural components of cell walls (fibre i.e. cellulose, hemicellulose and lignin as illustrated in the diagram below). The cell wall components are less palatable and livestock tend to choose younger plants (with less overall fibre) or plant parts with lower fibre (e.g. leaves).



In general, ryegrass and clover is more palatable to animals when young, tender and leafy. As leaves age and as flowering stems develop and mature, they become less palatable. Aging of clover does not reduce its palatability as significantly as that of ryegrass. Chicory leaf is very palatable to most livestock and anecdotal evidence suggests it will even be eaten when muddy or trampled where other species would normally be refused. Tetraploid varieties of ryegrass are often more palatable than diploid varieties.

Most animals find plants near dung deposits unpalatable, first because of the smell and later because the plants have had time to mature so are less palatable. Pasture sprayed with urine is less likely to be avoided because urine is quickly volatilised (vaporized) or leached.

The size and shape of an animal's muzzle influences the degree to which they are able to select preferred components. For example, animals with narrow muzzles (lambs) are more selective than those with wide muzzles (cows).

Palatable pastures typically have the same characteristics as high quality pastures.

Seasonal variations in pasture quality and palatability

Seasonal variations in pasture quality and palatability relate mainly to pasture changes in response to day length (photo-period) and temperature.

Spring

As soil and ambient (air) temperatures rise in early spring, plants grow quickly producing high quality, palatable leaf with a relatively low proportion of dead material and stem. Warmer ambient temperatures increase the rate at which plants convert sugars to growth and warmer soils increase soil mineralisation (the rate at which microbes make minerals available for plant uptake). In cold climates, such as Southland, mineralisation of dead material that has not decayed over winter provides an additional boost to readily available plant nutrients. If animals are able to graze pasture to maintain ryegrass at the 2.5 – 3 leaf stage quality will remain high.

As the pasture ages the quality of pasture decreases because both the cell wall:cell contents ratio and the degree of lignification in green plant tissue increase. The decline in quality with tissue age is minor in clover leaves, significant in grass leaves, and greatest in stem tissue. Quality decline continues through to death.

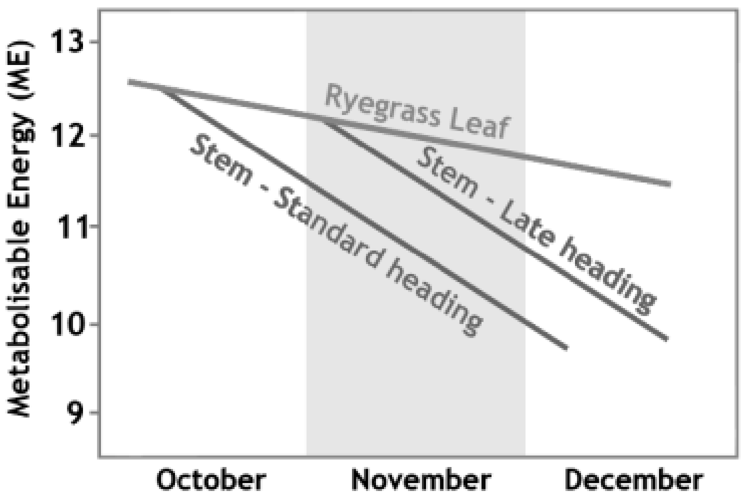
As spring progresses plants begin to initiate flowering. Most temperate grasses such as ryegrass require a short-day/long-night photoperiod with low temperatures during late autumn and early winter to produce reproductive (seedhead) tiller buds that will emerge in late spring. This process is called vernalisation. Perennial ryegrass requires a cold treatment of at least 12 weeks4 followed by a few long days of 14 hours or more5 to induce flowering. When these conditions are met, reproductive tillers elongate and the plant produces seedheads, typically from mid to late October onwards for ryegrass. Warmer than normal ambient temperatures can bring forward flowering or cooler temperatures may delay it.

Grass species vary in their vernalisation and day length requirements to initiate seedhead production. In all cases however, this leads to a drop in quality due to an increased proportion of stem in the pasture. The nutritive value of the stem is generally lower than that of the leaf in green material (e.g. 10.5 versus 11.5 MJME/kg DM) at the same age because more lignin and a more orderly cell structure lowers digestibility. So by late spring pasture quality will be declining due to seedhead development. Reducing the decline in quality can be achieved by using various management tools discussed on page 58.

Ryegrass leaf quality shows significantly less decline than the decline in stem quality, as illustrated in the following graph. The overall decline in quality for late flowering varieties of ryegrass (e.g. Bealey) is delayed compared to ‘standard’ varieties (e.g. Nui).

[4] Source: *A Terminal Flower1-Like Gene from Perennial Ryegrass Involved in Floral Transition and Axillary Meristem Identity.* Christian S. Jensen, Klaus Salchert and Klaus K. Nielsen, 2001

[5] Source: *Controlled Flowering Fact Sheet.* Dr Igor Kardailsky, Novemeber, 2010. AgResearch.



Source: Agriseeds

Summer

Summer pasture can be the lowest quality pasture. This is because many grasses have flowered but their seedheads and stems still remain in the pasture, either standing or accumulating as dead material (quality of dead material is < 8 MJME/kg DM). The exception to this is pastures with a high proportion of clover.

The quality of ryegrass and other temperate grasses drops with increasing temperatures over around 12°C. This is caused by an increase in the cell wall:content ratio, increased lignification of the cell wall and decreased leaf:stem ratio. At a temperature of 18°C grass leaf declines in quality at about 0.03 MJME/kgDM/day and for stem at about 0.06 MJME/kgDM/day[6]. So a particular mass of leafy ryegrass dominated pasture at 12°C will be of higher nutritive value than the same pasture grown at 18°C. This needs to be balanced by the fact that optimum ryegrass growth, in terms of mass, occurs between 15 - 20°C.

The optimum temperature for clover growth is 20 – 25°C. Leaf becomes plentiful in summer and clover starts to flower from about mid-summer through to early autumn. Although this results in an increased proportion of clover stem and seedhead the quality of these is still significantly higher than for grass stem and seedhead. Furthermore, grass stem and seedhead will accumulate in the base of the sward even after it has died, whereas clover decomposes quickly leaving little residue so does not add significantly to the dead component of the pasture.

Severe drought, which typically occurs in summer through to autumn, decreases pasture quality by increasing the quantity of dead plant tissue and decreasing the legume content in pastures. The invasion of low quality weeds after drought also lowers pasture quality.

Autumn

Grass quality starts to pick up in early autumn as temperatures drop and daughter tillers start to produce leaves. However clover growth drops off as ambient temperatures fall below 20°C. Combined with a build-up of dead seedhead and stems in the base of the sward, pasture quality drops overall. Lower light levels as

[6] *A practitioner's guide to pasture quality*. M.G. Lambert and A. J. Litherland.

autumn progresses leads to increased shading of grass tiller bases and increased die off of leaves adding to the reduction in quality.

Winter

Green leaf of ryegrass is of reasonable quality over winter but there may be die off at the base due to low light levels. Dead material is a major contributor to reduced quality over winter. Clover growth is also poor in winter, and can be negligible in colder regions, adding to lower pasture quality. Once ambient temperatures fall below 12ºC, as in winter for much of New Zealand, the rate of decline in quality is negligible in leafy pasture.

Rams eating green, leafy, high quality spring pasture

Source: Lee Clift

In summary, the features of a high quality and palatable pasture include:

- high green leaf content - green material has higher quality and palatability than dead material or stem
- high clover, other legume and herb[7] content – clover, legumes and some herbs have higher quality and palatability than grass
- low stem and dead matter – stem and dead matter are low in quality and not favoured by livestock
- young, recently grown herbage – quality declines with age; decline is slow for clover leaf; decline is significant for grass leaf; decline is even faster for stem
- herbage grown in cooler (e.g. late autumn/winter/early spring) compared to hot conditions (e.g. summer/early autumn) - decline in quality with age is faster at warmer temperatures; quality is lower overall at warm temperatures (mainly due to the predominance of grass over clover in most pastures)
- grazing animals have the opportunity to select a high quality diet i.e. pasture species, structure and allowance enables high intake

[7] Improved chicory and plantain varieties in particular – not all herbs are high in quality.

Methods for determining pasture quality

Pasture quality refers to the nutritive value of a pasture. Measuring the nutritive value can be done by direct laboratory assessment of pasture or by indirect visual assessment.

Q-Graze

Q-Graze is a computer package developed by the AgResearch AgSystems group under contract to Meat New Zealand. It is based on 'typical' ryegrass and white clover pastures. Q-Graze works by:

- estimating pasture metabolisable energy (ME) per kilogram of dry matter from visual assessments of pasture quality and mean maximum daily temperature readings
- predicting the intake of dry matter and ME from pasture botanical components, pasture ME and pasture dry matter yield
- estimating pasture intake using grazing factors such as diet selection, bite size, bite rate, time of grazing, chewing and rumination
- estimating the drive to eat using animal factors such as breed, gender, and hybrid vigour
- calculating liveweight gain from ME intake using energy requirements for maintenance, grazing and growth or liveweight loss

The first and most important step is to visually assess the quality and quantity of a pasture. Visual assessments can be verified by measuring pasture samples to give confidence that visual assessments are accurate. Over time farmers can develop very good visual estimate skills but measuring assessments, particularly during unusual seasons, will confirm estimates remain accurate. Quality measurement methods are explained on page 56.

Q-Graze requires four visual assessments of pastures. They are:

1. pasture dry matter yield, in kg DM/ha to ground level
2. dead matter, as a % of the total dry weight
   total dry weight = dead + clover and herbs + green grass leaf + seedhead and weeds
3. clover and herbs, as a % of the green dry weight
   green dry weight = clover and herbs + green grass leaf + seedhead and weeds
4. green grass leaf, as a % of the rest
   the rest = green grass leaf + seedhead and weeds

The final fraction (seedhead and weeds) is calculated as the remainder.

The most effective time to assess quality is in summer when it may significantly affect feed energy levels and animal intake.

To make a visual assessment a representative area of the paddock about 25 m^2 (5m x 5m) is chosen. In hill country or where pastures are very variable more than one area may need to be assessed. Avoid gateways, troughs and camps. Look over the area, getting down and parting the pasture to see into the base where necessary, and assess the dry matter yield, dead matter, clover and green grass percentage of the sward. Shadows on the pasture may alter your perceptions so look at the area from more than one angle.

Field assessments are recorded and transferred to the computer programme. The more accurate your assessments the more accurate the predictions made by the Q-Graze model. It is suggested by the developers of the programme that visual dry matter estimates should be within 200kgDM/ha and pasture components to within 5% of calibrated samples for best results.

The following information is entered into the Q-Graze programme once assessments have been completed.

- pasture mass
- grazing area
- rate of pasture growth
- average daily daytime maximum temperature
- dead matter %
- type of dead matter (old or dead due to dry conditions)
- clover and herb %
- green grass leaf %
- stock class including gender categories for sheep and cattle
- dam breed
- sire breed
- number of animals in the mob
- average liveweight of the mob in kg at the start of the grazing period
- grazing duration (the number of days you anticipate the animals being in the paddock)

Once this information has been entered the programme is run and a report is produced showing the following information:

- pasture dry matter yield present at the start of each day's grazing
- residual pasture, i.e. pasture that is left at the end of each day's grazing
- pasture metabolisable energy (MJME/kg DM)
- intake of dry matter in kilograms per animal
- diet ME, i.e. the metabolisable energy (MJME/kg DM) of the animals diet
- liveweight gain in kilograms per day
- average liveweight gain

Graphs can also be produced to show changes in pasture mass and composition, pasture and diet metabolisable energy, and liveweight gain over time.

Q-Graze can be used as a decision making tool by changing the input values to see what would happen to your pastures and livestock. This is particularly useful when drought or other adverse events are predicted. For example information could be inputted to answer the following questions.

- What aspects of pasture quality should I focus on at a particular time of year to improve animal performance?
- What is the impact on animal performance of increasing dead matter content in summer?
- What is the impact on animal performance of grazing to low residuals in spring with pastures with little dead matter, and summer pastures with high dead matter contents?

- What is the fastest rate I can expect animals to grow given the type of pastures I have on farm in summer?

More information about Q-Graze can be found in the Q-Graze Manual which can be downloaded from www.meatnz.co.nz .

Objective pasture quality measurements

Whether you use visual pasture quality assessments to input into Q-Graze or to help refine feed budgets it is important to calibrate visual assessments against measured samples.

When measuring pasture quality the sites chosen need to represent the range of pasture types that will be measured. At least five sites are needed, ranging from low to high pasture dry matter yield. If the pasture types vary greatly, such as old Browntop versus Italian ryegrass, separate measurements will be needed for each pasture.

Pasture sampling

To collect a pasture sample representative of a paddock, walk across a representative part (e.g. 100 m diagonal) of the paddock. Every second or third step, stop and cut three small samples of the pasture to ground level (one adjacent to each foot and then a sample midway between each foot). You could use scissors, clippers, electric hand piece or even sharpened spoon. You need at least 30 samples to estimate metabolisable energy to 0.5 MJME/kgDM. This sampling method can be used for assessing dry matter percentage and botanical composition or for sampling for laboratory feed quality analysis.

Following the instructions above, the sample collected in the paddock will be relatively large. This is needed to account for variation within the paddock.

- Samples for laboratory feed analysis (near infrared – NIR) should be greater than 100 g – about half a bread bag.
- For dry matter percentage determination, about 100 g is an ideal size.
- About 20 g is needed for dissections, although this may be less for fine-leaved pastures such as those that have been set stocked.

Pasture composition by dissection

To calibrate your visual quality assessment, the cut pasture sample is dissected into dead material, green clover and herbs, green grass leaf and seedhead and weeds before drying and weighing. Thorough mixing and accurate sub-sampling (taking of smaller samples from the original sample) is needed to get accurate results from laboratory or pasture dissection analysis.

First thoroughly mix the sample on a flat surface then, on the flat surface, divide the sample into quarters. Discard two diagonally opposing quarters, remix and repeat the process until about 20 g remains. Take small portions of the sub-sample and dissect fully before taking another small portion. This means you can stop part-way through the dissection if you have over-estimated the sample size.

Dissect using tweezers into the various components. Remove all dead matter (strip from sheath, remove part leaves) and put this into the dead component. Once the sample has been dissected into the various plant groupings it can sent to a laboratory for analysis or dried and weighed to calculate the percentage composition to compare it with your visual assessments.

Activity: Choose a paddock and do a visual quality assessment to estimate the percentages each pasture component. To see how accurate your visual assessment is, collect a pasture sample from the paddock (as described above) and complete a pasture composition dissection.

Drying and weighing

All visual assessments are on a dry matter basis, so fresh samples must be dried before working relative proportions of pasture components.

- It is essential that you weigh the fresh sample before drying. This is necessary to calculate the dry matter percentage.
- Using a standard oven, dry the sample at 80ºC for a minimum of 12 hours. More than one sample can be dried at once as long as each sample is well labelled and separated from other samples.
- Samples dried before NIR analysis should only be dried at 60ºC for 24 hours.
- Weigh dried samples as soon as they are removed from the oven because they will start to absorb moisture immediately.
- Dry matter dissection samples should be weighed to 0.01 g accuracy (i.e. two decimal places) ideally using digital scales.

Once you know the percentage of plant species and components of a pasture you can use published tables of metabolisable energy to estimate the quality of your pasture or for a more accurate assessment you can send samples for laboratory analysis.

Preparing pasture for laboratory feed quality analysis

Laboratory measurements that indicate the nutritive value of pasture include metabolisable energy (ME), digestibility, fibre and protein. Pasture samples are collected as explained above. Samples should be greater than 100g.

Cooling pasture samples soon after collection is important because respiration continues after the grass has been cut using up the carbohydrate (sugars) in the pasture. If samples can't be kept cool they should be microwaved as soon as possible for one minute on high in a paper bag or open dish to stop respiration. The pasture should be steaming immediately after removal from the microwave. The sample should be cool and dry (avoid collecting wet grass) when packaged in a zip-locked plastic bag for immediate mailing to the laboratory.

Reports of nutritive value of pasture will be supplied by the laboratory and can be used to check against your visual assessments.

Strategies used to manage pasture quality

Green, leafy pasture with high clover content provides the best quality for most livestock requirements so managing pastures to maximise green leaf of preferred plant species is the main aim when managing pasture quality. A balance needs to be met between managing pastures to maintain good quality and ensuring stock consume the required quantity of good quality feed to meet growth rate and weight targets. The value of some classes of stock, typically cattle, is their ability to help control pasture quality and growth for other higher value stock classes.

Grazing Management

Grazing ryegrass at the 2.5 to 3 leaf stage maximises ryegrass's potential for growth. However once the grass stem starts to elongate grazing at the 2 leaf stage helps to put more pressure on the plant and removes emerging seedheads before they fully develop. Grazing rotation length needs to be sped up to maintain residuals of about 1500 – 1600kgDM on dairy farms. If residuals start to lift above this, other options such as closing up paddocks for hay or silage need to be considered.

Pasture conservation

Shutting up paddocks for silage and/or hay is a simple way of reducing available grazing and increasing stocking rates on remaining pasture. It also enables feed to be conserved for times of feed deficit.

Grass silage in particular helps to control pastures over a time when growth rates normally exceed livestock requirements for many farms. Paddocks are shut up early in spring and can be cut for silage just before or as seedheads emerge resulting in good quality silage and leafy, good quality pasture regrowth with few seedheads.

For the best quality hay, pastures should ideally be cut before significant numbers of grass seedheads have emerged. However, in many parts of New Zealand weather conditions often prevent this as a longer period of warm, dry weather is required to make hay compared to silage making. However, shutting up pastures for hay still allows stocking rates on remaining paddocks to be increased, helping to retain the quality of these pastures. The warmer summer temperatures favour clover over ryegrass so pastures cut for hay often become dominated by clover during the regrowth phase providing good quality pasture for weaned lambs and calves.

Conserving pasture not only allows better control of pasture in spring but allows you to carry more stock through winter, when pasture deficits generally occur, resulting in more mouths to control pasture growth next spring.

In some cases on hill country where pasture conservation and cropping are not feasible it may be necessary to shut paddocks up and accept that these will become rank. Where possible don't shut up paddocks on steep land. Land with moderate contours is likely to be easier to clean up later on and produce a better growth response.

Stocking rate

Generally the lower the stocking rate the harder it is to control the pasture because growth rates exceed the amount animals can eat. Stocking rate can be increased by removing paddocks from grazing for cropping, conservation or pasture renewal, by purchasing additional livestock or leasing land out for grazing.

Adjusting birthing dates

Adjusting birthing dates may create a better match between feed requirements and feed supply. Young stock won't contribute greatly to grazing pressure until they are four to five weeks old. Ewes and cows often lose weight in early lactation even when pasture is plentiful due to rumen intake limitations so it is not until young stock start to graze that grazing pressure increases. Calculating expected feed requirements and pasture growth is essential to working out the optimum birth date.

Renewing pastures

New pastures typically have less dead material and higher clover content than the pastures they replace, hence higher quality. For a more long term approach, renewing pastures with improved ryegrass cultivars can improve the quality of pasture over time. Varieties with the right endophyte type for your area, use of tetraploid verses diploid types, early, medium or late heading date and the amount of aftermath heading can all help improve the quality of pasture.

Low aftermath heading ryegrass varieties can improve late spring/summer quality because they have a concentrated reproductive phase with fewer seedheads forming after the initial reproductive flush. This can improve the effectiveness of topping as fewer seedheads are likely to form after topping.

Cash and/or forage crops

Growing cash crops such as wheat, barley, potatoes, peas etc. reduces the area of pasture available for grazing. This effectively leads to an increase in stocking rate on the remaining pasture, allowing greater grazing pressure to help control pasture quality. Cropped areas can then be resown in pasture in autumn to provide feed later in winter. A forage crop, such as kale, may be sown to provide good quality feed in summer and/or autumn.

Pea crop in North Otago

Source: Lee Clift

Fertiliser

Applying nitrogen at moderate levels can also help maintain leafy pastures and increase protein content of plants. Nitrogen application methods and rates need to be carefully considered so the majority of the nitrogen is taken up by the pasture and losses to surface waterways and underground water sources are minimised.

Correcting nutrient deficiencies by applying appropriate fertilisers commonly increases pasture clover content and promotes faster nutrient cycling with quicker breakdown of dead material.

Also as fertility increases, high-fertility responsive grasses such as ryegrass increase in number in the sward and low-fertility responsive grasses such as browntop decline. Controlling ryegrass is often easier than controlling grasses such as browntop so pasture quality can be improved going into summer.

Subdivision

Both permanent and temporary subdivision allows greater control of pastures. Break feeding pasture behind an electric fence forces stock to eat pastures to target residuals. Set stocking in medium to small paddocks with appropriate stocking rates also helps to ensure enough pressure is put on pasture to reduce seedhead emergence and improve overall pasture quality.

Controlling weed and pest problems

A pasture infested with clover root weevil and thistles is likely to be of lower quality than the same pasture free of pests and weeds. Pests can kill or weaken plants leading to a lower density of desired pasture species and allowing space for lower quality weeds to establish. Monitoring pastures for pests and weeds is important throughout the year because the sooner problems are observed the lower the cost of remedial action and lost production.

Topping of pastures

Topping involves removing reproductive grass tillers by cutting (or grazing) below the growing point. This will initiate new tillers, most of which will be vegetative. Topping is considered a 'late fix' as the pasture has already reduced in quality once seedheads and/or rank growth is evident and needs to be topped.

Topping before or after grazing depends on individual farm conditions and locality. Topping before grazing leaves cut pasture on the paddock and is best if pasture quality hasn't deteriorated significantly as stock are likely to consume this along with pasture regrowth. With stalky pasture later in the season, when the grass has more lignin, it could be better to top after grazing as a lot of topping waste could provide leaf litter for facial eczema spores.

Chemical topping with light rates of products such as glyphosate can be used to suppress seedhead development and help maintain vegetative growth. It also has the effect of encouraging clover growth by reducing shading by grasses.

Test Yourself #4

1. Briefly describe the difference between pasture quality and palatability.
2. Describe how day length influences pasture quality.
3. Briefly explain the main steps in using Q-Graze to measure pasture quality and livestock liveweight gain.
4. Describe how you would collect a pasture sample for metabolisable energy analysis.
5. Describe how pasture renewal can be used to help maintain good pasture quality.

Pasture conservation

Conservation of pasture during times of surplus to provide feed during times of feed deficit has been carried out for centuries. This does not mean that producing good quality silage and hay is simple. Scientific studies have provided farmers with a better understanding of plant physiological changes and microbial action that occurs during conservation processes and how best to reduce loss of quality. Conserved pasture is always of lower quality than the fresh pasture it is made from so reducing loss of quality is a major aim during the conservation process. Poor quality hay or silage may keep an animal alive (hopefully) but it will not lead to good animal production.

Conserved pasture is made to:

- bridge seasonal gaps in pasture
- serve as a reserve to cushion the effects of climate (e.g. during drought or snow events)
- sell as a cash crop
- use as a normal part of the diet of livestock that do not have access to pasture (e.g. feedlot cattle)

Making silage

The making of quality silage involves the conversion of highly digestible plant material into a palatable animal feed with the minimum loss of nutrients. It is a fermentation process; microorganisms cause pasture sugars to break down into substances that preserve the feed for an extended period.

'Ensile' is a verb.
'Silage' and 'ensilage' are nouns.
So you ensile pasture to make silage.
Silage is often called ensilage in other countries.

Making silage involves four main steps:

1. cutting pasture
2. wilting pasture
3. gathering and preparing pasture for ensiling
4. the ensiling process

Silage can be made in:

- a pit – usually an area dug out of a slight rise so three sides and the base are formed from soil
- a bunker – an area above ground typically with three concrete sides and base
- a stack – an aboveground stack with no supporting sides
- a bale – a compressed bale wrapped in plastic, called balage (or in some countries haylage)

First we will look at the steps required for making silage in a pit, bunker or stack.

Cutting pasture

Livestock is kept out from paddocks to be used for silage (for a period of 35-40 days after it was last grazed), usually at the end of October, when a surplus of pasture growth has started to develop.

Pasture containing a high proportion of green, leafy material with few flower and seedheads is needed to make high quality silage. There should be no more than 10% of flower heads in the grass when cutting pasture for silage. The greater the number of flower heads, the lower the feed value of the silage that is produced. Large amounts of green, leafy material also ensure high levels of sugars, which provide the 'fuel' for the fermentation process.

Ideally pasture for making high quality pasture should have at least:

- 16% crude protein
- 70% digestibility of dry matter
- 10 MJ ME/kg DM of metabolisable energy

If possible the pasture should be cut after one or two days of warm, sunny weather which helps to increase sugar levels (cool, cloudy weather will result in lower sugar levels). Cut with a disc mower in the morning (ideally after 10am to let sugar levels rise after cool night temperatures) so pasture can be wilted and gathered within the same day.

Mowing with a disc/drum mower

Source: www.rtmachinery.co.uk

Wilting or drying pasture

We usually use the term ‘wilt’ rather than ‘dry’ because the grass is still quite moist when harvested and is not as dry as it would be if making hay. For silage the pasture is left to wilt until the dry matter content is about 30%. In other words the moisture content should be about 70%. Moisture content greater than 75% (dry matter content less than 25%) can prevent the silage from being preserved in a stable form and create large quantities of polluting leachate (liquid that leaks out of the plant material). Wilting should take a day or less.

Forage harvester picking up wilted pasture

Leachate production relates to the moisture content of the cut pasture. As a rule of thumb, leafy grass ensiled without wilting will produce about 500 litres of leachate per tonne of grass. Ideally forage with at least 30% dry matter should be used. For the best result, pit silage should be ensiled at 30 to 35% dry matter (DM). Round bale silage should be rolled at about 40 to 50%DM.

Each leaf should ideally be wilted to the same dry matter content. Cutting in dry, sunny weather will speed the wilting process. Care needs to be taken not to leave the cut pasture in the paddock too long. This will extend oxygen-dependant respiration of plant material. Plant enzymes, and bacteria, use the oxygen to turn sugars and proteins into energy. This produces heat, an increase in numbers of bacteria, and a loss of nutrients from the pasture. Sugars and proteins are lost from the silage when left too long in the paddock and can affect how well the silage preserves, resulting in silage of low nutritional value.

Measuring dry matter of wilted pasture

The dry matter of the wilted pasture can be measured by taking representative samples of pasture, mixing them thoroughly then take a subsample of approximately 100 grams. Cut the plant material into 3 – 4 cm lengths. Tare[8] a microwave proof plate. Spread the sample out on the plate and weigh the subsample to get an accurate weight. Put the subsample in the microwave with a glass of water and heat it on high for three minutes. Weigh it and record its weight. Stir the sample lightly then return it to the microwave and heat it for another minute on high. Weigh it again. If the weight has changed continue with this procedure, using 30 second heating periods until the sample weight reduces less than 2 grams from the proceeding weight or the sample begins to char. If it chars use the last weight before this happens to calculate the dry matter percentage.

To calculate the dry matter percentage:

$$\text{Dry matter \%} = \frac{wilted\ weight - dry\ weight}{wilted\ weight} \times 100$$

A standard oven is not suitable for measuring the dry matter percentage in these circumstances because it can take up to 12 hours to dry a sample. You may need to check the DM% a couple of times during a morning when drying conditions are good so a microwave is necessary for quick results.

Hand squeeze method

Hand squeezing is a quick and easy method to use in the field and is more accurate than ‘wringing’ a handful of unchopped grass. Initially it may be necessary to check your accuracy by using the microwave oven method or be guided by someone with experience in using this method.

1. Collect representative samples of the forage.
2. Mix the samples thoroughly and take a subsample.
3. Cut the forage into 1-2 cm lengths.
4. Tightly squeeze a handful into a ball for about 30 seconds.
5. Quickly open hand.
6. Estimate DM content from the table below.

[8] Put the plate on your scales and adjust the weight to zero.

Physical characteristics when trying to form a ball of wilted pasture	DM content
Free moisture runs through fingers as material is being squeezed. When pressure is released the ball of chopped forage holds its shape. A lot of free moisture is present on your hand.	Below 25%
Ball just holds its shape. No free moisture expressed. Hand moist.	25% - 30%
Ball falls apart slowly. No free moisture. Little or no moisture on hand.	30% - 40%
Ball springs apart quickly.	Over 40%

Note that at the same moisture content, stemmy material tends to feel drier than leafy material. For instance, grasses and lucerne feel drier than clover. Forage that is wet from heavy dew or rain will feel wetter than it is.

Gathering and preparing pasture for ensiling

The pasture is swept into windrows once the dry matter percentage is around 30%. A forage harvester then picks up the pasture. The harvester cuts the plant material into small pieces (about 3 – 5 cm) to release plant juices which aid the fermentation process. The extra cutting also increases the density of the silage and helps in the removal of oxygen from the silage stack.

Silage can be stored in a number of different structures, but a bunker or pit is the most common design. An important factor of any silage structure is that it must have supporting sides. This aids the compaction and covering of the silage. Another important factor to consider is efficient drainage. Seepage from well-made silage pits or stacks should be minimal but any seepage (also called leachate) should not be allowed to pollute waterways or ground water.

Self-propelled and towed forage harvesters picking up wilted pasture

Source: www.johnaustinltd.co.nz

The cut pasture is placed in the pit or stack and heavy vehicles are used to compact it to help remove oxygen. The plant material must be spread evenly as it is compacted. Farmers should even consider spreading the plant material by hand to ensure it is evenly spread. As soon as the silage stack is completed, it must be covered with polythene to keep the air and rain out. It is also advisable to weigh down the polythene with tyres. Well-made silage that is effectively sealed against air and water will keep for several years.

Tractor compacting silage stack

The ensiling process

The ensiling process preserves plant material through fermentation. This involves an aerobic and anaerobic phase.

Aerobic respiration

The first step is the removal of oxygen. This is achieved physically, by compacting the cut pasture, and chemically, by respiration of plant material. Compaction and quick covering of the silage to remove oxygen is a key to minimising respiration, hence quality, losses. An American trial showed that immediate sealing of a silage stack saw all oxygen used up after 5 hours. A similar stack left unsealed for 48 hours took 90 hours before all oxygen was used resulting in significant loss of silage quality.

Lactic fermentation

Once all the oxygen has been used up, anaerobic lactic bacteria begin to increase in numbers. They will only be present when there is no oxygen in their environment. The lactic bacteria turn sugars into lactic acid, which results in a drop in silage pH. A low pH preserves and stabilises silage, by preventing butyric fermentation (see below). The pH needed for stable silage changes with DM% of the pasture.

- Very low DM pasture (<15% DM or >85% water content) is unlikely to reach a pH low enough to become stable.
- As DM% increases, the pH needed for silage to become stable also increases. For 25-35% DM pasture, a stable pH is 4.3 – 4.6, but for 35-45% DM pasture a stable pH will be 4.6 – 5.0.

Compared with grasses, legumes (clovers and lucerne) contain less sugars, more protein and take longer to decrease in pH. Silage made from legumes will generally contain 20% or more of the total amount of nitrogen as ammonia. This is the reason why the pH level of legume silage takes so long to decrease. The botanical make up of a typical New Zealand pasture cut for silage is approximately 55% grass, 20% clover and 25% other species. Silage made from this contains approximately 10% of the total amount of nitrogen as ammonia, which is a level that will not restrict the decrease of the pH.

Butyric fermentation

If the pH is not low enough for the silage to become stable, then butyric fermentation will occur. This results in the breakdown of nutrients in the silage and reduces its palatability.

Clostridia bacteria cause butyric fermentation. They are another type of anaerobic bacteria which live in higher pH conditions than lactic acid bacteria. Clostridia turn lactic acid into acetic and butyric acid to get energy. They also get energy by breaking down protein into ammonia.

As the Clostridia bacteria use the lactic acid and protein to get energy the ammonia levels in the silage rise resulting in an increase in the pH of the silage. This makes the stack more suited to further butyric fermentation.

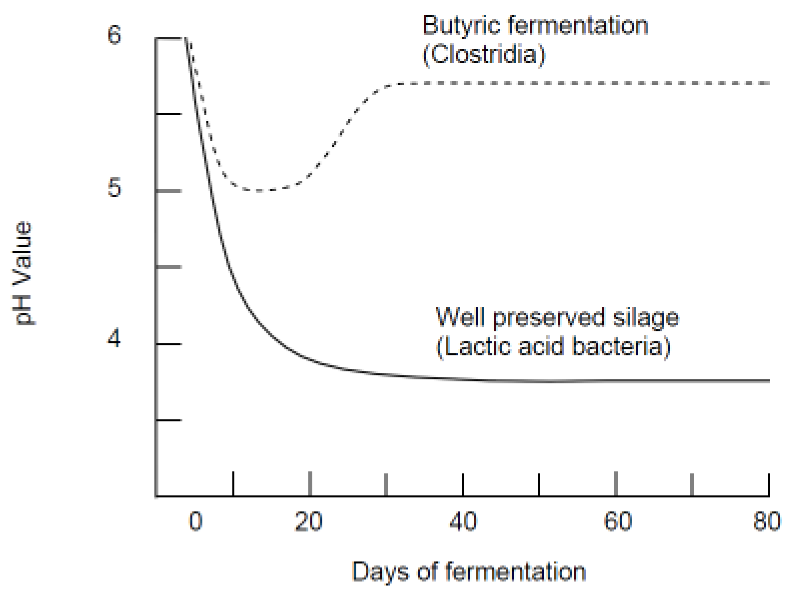
To prevent butyric fermentation:

- avoid soil being harvested with pasture (or crop) which can increase Clostridia numbers
- wilt pasture to about 30% dry matter which is also important to prevent seepage
- have a silage pH which is low enough to stop Clostridia functioning

Once the silage is sealed, nothing can be done to change the fermentation process.

Figure 11 illustrates the changes in silage pH during lactic and butyric fermentation.

Figure 9: Changes in pH during silage preservation



Source: DairyNZ FarmFact 1-43, www.dairynz.co.nz

Additives can be used to increase the chances of good silage fermentation. They *do not* replace the need for good quality pasture, good harvesting or good compaction techniques.

- Acids such as formic and sulphuric acid are added to lower pH in the silage, without relying on lactic acid bacteria to do it.
- Bacterial inoculants contain large numbers of lactic acid bacteria that are added to increase production of lactic acid in the silage, so that the pH drops quickly to a stable level.
- Soluble sugars such as molasses increase the amount of sugar available for lactic acid bacteria to turn into lactic acid.

In summary, to make good quality silage with minimal quality losses:

- wilt quickly to 30% DM to leave good sugar concentrations in the pasture
- compact quickly and effectively
- seal effectively to keep out oxygen, making conditions more suitable for bacteria to convert sugars into lactic acid fast, so the pH will drop quickly and produce a stable, quality silage

Advantages of silage
Advantages of making silage compared to hay include:

- higher feed quality and more palatable to most livestock – if well made
- well-made silage retains its quality longer than hay
- less dependent on long periods of warm, dry weather to make silage because a shorter drying period is required once pasture is cut
- less plastic used compared to balage
- lower fire risk when stored

Making balage

Balage is simply silage in a bale. The basic steps involved in making balage from pasture are similar to making pit silage but the ensiling process occurs inside a plastic wrapped bale rather than a pit or stack.

Cutting and wilting
Cutting and wilting of pasture for balage is the same as for pit silage with the exception that the percentage dry matter needs to be higher at 30% – 35% DM. This reflects the upper weight limit for bales to be easily moved. Lower dry matter percentages enable denser bales which may be too heavy to handle.

Baling
When the ideal dry matter percentage has been reached the wilted pasture is baled as compactly as possible to ensure as little air as possible in the bale. Balers create bales of similar density and weight, depending on settings made. To speed up the ensiling process, the balers chop pasture into smaller pieces as it is fed into the baling chamber. Additives, if required, can also be sprayed on the cut pasture before baling.

The aim is to pack as much DM into the bale as possible; ideally a minimum of 200kg of DM per bale. At 35% DM, this would require a bale weight of 570kg. Swath formation, pasture type, baler type and setting, and speed all influence the level of density achieved. High DM bales (over 35%) are more prone to butyric fermentation. The physical structure of high DM pasture often allows easier air movement within the bale and the less acidic environment promotes growth of undesired bacteria.
Bales can be large rounds or medium to large rectangles.

Wrapping

After baling, each bale is individually wrapped by specialised machinery in plastic wrap. Some balers include wrapping equipment so only one pass of the paddock is required. Alternatively, the bales are wrapped in a continuous tube of plastic, typically containing about 50 bales set end-to-end in a long row.

Square bale and round bale wrappers

Source: www.webblineagriculture.co.nz (left); www.landpower.co.nz (right)

Bale film type and width needs to efficiently exclude air and rain. Wider film (around 750mm) is quicker to wrap than narrower film with less opportunity for leakage. A quality stretch film should be used which stretches evenly, has high impact strength, good tear resistance, consistent UV protection, a high initial tack (in the same way plastic food wrap sticks to itself) and a good long term seal. Ideally bales should be wrapped where they are to be stored as it is easy to rip holes in the plastic when moving them. For this reason stacking of balage is also not recommended.

Silage tubes an alternative way to preserve baled silage. Tube wrapping can reduce the amount of wrapping used by up to 40% over individual wrapping. Basically, the longer the tube the cheaper the wrapping but there is a practical limit to length, storage and feeding out. Fifty bales is a useful compromise. When feeding out it is important to make sure the tube is carefully resealed after silage is removed to prevent spoilage from exposure to air.

Silage wrapped in tubes and protected from stock in a fenced off area

Source: Lee Clift

Although used plastic wrap has caused some pollution problems in the past there are now recycling options in most areas of New Zealand and farmers are strongly encouraged to use these.

The ensiling process

The ensiling process is the same as for pit silage. Natural plant respiration and the action of aerobic bacteria begin to heat the bale. On a warm day, all the oxygen in a wrapped bale may be used up in half an hour. If conditions are cooler, or there is too much air in the bale, this process can take hours or sometimes even days.

A well-compacted bale may heat as little as three degrees Celsius before it runs out of oxygen. Loose bales, often resulting from forage being too dry, have more air trapped in them and the heating process can continue too long resulting in heat damage and significant reductions in quality of the balage.

When the aerobic heating phase ends, the anaerobic bacteria take over. As fermentation continues, the bale becomes increasingly acidic. Ideally wrapped bales should drop below pH 5.0 in a few days or, at most, a week.

Advantages of balage

The advantages of balage over traditional silage pits or stacks include:

- ease and speed of harvest – compaction of the silage occurs in the field as pasture is harvested rather than transporting the grass to a pit then spending hours driving back and forth over the pit with a tractor to compact it
- ease of storage – can be stored in the field where it is to be used or other convenient locations on the farm
- ease of feeding out – machinery to lift and carry balage is readily available and it is usually less messy and time consuming than cutting silage from the face of a pit or bunker
- typically lower capital investments in equipment and labour
- ease of calculating silage requirements to be fed to livestock – balage weight and volume is generally easier to accurately calculate compared to silage in pits, hence, in conjunction with balage energy levels, it is easier to calculate the quantity of balage to be fed out
- possibly less risk of spoilage by clostridial organisms because pits generally have a higher moisture content than balage

Balage gives farmers an alternative to pit or stack silage that can give more flexibility to their farming operations.

Balage Handler

Source: www.webblineagriculture.co.nz

Making Hay

Hay is a well-recognised way of conserving surplus pasture. There are three main steps involved in hay making:

1. cutting
2. drying
3. baling

Cutting

As with silage, the better the quality of the pasture cut, the better the quality and palatability of the hay. This needs to be balanced with dry matter yield. Typically the best time to cut is around grass flowering time before grass seedheads have formed. A large number of grass seedheads, stem and dead material will reduce hay quality significantly.

Some farmers make a second hay harvest later in the summer when white and red clover are at their peak and grass seedheads have been removed by an earlier hay crop, topped or controlled by other means. Clover flowers, stems and seedheads are not significantly lower in quality than clover leaves so hay made from clover dominant pasture is generally of high quality.

Timing of actual cutting will depend on the weather. Hay needs one to three days to dry depending on how warm and sunny the days are (longer if the cut pasture gets rained on). You need to balance potential losses from possible rainfall with losses due to over maturity of pasture. A light shower may result in less loss of quality than leaving the pasture for another week or two before cutting.

The quicker pasture dries, the better the quality, so many mowers also ‘condition’ the pasture as it is cut to speed the drying process. Conditioning involves damaging the plants thin waxy outer layer, particularly that on stems. After cutting, the pasture passes through rollers or flails to lightly crush, crinkle or abrade it before falling to the ground. Rollers are less damaging to leaf material and better for more delicate clover plants.

If cut pasture is not conditioned the stem material takes considerably longer to dry. This can result in losses of leaf material near the end of the drying process due to shattering because leaf dries quicker than stem. In general, the thicker, stalky stems receive more damage from the conditioners than the thinner leaves so drying time for all parts is evened out more.

Conditioning is most effective in warm, dry sunny weather where the drying period is short. When conditions are cloudy and with high humidity, losses from leaf shattering can be high because of the longer drying time needed. Also rain falling on conditioned plant material generally reduces hay quality more than unconditioned plants. However, in most circumstances conditioning is recommended as it reduces drying time, which typically reduces loss of quality and requires fewer days of good weather for drying.

Pasture can be cut into swaths, the pasture falling where it is cut, or into windrows, where it forms a small, narrow stack of pasture with cut areas showing between. A well-made windrow allows hay to dry more evenly but in less than ideal drying conditions a swath may be necessary to start the drying process.

Drying

In New Zealand field drying of pasture is the usual method for making hay. Economically, it is still the best option, being significantly cheaper than artificial drying.

The drying process occurs through a physical activity called '*diffusion*'. The energy needed to dry the plant material comes from natural sources:

- heat from the sun (*solar radiation*)
  Solar radiation heats the surface of the drying plant material and the air around it. This causes moisture to be removed from the plant material. The sun does not damage the plant material because as water leaves the plant material, it keeps the surface of the plant material cool. When the plant material is almost dry, solar radiation will cause the plant material to change colour from green to yellow.
- the 'dryness' of the air *(relative humidity*)
  Relative humidity is the amount of water vapour in the air at a certain temperature compared to the amount of water vapour needed to totally saturate the air at the same temperature. Air with a low relative humidity absorbs more water vapour from drying plant material than does air with a high relative humidity. Changes in temperature will also influence the air's ability to hold water vapour; hot air will hold more water vapour than cold air.
- the movement of the air (*wind*)
  A light to moderate wind will absorb more water vapour than air that is not moving because it continually blows the air that holds the absorbed water vapour away from the drying plant material, replacing it with drier air.

In some countries, such as parts of the USA, pasture is only partially dried outdoors. It is then taken to a barn to complete the drying process. A barn hay dryer uses a fan and air duct distribution system to force outside air through the partially dried hay. The movement of air through the hay removes heat and excess moisture and eventually completes the drying process.

Diffusion works by the movement of water from a wet to a dry area until the water content of both areas is equal. Dry air surrounding freshly cut plant material draws water out from the plant material to its surface, from where it evaporates into the air. Since the air is almost always moving and dry air replaces wet air, the plant material will continue to lose water until it is dry. If the condition of the air changes, the drying process will slow down and the hay may even start to take up water from the air.

When plant material is cut for hay, approximately half its water content is in the sap or between the cells. The water is easily removed from there but once the water content falls below 40%, plant cells begin to die. When the water content falls to 25% all the cells of the plant material will have died. To remove any of this last 25% of water takes more energy than before because the dead plant cells hold onto the remaining water with more resistance as they dry out.

Efficient haymaking requires techniques that ensure water is lost from the cut pasture as fast as possible. Rapid drying is needed to ensure that fungi and bacteria do not invade the cut plant material and spoil it, by turning it mouldy. Also, as noted with silage, plant respiration continues for a time after plants are cut leading to losses in quality. The quicker the plant material dries, the quicker that respiration is slowed and the smaller the loss in quality.

Rotary tedder

Source: www.agroequipobravo.com

Since hay on the top a swath dries faster than the hay on the bottom the hay needs to be turned to even up the drying process. This can be done using a tedder to turn the swath or a rake to form a windrow. Turning should be carried out when the moisture content of the pasture on the top of the swath is about 40% to 50%.

A tedder turns and fluffs the swath up but leaves it spread out on the ground. A rake forms the cut pasture into a continuous, small, loose, triangular shaped stack; a windrow. This usually provides a better drying environment than a swath. The drying conditions on the bottom of a swath are fairly poor whereas the interlocking plant parts create an open structure in a windrow improving internal and external air circulation. The windrow can be varied in width to suit the pasture density and drying conditions. The number of times the hay is turned depends on the drying conditions. Under good drying conditions it may need to be turned more than once a day to get even drying. Keep in mind that with each turning some loss of material will occur.

Hay rake forming windrow

Source: paddon.co.nz

Baling

The advent of new baling and handling equipment over the last two decades has given farmers a choice of bale size to suit their farming systems.

Small 'traditional' rectangular bales are still ideal for many small farms with low stock numbers whereas large round and square bales are well suited to large farm systems with good vehicle access and high stock numbers. Large bales mechanically fed out to stock can reduce time and labour costs compared to distributing many small bales to stock.

Many farmers today do not own hay making equipment but contract the services of a hay maker. This means farmers reduce their capital costs and are not bound to produce any particular hay bale size from one year to the next. If circumstances change or improved equipment is manufactured farmers can take advantage of the most appropriate bale type at the time.

The dry matter percentage of dried pasture for baling varies with the size and type of bale. The same method for measuring dry matter percentage in wilted pasture for silage (see page 63) can be used to check the dry matter percentage of dried pasture to check when it is ready for baling.

Dry matter percentages for baling:

- square bales – grass dominated pasture, 80% - 85%
- square bales – legume dominated pasture, 77% -80% (above 80% leaf loss can be high)
- round bales – grass dominated pasture, 75% or greater

Rectangular bales are usually held together with baling twine. Round bales use either twine or netting. Netting covers the rounded part of the bale leaving the flat ends open. Netting provides some protection from water penetration as water sheds down the lines of the net and off the bale.

Immediately after baling the internal bale temperature rises as a result of plant respiration, enzyme activity and microbes associated with the plant in the pasture or crop. Heating usually continues for a few days and then decreases. This temperature decrease is then often followed by a further prolonged period of heating that can last several weeks and is due to the respiration of microorganisms (aerobic bacteria, yeasts and moulds) during storage.

In hay baled at the correct moisture content, this heating will also subside, resulting in minimal losses. The temperature decline is dependent on the drying or storage conditions and the type of bale. It stabilises when the interior bale temperature is in equililbrium with ambient (surrounding air) temperature. Bales should be stored in a dry shed with good ventilation.

A rule of thumb useful in estimating yield loss of round bale hay is that 1% of original yield will be lost for each 1% moisture that is lost as stored hay reaches its equilibrium storage moisture. For example, when hay is baled at 20% moisture, and then dries to 14%, dry matter loss will be approximately 6%.

Advantages of hay

The advantages of good quality hay compared to silage and balage include that it:

- can be made into small bales light enough for easy handling (although balage is also now able to be made in smaller, manageable bale sizes)
- is good for providing fibre for stock grazing high quality, high digestibility crops that may be low too in fibre for good rumen function
- can provide adequate nutrients to maintain stock in winter as well produce heat during rumen fermentation (as fibre breaks down), reducing energy loss needed to keep the animal warm

Round bale, wrapped in netting, leaving the baler

Source: www.farm-equipment.com

Deferred grazing

Deferred grazing simply means removing a paddock from grazing during times of pasture surplus in spring and grazing it at a later date when pasture becomes scarce, usually summer or autumn. Simple as it sounds, skill *is* required to get the most out of the system. You need to:

- choose the most appropriate paddocks to shut up
- have suitable subdivision in place
- shut the paddocks up at the correct time
- utilise deferred pasture effectively
- stay flexible – compromises between animal performance and pasture benefits may be needed at times

Deferred grazing is a low cost method of pasture conservation. On dairy farms hay and silage conservation systems typically account for about 18% of total farm operating expenditure. Deferred grazing can also form part of a pasture renovation programme. Allowing ryegrass to seed in deferred pastures on dairy farms can results in significant increases in ryegrass populations. Pastures which have reseeded may produce an extra 15% in the year following deferring.

Appropriate subdivision can give more choices as to which paddocks or parts of paddocks are shut up. Dry northerly aspects in hill country often benefit from deferred grazing due to reseeding of clover. It can turn sparse, poor quality pasture into palatable, high quality clover-dominated sites giving greater flexibility for feeding options in summer and early autumn.

Shutting up paddocks

Paddocks should be shut up as soon as pasture growth and mass become greater than animal requirements. For reseeding to occur, paddocks must be removed from grazing during the ryegrass reproductive phase, around mid October to mid November depending on region.

Pastures with a low density of ryegrass and white clover are ideal paddocks to shut up as reseeding will help to increase the density of these desired species. On dairy farms it is recommended that to allow cows to be fed to requirements during December/early January, the proportion of the farm designated for reseeding, at a moderately high stocking rate, should not exceed 10%.

Grazing deferred pastures

For reseeding to be successful, deferred pasture should not be grazed until the seed is mature (readily shed from the seed head), generally mid-January for grasses and around mid-February for clover. Grazing late February, early March results in both good seedling establishment and allows breakdown of dead material before winter. Dairy farmers wishing to increase ryegrass density may choose to graze after grass seeding is complete whereas sheep and beef farmers may benefit more by allowing clover to reseed before grazing.

Deferred pastures can be treated as a supplement like hay, where livestock receive a break of deferred pasture to supplement their other grazing. On dairy farms deferred pastures can be strip grazed between morning and night milkings. Utilisation of about 50% will allow cows to select the better quality feed. A drop in milk production is likely in the first two to three days until cows get used to the deferred pastures.

Pastures may need to be cleaned up by cattle or cows in late autumn/early winter to remove any remaining stalky material and improve quality going into winter. Grazing should occur before winter as paddocks grazed later than autumn usually don't recover as well the following spring.

A balance has to be kept between animal production objectives and pasture renovation benefits. At times the deferred pasture may have to be grazed before the ideal time for reseeding and seedling establishment due to unexpected feed shortages. Alternatively, a dry spring may lead to lower than expected pasture growth and the deferral policy may need to be adjusted (e.g. less area deferred or greater destocking later to take account of lower production in deferred paddocks).

Advantages of deferred grazing

The advantages of deferred grazing are usually due to:

- longer term improvements in pasture quality and quantity due to reseeding
- short term savings by reducing or eliminating costs from mechanical pasture conservation methods

Pasture advantages

Pasture improvement comes about through an increase in plant density from reseeding and new seedling establishment and by 'resting' older plants. As plants are not being routinely grazed they grow bigger and deeper root systems and build up reserves. Deferred grazing allows the pastures to reseed properly allowing seed banks to recuperate.

There can be a change in pasture species when improved clover density, due to reseeding, leads to improved fertility. In the Springvale Station example, their northerly and westerly facing paddocks used to have a large component of rats-tail, which they had to force the cows to eat after weaning. But, as part of their deferred grazing programme, the clover is re-establishing on the northerly faces and little or no rats-tail is left.

Pasture in paddocks that have been shut up in spring can be higher quality in summer/early autumn than hay, as plants are still growing with reasonable levels of green leaf present (even though stem and dead material levels may be high).

Soil advantages

Deferred grazing can improve soil moisture-holding capacity as well as improved levels of humus and earthworms. This is of particular benefit in areas prone to summer drought. Higher soil organic matter from dead matter being incorporated back into the soil, through insects and worms or directly through a larger or deeper root system in the plant, improves the ability of the soil to absorb and hold moisture. A deeper rooting profile gives plants greater access to more soil moisture during dry times and aids plant survival and production.

Financial advantages

Deferred grazing can be used either to reduce the amount of silage/hay made on the farm or as part of a nil conservation system (no silage or hay made). The Taranaki Agricultural Research Dairy Farm produced similar milkfat, but more protein per hectare (3.7 cows/ha) with nil conservation, including deferred grazing, compared with traditional dairy farm conservation systems. The extra income and reduced costs resulted in an increase in profit of $360/ha.

Production losses may be incurred in the first year when deferring grazing due to lower production from the poorer pastures that are shut up. Generally, the less productive the area you defer, the lower the cost to the overall system in the first year. However, reseeding and new seedling establishment should improve pasture production in following years leading to better animal production. For example, a Sustainable Land Management report published by the Ministry of Agriculture and Fisheries looked at the effects of a deferred grazing programme on Springvale Station in Hawkes Bay. In year three, with 100 hectares renovated (50 hectares deferred each year for the previous two years):

- a 600 kilograms of DM increase per hectare on the renovated area (a 12% improvement in pasture production) added $7500 to the farm’s gross margin
- a 1500 kilograms DM increase per hectare on the renovated area (a 30% improvement) added $16 000

Deferred grazing is another tool farmers can use to provide supplementary feed for livestock. It can form part of an overall supplementary feed system which could include a combination of deferred grazing and conserved feed such as hay or silage.

How to calculate volumes of dry matter of conserved pasture

Volume and weight of dry matter in a silage stack or pit

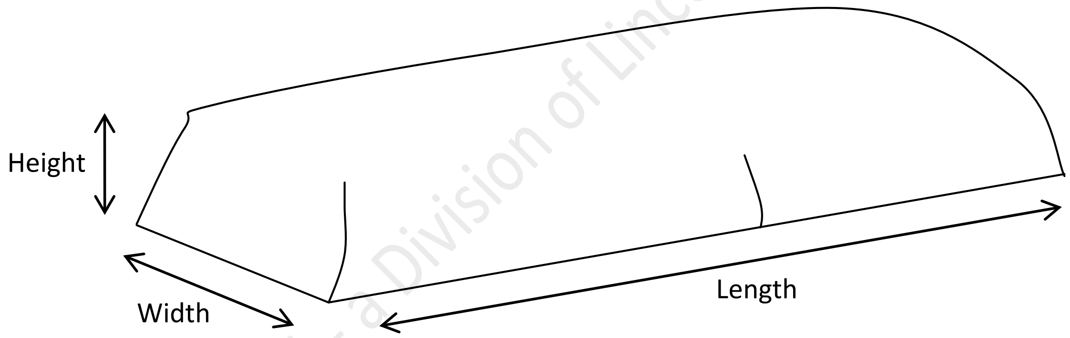
There are many ways in which dry matter can be lost during the making and storing of silage due to processes such as fermentation, aerobic deterioration and surface wastage. Consequently at the time of feeding out (or selling or buying) you need to assess the kgDM/m³ of silage and the total volume of the stack or pit to enable you to calculate the amount of silage to feed out to meet production targets.

The amount of silage in a stack or pit will depend on the dry matter content of the silage, how well compacted the silage was and the height of the stack (deep pits have more compaction at the bottom of the heap). A good average dry matter density for silage in the stack with 30% DM is 180 kgDM/m³.

To assess the volume and weight of dry matter (DM) in a stack of silage:

Estimate the volume of silage in cubic metres (average length x average height x width). Allow for surface wastage when you estimate the length, width and height. (Silage chopped to the right length, well compacted and covered without delay is likely to minimise surface waste.)

Example 1: Volume and weight of dry matter in a silage stack



Take measurements at various points along the stack to get an average height, width and length.

If:

Average length	= 32m
Average width	= 7m
Average height	= 2m
Then:	
Stack volume	= 32 x 7 x 2
	= 448m³
Measure the DM%	= 29% or 0.29 kgDM/m3
So total volume of DM	= 0.29 x 448
	= 130 m3 of DM

If the kgDM/m³ is 180, then:

Total weight of DM	= 448 x 180
	= 80,640 kgDM or 80.64 tonnes of DM

Farmers with block cutters or shear grabs can estimate the density of their own silage by cutting out and weighing a block of undisturbed silage from their stack (do not include spoiled areas that will be discarded). This measures the kg of wet silage/m^3. By measuring or estimating the dry matter percentage the amount of DM/m^3 can be calculated.

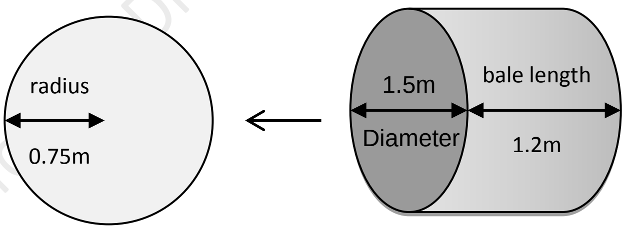
Examples of shear grabs

Analytical laboratories can measure the DM% of a sample of silage or you can do this at home using the drying method explained for assessing pasture DM% or the squeeze test (page 64).

Volume and weight of DM in balage, silage tube and hay

To measure the **volume** of DM in a bale of round balage or hay, measure the average radius of the bale and length of the bale. Remember the radius is the distance from the centre of the circle at the end of the bale to the outer edge. Ideally measure the radius of a number of bales before they are wrapped to get a more accurate estimate. Baling machines can produce very consistent bales if baler is set correctly and pasture is even but it pays to check.

Example 2: Volume and weight of dry matter in 150 bales of round balage



The formula to calculate the volume is:

v = π x r2 x l   where π is approximately 3.14, r is the radius and l is the length
(Remember that the radius is half the diameter)

So the volume of the bale is:

Volume (m3)   = 3.14 x 0.752 x 1.2
= 3.14 x 0.5625 x 1.2
= 2.12 m3

Multiply by the number of bales to get total volume. Say you had 150 bales of balage (either individually wrapped or in a tube):

Total volume	= 2.12 x 150
	= 318 m3
If DM%	= 32%
Total volume of DM	= 0.32 x 318 m3
	= 102 m3

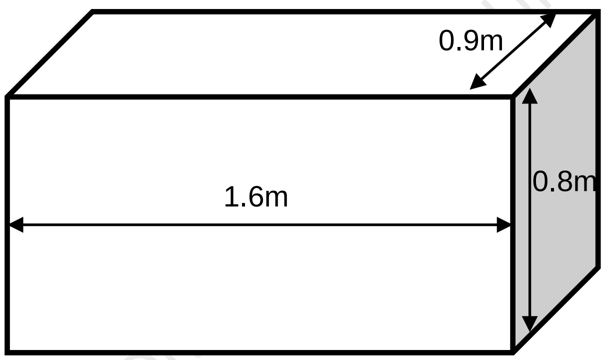
If the kgDM/m3 is 180, then

Total kgDM	= 102 x 180
	= 18,360 kgDM or 18.36 tonnes of DM

Example 3: Volume and weight of dry matter in 150 bales of rectangular balage

For square or rectangular bales the formula of the volume of the bale is:

v = w x h x l   where w = width, d = depth and l = length



Volume of bale	= 0.9 x 0.8 x 1.6
	= 1.152 m^3
Volume of 150 bales	= 150 x 1.152
	= 173 m^3
If DM%	= 32%
Total volume of DM	= 0.32 x 173
	= 55 m^3

If kgDM/m^3 is 180, then

Total weight of DM	= 55 x 180
	= 900 kgDM

For hay, the same formulae for calculating volume apply but the dry matter of hay is usually around 85%.

Hay baler specifications will give the size and weight of bales they produce. For example, the John Deere 448 Variable Chamber Baler produces round bales 1.2 m wide and up to 1.2 m tall, with a maximum weight of 340 kilograms. Bale diameter can be adjusted to meet feeding and handling requirements. If you are making your own hay or arranging your own contractor this information should be readily to hand.

However, if buying in hay you need to measure and weigh bales (where practicable) or get the specifications from the seller.

The following table gives a guide to the fresh weight and dry weight of a range of bale types.

	Fresh weight of bale (kg)	**Approximate kgDM per bale**
Conventional 'small' bales	19 - 24	15 - 20
Round bales:		
▪ Fixed chamber baler 1.2 x 1.2m	180 - 300	150 - 250
▪ Variable chamber baler up to 1.8 x 1.2m	300 - 500	250 - 420
Medium square bales:		
▪ 'Normal' size, not rotary cut in baler - 0.8 x 0.9 x (say) 1.6m long	up to 320	up to 270
▪ 'Normal' size, rotary cutter in baler - 0.8 x 0.9 x (say) 1.6m long	up to 520	up to 430
Big square bales:		
▪ Rotary cutter in baler - 1.18 x 0.87 x (say) 2.1m long	up to 770	up to 640

Example 4: Volume and weight of dry matter of 150 large round bales of hay

One round bale, 1.2m long x 1.5m diameter, has a volume of 2.12 m^3 (see example 2 above).

DM% = 85%

Volume of DM/bale = 0.85 x 2.12
= 1.802m^3

DM/150 bales = 1.802 x 150
= 270.3m^3

If kgDM/bale is 200, then

Total weight of dry matter = 150 x 200
= 30,000 kgDM or 30 tonnes of dry matter

Test Yourself #5

1. Describe the difference between butyric and lactic acid fermentation when ensiling pasture.

2. Describe the differences between the process of making silage in a pit and as balage.

3. Calculate the volume and weight of dry matter in a silage pit with the following dimensions and 29% dry matter and 180 kgDM/m^3:

   average length = 29m
   average width = 7m
   average height = 2m

4. Calculate the volume and weight of dry matter of 75 round bales of hay with the following dimensions and 85% dry matter and 200 kgDM/bale:

   diameter = 1.5m
   length = 0.75m

5. Calculate the volume of dry matter in 125 rectangular bales of balage with the following dimensions and 32% dry matter.

   width = 0.9
   height = 0.8
   length = 1.6

6. Briefly describe the main aims of deferred grazing.

7. Explain the benefits of windrowing when drying pasture for hay.

8. Compare the advantages and disadvantages of wrapping balage bales individually and in a tube.

9. At what dry matter percentage should cut pasture be gathered for pit silage, balage silage and hay?

References and further reading

Beef + Lamb New Zealand R & D Briefs

- R&D Brief 127 Using Subterranean clover
- R&D Brief 133 Caucasian clover
- R&D Brief 93 Forage options – birdsfoot trefoil and sulla
- and others – see their website www.meatnz.co.nz

DairyNZ Farmfacts

- How do pastures grow? (1-20)
- Understanding endophyte (1-22)
- Pasture renovation/renewal (1-23)
- Grass silage - the preservation process (1-43)
- Losses when making pasture silage (1-44)
- Analysis of pasture silage (1-45)
- What is high quality pasture silage? (1-46)
- Assessing quantities of silage (1-47)
- and others – see their website www.dairynz.co.nz

A practitioner's guide to pasture quality. M.G. Lambert and A. J. Litherland. www.beeflambnz.com

A Terminal Flower1-Like Gene from Perennial Ryegrass Involved in Floral Transition and Axillary Meristem Identity. Christian S. Jensen, Klaus Salchert and Klaus K. Nielsen, Plant Physiol, March 2001, Vol. 125, pp. 1517-1528

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Lincoln University Farm Technical Manual. 2003, ed. Peter Fleming

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www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/riskassessments-1

Other websites with information on pasture species and growth
www.agriseeds.co.nz
www.cropmark.co.nz
www.seedforce.com
www.specseed.co.nz
www.dpi.nsw.gov.au/agriculture/field/pastures-and-rangelands
www.fog.org.au/grasses_of_nsw/grasses_of_nsw.htm
pastureinfo.massey.ac.nz

Appendix

Pasture Growth rates for various New Zealand locations (kgDM/ha/day – averaged over 30 years)

Site	Dargaville	Helensville	Rukuhia (Hamilton)	Gisborne	Gisborne Hills	Hastings	Wairakei (flat site)
Soil Type	Kaipara clay	Red hill sand complex	Hamilton clay loam	Recent alluvial soils	Gisborne sandy loam	Takapau light silt loam	Atiamuri sand
Jun	25	17	8	18	10	10	4
Jul	24	18	12	19	8	10	5
Aug	33	29	32	33	14	20	5
Sep	50	37	50	47	25	40	17
Oct	58	51	53	47	46	40	30
Nov	63	50	44	38	52	13	33
Dec	73	45	42	37	52	14	33
Jan	59	32	17	29	52	9	19
Feb	61	29	21	30	38	13	14
Mar	50	31	21	32	39	15	11
Apr	41	36	23	29	29	18	9
May	32	26	13	24	15	18	8
Annual average*	17150	12750	10200	11750	11550	6750	5750
Annual range**	13550-20750	10400-15150	8000-12400	9050-14450	8390-13340	5550-7950	4300-7200
Site	***Wairakei (hill site)***	***Stratford***	***Hawera***	***Marton***	***Bulls***	***Masterton***	***Westport***
Soil Type	Oruanui hill soil	Stratford sandy loam	Egmont brown loam	Marton silt loam	Rangitkei loamy sand	Katatau silt loam	Addison 'pakahi'
Jun	8	8	11	12	13	16	11
Jul	4	8	12	13	5	16	10
Aug	11	15	18	23	8	32	13
Sep	29	25	36	44	21	56	16
Oct	45	42	46	47	27	70	38
Nov	42	42	46	40	28	51	55
Dec	52	43	44	43	22	30	54
Jan	34	38	38	32	17	15	49
Feb	18	30	26	26	19	12	40
Mar	24	34	30	29	15	21	32
Apr	18	25	28	25	14	26	21
May	13	14	20	17	15	25	10
Annual average*	9000	9940	10665	10850	6250	10900	10900
Annual range**	7600-10420	7670-11300	6260-13600	8900-12800	5500-7050	8500-13300	10200-11650

*Average: Production (kg/ha/year) averaged over 30 years
**Range: Annual pasture production falls within this range in most (2 out of 3) years
Source: Lincoln University Farm Technical Manual

Pasture Growth rates for various New Zealand locations (kgDM/ha/day – averaged over 30 years)

Site	Greymouth	Hokitika	Motueka	Winchmore (dry land)	Winchmore (irrigated)	Waitaki Plains (irrigated)	Awamoko (irrigated)
Soil Type	Ahaura stony silt loam	Hari Hari silt loam	Rosedale silt loam	Lismore stony silt loam	Lismore stony silt loam	Steward very stony silt loam	Georgetown silt loam
Jun	5	5	13	5	5	5	4
Jul	3	3	17	5	5	5	4
Aug	7	4	30	9	11	5	13
Sep	32	20	58	30	31	20	45
Oct	51	32	57	37	40	50	72
Nov	51	50	55	27	41	65	74
Dec	34	32	36	19	48	62	64
Jan	36	31	15	13	48	54	62
Feb	35	33	14	14	43	48	53
Mar	34	33	32	16	31	35	48
Apr	21	20	30	14	20	26	29
May	8	10	16	8	10	9	15
Annual average*	9370	8100	11550	5850	10150	11500	15073
Annual range**	7730-11620	5610-11000	9500-13600	4750-6700	9150-11200	10660-12370	10410-19180

Pasture Growth rates for various New Zealand locations (kgDM/ha/day – averaged over 30 years)

Site	Windsor (Oamaru)	Palmerston	Arrowtown (irrigated)	Cromwell (irrigated)	Poolburn	Otago Plateau (Alexandra)	Hindon (Dunedin)
Soil Type	Kauru silt loam	Claremont silt loam	Shotover silt loam	Molyneux loamy sand	Linnburn sandy loam	Teviot silt loam	Wehenga silt loam
Jun	1	3	0	0	0	0	2
Jul	2	4	0	0	0	0	2
Aug	10	11	0	0	0	0	2
Sep	25	27	19	16	15	1	15
Oct	44	53	48	39	24	18	35
Nov	31	55	66	48	17	20	58
Dec	28	39	58	52	12	16	43
Jan	23	28	56	42	12	14	36
Feb	15	20	54	35	7	8	32
Mar	18	25	42	27	7	7	25

Apr	13	13	19	13	5	0	23
May	6	7	3	3	1	0	7
Annual average*	6583	8824	10850	8300	2800	2540	8820
Annual range**		2546-13264	8880-12180	6700-9900	770-4570	1520-3830	7520-12760

*Average: Production (kg/ha/year) averaged over 30 years

**Range: Annual pasture production falls within this range in most (2 out of 3) years

Source: Lincoln University Farm Technical Manual

Pasture Growth rates for various New Zealand locations (kgDM/ha/day – averaged over 30 years)

Site	Taieri Plain (Dunedin)	Taieri Hill	Mona Bush (Invercargill)	Winton (Invercargill)
Soil Type	Alluvial soil	Warepa series	Waikiwi silt loam	Otapiri silt loam
Jun	5	5	6	8
Jul	5	5	5	9
Aug	12	9	8	10
Sep	32	25	35	26
Oct	55	46	35	53
Nov	49	47	70	54
Dec	47	44	69	54
Jan	40	36	58	53
Feb	33	28	58	51
Mar	29	24	49	42
Apr	18	16	31	26
May	8	9	10	13
Annual average*	10400	8900	14600	12000
Annual range**	8800-12000	6500-11100	11850-17350	9700-14300

*Average: Production (kg/ha/year) averaged over 30 years

**Range: Annual pasture production falls within this range in most (2 out of 3) years

Source: Lincoln University Farm Technical Manual

Test Yourself Answers

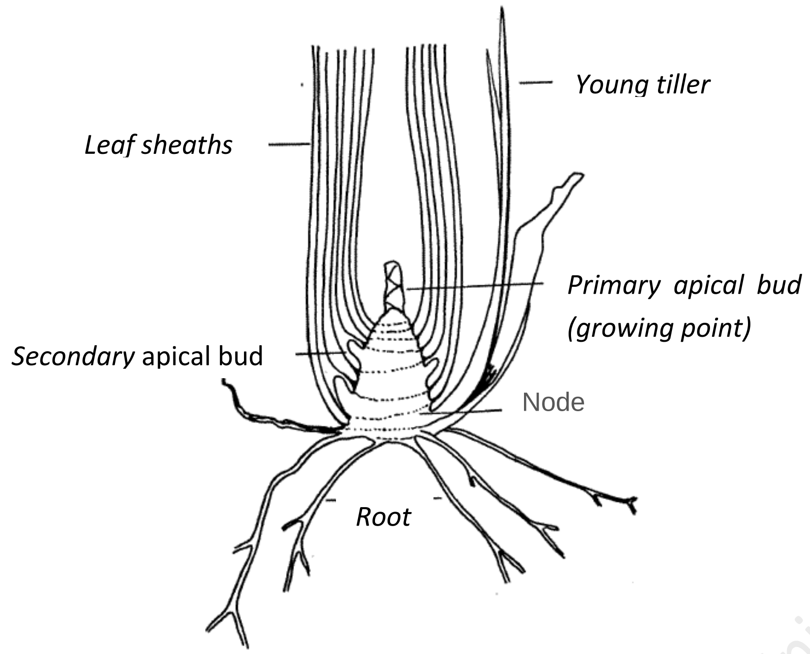
Test Yourself #1

1. *If you are unsure if you have correctly identified the grasses and clovers check with experienced farmers, agricultural consultants, agricultural teachers or agronomists.*
2. *All belong to the genus Lolium. Short and long rotation ryegrasses are hybrids of perennial ryegrass (Lolium perenne) and Italian or annual ryegrass. Italian and annual ryegrasses are different types of the same species, Lolium multiflorum.*
3.
   a) *L. perenne usually has narrower and shorter leaves than L. multiflorum; about 7mm wide and 30cm long compared to 5 – 12cm wide and up to 40cm long*
   b) *The emerging leaf of L. perenne is folded and that of L. multiflorum is rolled.*
4.
   a) *It can be sown as a specialist pasture specifically to provide winter feed.*
   b) *It can be sown to provide winter feed after summer crops are harvested and before sowing new crops in spring.*
5.
   a) *a petiole – the stem holding up the leaf*
   b) *a node – the part where leaf and roots grow on a stolon*
   c) *an inflorescence – the flower head*
   d) *an internode – the part of a stolon between nodes*
   e) *a stipule – a filamentous structure where the peiole grows from the stolon*
6. *Red clover*
7. *Winter and early spring*
8. *Strawberry clover, Caucasian clover and red clover*
9. *L. corniculatus (birdsfoot trefoil) is usually a paler green than Lotus uliginosus (lotus). Birdsfoot trefoil is erect in growth habit whereas lotus starts off erect but its stems cannot support its weight and they sprawl over to form a loose mat. Birdsfoot trefoil flower heads usually only have 4 – 6 florets whereas lotus has 6 – 8 florets.*

Test Yourself #2

1. *A grass tiller is group of leaves that grows from an apical bud at a node between leaf sheaths. It develops its own root system and, once roots are developed, it can exist without the parent plant if it becomes separated or the parent plant dies. In this way ryegrass plants can reproduce vegetatively as tillers grow and spread out from the initial growing point. Tillers capture sunlight for photosynthesis to create plant nutrients for growth.*
2. *After the first leaf emerges, subsequent new leaves grow up encircled by the last one. The oldest leaf is always on the outside and the youngest expanding leaf in the centre. Each new leaf continues to grow from tissue at the base. Leaves can continue to grow rapidly even after the tips have been removed by grazing or cutting. Ryegrass plants produce three live leaves on the main shoot and each tiller. As each new leaf emerges the oldest one dies. When the tiller has three leaves it doesn't stop growing. A fourth (new) leaf is produced, and the first (oldest) leaf starts to die. Then a fifth leaf is produced, and so on.*
3. *In spring they may live for about 15 days and in winter about 50 days*

4.



5. *It is best to graze ryegrass when most tillers have 2.5 – 3 leaves.). At this stage many plants will have their third leaf (on some tillers it will be small, on others fully developed) and plant reserves will have recovered enough to graze. Grazing before the second new leaf appears doesn't allow the plant reserves to be fully restored. Repeatedly grazing before the second leaf appears decreases yield and persistence.*

6.

   a) *wind*
   b) *by passing through a ruminant's digestive tract*
   c) *by attaching to, then falling off, sheep wool*

7. *In cold humid climates soil organisms are inactive over winter allowing nitrogen-rich material (dead clover roots and uneaten leaves) to accumulate. When soil temperatures rise above 6 ºC in spring, microbial activity increases and these organic materials are broken down, releasing nitrogen and creating a surge of pasture growth. In the warm humid climates, where microbial activity and mineralisation continue during winter, there is a more gradual increase in spring growth. In general, the colder the winter, whether from seasonal effects, greater altitude or higher latitude, the lower the winter growth rates and the greater the spring 'flush' of growth.*

8. *You need to take into account seasonal temperatures and rainfall. For example, white clover is likely to perform well in Northland (warm and moist) whereas strawberry and Caucasian clovers are likely to perform well in Hawkes Bay (warm and dry).*

9. *When considering what modifications may be necessary take into account soil fertility and acidity, rainfall and any physical aspects of the soil that may need modifying. Both ryegrass and white clover need moderate to high fertility and moderate levels of soil moisture (not too wet or too dry) to perform well.*

Test Yourself #3

1. *When land is too steep or rough to sow by other methods and when minimal cost is required, or when minimal loss of grazing is required.*
2. *Novel endophytes provide ryegrass plants with some protection from pest species such as black beetle but have a low risk of causing animal health problems such as ryegrass staggers.*
3.
   a) *Oversowing existing pasture – where land is too steep to use other means*
   b) *Undersowing into existing pasture – where simplicity and low cost are required, or a short term boost to production is acceptable*
   c) *Spray and direct drilling – pasture to pasture – where weeds and undesirable grasses need to be eliminated*
   d) *Full cultivation – crop to pasture – to reduce persistent soil and pasture pests, and weeds, or to correct soil problems, or to have the best chance of establishing a persistent pasture*
4. *Good quality seed, such as Certified Seed produced under the NZ Seed Certification scheme run by AssureQuality, guarantees that you are buying the cultivar stated and that it has minimal contamination of other seeds, including weeds. The seed should have no contamination from noxious weeds. Germination, purity and endophyte certificates should be checked. The germination should be 90% or greater, seed purity 99% or greater and perennial ryegrass with endophyte should have 70% or greater endophyte. These all ensure the seed is likely to germinate and establish well. Buying seed that has been treated (coated) with fungicides and/or insecticides also gives seeds and seedlings some protection during the germination and emergence phase.*
5. *Herbicide can be used to reduce competition from existing pasture plants and weeds, giving new seedlings time to establish before undesirable grasses or weeds can grow.*

Test Yourself #4

1. *Pasture quality is a measure of the nutritive value of a pasture whereas palatability is the preference an animal has for a particular pasture plant or plant part.*
2. *Day length initiates grass elongation and seedhead production, hence a drop in overall quality of a pasture. Most temperate grasses such as ryegrass require a short-day/long-night photoperiod with low temperatures during late autumn and early winter to produce reproductive (seedhead) tiller buds which will emerge in late spring. Perennial ryegrass requires a cold treatment of at least 12 weeks followed by a few long days of 14 hours or more to induce flowering. When these conditions are met, reproductive tillers elongate and the plant produces seedheads, typically from mid to late October onwards for ryegrass. Warmer than normal ambient temperatures can bring forward flowering or cooler temperatures may delay it.*
3. *Four visual assessments of pastures are made; pasture dry matter yield, dead matter, clover and herbs, and green grass leaf, and seed head and weeds. These values are entered into the Q-Graze program along with pasture mass, grazing area, rate of pasture growth, average daily daytime maximum temperature, type of dead matter (old or dead due to dry conditions), stock class including gender categories for sheep and cattle, dam breed, sire breed, number of animals in the mob, average liveweight of the mob in kg at the start of the grazing period, grazing duration (the number of days you anticipate the animals being in the paddock). Reports can then be extracted on possible livestock liveweight gains.*
4. *To collect a pasture sample representative of a paddock, walk across a representative part (e.g. 100 m diagonal) of the paddock. Every second or third step, stop and cut three small samples of the*

pasture to ground level (one adjacent to each foot and then a sample midway between each foot). You could use scissors, clippers, electric hand piece or even sharpened spoon. You need at least 30 samples to estimate metabolisable energy to 0.5 MJME/kgDM.

5. *New pastures typically have less dead material and higher clover content than the pastures they replace, hence higher quality. For a more long term approach, renewing pastures with improved ryegrass cultivars can improve the quality of pasture over time. Varieties with the right endophyte type for an area, use of tetraploid verses diploid types, early, medium or late heading date and the amount of aftermath heading can all help improve the quality of pasture. Using low aftermath heading ryegrass varieties can improve late spring/summer quality because they have a concentrated reproductive phase with fewer seedheads forming after the initial reproductive flush. This can improve the effectiveness of topping as fewer seedheads are likely to form after topping.*

Test Yourself #5

1. *During lactic acid fermentation anaerobic bacteria turn sugars into lactic acid that results in a drop in the pH of the silage. As long as the pH drops below 5 the silage remains stable. If the silage pH is above 5 then Clostridia bacteria turn the lactic acid into acetic acid and butyric acid to get energy, as well as breaking down protein into ammonia. As the Clostridia bacteria use the lactic acid and protein to get energy the ammonia levels in the silage rise resulting in an increase in the pH of the silage. This makes the stack more*
2. *Cutting and wilting of pasture for balage is the same as for pit silage with the exception that the percentage dry matter needs to be higher at 30% – 35% DM. With pit silage wilted pasture is transported to a pit and is compacted, usually by driving backwards and forwards with tractor, to remove as much air as possible from the grass. In contrast, wilted grass is compressed into a bale by specialist baling machinery to remove air. The bale is then wrapped in plastic to prevent air entering the bale. Once a pit has been finally compacted it is covered with plastic that is weighted down, usually with old tyres, to keep out moisture. It is not sealed in the same way as a balage bale so there is some spoilage of the surface areas of the pit silage that are exposed to air.*
3. *Volume = (29 x 7 x 2) x 29% = 118m3*
   Weight = 118 x 180 = 21,240 kgDM
4. *Volume = 75 x (3.143 x 0.92 x 1.5) x 85% = 243.4m3*
   Weight = 75 x 200 = 15,000 kgDM
5. *125 x (0.8 x 0.68 x 1.3) x 32% = 28.3m3*
6. *Deferred grazing aims to provide a low cost method of pasture conservation, providing feed during late summer and early autumn. It can also form part of a pasture renovation programme to increase pasture grass and clover populations to increase both pasture mass and quality. Another aim may be to increase soil organic levels to enhance the soils water holding capacity.*
7. *Diffusion works by the movement of water from a wet to a dry area until the water content of both areas is equal. Dry air surrounding freshly cut plant material draws water out from the plant material to its surface, from where it evaporates into the air. Since the air is almost always moving and dry air replaces wet air, the plant material will continue to lose water until it is dry. The drying conditions on the bottom of a swath do not favour this process. However, the interlocking plant parts create an open structure in a windrow improve internal and external air circulation and the diffusion process. The windrow can be varied in width to suit the pasture density and drying conditions.*

8. *Wrapping bales individually makes moving bales easier. If one bale is spoiled due to air getting through damaged plastic not all bales are affected. Individual bales have more flexible storage options than tubes. Tubes use less plastic than individually wrapped bales, hence overall costs are lower. Tubes need to be carefully sealed after silage is removed to prevent spoilage.*
9. *Pit silage = 25 – 35%; Balage = 30 – 35%; Hay = 75 – 85%*