Chicory

In brief

Chicory (*Cichorium intybus*) is a deep rooted summer-active, short-term (2–4 years) perennial herb with good nutritive characteristics. There has been renewed interest in chicory's potential to provide high-quality summer forage for grazing on southern Australian dairy farms.

Experimental studies, at both a plot and paddock scale and implementation on partner farms as part of the 3030 Project have generated valuable information, particularly about potential production, seasonality, grazing management, agronomic requirements and potential system fit.

This Information sheet summarises the key findings and some practical aspects of chicory management.

Key features

- Reliable summer growth, even with low rainfall, due to its deep taproot system.
- High nutritive characteristics when grazed (+12 MJ ME/kg DM and up to 25% DM crude protein).
- Grazing frequency and intensity guidelines should be strictly observed to optimise DM yield, nutritive characteristics and persistence beyond the second year.
- Role as 1 or 2-year summer crop in pasture renovation programs that allows a seamless return to grazing.
- Role as 2 to 4-year perennial crop (or more if allowed to self-seed) that can be oversown with cereals, annual or perennial grasses.
- Less susceptible to insect damage than many other forages. Typical pasture pests such as lucerne flea, slugs and red legged earth mite could have some impact during early establishment.
- No major risks to animal health, although at very high feeding rates there is anecdotal evidence of chicory having caused acidosis and bitter taint in milk.
- Has a number of desirable features in common with Lucerne, but is adapted to a much broader range of soil types.

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Understanding chicory growth

Chicory growth is different from most perennial or annual forage crops used in southern Australian dairy farms. Its life cycle needs to be understood and managed to optimise the crop's productivity, nutritive value and persistency.

A chicory crop can persist for 2–3 years or longer if the plant is allowed to set seed. The plant needs to go through a vernalisation process (the plants must be exposed to the prolonged cold of winter) for the reproductive stage to initiate. The chicory plant reportedly needs at least three weeks of exposure to minimum daily temperatures below 4°C to be vernalised (Demeulemeester and De Proft, 1999). If sown in spring, chicory will not produce reproductive stems until the following spring, as shown in Figure 1.

Figure 1. The life cycle of chicory in the first 18 months after spring sowing.

The appearance of reproductive stems has implications for grazing management.

During autumn, chicory normally accumulates sugars in the root system to replenish reserves for winter. In winter, plant growth is slowest, although some of the newer cultivars do have better winter activity. The general recommendation has been to avoid severe grazing during late autumn and winter.

In spring, plant growth increases and, if the plant was vernalised through winter, hollow reproductive stems appear later in spring. If the reproductive stems are not removed by grazing or mechanical cutting they become hard, flowering occurs and seeds are produced. These seeds mature by the end of summer and drop to the ground near the plant.

Not all chicory plants within a sward will become reproductive in a given year. Studies in New Zealand have reported that about 60% of the plants become reproductive every year (Li and Kemp, 2005). Those plants that stay vegetative during one year are more likely to become reproductive in the following year.

At the 3030 Gippsland Partner Farm in South Gippsland (Poowong) some spring-sown chicory crops did not go into the reproductive stage in their second year. The same was seen in autumn-sown chicory crops in their first spring. Chicory reportedly needs at least three weeks of air minimum temperatures below 4°C to be vernalised (Demeulemeester and De Proft, 1999). It is possible that such low temperatures were not reached for the required length of time at the site where this lack of flowering was observed. Importantly, chicory's growing point is at ground level during the vegetative stage and the temperature at that level can vary substantially between paddocks due to topography and ground cover.

From the experience at Poowong it appears that after a warm winter some chicory plants might not develop reproductive stems. Analysis of 108 years of Poowong's climatic records shows the long-term probability of temperatures below 4°C in June, July and August was only 28, 37 and 30%, respectively. In addition, previous glasshouse studies reported that chicory plants less than one month old were not sensitive to the vernalisation effects. This could explain the lack of vernalisation in the autumn-sown chicory crops. More research is needed confirm this.

Where does chicory fit into a feed plan?

Summer feed gap

Because of its late spring and summer growth potential, chicory can complement the seasonal production pattern of perennial ryegrass. In the 2010/11 summer at Terang, the growth rate of chicory peaked in mid-summer at the time when perennial ryegrass growth rates were declining (Figure 2). Chicory can grow under drier conditions than perennial ryegrass due to its deep taproot system and its ability to respond rapidly to any summer rainfall. In a dairy system this species can provide valuable home-grown feed that complements the lower summer production of perennial ryegrass.

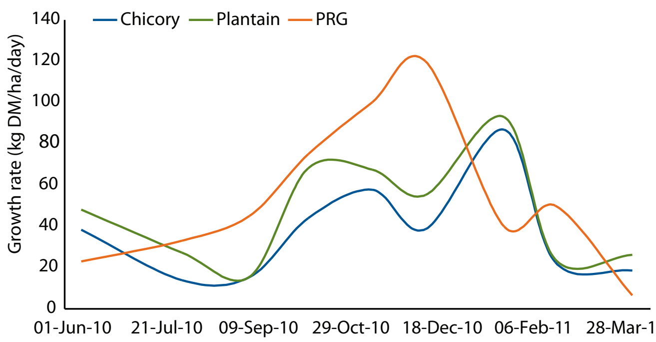

Figure 2. Growth rate of chicory, plantain and perennial ryegrass (PRG) at Terang, 2010/11.

Because of its normally high metabolisable energy, high crude protein and low fibre content, chicory can be a valuable component in the diet of lactating cows. Its contribution is particularly valuable during summer, when ryegrass production is low, unreliable and usually of lower quality. Having a portion of the farm sown to chicory can provide a more even flow of high-quality grazeable forage throughout the year and reduce the need for conserved or purchased fodder and/or additional concentrates.

Figure 3 illustrates the potential role of chicory on a perennial ryegrass-based dairy farm. The production is compared to the estimated forage requirements of a winter-calved herd at different stocking rates. The forage requirement curve assumes a maximum intake of pasture (alone or with chicory) of 15 kg DM/cow/day. This figure shows how the inclusion of chicory could increase the availability of grazeable forage during January–February–March.

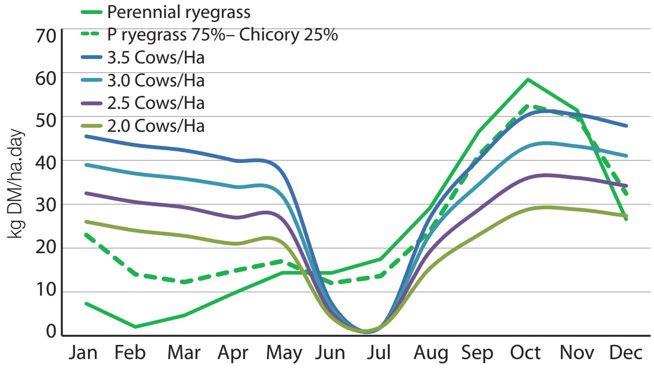

Figure 3. Supply of forage from a farm with perennial ryegrass pasture only, 75–25% pasture area to perennial ryegrass and chicory, and demand for forage from a winter calving herd at stocking rates from 2–3.5 cows/ha, at Terang.

At some of the 3030 Project partner farms, chicory was used as a perennial to fill the summer/autumn feed gap. It was sown alone or in combination with perennial grasses (tall fescue or ryegrass) or white clover. It was chosen by the farmers and advisers leading the partner farms because it does not need to be sown each year and is not affected by common pests (e.g. it was sown in paddocks where ryegrass was devastated by red-headed cockchafers).

Renovation program

Chicory can be used with winter cereals or annual ryegrass in a 12 or 18-month pasture renovation plan, although a renovation plan over a single summer is also feasible. These alternatives should be considered on a case-by-case basis.

Chicory can be used in a short-term (six month) renovation program. It can be sown either as a sole forage or in combination with other summer forage crops, grazed over summer and autumn, then oversown with perennial ryegrass or tall fescue in autumn. This has been the most common option for the use of chicory in renovation programs.

In situations where an invasive weed such as "bent grass" (*Agrostis capillaris*) is a problem, then a longer renovation program of 12 or 18 months may need to be implemented to provide the opportunity for multiple sprayings of the weed.

In a 12-month renovation program, chicory can be sown in spring and the perennial pasture drilled into it in the following spring.

In an 18-month renovation program, chicory would be typically sown in spring with perennial ryegrass drilled into it in the autumn approximately 18 months later. Another option, similar to the traditional renovation program adopted by dairy farmers in southern Victoria, is to start the 18-month renovation program with an annual summer crop (e.g. millet or turnips), followed by a winter cereal or annual ryegrass and sow the chicory in the spring of the following year (see Figure 4).

Recent plot trials at the DemoDairy in Terang, western Victoria, have shown that drilling winter cereals into an existing chicory stand in autumn can provide additional feed in autumn–winter without affecting the original density or productivity of the chicory crop (see *3030 Report* January 2011, pp. 38–43). This option could suit either 12 or 18-month renovation programs.

Another option is not to spray out the chicory in autumn (e.g. last spraying in March in Figure 4) and direct drill the perennial ryegrass into the chicory stand. This option is being trialled at Terang and shows potential benefits as the chicory post-grazing residue is normally low enough for the direct drilling of pasture. The new pasture grows with the chicory as a mixed sward. In addition, white clover can be sown with chicory in spring. This enables the white clover to establish well and be an on-going part of the mix when oversown with grass. Further details of this practice and alternatives are discussed below.

Selective herbicides can be used without affecting the chicory plants so, used as a break-crop, chicory can help in the control of barley grass. Note that any herbicide selection should be done under professional guidance and at label recommended rates.

Chicory is not vulnerable to red headed cockchafers which can ruin a established grass pastures and for this reason this species has been used on commercial farms that have suffered severe attacks repeatedly.

Figure 4. An 18-month renovation program for perennial ryegrass pasture (PRG).

Heavy soils—subsoil moisture

Chicory could be an alternative for paddocks with good sub-soil moisture that would be out of reach for perennial ryegrass or other shallow-rooted species. Although lucerne could also perform well in these conditions, chicory can grow on heavy clay or acidic soils where lucerne would not establish successfully.

Chicory is not adapted and will have poor persistence on poorly drained soils, so better adapted species such as tall fescue should be used on such soils.

Yields

The DM yield of chicory was measured at Terang as part of a 3030 Project study to evaluate the response of different forage crops to the application of dairy effluent.

The DM yield of chicory was similar to other common summer crops such as regrowth Brassicas (cultivars Hunter and Winfred), sub-tropical C4 species (sorghum and millet) and a plantain crop. However, DM yields were highly variable depending on summer rainfall and N applied in the effluent, and ranged between 2.7 and 10.1 t DM consumed/ha/year (see Table 1). This is consistent with previous experiences in New Zealand, where yields between 7 and 9 t DM/ha/year were frequently achieved in the first two or three years of the crop, with sufficient summer rainfall. The application of effluent to pastures is discussed later in this Information sheet.

Table 1. Yields of summer forage crops with and without dairy second pond effluent application (kg N/ha) over two years at Terang (adapted from Jacobs et al. 2008).

		Year 1		Year 2	
Rainfall November–March	(mm)	327		161	
		0 N	**132 N**	**0 N**	**160 N**
Chicory	(t DM/ ha)	5.2	10.1	2.7	4.2
Hybrid brassica (cv. Hunter)	(t DM/ ha)	3.9	9.1	3.1	4.6
Sorghum (cv. Sweet Jumbo)	(t DM/ ha)	3.6	6.5	3.7	5.2
Hybrid brassica (cv. Winfred)	(t DM/ ha)	4.1	9.2	3.9	5.4

The main difference between the various summer forage crops evaluated in the Terang study was the time required to reach grazing maturity. Chicory was the first crop ready to be grazed, earlier than Brassicas, millet and sorghum.

Figure 5. Stem elongation in chicory (West Gippsland, Dec 2010).

Feeding chicory to dairy cows

It is accepted that up to 25% of a dairy cow's total daily diet can be chicory without causing bitter taint in milk (Barry, 1998). However, estimated intakes of up to 40% of the total daily diet have been observed on commercial farms with no evidence of detrimental impacts. In these cases, chicory was grazed for about half the day and a different pasture was fed for the rest of the day. There is little experience feeding high intakes of chicory over an extended period on commercial farms.

Chicory leaves normally contain high ME and low fibre [12–13 MJ/ kg DM and 18% neutral detergent fibre (NDF)] while the reproductive stems normally have low ME (7 MJ/ kg DM) and high fibre content.

At the early stages of stem elongation (late spring or early summer, depending on soil moisture), cows can consume a considerable proportion of the stems, which are still hollow and palatable. A leaf:stem ratio of 70:30% is considered a good compromise between quality and quantity for grazing cattle (Li and Kemp, 2005).

As the reproductive phase progresses, stems tend to get thicker and harder, and cows will select only the leaves and reject the stems. When this happens (see Figure 5), slashing after grazing to 5–10 cm height is recommended to remove the stems and allow better-quality regrowth. There is also anecdotal evidence of pre-grazing topping working well in such conditions. In this case, animals consume most of the cut material with little plant material left on the paddock compared to post-grazing topping.

Regrowth of chicory will be produced as new shoots from the basal nodes of the plant (see Figure 6). There is anecdotal evidence of chicory crops in conditions as shown in Figure 5, being cut and conserved as silage successfully, although there is no data regarding the nutritive value of that feed.

Figure 6. Regrowth from the base of a chicory plant after the stem was removed on a commercial farm in West Gippsland (13 Dec, 2010).

In the vegetative phase (when stem elongation has not taken place) chicory has a low DM content (10–12% DM) and the crude protein (CP) can be as high as 22–25% DM. The effluent application study at Terang found no significant changes in the CP content of chicory with increasing N applications, contrasting with the other summer crops (Brassicas and sorghum), which showed a linear increase (Jacobs et al., 2008).

The same study found that the ratios of potassium to calcium plus magnesium [K to (Ca + Mg)] for the unfertilised chicory crops ranged from 1.2 to 2.6, which is generally below the level that can predispose animals to hypomagnesaemia (>2.2). The application of effluent increased this ratio, reaching levels from 2.7 to 4.2. Although such ratios may increase the likelihood of hypomagnesaemia, chicory is normally only provided as a proportion of the diet. Unless the other feeds have similarly high ratios, it is unlikely to cause animal health problems. However, care should still be taken with some classes of livestock such as animals close to calving.

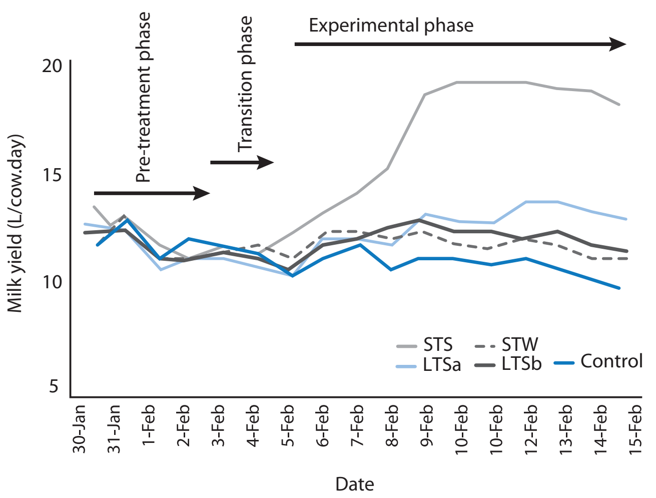

Figure 7. Summer milk yield for autumn-calved cows offered 45 kg DM/day of swards of chicory-white clover (STS), summer-active fescue-based pasture (LTSa), Italian ryegrass-based pasture (STW), winter-active fescue-based pasture (LTSb) and perennial ryegrass-based pasture (control). Source: Chapman et al. (2008).

To evaluate milk production from different pastures, a detailed expriment was conducted in Terang as part of the 3030 Project. Late lactation cows grazing chicory in February produced 5 L/cow/day more than those grazing perennial ryegrass-based, Italian ryegrass-based or fescue-based pasture (see Figure 7). This supports the potential of chicory to produce more milk when fed to lactating cows compared to other summer grazing options.

Chicory has also been shown to reduce the effects of internal parasites in sheep (anti-helminthic properties), but the reasons behind this are still unclear (Li and Kemp, 2005).

How chicory compares to turnips as a summer forage?

Turnips (*Brassica rapa*) have been the one of the preferred summer forage crops on dry land dairy farms in southern Australia for many years. This section compares the main features of turnips and chicory.

- **Establishment:** Both crops are relatively cheap and easy to establish. However, chicory can adapt to less fertile soils and is more tolerant of acidic conditions.
- **Nutritive value:** Both species can produce high ME (+12 MJ/kg DM), low NDF levels (~23%DM) and high CP (12–25 %DM). However, turnip plants do not normally become reproductive within the summer period, whereas chicory NDF levels will increase and ME decrease if allowed to elongate their reproductive stems in the second year of the crop.
- **Perenniality:** Turnips will only produce feed for a short period (typically 3–4 months), but chicory can produce feed for a longer time (spring–summer–early autumn) and persist for 2–3 years or more if managed correctly. Also, the need for re-sowing following turnips means that land will not be producing adequate DM for grazing for some time (usually until winter); chicory can continue to provide feed into the autumn and can be oversown and then act as a cover crop for the germinating grass.
- **Feed supply:** Turnips are grazed only once, whereas chicory can be re-grazed a number of times, allowing a constant supply of high nutritive value feed during summer. On the other hand, the potential to accumulate DM before the first grazing is higher for turnips, due to the development of bulbs that are not present in chicory.
- **Drought tolerance:** If there is enough soil moisture present in the soil profile, chicory can grow under summer drought conditions because its tap root can reach several meters deep. Turnip growth can be severely affected by lack of soil moisture. A survey by Jacobs et al. (2001) showed that turnip DM yields ranged from 0.4 to 19.2 t DM/ha, mainly due to variations in water received and soil moisture at sowing.
- **Pests:** Chicory is only threatened during establishment by slugs and sometimes by red-legged earth mite. Turnips can be seriously affected by a wide range of pests (red-legged earth mite, slugs, aphids, cabbage moth, cabbage white butterfly, diamond black moth, cutworms, lucerne flea, wingless grasshoppers and leafminers) and require close monitoring to prevent these attacks.
- **Body of knowledge:** Turnips have been used extensively on dairy farms for more than 50 years and have been the subject of continual research. The commercial experiences and research studies related to the use of chicory for southern Australian dairy farms are still scarce.

Grazing management

The main objective with a chicory crop is to maximise leaf production and minimise stem production without affecting persistence. Grazing frequency and intensity requirements vary with the time of the year in relation to the growth stages and the availability of water for the plant. Table 2 gives general guidelines for grazing management.

Because the chicory plant is usually vernalised through winter and stem elongation initiated, the grazing frequency should be shortened to 2–3 weeks in spring of the crop's second year (or for autumn-sown chicory in spring of the first year).

A short rotation makes it possible to remove the stems by grazing, when they are still hollow and more palatable, which will also help the nutritive value of the regrowth. It is important to graze the crop down to ~5 cm, otherwise slashing is required to remove the remaining stems.

Although there is some growth during the autumn, the grazing intensity should be reduced, ensuring some remaining 'green leaf' for the plant, so it is able to replenish root reserves and persist through winter.

Avoid grazing during prolonged waterlogging in winter and early spring. This can directly damage the base of the plant and deplete plant reserves.

Another problem in winter and early spring can be the accumulation of water in the base of the hollow stems that were cut or removed by grazing. If the cut stem fills with water, it can decompose, causing the tap root to rot and killing the plant. Do not cut or graze mature stems in autumn or winter, particularly in the presence of wet weather and/or saturated soil.

Table 2. Recommended grazing management of chicory for optimum production and persistence.
Note: The frequency recommendations are for a spring-sown chicory crop; for autumn-sown crops follow same recommendations as in year 2.

	Spring	Summer	Autumn	Winter
Frequency (time between grazings)	Year 1 of the crop: 4–5 weeks. Year 2 onwards: 2–3 weeks (unless water stressed)	Year 1 of the crop: 4–5 weeks. Year 2 onwards: 2–3 weeks (unless water stressed)	4 weeks or more	6–7 weeks or not grazed at all.
Intensity of grazing	Down to ~5 cm height (otherwise slash post-grazing to remove stems)	Down to ~5 cm height (otherwise slash post-grazing to remove stems)	Very light (down to 7–10 cm height), to avoid loss of plants and let the plant accumulate carbohydrates in the root before winter.	Avoid cattle trampling if the soil is wet. Damaging the crown of the plant can kill it.

Responses to N application

Urea

A plot study at Terang evaluated the DM response of chicory to urea applications (see *3030 Report* January 2011, pp. 25–33). Rates of 10, 20, 30 and 40 kg N/ha were applied after grazing from May to November (except in July, when the crop was not grazed). There were no significant responses in DM yield to N applications from May to August, however, by the September application all rates of N resulted in an increase in DM yield (see Figure 8). The cumulative DM response to the total N applied was 28, 17, 15 and 10 kg DM/kg N for the 10, 20, 30 and 40 kg N/ha applications, respectively.

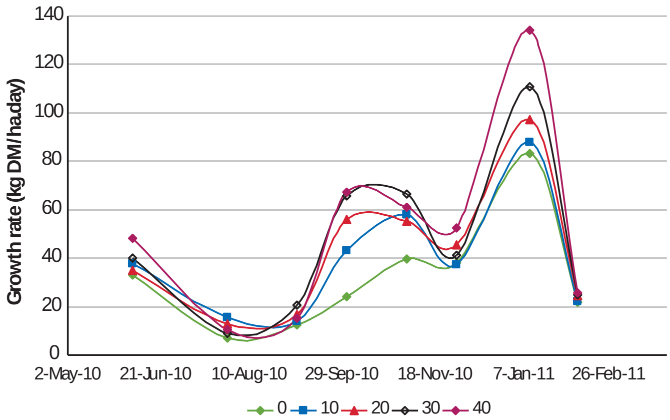

Figure 8. Growth rate (kg DM/ha.day) of chicory at different times of year with varying levels of N (kg N/ha) applied after every grazing (May application is not shown). Source: J. Jacobs (2011), unpublished.

In a previous trial at Terang (Jacobs and Ward, 2011), yield responses of chicory to N applied as urea during summer were relatively poor (0 to 4 kg DM/kg N applied) due to lack of moisture. This was also true for plantain, turnips, regrowth Brassicas, sorghum, millet, and a millet/regrowth Brassica mixture.

Responses to applied N are strongly influenced by the paddocks' recent history and the availability of soil moisture. For spring sowing, nitrogen should not be required during the first spring and summer after perennial pasture when there may be high levels of soil N from mineralisation of organic matter. In other situations, N should only be used when there is sufficient summer rainfall to allow crops to utilise the applied N.

The potential DM response of chicory crops to increasing levels of N application for the full crop cycle is currently being investigated by Jacobs et al. (pers. comm.) in south-west Victoria.

Effluent

A two-year plot study at Terang compared the responses of different summer crops to effluent application (Table 1). The trial included chicory (cv. Grouse), two hybrid Brassicas (cv. Winfred and Hunter) and sorghum (cv. Sweet Jumbo).

Second-pond dairy effluent containing 146 kg N /ML was applied at rates of 0, 40, 80, and 100 mm, with applications split into two: 6–10 weeks after sowing (early January) and immediately after the first grazing (early February).

During the first year of the study, soil moisture was not limiting and all crops showed a linear response to effluent application, which was about 50 kg DM/ha/mm (34 kg DM/kg N applied) for both chicory and Brassicas. Sorghum responses were lower (around 30 kg DM/ha/mm). In the second year of the study, there was little summer rainfall. Responses were low and similar for all crops (15 kg DM/ha/mm). Total DM yields from this trial are shown in Table 1.

Interestingly, chicory was the only forage to show a linear positive response in terms of ME concentration to increasing effluent application. All other crops showed negative or no ME response.

From the total N applied in the effluent, the apparent N recovery (percentage of N applied that was extracted by the plants) at the first grazing of chicory was in the 26–35% range, although this was higher for the Brassicas (40–75%). When soil moisture was not limiting and DM responses were optimum, the recovery was between 83 and 97%. This is consistent with previous studies in New Zealand, where 80% of the N was recovered by the chicory, working on soils with adequate moisture content.

While effluent can improve DM yields when soil moisture is limiting, responses from effluent applications are even higher when there is additional rainfall.

Chicory mixtures

Chicory + cereals

A recent experiment at Terang evaluated the sowing of chicory in spring (October) and drilling of cereals (wheat or triticale) into the existing chicory crop the following autumn (see Figure 9). The resulting mixed crop was grazed once and the regrowth cut for silage later in late spring. This process was then repeated the following autumn after the chicory has been grazed over summer. Preliminary results (Table 3) show that both combinations of chicory (with triticale or wheat) could increase the total DM yield compared to single crops.

Only a slight improvement in the ME content of the silage was achieved by the addition of the chicory to the cereals when the material was cut for silage. This reflects the fact that the chicory had entered its reproductive phase and hence the ME and CP of the chicory had declined. Earlier harvesting in spring may have led to a higher ME and CP but would have also lowered the DM yield. Decisions on when to cut need to be considered in light of the expected end use of the silage, that is to say, will it be used as part of a production feed in lactation or as a low quality feed for dry cows.

The combination of chicory + cereals does have potential as a double-cropping option within a paddock renovation program, as discussed earlier. Chicory's consistent performance during dry summers can provide reliable summer feed and the opportunity to control grass weeds. The cereals fit in well during a period when the DM contribution of the chicory is normally poor (winter), but they do not swamp the chicory and reduce plant numbers, thus allowing it to continue production in the following summer.

(a) (b)

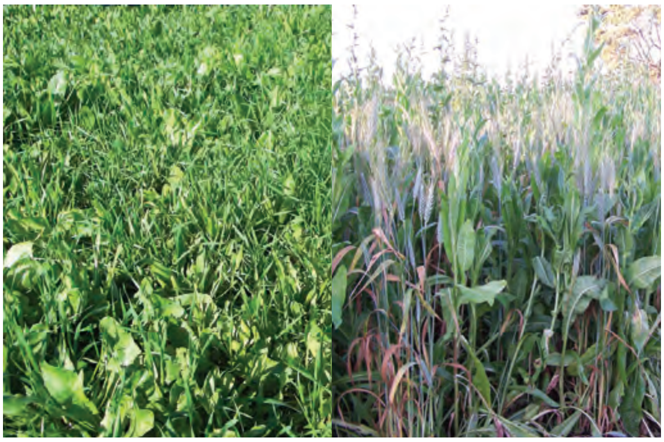

Figure 9. Chicory + wheat mix prior to grazing in early winter (a) and at harvest (b) at 3030 Project studies at Terang.

A recently completed experiment compared a range of double cropping options with perennial ryegrass over a 30 month period. One of the forage crops options was to sow a chicory based mixture (also included plantain and red clover) in spring, graze this over summer and then oversow with winter wheat in autumn. This was then grazed in early winter and subsequently locked up until late September when it was cut for silage.

The chicory based sward then provided grazeable feed over the remainder of spring and summer before the winter wheat was again oversown in autumn and the same winter process followed. By the end of the third summer (30 months), this forage combination had produced 37.5 t DM/ha compared with 33.5 t DM/ha from the perennial ryegrass sward.

The decision to use winter cereals should be based on the farm system feed requirements. Do not assume that winter cereals can be successfully combined with chicory in all circumstances. The management, harvest, ensiling and feeding out of winter cereals also require specific skills.

Table 3. Total DM yields and ME content of winter cereals and chicory sown alone or in combination at Terang (preliminary results).

	Winter (t DM/ha)	Summer (t DM/ha)	Winter (t DM/ha)	Total (t DM/ha)	Winter Grazing ME (MJ/ kg DM)	Silage ME (MJ/ kg DM)
Chicory alone	11.2	6.2	6.1	**23.5**	11.2	9.3
Triticale alone	13.2	4.4	7.4	**25.0**	11.6	8.2
Wheat alone	11.3	4.7	8.1	**24.1**	12.4	8.3
Chicory + triticale	13.8	5.9	7.7	**27.4**	11.4	8.3
Chicory + wheat	12.9	5.3	7.3	**25.5**	11.3	8.5

Chicory + plantain

A current experiment at Terang is evaluating mixtures chicory with plantain (*Plantago lanceolata*). Like chicory, plantain is a herb and grows as a rosette close to ground level and has high nutritive value for dairy cows. The easiest way to identify plantain is by the presence of 4–7 longitudinal 'nerves' in the leaves (see Figure 10); chicory has only one central nerve.

In this experiment, plantain seemed to complement the growth of chicory, particularly during winter, when plantain represented as much as 50% of the DM available (see Figure 11 and 12), while chicory provides the bulk of the forage in the warmer periods.

In the same experiment, a range of grass species oversown into the chicory/plantain sward in autumn and grazed by dairy cows to measure DM yield (see Figure 13). Preliminary results from the first 18 months showed that oversowing chicory/plantain with annual ryegrass (Figure 14) or Italian ryegarss provided the highest DM yields. However, these results represent yields from the first 18 months and it is noticeable that perennial ryegrass started to produce consistently higher DM yields at each grazing once fully established.

Chicory + perennial grasses (tall fescue or ryegrass)

The combination of chicory and perennial grasses offers the convenience of autumn-drilling the perennial pasture into the existing first or second year chicory crop as part of a renovation program. This reduces the gap when the renovated paddock does not provide any feed to the system, providing a smoother transition from crop into permanent pasture. The implications of this practice on the final density of the perennial ryegrass sward, compared to this perennial ryegrass sown alone, are yet to be determined.

Figure 10. Plantain sward in vegetative stage.

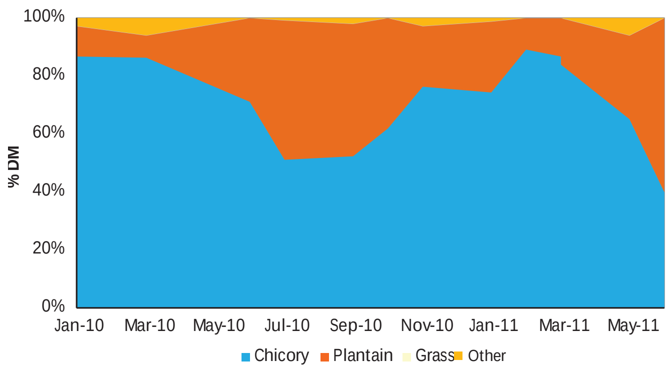

Figure 11. Changes in botanical composition (% DM) at each grazing for a chicory-plantain mix sown in spring at Terang (see *3030 Report* January 2011, pp.38–43).

A tall fescue and chicory mix, sown together, was successfully established at the 3030 Gippsland Partner Farm on heavy clay soils that are normally susceptible to waterlogging.

Chicory + white clover

This mix has been sown in spring on a paddock at the 3030 Gippsland Partner Farm on heavy clay soils in 2010. Visually, competition does not appear to have changed the relative plant density of both species, and the combination performed exceptionally well in the first year with above average rainfall.

Further research is necessary to determine potential productivity, nutritive value and agronomic requirements, as well as the potential for reduced use of N fertiliser using this mix.

Figure 12. Chicory+plantain mix at 3030 project studies at Terang (October 2009).

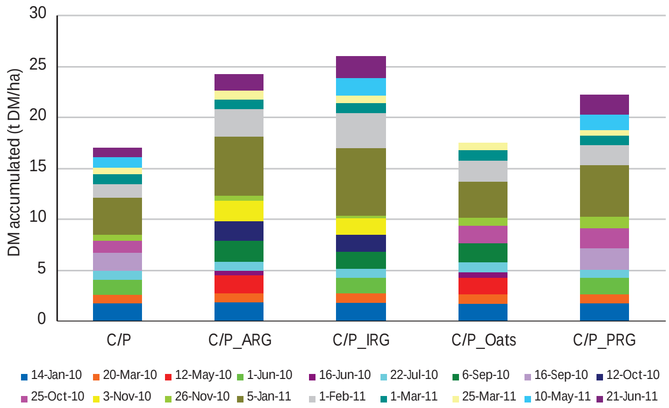

Figure 13. Dry matter accumulated (t DM/ha) at each grazing for chicory/plantain (CP), chicory/plantain oversown with annual ryegrass (CP/ARG), Oats (CP/Oats), Italian ryegrass (CP/IRG) or perennial ryegrass (CP/PRG).

Figure 14. Chicory, plantain and annual ryegrass mix at 3030 project studies at Terang (October 2009).

Figure 15. Chicory+plantain+regrowth brassica (cv Hunter) mix at 3030 project studies at Terang (January 2011).

Chicory + summer crops

Anecdotal evidence is that, where herbs such as chicory or plantain are sown in spring with a summer forage crop (Brassicas or millet), nutritive value can be improved without adversely affecting summer DM yield (Figure 15).

There have been reported increases in forage production during the following autumn compared to single summer crops. Also, there were fewer weeds in the newly sown pastures during the first year after implementing a combination of chicory and summer crops.

Agronomy of chicory

Sowing:

- As a single crop, the sowing rate for chicory is normally 4–6 kg of seed/ha.
- Can be sown into a cultivated seed bed or direct drilling, although it is important to make sure that the seed is no more than 10 mm deep.
- Soil temperature needs to be greater than 10°C for a successful establishment.
- Sowing in spring is the preferred practice in southern Victoria, although autumn sowing is also possible. If sowing in spring, ensure adequate soil moisture for the establishment before summer, as well as absence of broadleaf weeds. Autumn sowing often results in slow establishment and an increased likelihood of severe weed infestation occurring. Sowing in autumn also means the plants can produce reproductive stems in the spring of their first year. Avoid sowing in late autumn where there is a risk of exposing the young seedlings to frost.

Pests

Pests have only been a problem during the establishment phase of chicory. Red legged earth mites (*Halotydeus destructor*) can be a threat and residual insecticides are necessary in some situations. Slugs can also cause significant damage and possibly crop failure, particularly in direct-drilled chicory and during the germination phase. Anecdotal evidence in Gippsland shows that lucerne flea (*Sminthurus viridis*) can also have some impact during establishment.

Chicory is not affected by insects such as the diamond back moth or cabbage moth (*Plutella xylostella*) or the cabbage white butterfly (*Pieris rapae*). This is one comparative advantage over other broadleaf summer crops such as the Brassica species. At the commercial farms where chicory has been sown, red headed pasture cockchafer (*Adoryphorzrs coufoni*) did not have any impact either.

The PestGenie website (**www.pestgenie.com.au**) has more information on options for chemical control of pests.

Weed control

Grass weeds in chicory can be controlled with selective herbicides. Sowing chicory can help with the control of annual grass weeds, which is one of the reasons for its increasing popularity among dairy farmers (particularly for barley grass problems). Chicory normally presents a more open canopy (especially at early stages of regrowth) than most of the summer *Brassicas*, allowing for more effective spraying of targeted weeds.

On the other hand, there are no selective post-emergent herbicides to control broadleaf weeds in chicory. The use of flumetsulam is being evaluated, but some minor damage to chicory seedlings cannot always be avoided (Hackney et al., 2006).

It is crucial to make sure that paddocks to be sown to chicory are free from broadleaf weeds, especially during the establishment period when early competition can affect plant density. To achieve this, start broadleaf weed control from the previous year.

If chicory is direct-drilled into an existing pasture, broadleaf weeds should have been controlled the previous year or at least not allowed to seed (mechanical cut). However, this practice is not recommended as it will lead to very poor establishment of the chicory.

If sowing into a prepared seedbed, the soil disturbance will allow the emergence of new weeds. In this case, broadleaf weeds should be allowed to germinate and emerge. They should be controlled before or at the same time as the chicory is sown.

Once the canopy has closed, and provided the density is maintained, the competition from new weeds should be minimal.

Soil requirements

Chicory can be grown on a broad range range of soil types. For example, it can be sown in heavy black clay soils where lucerne could not be established successfully. New Zealand reports suggest that chicory can tolerate a range of soil pH($CaCl_2$) from 4.8 to 6.5 (Barry, 1997).

Waterlogging for extended periods can kill plants, as water accumulates on the basal part of the plant ('crown'), leading to fungal disease and rotting of the growing point. However, chicory crops evaluated at Terang have tolerated to short periods of waterlogging without harming plant growth.

Persistence

About 30% of the original plants are expected to be lost each year. Although seed production can occur after the first year of the crop, new seedlings from natural re-seeding do not always survive grazing, probably due to trampling of the fragile seedlings (Li and Kemp, 2005). Persistence of chicory largely depends on the survival of the original plants.

In New Zealand, the optimum plant density is greater than 50 plants/m^2, with 2–4 shoots per plant. When density dropped below 25 plants/m^2, production was likely to be more than halved (Li and Kemp, 2005). The optimum and minimum density for the southern Australian environment has not been established, but it may be lower than for New Zealand (J. Jacobs, *pers. comm.*).

When estimating plant density, it is important to distinguish between plants and 'daughter shoots'. The latter are produced from the division of the crown of the original plant and sometimes appear 5–10 cm apart.

For further information on chicory go to the DPI NSW site at:
http://www.dpi.nsw.gov.au/agriculture/field/pastures-and-rangelands/species-varieties/factsheets/chicory/part-a

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About 3030

PROJECT 3030 aims to help farmers achieve a 30% improvement in farm profit by consuming 30% more home-grown forage (pasture plus crop). It is aimed at dryland farmers in southern Australia who have mastered the challenge of growing and using ryegrass pasture for dairy-cow feeding.

For further information

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