Managing forage brassicas in Australian mixed farming regions

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Information presented in this booklet was generated during a Meat and Livestock Australia project: Improving the use of forage brassicas in mixed farming systems (P.PSH.1044). It contains relevant information on forage brassica management in context to their use in Australia's mixed farming region.

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Contents

9 Steps for success when using forage brassicas in your farming system

Target winter-spring feed gaps – make the most of forage brassicas to maintain high forage quality or fill gaps in feed supply from other on-farm forage sources.

Variety selection – there are numerous forage brassica types, so be careful to choose the best variety to suit your intended use.

Paddock selection – Choose smaller paddocks (if possible) and avoid those with a risk of residual herbicides, brassica weeds or recent brassica crops (< 2 years).

Boost early growth via a focus on establishment, early weed control and initial crop nutrition.

Conduct an N budget applying around a third at sowing, and the rest after each grazing.

Monitor for pests and weeds throughout the season and manage with grazing and/or pesticides as needed.

Manage grazing to maximise animal performance – don't graze within 4 weeks after applying fertiliser, and leafy types should be 30–40 cm high. Remove stock once leaf is fully utilised.

Allow animals to adapt by slow introduction and allow access to fibre-rich feed of good quality. Avoid a rapid change in diet (aim for > 4 weeks of brassica grazing).

Monitor animal health closely, particularly during the first week of grazing and ensure vaccinations (e.g., 7-in-1) are up to date.

Introduction

Forage brassicas are members of the Brassicaceae family (like cabbages and cauliflower) that have been specifically developed as high-quality forages for livestock. They are like canola, but remain in a vegetative growth phase for much longer, allowing an extended grazing period. A range of different brassica species are used as forages for livestock. Forage brassicas are widely used in higher rainfall livestock systems (e.g., dairy) in cooler parts of south-eastern Australia and New Zealand where they are typically sown in spring to provide a quick and abundant high-quality feed over summer, autumn, and winter. When grazed they can produce excellent weight gains in livestock (> 300 g/day in sheep or >1.5 kg/day in cattle). Like other brassicas, they also provide a range of crop rotational benefits such as weed and disease control to subsequent cereal crops or perennial pastures.

Until recently, the use of forage brassicas outside the temperate-cooler environments has been limited. However, recent work has demonstrated much wider potential for forage brassicas into the medium and lower-rainfall regions across Australia's mixed farming zone (refer to Figure 1). The hotter and drier summers in these regions, mean that sowing brassicas in autumn to provide winter, spring and early summer feed is likely to be a more viable option. Recent work has shown they can produce similar or more energy for livestock than forage cereals such as oats, barley, or wheat, and could be grown in situations where canola is unsuited or unreliable. However, the agronomy and management of forage brassica crops is likely to differ significantly from where they are commonly grown, due to different patterns of use and lower productivity potential.

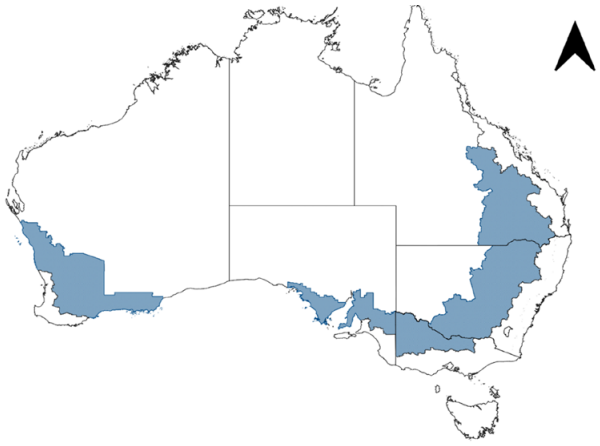


Figure 1. Distribution of Australia's mixed farming zone (blue)

This document provides current best-bet guidelines on the use of forage brassicas across Australia's mixed farming zone, including information to help answer questions such as:

- How would I best fit the forage brassicas into my current farming system?
- Which forage brassica types and varieties would best suit my environment and intended use?
- What should I do to prepare for and establish my crop?
- How should I manage fertiliser applications and the control of weeds, pests, and diseases?
- How should I manage my grazing livestock to maximise their potential performance and avoid animal health risks?

Forage rape. Photo: M Murray

Integrating forage brassicas into your farming system

Considerations of how forage brassicas may best fit your farming system is critical to maximising their value. A good fit is where they can provide additional benefits either to subsequent crops, reduce disease or weed problems or complement the existing forages and crops on your farm. Forage brassicas are likely to play a similar role to canola in crop rotations, but with less upfront costs and production risks in more marginal environments, drier seasonal conditions or where there is less reliable in-crop rainfall.

Filling feed gaps with forage brassicas

Forage brassicas can be used to fill periods of feed shortages and enable a grower to match forage supply and livestock demand throughout the year. This may allow stocking rates to be maintained or increased over the period of feed shortage, and/or reduces supplementary feed costs.

It is important to consider the correct proportion of the area you might grow to avoid oversupply of forage and replacing other critical forage options. Analysis across drier regions of the crop-livestock zone has shown that using forage brassicas on about 15% of your grazed area could reduce supplementary feed requirements in dry years by 20–40% and/or allow the stocking rate to be increased by 15–30%.

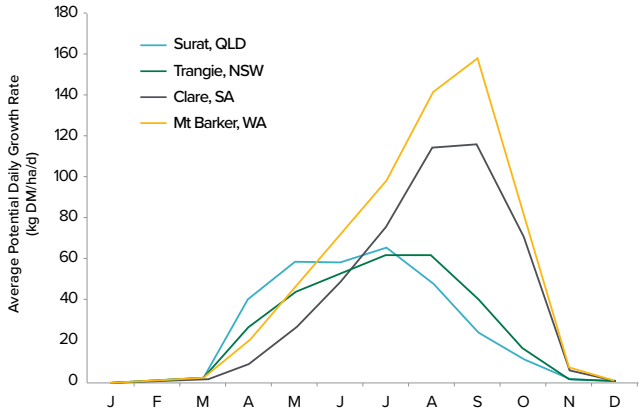


Figure 2. Forage brassicas exhibit different growth patterns through the year when grown in different regions

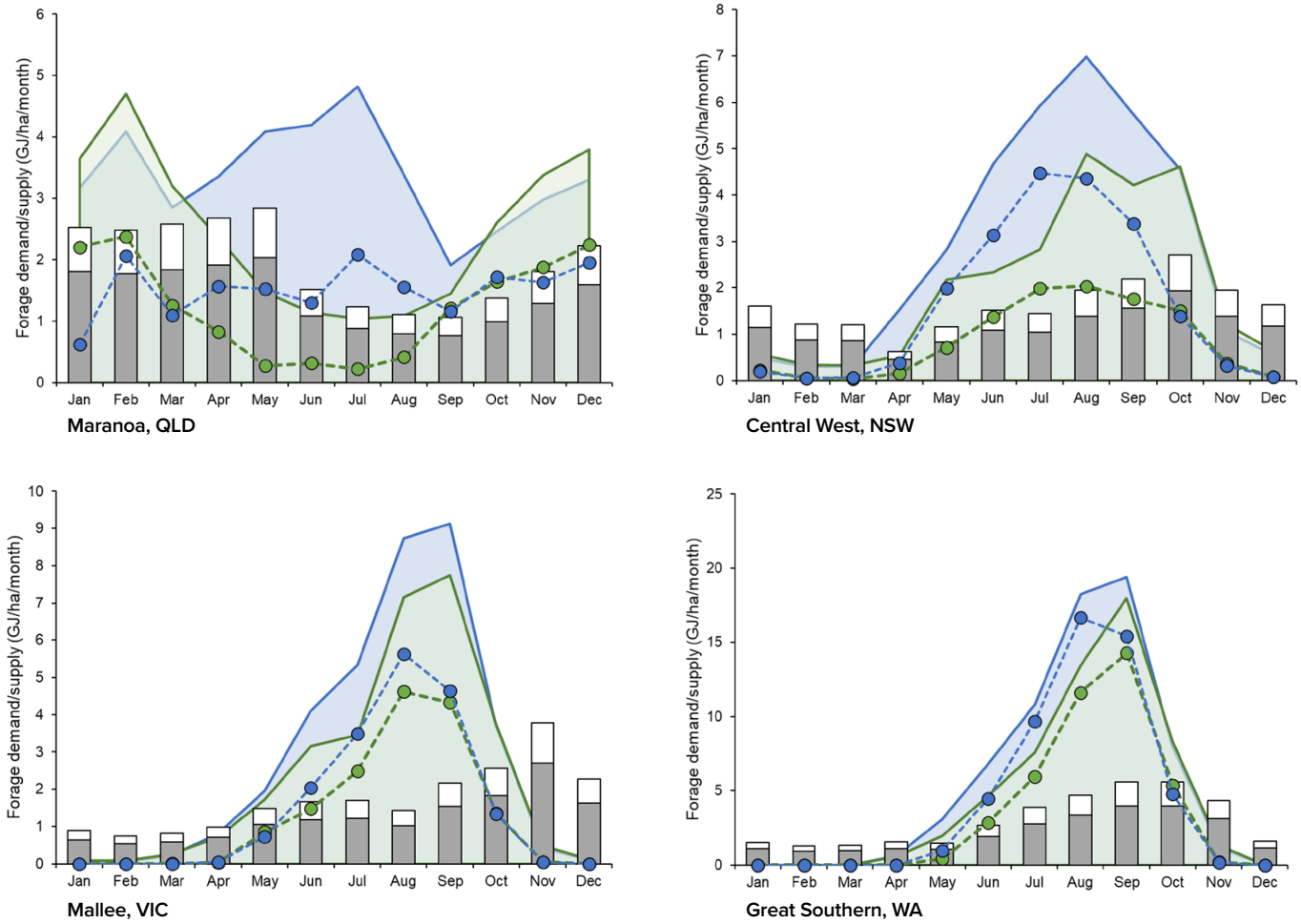


Figure 3. Impact on forage supply throughout the year of integrating forage brassicas at 15% grazed area (blue) into a typical pasture-based (green) farm feedbase. Solid lines indicate a median year, while dotted lines indicate a decile 3 year for total forage growth. Bars indicate the monthly demand for a typical livestock enterprise – the grey portion are for a stocking rate achieving an average 40% pasture utilisation and the white bars are the additional demand for a 40% higher stocking rate

Use patterns and capacity to fill feed gaps

Brassicas are a highly flexible crop with the ability to grow at different times of the year to suit the livestock enterprise and seasonal feed supply on-farm. Two main patterns of use are:

Spring sowing (e.g., Sept–Oct) to provide feed during early summer to early autumn. This is mainly used in more temperate climates where there are milder summers with some reliability of summer rainfall. In regions with hotter and drier summer conditions, while desirable, this is unlikely to be reliable.

Autumn sowing (e.g., March–May) to provide feed in winter and spring and sometimes this may extend into early summer. This is likely to be a more reliable option in Australia's mixed farming zone with milder winter temperatures and more reliable winter rainfall.

While production environment and seasonal conditions can significantly affect the productivity of forage brassicas, growth rates over winter often average around 60kg dry matter/ha/day (Figure 2). This is sufficient to support an average stocking rate of 25–30 DSE/ha. Over the whole growing season, they can provide more than 3000–4000 DSE grazing days/ha/year.

Sheep grazing on forage rape. Photo: L Watt

As forage brassicas are incorporated into the feed-base there is a likely need to adjust the livestock enterprise to make use of the additional feed provided. For example, Figure 3 shows how incorporating a portion of the farm grazed area to a forage brassica crop can effectively increase the supply of forage over different times of the year. This can allow livestock grazing numbers to be increased without dramatically increasing the risk of supplementary feed requirements. Figure 3 shows that the greatest benefit of a winter-sown forage brassica would be to fill mid-winter and early spring feed-gaps in summer-dominant rainfall environments (e.g., Maranoa, Qld) or where summer-active pastures are common. In situations where, spring feed is usually plentiful then the brassicas are more likely to provide benefit in late-autumn or early winter.

Grower comment...

"Oats are commonly grown in the area, but they have been falling over with disease leading to low productivity. Forage brassicas are a great break-crop option to help clean up grass weeds and break disease cycles."

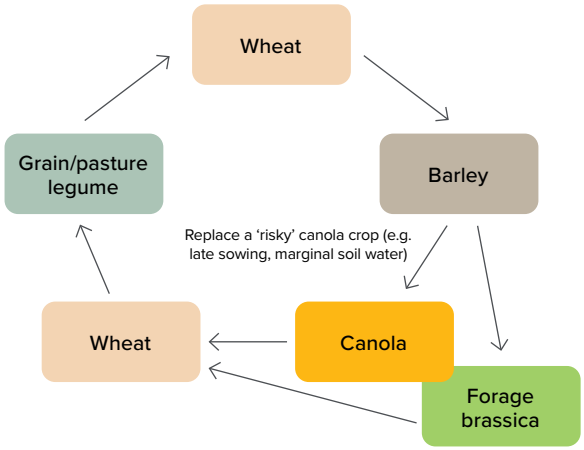
Martin Murray – Agronomist and Grower, North-west slopes, NSW

Crop rotation benefits & considerations

Like canola, forage brassicas offer several potential benefits (Table 1) when used in a crop rotation or to prepare a field for pasture renovation. They are likely to offer the greatest opportunity as a break crop in cereal crop rotations where other break crops (e.g., canola) are unprofitable or unreliable, or in paddocks regularly dedicated to forage cereals (e.g., oats). Using brassicas about 1-in-5 to 1-in-3 years is likely to provide the best balance in the system.

Some example rotations showing how forage brassicas may be used are shown in Figure 4.

Grain cropping rotation with a tactical forage brassica



Diversifying a forage cropping rotation

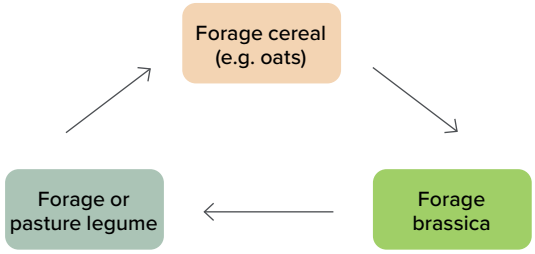


Figure 4. There are a range of considerations or attributes that may allow forage brassicas to be targeted in your farming system

Table 1. Brassica crop rotation benefits and cautions

Pest and Disease	Weeds	Nutrients and Water
• Brassicas are resistant to *Pratylenchus thornei* (Root lesion nematode). In problem paddocks, use in combination with another resistant crop to create a 2-year break that reduces the nematode populations. • Brassicas can reduce levels of cereal diseases such as *Fusarium* (crown rot), *Bipolaris* (Common root rot), Take-all, or yellow leaf-spot. • **Caution:** avoid sowing within 2-years after canola or in adjacent fields to mitigate risks of infection or building populations of blackleg, sclerotinia or diamond-back moth.	• A Brassica rotation can reduce palatable grass weeds (e.g., Ryegrass, Brome grass) via selective grass herbicides and early selective grazing. • Brassica populations with early and persistent canopy cover can create a competitive environment for later emerging or less competitive weeds. • **Caution:** avoid paddocks with presence of unpalatable broad-leaf weeds such as turnip, mustards, or thistles as there are no selective herbicide options to control these in forage brassicas.	• Brassica residues can decompose quickly providing more cycled mineral N compared to a cereal crop. • **Caution:** heavy grazing can leave low residue levels, either reducing water infiltration or potentially creating a less suitable soil environment for subsequent crop establishment. • **Caution:** water extraction is similar to canola and forage cereals, except where the brassica growing season is extended, which can result in less available water at sowing of subsequent crops.

Forage brassica variety selection

There are many different forage brassicas available on the commercial market in Australia (Table 2). However, most fall into three main groups: the leafy multi-graze types (e.g., forage rapes), those offering a standing forage crop (e.g., kale) and those that accumulate a bulb, offering a single grazing (e.g., bulb turnips or swedes).

Key considerations when selecting a forage brassica variety for your purposes (Figure 5):

1. Intended grazing use - whether you want to obtain several repeated grazing events from the crop or if you are using it for a single-graze.
2. Grazing maturity – forage brassica types vary greatly in grazing maturity (i.e., the time required before the crop reaches a stage best suited for grazing).
3. Adaptation to your environment – some varieties or types offer a much longer growing season due to greater tolerance to heat and/or moisture stress.
4. Ability to manage the grazing intensity (or stocking rate) and utilisation of the crop – it is ideal to be able to limit the size of the paddock to allow even grazing or stock heavily to best utilise the crop over a short period.
5. Sheep or cattle – Some forage brassicas pose larger risks to grazing with cattle than sheep. For cattle, forage rapes can induce greater risk of bloat and small bulb turnips can present a choking hazard. Most varieties are suitable for sheep.

Multi-graze forage brassicas

Multi-graze type forage brassicas include only leaf-types such as forage rape (both early and late-maturity types), raphanobrassica and leafy turnip. All three brassicas have high regrowth potential and can withstand several grazing events, although the plant stand, and length of each grazing event may reduce overtime as the crop deteriorates.

Raphanobrassica before first graze. Photo: B Rheinheimer

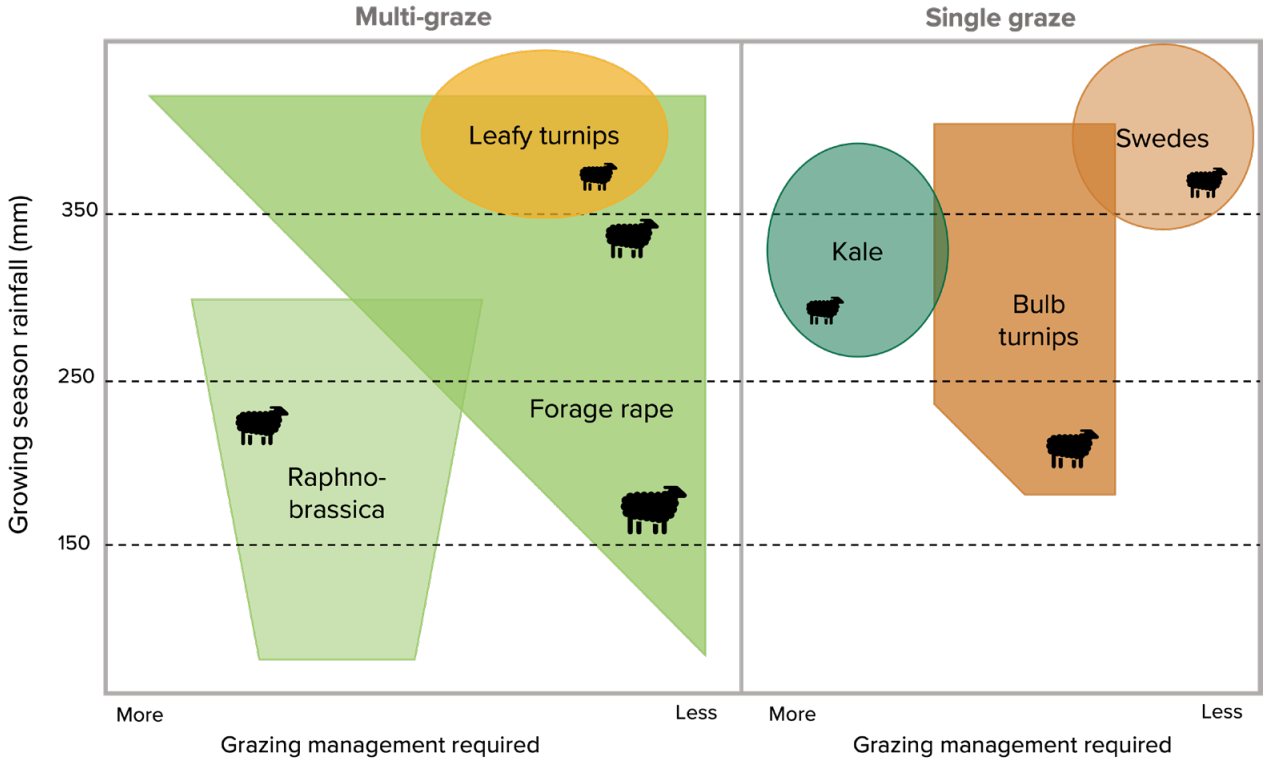


Figure 5. Recommended suitability of different forage brassica types as dictated by the number of grazing's, the expected growing season rainfall and the grazing management intensity required. The location of the cattle or sheep indicate the relative suitability of grazing with those animals under those conditions/management regime

Multi-graze forage brassicas are often used for finishing young livestock as they can provide high quality feed adequate for growth over extended periods (i.e. crude protein (CP): 16%, and metabolisable energy (ME): 12 MJ ME/kg DM). Some varieties have much fewer days to reach grazing maturity and hence are highly suited to multiple grazing, while the later maturity types are often slower to respond after defoliation.

Of the multi-graze types, autumn planted forage rapes and raphanobrassica have been identified as better suited to lower rainfall livestock systems, especially later in the season, achieving 2–11 t DM/ha (approximately 12% higher than other brassicas) with only 100-235 mm of growing season rainfall.

Raphanobrassica has shown an ability to maintain green leaf and withstand dry periods and more consistent production across different growing conditions. Leafy turnips are a more suitable option for livestock producers in areas where soil moisture is not limiting, so are less suited outside high-rainfall regions.

Single-graze forage brassicas

Single-graze type forage brassicas include mostly bulb-types, such as bulb turnips and swedes. Kale is also classified as a single-graze crop and is generally grazed by cattle in a single-grazing event when the stems are still fleshy, though it can regrow after light grazing. Generally, single-graze forage brassicas are stockpiled and grazed in a single event when a flush of high-quality feed is needed.

For bulb-type brassicas, both the leaf and bulb portions can be accessed by livestock, though the bulb of some cultivars sits approximately two-thirds above the soil surface, that can make them more easily accessible to livestock. Speak to your local agronomic advisor for more information.

In summary, variety choice is based on...

- Growing season rainfall
- The grazing required (multiple or single)
- Paddock design / grazing management
- Livestock type: Sheep or cattle

Table 2. Forage brassica varieties available in Australia and the time after sowing when they are available to initiate grazing (i.e. grazing maturity)

	Common varieties	Seed company	Grazing maturity (weeks)
Multi-graze types			
Forage rape	Interval	Barenbrug	8–10
	Leafmore	Barenbrug	8–10
	Subzero	S&W Seed Company	8–12
	Winfred	DLF Seeds	10–12
	Mainstar	DLF Seeds	10–12
	SF Greenland	Seed Force	10–12
	Titan	DLF Seeds	10–13
	Goliath	DLF Seeds	13–17
	Pillar	DLF Seeds	13–16
Raphanobrassica	Pallaton	DLF Seeds	8[1]
Leafy turnip (hybrid)	Hunter	DLF Seeds	6–8
	Falcon	Barenbrug	6–8
	Pacer	Seed Force	6–8
	Pasja II	DLF Seeds	6–10
	Appin	DLF Seeds	6–10
	Cleancrop™ leafy turnip	DLF Seeds	6–10
	Bouncer	S&W Seed Company	8
Single-graze types			
Kale	SovGold	DLF Seeds	18–24
	Regal	DLF Seeds	21–31
	Firefly	DLF Seeds	21–31
	Caledonian	Barenbrug	21–31
Bulb turnip	Toto	DLF Seeds	8–13
	Dynamo	Barenbrug	9–13
	Rival	DLF Seeds	10–12
	Barkant	DLF Seeds	10–13
	Australian Purple Top	DLF Seeds	12–14
	Cleancrop™ Toto turnip	DLF Seeds	11–16
	Green Globe	DLF Seeds	13–17
	New York	DLF Seeds	14–16
	SF G2	Seed Force	14–16
Swede	Major Plus	DLF Seeds	21–31
	Domain	DLF Seeds	24–30
	Clutha Gold	DLF Seeds	24–36
	Hawkestone	DLF Seeds	24–36
	Invitation	Barenbrug	24–36

[1] Grazing withholding period after sowing due to seed treatment.

Establishment of forage brassicas

Paddock selection

To reduce risk of crop failure in lower production environments, paddock selection for forage brassicas should target land area that is suitable for cropping and/or highly productive pastures.

Avoid paddocks that have:

- A high risk of waterlogging.
- Very high or very low concentrations of mineral N.
- Very high or very low crop residue loads as this could impact establishment.
- High pressures from broad-leaf weeds, particularly other brassicas (e.g., turnip, radish) or unpalatable weeds.
- Highly acidic soils or those with significant sub-soil constraints.

Previous crop history

Good knowledge of previous crop history including herbicides applied and plant-back periods, especially following a cereal crop, is essential. Forage brassicas, like canola, are highly susceptible to Group 2 or Group B (Herbicide Mode of Action group) herbicides including sulphonylureas (SUs), sulfonamides (TPS), and imidazolinones (IMIs) both from direct spray contact and soil residue. It is also important to understand how chemical breakdown in the soil may be impacted by soil pH and or wet/dry conditions. Speak to your local agronomic advisor for more information.

Establishing brassica in cereal stubble. Photo: L Watt

Where canola (or another brassica) has been used in the last 2 years there is likely to be higher risks of soil-borne diseases that infect these crops (e.g., sclerotinia, black-leg).

Paddock size, infrastructure, and surrounding environment

Forage brassicas are highly variable in the amount of biomass produced and this can also vary with each grazing cycle in multi-graze brassicas. To maximise grazing efficiency, paddock size should be a key consideration in paddock selection. Smaller paddock sizes (< 20ha) or the ability to partition them using additional infrastructure (e.g., electric fences) will allow more precise grazing management for better forage utilisation. Larger paddocks may require significantly higher stocking density and/or reduce even forage utilisation across the paddock.

Finally, paddocks that are near commonly used roads or that can be frequently visited may be better to allow for regular monitoring of livestock health.

Soil type considerations

In New Zealand and south-eastern Australia, forage brassicas are grown across a range of soil types of varying fertility and characteristics. Higher productivity is generally achieved in deeper soils with good drainage, higher fertility, and soil pH ($CaCl_2$) greater than 4.5. In highly acidic soils (pH_{Ca} < 4.5) a fine-grade lime should be applied and incorporated within the top 10–15 cm of soil up to 12 months prior to sowing.

Paddocks with areas of adjacent grass pastures (like the paddock pictured) allow animals to access alternative feed sources.
Photo: L Watt

In summary, paddock selection considers...

- Suitability for cropping or highly productive pastures.
- Data available on previous paddock nutrition / soil test / crop history.
- A suitable soil pH ($CaCl_2$) of > 4.5 OR lime applied up to 12 months pre-sowing.
- No risk of Group B herbicide residues.
- Suitability for optimal livestock grazing efficiency OR infrastructure is available to allow for a crash grazing option.

Because forage brassica use has been largely limited to higher production environments in Australia and New Zealand, the adaptability of brassica types to more severe soil constraints (e.g., acidity, salinity, sodicity, boron, aluminium toxicity, surface crusting) more prevalent in lower production environments is not well understood, though they are expected to respond to these constraints in a similar way as for canola grown throughout areas of Australia's mixed farming zone.

Soil testing is recommended to help guide paddock selection, preparation, and in-crop nutrient management. Speak to your local agronomic advisor for more information.

Crop establishment

Pre-emergent herbicides, and seed treatments

Forage brassicas can be highly susceptible to competition with weeds in the early stages of crop development so effective weed management is essential prior to sowing. Managing weeds prior to sowing will also help to conserve soil moisture needed for successful establishment. In Australia, ForageMax (soon to be discontinued) is the only in-crop herbicides registered for use in forage brassicas.

Pre-sowing weed control methods may include mechanical cultivation, long fallows, application of a total knockdown herbicide (e.g., glyphosate) around two to three weeks prior to sowing, or a combination of these.

Low or uneven plant populations can create opportunities for weeds to use the unoccupied space. Photo: L Bell

To optimise seedling establishment in brassicas, an insect and fungal prevention program is also required prior to sowing. Purchasing insecticidal and fungicidal treated seed (e.g., Ultrastrike, Superstrike, Gaucho) is a common practice and generally the most cost-effective option, though these treatments may impact the first grazing due to chemical withholding periods. Read product labels and speak to your local agronomic advisor for more information

Sowing timing and methods

Forage brassicas have a wide sowing window and can be planted in autumn or spring depending on the feed gap being filled and climatic conditions of the regions in which they are grown. Traditional use of forage brassicas has been a spring- or early summer-sowing where they provide summer and/or early autumn forage in cooler, temperate environments with high chances of summer rainfall. However, in the mixed farming zone which experiences higher average temperatures and more extreme heat events, especially over late spring, and summer (October to May), sowing in spring or summer is not recommended. Instead, autumn-sown forage brassicas are more likely to successfully establish and provide a late autumn, winter, and spring feed for livestock in these mixed farming systems.

In general, the sowing window for autumn-sown forage brassicas is the same as for winter canola, commencing in early March and closing in early June. Sowing in colder conditions will slow emergence and early vigour, so earlier sowing will optimise total biomass production. However, forage brassicas offer greater production advantages over cereal forages in later sowing windows (e.g., from early May), because they have delayed reproductive development in spring.

Typically forage brassicas are planted into a cultivated seed bed, though they can be successfully direct-drilled in reduced or no-till systems using methods similar to those for canola. A sowing implement with good depth control using either a knifepoint or disc with a press-wheel that ensures good seed-soil contact is recommended.

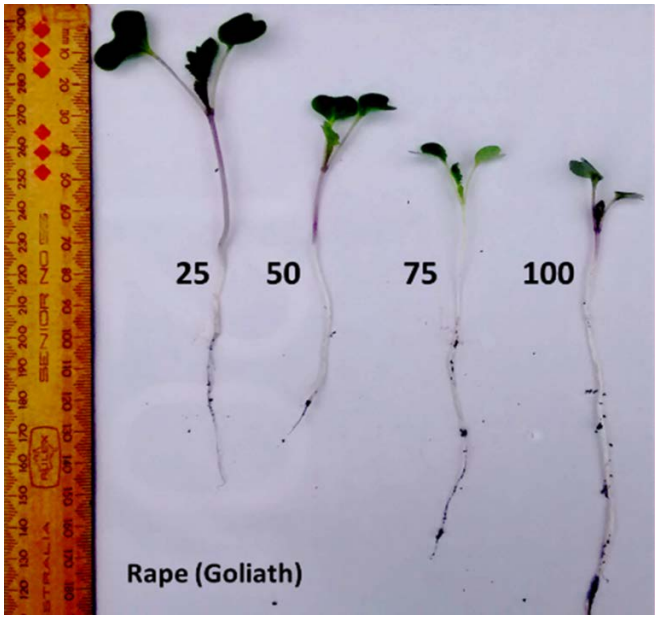
Planting rate and depth

Seed size varies considerably amongst forage brassicas ranging from very small-seeded types such as bulb turnips and swedes (approximately 0.2 g/100 seeds), medium-seeded brassicas such as forage rape (approximately 0.4–0.5 g/100 g seeds), to larger-seeded types such as raphanobrassica (approximately 1 g/100 seeds). This means that the recommended sowing rates for the different forage brassicas also vary (Table 3). Most forage brassica seed is sold with details of germination and seeds per kg.

Table 3. Recommended sowing rates and target plant densities for different forage brassicas

Brassica type	Sowing rate (kg/ha)	Target density (plants/m^2)
Forage rapes	3–4	30–60
Leafy turnips	3–6	110
Kale	4–6	80
Bulb turnips	0.8–2	30
Swedes	0.8–2	20
Raphanobrassica (*cv.* Pallaton)[1]	8	30–60

[1]Pallaton Raphno® is the only raphanobrassica commercially available in Australia. It is sold by the hectare and seed is available under agency agreement through accredited retailers only.



Ability of forage rape to emerge from depth was inhibited below 75mm sowing. Photo: C Gautlier

Establishing a good population is advantageous to help with weed competition and early biomass production. However, in lower production environments it might be advisable to reduce sowing rates by 10–20% to achieve densities between 30–40 plants/m^2, whilst higher production environments (up to 550mm average annual season rainfall) are more likely to require 50–60 plants/m^2.

Because of their small seed, optimal sowing depth for forage brassicas is 10–15mm. This is optimal in wetter environments where follow-up rain is expected to maintain surface moisture. However, in drier environments, including many areas throughout Australia's mixed farming zone, less reliable or a lack of follow-up rain after sowing may necessitate deeper sowing. This can reduce establishment rates (i.e., the proportion of seeds that emerge), but could ultimately be a better choice if avoiding false-breaks or inconsistent surface moisture conditions. Planting at depths of 30mm is typically safe or up to 50mm on soils less prone to surface crusting, when using a medium and large-seeded brassica.

As for all crops, good seed to soil contact is important at planting, and adequate sub-soil moisture (at least 800–1000mm depth of wet soil) will help ensure viable plant populations are achieved.

Starter fertiliser

Phosphorus (P) is essential for forage brassica establishment. Apply a starter fertiliser (e.g., mono-ammonium phosphate (MAP), di-ammonium phosphate (DAP), or other similar products) at 50–75 kg/ha banded beside or below the seed at sowing. Brassicas are sensitive to excessive nitrogen (N) on germinating seedling, so avoid using starter fertiliser applied over 30kg N/ha in close contact with the seed; higher rates are safe if fertiliser if side-banded (> 50mm from seed row) or surface spread. On soils with known sulphur (S) deficiencies there may be a need to apply S fertilisers, but rarely are growth responses found on most soils. If applying sulphur (S) fertiliser, then avoid high rates (i.e., > 20kg S/ha) as this can induce excess production of plant secondary metabolites associated with potential animal health issues. Speak to your local agronomic advisor for more information.

Crop nutrition and protection in forage brassicas

Nitrogen fertiliser management

There is no standard recommendation for fertilisers for forage brassicas because of large differences in soils and production potential, meaning that nutrient demand will vary dramatically. Soil testing is recommended to understand the likely nutrient limitations and to guide fertiliser applications.

Nitrogen (N) availability will have a large influence on forage brassica production, but the challenge is working out how much and when to apply to avoid accumulating high nitrate concentrations in the biomass while also avoiding deficiencies that limit growth. Like canola, forage brassicas have a high potential demand for N with an average of around 3.0% N in their biomass. This means that the crop will take up 30 kg of N per tonne of biomass produced. Making an estimation of the N to apply will be influenced by the production potential of the environment and the background mineral N status (see calculation below). Most dryland crops across Australia's mixed farming regions are likely to require 120–300kg N/ha.

Advisor comment...

"We always start any paddock renovation with a soil test, depending on nutrient deficiencies and/or hotspots we will generally follow a similar program to our ryegrass/clover pastures or forage cereals. Depending on pH, lime would be applied prior to planting, Phosphorus + potassium (if K is needed) around planting time and Nitrogen and Sulphur throughout the growing season to keep production ticking along."

Rikk Thompson – regional agronomist, South-west slopes, NSW and VIC

For example, to grow a 6 t/ha forage rape crop (on a dry matter basis), this would require the crop to have 150kg N/ha available. If the soil profile had 50 kg of N at sowing, the crop would need to access 100kg N from fertiliser. Assuming about 60% of fertiliser N is recovered by the crop then this means that 170kg of N/ha (or 350 kg/ha of urea) would need to be applied over the growing season. To do this estimation with some confidence requires a soil test including mineral N to be conducted at or shortly before sowing.

It is not advised to apply all the N required by the forage brassica crop at sowing. This creates a high concentration meaning the crop is likely to take up surplus N during early growth and potentially cause high nitrate-N in the biomass. Delaying applications can allow for adjustment in the amount applied in response to seasonal conditions – with more fertiliser applied as more favourable conditions unfold, or avoid further applications if conditions are dry. It is suggested that around 35–50% of the required N is made available to the crop at sowing, and that any fertiliser be either mid-row banded between seed rows or spread evenly across the field. The remaining N would be applied either 6 weeks after sowing or after each successive grazing event. Typically, this would be done via surface spreading prior to a forecast rain event to mitigate losses.

Potassium (K) demand of forage brassicas can also be quite high. While many soils will provide sufficient K, in some cases there may be a deficiency. This is best identified via a tissue sample. In such situations a strategic application of K fertiliser is likely to be needed. Some micro-nutrients may also limit production of forage and brassicas but are rarely addressed as it will not equate to an economic loss.

In summary, fertiliser requirements should consider...

- Soil sample results – to know background soil mineral N availability
- The production potential – to refine the nutrient budget
- N fertiliser at sowing – topped up to 35-50% of total demand
- N fertiliser applied post-grazing – and adjust as the season unfolds
- Tissue test results - to help identify any other potentially limiting nutrients

Weed management

Autumn-sown forage brassicas are generally planted in March–May, a time when many winter weeds have not yet emerged. Unlike canola, there are currently limited in-crop weed control options for managing broadleaf weeds in forage brassicas. Control of grass weeds with selective post-emergent herbicides is possible but please consult your local agronomist.

Not all forage brassicas are tolerant of the same herbicides that may be used in canola or other broadleaf crops, though herbicide tolerant lines are being developed but are not yet commercialised in Australia.

Clean paddocks, the use of pre-emergent herbicides (e.g., Trifluralin), and timing of grazing events will help limit weed risks. Integrating forage brassicas into cropping rotations provides greater flexibility in herbicide management, especially to help deal with problematic grass weeds such as barley or rye grass that often evade pre-emergent herbicides due to delayed emergence. In-crop infestations of these grasses are a generally a low issue for farmers using forage brassicas, as grass populations can be well controlled with regular grazing. During the early phases of grazing a forage brassica crop, livestock often seek out and heavily graze annual grasses. This can provide an additional tool to reduce herbicide use and resistance in these weeds, provided subsequent seed set is managed.

Most forage brassicas are highly competitive to weeds once the canopy is closed, and herbicide applications may not be required or effective. Weed management may be required to remove weeds after a grazing event.

Some pre- and post-emergent herbicides have grazing withholding periods, so please check product labels before you commence grazing.

Grower comment...

"Forage brassicas can be grown in mixtures with oats and barley but planting them as a monoculture gives more options for grass weed control."

Aidan Rodstrom – Grower, Boggabri, NSW

Insect pests

The major insect pests in canola, are also common in forage brassicas (Table 4). In general, seed treated with appropriate systemic insecticides can help to prevent insect attack in newly emerged seedlings. Regular monitoring of crops and a well-targeted management plan is essential to prevent widespread loss from insect pests.

In mixed farming regions where canola is also commonly grown, forage brassica crops may become more susceptible to insect attack as they move from canola after harvest. In these regions, spring-sown forage brassicas may be at greater risk of losses than well-established autumn-sown crops. Drought stressed crops can also be more susceptible to attack from insects, so regular monitoring is essential in reducing total crop losses, especially in lower production environments. While applications of insecticides may be warranted to avoid losses and control insect populations, regular grazing by livestock may be a viable control method in the early stages of infestation for several insect pests.

Diamondback moth (Plutella xylostella) – HIGH RISK

Diamondback moth is the major pest of brassica crops, and frequently breed on various brassica species, including weeds (e.g., turnip weeds, wild radish). They typically feed on the growing tips of plants, impacting further crop growth. Diamondback moth can be difficult to control with insecticides due to generational resistance, so monitoring is key to ensure prompt and appropriate control measures are put in place. High rainfall events, coupled with warm temperatures (>18-25°C) can significantly reduce larval populations from drowning and fungal disease outbreaks.

Advisor comment...

"In canola growing regions, spring-sown brassicas are likely to come under high pest pressure as canola crops mature. These pests are often resistant to commonly used insecticides and if the brassica crop is not at a grazable stage, we are unable to use grazing as a means of managing pest incursion."

Sandy Middleton – regional agronomist, South-west slopes, NSW

The diamondback moth. Photo: D McClenaghan

Advisor comment...

"In south-western slopes NSW, aphids, and diamond back moth can be a real issue for canola growers in spring. Autumn-sown forage brassicas that are well established are much more likely to withstand this insect pressure, whilst spring-sowing is a big risk in most years."

Rikk Thompson – regional agronomist, South-west slopes, NSW and VIC

Red-legged earth mite (Halotydeus destructor) – HIGH RISK

Red-legged earth mite is considered the most problematic pest for brassica seedlings throughout southern regions of Australia's mixed farming zone and areas of Victoria and Tasmania. The critical monitoring period for red-legged earth mite is from autumn to the end of winter when nymphs and adult mites are most prevalent, making them considerably problematic for winter broadacre crops. Canola is especially susceptible to red-legged earth mites during establishment, with risk of seedling death or growth retardation, and is a concern also for forage brassicas grown in current and newer environments of Australia's mixed farming zone.

The Timerite® calculator is an effective tool to help identify the right time to spray for red-legged earth mite and avoid resistant populations in your area (wool.com/land/timerite/).

Cowpea Aphids – this winged form that can move and locate new hosts. Aphids will give birth to live young without the need to mate. Photo: J Wessels

Aphids – MODERATE RISK

The main aphids known to affect forage brassica and canola crops in Australia are cabbage aphid, green peach aphid, and turnip aphid. Aphids are most prevalent under warm conditions, especially in spring and can quickly infest crops. High infestations are especially problematic during flowering and podding, and so are more of an issue for oilseed canola. In forage brassicas, aphid infestations in the vegetative stages of plant growth can be controlled by grazing; however, aphids are well known vectors of many viruses. So mitigating risk of infestation with insecticidal treated seed and targeted insecticides is important.

Cutworm (Agrotis spp.) – LOW RISK

Cutworm are widely distributed across Australia and known to occasionally damage canola and forage brassica crops. Mature larvae migrate from summer-autumn weeds onto autumn-planted crops that are most vulnerable to damage from May to June during plant emergence.

A cutworm larvae – chew through the stems of young brassica seedlings. Photo: P Room

Cabbage white butterfly (Pieris rapae) – LOW RISK

The cabbage white butterfly are a relatively low risk to forage brassicas and canola, targeting mostly plant foliage that can be easily controlled with grazing in forage brassicas. They are especially active in the summer so pose greatest risk to spring-sown brassicas that are less well established.

Cowpea Aphids – this winged form that can move and locate new hosts. Aphids will give birth to live young without the need to mate. Photo: J Wessels

Rutherglen bug (Nysius vinitor) – LOW RISK

Rutherglen bug is native to Australia and can be found across many regions breeding on soil and weeds. They can cause widespread damage in canola, especially during flowering and seed set; though the greatest threat to spring-sown forage brassicas is in the seedling phase, with bugs moving in from nearby harvested canola. Once the forage brassica crop is well established, further damage can be minimised by regular grazing.

Rutherglen bugs – showing the top and underside of adults (left) and nymphs (right). Photo: QDPI

***Heliothis (Helicoverpa spp.)* – LOW RISK**

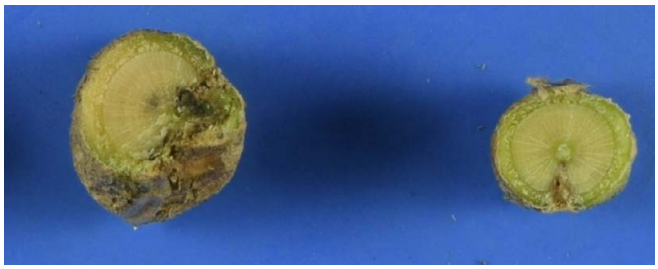
Heliothis (or native budworm) can cause significant damage to canola crops during flowering and podding, but damage to foliage is less of a concern. Heliothis in forage brassicas during the vegetative stage can be largely controlled with grazing.

Crop diseases

There are several crop diseases that affect forage brassicas, but many can be controlled by seed fungicidal treatment and good crop rotation (i.e., frequent rotation of forage brassicas with cereal crops and/or grasses). A summary of the major crop diseases including signs and risk factors are detailed in Table 4.

***Blackleg/dry rot* – HIGH RISK**

Blackleg/dry rot, caused by *Leptosphaeria maculans*, is a major fungal disease in *Brassica* crops and considered the most damaging disease of canola in Australia. Infection from spores most often originate from infected stubble of previously sown *Brassica* crops and/or airborne transfer from infected neighbouring crops (within 500m of each other). Hence, the best management option is to avoid sowing forage brassicas in paddocks following or adjacent to other brassicas (e.g., canola).



Cross-section of brassica stem infected with blackleg.
Photo: S Sprague

***Club root* – LOW RISK**

Club root, caused by the soil borne fungus *Plasmodiophora brassicae* is common in forage brassica crops grown in temperate cool-season wet environments in Australia and New Zealand. The disease is less common in canola grown in Australia, largely because regions where forage brassicas have been typically grown are not typical growing regions for canola. Some forage brassica genotypes, such as kale are more resistant to club root and plant breeding has targeted more tolerant cultivars (e.g., swede cv. Clutha Gold) and genotypes (e.g., raphanobrassica cv. Pallaton).

Because club root is a soil borne disease, it is unlikely to be an issue for forage brassicas grown in Australia's mixed farming zone; however, if it is to become endemic in mixed farming regions, soil conditions such as acidity where the fungus thrives, could make control measures more difficult.

***Sclerotinia stem rot* – LOW RISK**

Sclerotinia is a fungal disease caused by *Sclerotinia sclerotiorum* that lives in or on the soil. It occurs sporadically under prolonged wet or humid conditions. Sclerotinia is less likely to be an issue in multi-graze forage brassicas as regular grazing will reduce excessive biomass accumulation and promote a less favourable environment for the fungus.

***Downy mildew* – LOW RISK**

Downy mildew is caused by the fungus Peronospora parasitica that survives in soil or on infected plant matter. Cotyledons of newly emerged seedlings and leaves close to the ground are especially susceptible under wet, cooler temperatures and can result in significant biomass loss if not appropriately controlled.

In summary, managing pests and diseases in forage brassica should keep in mind...

- Regular monitoring
- Knowing your pests and diseases
- Watch for pests coming out of nearby harvested canola
- Seed treatments can assist with pest and disease control
- Rotating your Brassica crop with cereals or grasses can lower risk of disease

Table 4. Important insect pests and diseases in forage brassicas and canola grown in Australia's mixed farming zone. Risk rating as high (red), moderate (orange), low (blue)

Pest/disease	Susceptible Stage	Damage	Risk factors
Insect pests			
Diamondback moth	All stages	Irregular holes on leaves; slender grey moth (~10mm long) present; light brown to dark green larvae (depending on maturity).	Warm, dry conditions; other Brassica hosts nearby (e.g., canola, brassica weeds).
Red-legged earth mite	Seedling	Whitening/silvering on all or parts of leaves; adults (~1 mm long) are velvety black with 8 red legs.	Sowing un-treated insecticidal seed; sowing into old pasture paddocks; high weed burden in paddock or neighbouring paddocks.
Aphid spp.	All stages	Yellowing and wilting of plants; small (~2mm long) insects yellow, dark green or brown in colour (depends on spp.) visible on leaves and upper stems.	Sowing un-treated insecticide seed; warm, dry conditions; drought stressed plants; autumn and spring planting.
Cutworms	Seedling	Complete removal of top plant growth or severe damage to leaves; caterpillars can be grey-green, dark grey or near black (~40–50mm long) and only visible in the evening/night when they feed.	Direct drill/no-till planting into old pastures (especially if weedy); high weed burden in paddock or neighbouring paddocks; warm conditions.
Cabbage white butterfly	All stages	Masses of flying white moths; irregular holes on leaves with green or black droppings; dull green larvae present.	Warm conditions; other Brassica hosts nearby.
Rutherglen bug	Seedling	Wilted seedlings; narrow bodied adults greyish brown with dark markings (~4mm long) and transparent wings.	High summer -autumn weed burdens (e.g., fleabane, wireweed, capeweed) in paddock/ neighbouring paddocks; autumn planting.
Heliothis spp.	Early vegetative to maturity	Large holes in leaves; presence of brown moths with dark patch on hindwing (~25mm); cream-coloured larvae with brown heads transform to dark brown with stripes as they mature.	Sporadic; wet conditions in inland areas (central Australia) favour breeding; seasonal conditions influence migration; other Brassica hosts nearby (e.g., canola, brassica weeds).
Crop diseases			
Black leg/dry rot	All stages	Whitish lesions on leaves with black spores.	Un-treated fungicide seed; poor crop rotations; higher rainfall conditions.
Club root	All stages	Wilting/stunting of leaves; swollen, galled roots; transform from firm and white to greyish-brown as they decay.	High soil moisture and warm temperatures (> 20–25°C); acidic soils.
Sclerotinia stem rot	Flowering	Stem wilt and death; light-brown lesions on stems transform to a greyish-white colour.	Prolonged wet or humid conditions; poor crop rotations.
Downy mildew	Seedling and early vegetative	White spores followed by black spots and yellowing of leaves.	Wet, cool temperatures (8–16°C); poor crop nutrition, especially P available to seedlings.

Grazing management of forage brassicas

Forage brassicas offer potential for high animal growth rates due to their high quality; however, they typically require more grazing management than other forages. There are several animal health risks that producers should be aware, and animals should be monitored closely when grazing forage brassicas, especially during the first week of grazing.

Nutritional value

Forage brassicas are highly digestible with high metabolisable energy and low fibre content compared to pasture. They also provide adequate levels of crude protein for growing livestock. Table 5 shows some indicative nutritive qualities for forage brassicas compared to canola, forage cereals and perennial pastures demonstrating their relatively high quality compared to other forage sources. Brassicas also maintain their quality for longer than many other forage options, because they maintain a higher proportion of leaf and are often slower to initiate reproductive development. Hence, while brassicas may not produce as much biomass, their higher quality means they often provide equal or more metabolisable energy for livestock. This has benefits for reducing methane emissions compared to pasture-fed ruminants.

Animal health risks

The nutritive characteristics of forage brassicas can expose grazing livestock to a variety of health issues. Like many other very highly digestible forages (e.g., clovers, medics, lucerne), livestock grazing a diet dominant in forage brassicas may be at increased risk of developing bloat or pulpy kidney disease. Under some conditions brassicas can also accumulate nitrates and sulphur-containing compounds (glucosinolates and S-methyl cysteine sulphoxide; SMCO) at levels that can induce mild to severe responses in livestock. High nitrate levels, often found in stressed crops with high N availability or shortly after applying fertiliser, can be a particular risk. In general, cattle are at more risk than sheep because they ingest a higher proportion of the brassica stems where nitrates accumulate, while leaves often have lower concentrations. The sulphur-based compounds found in brassicas are also implicated in several illnesses and may impart flavours that reduce voluntary feed intake. Close monitoring of livestock will help to mitigate the risks, but feed nitrate testing can also be used to either assess the risk prior to introduction or to diagnose problems when they are observed.

Photosensitisation can result in swelling of the face.
Photo: G Refshauge

Table 5. Key nutritional values of forage brassicas compared to other forages grown as winter-spring feed (means and ranges provided in brackets)

	Forage brassicas		Canola	Forage cereals	Perennial pasture
	Leaf types	**Bulb types**			
Dry Matter Digestibility (% DM)	76 (53–83)	77 (67–83)	74 (46–81)	67 (54–82)	70 (55–80)
Metabolisable Energy (MJ/kg DM)	11.4 (7.4–12.6)	11.6 (9.9–12.6)	10.9 (6.2–12.3)	9.8 (7.6–12.3)	10.4 (8.0–12.5)
Crude Protein (% DM)	19 (5–33)	20 (6–30)	20 (6–29)	15 (8–28)	26 (10–33)
Neutral Detergent Fibre (% DM)	26 (12–56)	23 (13–39)	28 (16–59)	46 (29–65)	53 (30–67)
Acid Detergent Fibre (% DM)	17 (9–41)	16 (9–30)	18 (10–38)	24 (14–36)	26 (20–34)
Sheep expected growth (kg/day)	0.17	0.17	0.17	0.15	0.16
Cattle expected growth (kg/day)	0.60	0.60	0.57	0.46	0.51

Nutritive values of forage brassicas, canola, and forage cereals (triticale and oats) from field trials conducted in 2018 and 2019 at sites in WA, NSW, and Qld (see Watt et al. 2020 for more information). Pasture values based on other studies in temperate and subtropical regions of Australia.

Expected growth rates were calculated in GrazFeed using mean nutritive values above for Border Leicester x Merino mature wethers and Angus mature steers rotationally grazing 3 t DM/ha green herbage at 20 cm height in July at 35°S latitude.

Knowing what to look out for is important so that problems can be identified early, to avoid animal welfare issues and production losses. Table 6 outlines the signs of possible health issues in livestock grazing forage brassicas and their likely cause. If in doubt, contact your local livestock veterinarian for advice. In all cases where signs of ill-health are observed, animals should be removed from the brassica crop onto alternative pasture.

Grower comment...

"There are many ways to manage cattle grazing brassicas. Some growers allow animals to move between a brassica and wheat crop for the first two-weeks. On my farm I often leave two to five hectares of native grass in the paddock that animals can access. Forage brassicas can also be grown in a mix with vetch. This helps reduce animal health risks – though it does make weed control more difficult."

Martin Murray – Agronomist and Grower, North West Slopes, NSW

The leaf portion of forage brassicas typically contains more protein, is more digestible (higher in energy and lower in fibre) and contains less toxins than stem material and is therefore grazed preferentially by livestock. Strip grazing facilitates better utilisation of the crop and reduces risks associated with grazing only stems. Photos: R Stutz

Introducing livestock onto brassicas

Livestock often have a period of low rate of liveweight gain when first introduced to brassica crops. This may be related to rumen adjustment to highly digestible forage or lower feed intake due to flavours associated with sulphur-based compounds in brassicas. Farmers often observe that livestock will avoid the brassicas at first, preferentially grazing the annual grasses or weeds from within the paddock. However, once they are accustomed to brassicas in their diet, they quickly accept and heavily utilise the crop.

Follow the recommended guidelines in Table 7 to mitigate animal health risks.

When leafy-type forage brassicas reach a height of around 30-40cm is an ideal time to start grazing. Photo: R Stutz

Remove stock from crops of leafy types when leaf is fully utilised. Photo: R Stutz

Table 6. Signs of possible animal health issues when grazing forage brassicas. Stock should be removed from brassicas at any signs of ill-health

Signs	Possible cause
• Sudden death • Appears in good condition	**Pulpy kidney / Enterotoxaemia** (mostly affects sheep) Sudden change to high soluble carbohydrate and low fibre diet resulting in increase in intestinal bacteria that produce a toxin, poisoning the animal.
• Distended left rump • Reduced feed intake • Low condition score • Diarrhoea • Frequent urination • Stomping / kicking • Laboured breathing • Sudden collapse	**Bloat** (mostly affects cattle) Sudden change to high soluble carbohydrate and low fibre diet resulting in ruminal acidosis, reducing ruminal contractions and belching.
Appears in good condition	
• Reduced feed intake • Diarrhoea • Salivation • Abdominal pain • Staggers • Convulsions • Abortions	**Nitrate poisoning / Nitrate toxicity** Ingestion of high levels of nitrate which is reduced to nitrite in the rumen, resulting in lower capacity of blood to carry oxygen (anoxia).
• Aimless wandering • Hyperexcitability • Convulsions • Head pressing • Rapid eye movements	**Polioencephalomacia / Rape blindness** Swelling of the brain which is thought to be caused by ingestion of excess sulphur (>4 g/kg DM) but the mechanism is not fully understood.
• Red urine • Reduced feed intake • Reduced liveweight gain	**Anaemia / Kale anaemia / Red water** Ingestion of excess S-methyl cysteine sulphoxide (SMCO) which is fermented to dimethyl disulphide in the rumen, resulting in damage to haemoglobin and reduced red blood cell count.
• Rapid, laboured breathing with grunt on exhale • Dilated nostrils • Open mouth with extended tongue	**Respiratory distress** Ingestion of high levels of tryptophan which is converted to 3-methyl indole in the rumen, resulting in damage to the lungs.
• Swelling, blistering and scabbing of face, ears, udders and other areas of unpigmented skin	**Photosensitisation / Rape scald** Ingestion of photodynamic agents (possibly related to breakdown products of glucosinolates) that cause sensitivity to sunlight. Mechanism is not well understood but is more likely when brassica crops are grazed prior to maturity / grazed by young animals.
• Enlarged thyroid (swelling in throat area).	**Goitre** Iodine deficiency caused by low levels iodine in brassicas, exacerbated by low levels of copper and selenium and/or presence of glucosinolates.
• Constipation • Reduced feed intake	**Rumen stasis** Rumen stops moving due to prolonged brassica consumption / poor adaptation to brassica diet.
• Choking • Bloat	**Choking on bulbs** (mostly cattle) Bulb type brassicas impacted in throat / oesophagus. More likely with round rather than tankard varieties and when bulbs are small.

In summary, grazing management should consider...

- Crop management before grazing, including avoiding excess fertiliser and growing the crop to about 30 to 40cm
- Good animal husbandry, including up to date vaccinations for pulpy kidney in both sheep and cattle and keeping a close eye on animal health
- A gradual introduction of livestock to the Brassica crop
- Providing livestock with clean water and fibre-rich pasture, grass or hay during Brassica grazing
- Where possible strip grazing will better utilise the Brassica

Table 7. Recommended guidelines for mitigating animal health risks and facilitating their introduction onto brassicas

Before grazing
• Avoid applying excess N and S fertilisers at sowing and top-up during establishment based on expected growing conditions. Ensure P levels are adequate. • Ensure crop is well-anchored, has reached 8-leaf stage and has accumulated at least 2 t DM/ha. • If in doubt, test the nitrate content of the crop, particularly after frost or drought stress, if the crop is flowering, in overcast conditions or when grazing regrowth. • To reduce bloat risk, do not graze while crop is frosted. • Vaccinate young animals against pulpy kidney and maintain yearly booster schedule.
When introducing animals
• Ensure they are full prior to introduction. • Gradually increase access to crop starting with a few hours and increasing exposure over 7 to 10 days. • Provide access to fibre-rich feed such as a dry pasture area or a pasture or grass hay of reasonable quality; alternatively, sow brassicas as a mixed forage with a grass component.
During grazing
• Monitor animals daily to catch potential health problems early and remove animals immediately if signs of ill-health are observed (provide shade if animals show signs of photosensitisation). • Maintain a clean water supply for animals; troughs are readily contaminated by plant material. • Allow animals to graze for at least 3 weeks to allow for acclimation of rumen microbes. • Break feed / strip graze to achieve better utilisation and minimise periods where only stem material is available.

Further reading

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