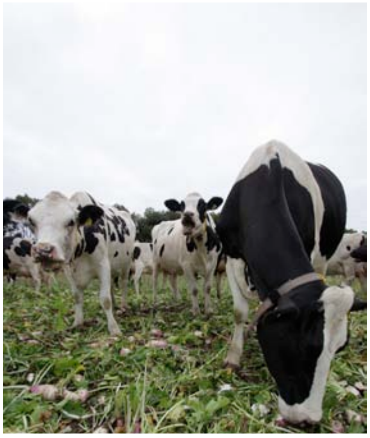
Turnips

In brief

Brassica forage crops are grown on about 70% of dryland dairy farms in southern Victoria and Tasmania. Turnips (*Brassica rapa*) are one of the main Brassica forage crops due to their high potential for growth during summer and exceptional nutritive value for dairy cows.

The 3030 Project looked at different aspects of turnip management to increase home-grown feed production and utilisation, and their role on pasture-based dryland farms. Several plot-based experiments and on-farm studies were conducted, and experience gained from implementation on commercial farms.

This Information Sheet summarises some of the key findings. It focuses on the 'bulb' turnip cultivars; the cultivars known as 'leafy' turnips or 'hybrid Brassicas' are covered by 'Regrowth Brassicas' Information Sheet in this series.



Key features

- Higher dry matter (DM) yield potential as a summer crop over a given period compared to other Brassica species, but regrowth Brassicas can grow for longer.
- Highly variable yields (1–10 tonnes DM per ha) as they are sensitive to lack of soil moisture and insect damage. The cost per tonne of DM consumed is also highly variable.
- Do not regrow after being grazed, so the utilisation period is more limited than for other Brassica species.
- Can combine well with fibrous supplements such as cereal silage in the diet of dairy cows.
- Metabolisable energy content is similar to barley grain.
- Are a valuable source of crude protein over summer.
- Require careful grazing management and allocation in order to achieve high utilisation and avoid health disorders.
- Can be sown in early autumn to provide cheap feed during the autumn.
- A range of different maturity times allows crops to be available for grazing at different times over summer.

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Where do turnips fit into your feed plan?

Balancing summer diet

Dryland perennial ryegrass based dairy systems usually have a feed gap in summer when pasture growth declines due to increased temperatures and moisture stress. This is coupled with a drop in digestibility, an increase in fibre content and a decrease in protein content of pasture.

Well-managed turnip crops have high digestibility, low fibre and high crude protein content. These characteristics can complement the declining nutritive value of pasture herbage over summer. Spring sown turnips can transfer high-quality grazeable feed from spring to the low-growth summer period.

The 3030 Project farmlet studies at Terang found that summer milk production (yield and milk solids) increased significantly when turnips were included in the ration of dairy cows in late lactation at rates of 5–6 kg DM/cow/day to replace conserved feeds. This increase in milk production reflected an increase in metabolisable energy (ME) intake.

Inclusion of turnips in the summer diet had two main advantages:

- Increased milk solids output during a period when milk production was expected to fall.
- Decreased need to buy-in feeds.

However, it is difficult to produce consistently high yields from summer turnips under dryland conditions. If soil moisture starts to decline early in the season (e.g. late spring) the establishment of the turnip crop is likely to be adversely affected or even fail. This was highlighted during the first four years of the 3030 Project farmlets at Terang when spring rainfall was below average. The turnip crops underperformed due to the short spring in 2005/06 and drought in 2006/07. Consumed DM yields of turnips were in the range 1.1–4.5 t DM/ha. Turnips were incorporated into the complementary forages (CF) farmlet as part of the double-cropping strategy (along with winter cereals for grazing and silage). The shorter-than-expected growing seasons meant that it was not possible to achieve high DM yields of one crop without compromising the other.

The low DM yields, apart from producing a gap in the supply of home-grown feed, increased the cost per tonne of DM consumed by the cows. Jacobs et al. (2001) evaluated the relationship between yield and cost in a survey of 142 dairy farms and 266 paddocks in south-western Victoria during a whole growing season of turnips (spring + summer). The rainfall for the period was similar to the regional long-term average. Yield variations between farms and paddocks within the same season resulted in the cost of turnips ranging from $21 to $1,263 /t DM (Figure 1).

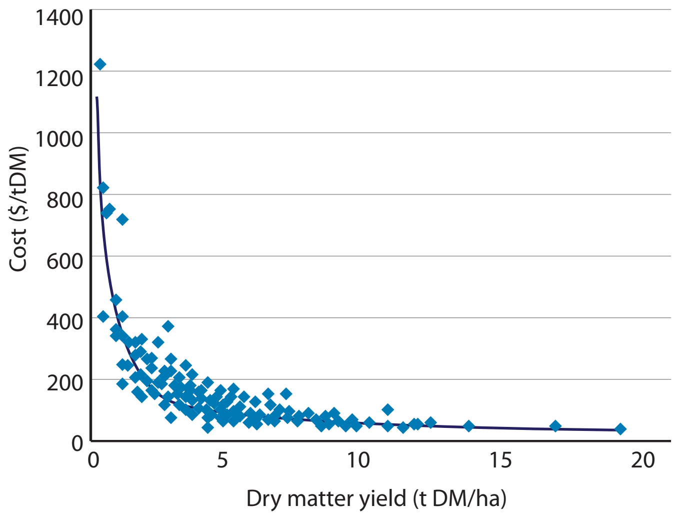

Figure 1. Relationship between the DM yield of turnip crops (t DM/ha) and the cost of the crop ($/t DM) for paddocks surveyed in western Victoria in spring 1999 (adapted from Jacobs et al. 2001).

Renovation plan (as break crop)

Because of its ability to produce large amounts of quality feed in a short period during summer, turnips have been traditionally used as a 'break crop' in pasture renovation programs. Turnips are normally sown in spring after spraying and then cultivation of an old sward of perennial pasture. After grazing off the turnip crop, the new pasture is sown in the following autumn. This allows for the control of weeds, although sometimes this process may need repeating for a second year to ensure the complete elimination of perennial or problematic weeds.

Benefits of this process include the preparation of a fine, clean seedbed for pasture establishment and breaking disease cycles.

The 'break crop' role of turnips is complementary to its role in balancing the summer diet that was described above. In a field evaluation of 11 forage summer crops in Tasmania (Eckard et al., 2001), turnips showed the highest DM yield and had the highest quality (metabolisable energy and crude protein), supporting their widespread use in dairy pasture renovation programs.

Autumn feed gap

Brassicas are cool season crops that have been adapted into dryland southern Australian dairy systems as spring-sown summer forage crops. However, most forage turnip cultivars can be autumn sown.

The purpose of sowing turnips in autumn is to fill the feed gap produced by low pasture growth and reduced feed availability caused by a number of paddocks being out of the grazing rotation while newly sown pastures establish.

While autumn-sown Brassicas have the potential to be consistently high yielding, wet conditions typical between May and September can result in poor utilised yields, damage to soil structure and crop failure due to waterlogging.

One of the advantages of autumn sowing is the lower risk of reduced soil moisture, although excess moisture may result in more rapid deterioration of bulbs during winter.

Brassicas are sometimes sown in dry conditions in autumn, before the first substantial rainfall ('autumn break'). When dry sown, the crops will germinate at the same time after the autumn break occurs and so will be ready to be grazed at a similar time. This effectively limits the area or number of paddocks sown to Brassica/annual ryegrass mix. Sowing cultivars with different maturity times will increase flexibility. However, if paddocks are left too long before grazing, the quality of the Brassicas can decline substantially.

Dry matter yield of turnips

Turnips have a very high potential for growth during summer. In the 3030 Project plot-based experiments, turnips yielded up to 11 t DM/ha, reflecting their growth potential as a single grazed crop. Similar yields were estimated at the 3030 Project Gippsland partner farm near Poowong (see Figure 2).

Figure 2. Turnips crop in summer at the 3030 Project partner farm in Poowong, Victoria.

In the survey of 266 turnip crops on 142 farms of south-west Victoria (Jacobs et al., 2001) the average DM yield was about 5 t DM/ha, ranging from 0.4 to 19.2 t DM/ha. The range illustrates both the crop's potential and the difficulty of achieving high and consistent yields in practice.

In studies in Tasmania (Eckard et al., 2001) and Gippsland, Victoria, (Notman, 1994) yields of around 9 t DM/ha were estimated. In south-western Victorian dairy farms, where summer rainfall tends to be lower and less reliable, the average DM yield is estimated to be closer to 5 t DM/ha (G. N. Ward pers. comm.), which agrees with the average of the survey by Jacobs et al. (2001). In the 3030 Project farmlets at Terang, consumption rates of turnips were in the range 1.1–4.5 t DM/ha per year, although this was during years with below average rainfall.

Summer rainfall has the largest impact on turnip DM yields in dryland dairy systems. Turnips can tolerate high temperatures if soil moisture is adequate. However, high temperatures cause high evaporation and reduce soil moisture. In 'drought' conditions, the turnip plant can go into dormancy.

Feeding value of turnips

In the survey by Jacobs et al. (2001) the nutritive characteristics of turnips were evaluated on 266 turnip crops in western Victoria (see Table 1). Turnips show a high metabolisable energy content in all plant parts, generally good crude protein content (although this can be variable) and low neutral detergent fibre.

Turnips are a good complement to diets based on feeds that have the characteristics of whole crop cereal silage (high NDF but low ME and CP) because their inclusion can increase the nutritive value of the diet. A 3030 Project study found that milk production (yield and milk solids) was elevated significantly when turnips were included in the ration of late lactation dairy cows in summer at rates of up to 5.5 kg DM/cow/day. Compared to a diet based on grazed

Table 1. Nutritive characteristics of leaf and root components of turnip crops surveyed in western Victoria in spring 1999 (adapted from Jacobs et al., 2001).

		Metabolisable energy (MJ/kg DM)	Crude protein (%DM)	Neutral detergent fibre (%DM)	Water soluble carbohydrates (%DM)
Leaf	average	13.4	15.9	23.2	14.8
	min	10.7	7.2	18.7	1.1
	max	14.4	29.6	33.5	26.9
Root	average	13.9	14.8	21.5	-
	min	11.7	4.6	14.3	-
	max	14.8	26.7	34.3	-
Whole plant	average	13.7	-	22.5	-
	min	11.3	-	16.9	-
	max	14.6	-	30.5	-

pasture, pasture silage and lucerne hay, a diet including turnips and triticale whole silage increased voluntary intake by 3–5% and milk production by 5–10% (Figure 3). Turnips were not the only ingredient that differed between the diets, so these results cannot be interpreted as a direct consequence of the turnips. However, it does represent a successful example of using turnips to increase the nutritive value of summer diets.

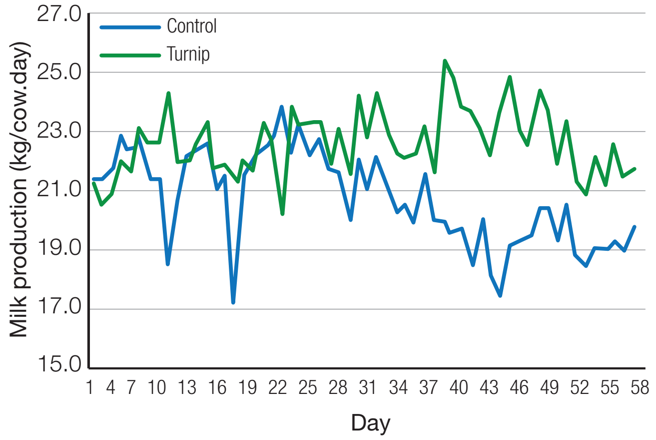

Figure 3. Milk production response (kg/cow.day) of late lactation cows offered a control (pasture-based) diet or a diet that included turnips and whole crop triticale silage. Turnips were included into the ration 14 days after the start of the experiment.

Grazing management of turnips

Cows normally consume the turnips bulbs during grazing so the plant is unable to regrow. Grazing management should aim to maximise the crop's utilisation and minimise wastage in the first and only grazing.

An important decision for the efficient utilisation of turnips is when to start grazing. This decision is a trade-off between allowing the crop to accumulate as much DM as possible in the bulbs and avoiding the senescence (death) of leaf material.

Turnip varieties reach close to their maximum DM yields and should be grazed at around their stated maturity times providing moisture, fertility and temperature are not limiting.

Some varieties have better stand over characteristics than others. Normally, the older leaves in the lower parts of the plant will die first but with some varieties the bulbs can also start to rot. According to Jacobs et al. (2001), most cultivars will remain at their optimum for 3–4 weeks after maturity, although this depends on having favourable climatic conditions and minimal insect damage.

The loss of material and nutritive value can be particularly important in summer if a large area of turnips has been sown. Even if grazing commences at the ideal growth stage, the crop can lose quality by the time the end of the paddock is reached. Most turnip crops are grazed about 12 weeks after sowing, around mid-January (Jacobs et al., 2001). When sowing an area that would need to be grazed for more than 4 weeks from the start of grazing, adjust the management to ensure that all crops do not reach maturity simultaneously.

Consider the following options:

- Staggered sowing times
- Sow different paddocks to varieties of differing maturity types:
  - Early-maturing, 'tankard bulb' type varieties that reach optimum DM yield and maturity in 8–10 weeks but do not stand over very well.
  - Mid-season, soft bulb stubble turnip varieties that mature in around 12 weeks and do not stand over very well.
  - Later-maturing, hard globe varieties that mature in 14 weeks or more but stand over well.

As a general rule, it is not advisable to use soft bulb types to stand over because leaf senescence increases and bulbs can rot. Hard bulb types stand over much better with less leaf and bulb deterioration.

To achieve good crop utilisation and control intake, turnips are normally strip-grazed with an electric fence. Ideally, the electric fence should be set to maximise the length of the grazing 'front' rather than the 'depth'. This reduces the chances of cows walking over the crop, 'trampling', defecating and making the material unpalatable, which leads to increased feed wastage.

Low utilisation generally occurs on rainy days when some of the turnips are trampled into the mud.

Feeding levels from 3 to 6 kg DM/cow/day have been reported for grazing conditions on commercial farms. Moate et al. (1998) have suggested 5 kg DM/cow as the maximum daily intake of turnip due to its 'bulkiness' and high water content (8 to 11% DM).

An adaptation period of 3–7 days (at the higher end for higher target intakes) is needed for the rumen microbes to adapt to this new feed and also for the cows to 'learn' to graze the crop, if they have not been exposed to it before. Start with a low allocation per animal and gradually increase the area grazed and hence the daily allocation. Use electric fences to manage access or restrict the grazing time to achieve the desired allocation.

It is important to ensure that cows have enough long (effective) fibre in the diet when grazing turnips. This is particularly important if cows are being fed levels of starch-based concentrates of 4–5 kg/cow/day or more. Turnips with a high proportion of bulbs can be similar to concentrates in terms of NDF and ME value.

The other important issue is that while the herd may be allocated 4–5 kg DM/cow/day, individual cow intake could be 50–100% higher than the average. Providing a source of long fibre will promote 'cud chewing' and help ensure that a more stable rumen environment is maintained.

Brassica-related metabolic disorders are relatively rare (e.g. bloat, nitrate poisoning, red water, photosensitisation) and most occur during the first two weeks of grazing. In most reported cases, the disorders could have been prevented by ensuring the cows were relatively full before they start grazing the crop.

According to Jacobs and Ward (2011) Brassicas may accumulate nitrate-N when grown under stress (e.g. high temperatures and limited available water), particularly if N fertiliser is applied. If cows are very hungry, do not allow them into a paddock of turnips with more than the daily allocation.

Another hazard, although rare, is the risk of cows choking when swallowing entire bulbs. The risk of this is higher when the bulbs are small.

Responses to N application in turnips

A study at Terang (Jacobs and Ward, 2007) observed responses in turnips to the application of second pond dairy effluent of 29, 89 and 50 kg DM/ha/mm applied for each of the study's three years respectively. This was equivalent to a response of 18, 57 and 33 kg DM/kg N applied.

In this study, effluent was applied during summer, 6–8 weeks after sowing. While NDF tended to increase with the application of effluent, the WSC tended to decrease. There were also increases of 0.27 and 0.19% in leaf and root CP for every 10 kg effluent N/ha applied, which were consistent with the survey by Jacobs et al. (2001), who found increases in CP of 0.35 and 0.4% for leaf and root per kg N fertiliser applied, respectively.

Turnips leaf:root ratios increased with effluent application across all years in the study by Jacobs and Ward (2007). This effect can be beneficial in terms of ease of harvest of the material. A further study by Jacobs et al. (2008) showed DM yield increases of 32 and 39 kg DM/ha/mm effluent applied in the first and second years of the experiment.

This study evaluated further applications of N fertiliser after the effluent was applied but no responses nor interaction between effluent and N application were seen in either year. However, there are situations where N fertilisers will give a response, such as when the soil has been used over a number of years for crops and where soil moisture supply is good. Besides this, DM yield responses to effluent applications in the Jacobs and Ward study were similar across both years, despite contrasting climatic conditions, highlighting the ability of turnips to respond to limited moisture inputs.

The recommendation from the 3030 Project experiences is to apply dairy effluent at the start of bulb development (6 weeks after germination) and again at 10 weeks after germination. It is important not to graze the crop within three weeks of application as nitrate levels in the plant can be too high.

Studies on effluent applications have shown a significant linear increase in potassium content of turnip leaves and roots (Jacobs and Ward, 2007; Jacobs et al., 2008), which can sometimes lead to a decrease in calcium and magnesium contents. Although these changes in mineral content can result in ratios of potassium to calcium plus magnesium which predispose cattle to hypomagnesaemia, turnips constitute generally less than a third of the diet and so cattle grazing turnips are unlikely to be at risk.

How do turnips compare to other summer crops?

Using complementary forages as summer crops to increase the DM yield of home-grown feed on pasture-based farms can be challenging. Without irrigation, their DM yields cannot be guaranteed.

Some aspects of the alternative summer crops available are discussed below:

- Regrowth Brassicas (forage rape, kale, leafy turnips and hybrids) are candidates to replace turnips but their DM yields were generally lower than turnips in most 3030 Project agronomic studies and previous experiments. In terms of filling the feed requirements of dairy herds there are differences in the 'time window' for the utilisation of Brassicas. The regrowth Brassicas can regrow after grazing if there is adequate soil moisture, allowing for multiple feeds during the crop cycle; turnips can only be grazed once. Further details of these crops can be found in the 'Regrowth Brassicas' Information Sheet in this series.

  In a controlled trial by Jacobs et al. (2002), turnips showed higher water use efficiency (WUE) than rape and pasja Brassicas in most years (see Table 2). However, both rape and pasja showed higher growth rates in the early stages of the crop whereas turnip accumulated DM at the end of the plant cycle when bulb DM deposition occurs. No differences in ME value were detected in that study.

Table 2. Water use efficiency (kg DM/ha/mm) of different Brassica crops sown in south-western Victoria (adapted from Jacobs et al., 2002).

Water Use Efficiency (kg DM/ha/mm)				
	Site A		Site B	
	Year 1	Year 2	Year 1	Year 2
Pasja	14.9	8.8	21.7	29.0
Rape	13.1	6.4	20.8	23.2
Turnip	16.4	4.8	28.4	31.3

- Maize (*Zea mays*) is unlikely to fit with the temperature and soil moisture profiles of south-western Victorian rain-fed dairying regions but may do so in parts of Gippsland with higher summer rainfall. It is expensive to grow and must return very good yields to ensure profitability.
- Millet (*Echinocloa utilis*) and sorghum (*Sorghum bicolor*) are two further possibilities. Sorghum can be direct grazed and is reasonably tolerant of dry conditions but, again, its yield in 3030 Project agronomic studies did not exceed that of turnips. In addition, the nutritive value of sorghum is well below turnips in terms of ME, CP and NDF. See the 'Millet and Sorghum' Information Sheet for further details.
- Chicory (*Cichorium intybus*) is more tolerant to drought than turnips and can have similarly high nutritive value (also considered a 'home-grown concentrate' in terms of feeding value). It has the additional advantage of being able to provide grazeable quality feed for longer than turnips. However, if the conditions are favourable, turnips have an increased ability to accumulate DM in a short time compared to chicory. See the 'Chicory' Information Sheet for further details.

- Swedes (*Brassica napobrassica*), mangles and other similar root Brassica species are generally sown in the late spring/summer and grazed the following winter. Swedes have proven to be too slow growing to provide summer feed following a spring sowing in southern Victoria. Swedes have a larger bulb than turnips and are slower to mature (20 to 24 weeks). They are better than turnips at maintaining bulb quality and therefore more suited to standing over.
- Fodder beet (*Beta vulgaris*) has a high potential yield when irrigated and can be sown either in spring or autumn/winter. Because it does not belong to the Brassica family, the fodder beet is not exposed to the same pests and diseases (particularly diamond back moth). However, the fodder beet seed is normally expensive and can be difficult to establish, needing precision planting with careful weed control during the early stages of the crop. The high sugar content in the bulbs could cause acidosis in cattle if the allocation and intake are not strictly observed. There is anecdotal evidence of fodder beet crops yielding above 30–35 t DM/ha under pivot irrigators in south-western Victoria (see Figures 4 and 5).

Figure 4. Grazing strip of a fodder beet crop in South-West Victoria (courtesy of A. Drummond).

Figure 5. Fodder beet crop at farm in Colac, South-West Victoria in 2006.

Agronomy of turnips

Establishment requirements

- **Soil water:** soil moisture conservation is key to successful establishment of turnips, particularly in areas, such as south west Victoria, where late spring and summer rainfall is not reliable. The survey by Jacobs et al. (2001) showed that 10 and 20% increases in soil moisture at sowing were associated with increases in yield of 0.4 and 0.9 t DM/ha, respectively.
- **Sowing date:** The average sowing date recorded on a survey of 142 commercial farms was mid-October, ranging from 14 September to 17 December (Jacobs et al., 2001). A study by Jacobs et al. (2002) in south-west Victoria showed that sowing early (mid-October) rather than later (mid-November) ensured higher soil moisture at the time of sowing.
- **Cultivation and weed control:** The study by Jacobs et al. (2002) evaluated different cultivation techniques and found that a full inversion technique (mouldboard ploughing) reduced weed germination in comparison to chisel ploughing. This can be an alternative for broad-leaved weeds that cannot be controlled chemically in the turnip crop, such as capeweed (Arctotheca calendula). In some cases, the sowing might need to be delayed to repeat the chemical control and capture second germinations so as to ensure a seedbed free of broadleaf weeds before sowing turnips.
- **Sowing rate:** Sowing rates from 1.6 to 2.2 kg/ha have been used in southern Victoria, reaching seedling densities from 28 to 45 plants/m^2 (Jacobs et al., 2001). Lower rates (0.5 kg/ha) encourage bulb development and high rates (up to 2 kg/ha) allow early yield and a high leaf:bulb ratio. When seeds are coated, the sowing rate might need to be increased.
- **Seedbed:** Turnips should be sown shallow (5–10 mm) in a firm and moist seedbed. Rolling after sowing to improve the seed-soil contact is a normal practice with this species. They can also be suitable for direct-drilling in friable soils, although a successful establishment is more difficult with this technique.
- **Fertiliser:** Turnips are normally sown with 20 to 25 kg P/ha as triple super, MAP or DAP. It is important to ensure that molybdenum (Mo) and boron (Bo) are not deficient (Mo can be provided with seed coating). Although turnips can adapt to a broad range of pH, they perform better on soils with a pHCaCl$_2$ of more than 5.5.
- **Establishment pests:** is important to monitor for red-legged earth mite (RLEM) and lucerne fleas during the germination phase. Insecticide-coated seed is available to protect the seed and seedling during early establishment.

Pests of importance

In the survey by Jacobs et al. (2001), insect damage had the highest impact on total yields compared to other factors such as total water received, soil temperature, soil moisture and seedling density.

Several pests affect turnips: red-legged earth mite, slugs, aphids, cabbage moth, cabbage white butterfly, diamond back moth, cutworms, lucerne flea, wingless grasshoppers and leafminers.

Although the weather, paddock characteristics and history, and other seasonal factors determine the relative importance of each of them, the diamond back moth is probably the most common and damaging pest of Brassica crops throughout Australia and has had a severe impact in forage turnip crops of dairy farms in southern Victoria.

Diamond back moth (*Plutella xylostella*)

There are no documented threshold levels of pest damage on forage turnips to determine when it is necessary to spray for diamond back moth. Because turnips do not regrow, they are more sensitive to the attack of this pest as the 'quick grazing' used on regrowth species as an alternative to stop the damage is not possible.

The crop should be monitored weekly, particularly during its early stages, for both 'grubs' and adults (moths), since the development from egg to adult can be as short as 14 days at 28°C and severe damage can be done in a few days.

In the early stages, the grub appears as a leaf-mining larva that can be detected by the silver markings they cause on the leaf surface (see Figure 6).

Figure 6. Diamond back moth larvae consuming a Brassica leaf (from Markham and Endersby, 2010).

The decision to spray should take into account the damage to the crop (percentage of leaf disappearance), the presence and different development stages of the insect, and also the crop's vigour and potential.

Chemicals do not control adults or eggs. Applying them when most of the larvae have already developed to adult is a waste of product and will destroy natural predators. Once this natural defence is removed, it is likely the crop will have to be continually sprayed every 10 to 14 days until it is grazed. Before any spraying is undertaken, check grazing withholding periods and ensure they are observed.

Cultivars

There are a range of turnip varieties with differing maturities. In the survey by Jacobs et al. (2001) there were no significant yield differences between cultivars (Table 3). The leaf:root ratios were also similar, with the exception of Appin, which could be considered a 'leafy turnip'. The ME value of both leaf and root was similar across cultivars (data not shown).

Table 3. Dry matter yield (t DM/ha) and leaf:root ratios for turnip cultivars surveyed in western Victoria in spring 1999 (adapted from Jacobs et al. 2001).

	Yield (t DM/ha)		Leaf:root ratio
Cultivar	average	range	average
Appin	4.3	2.1–5.2	2.9
Barabas	5.0	1.9–10.8	1.0
Barkant	5.3	1.0–11.5	1.2
Marco	4.6	0.6–9.0	1.1
Mamm. Purple Top	4.7	0.4–19.2	1.7
Polybra	5.3	2.8–6.7	1.1
Rondo	4.1	1.4–7.9	1.0
Samson	5.2	0.6–16.8	0.8
Vertus	4.5	1.0–13.7	1.1
Vollenda	5.3	0.8–12.3	0.8

Not all currently available turnip cultivars are included in Table 3, as the survey was conducted in 1999. A more complete list of available cultivars and sources is available at the 'Pastures Australia' website (www.pasturepicker.com.au).

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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

Contact Dairy Australia

T 03 9694 3777

E enquiries@dairyaustralia.com.au

W www.dairyaustralia.com.au

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