Millet and sorghum

In brief

Millet and sorghum are summer forage options for dairy farms due to their potential to accumulate DM rapidly in warm conditions. The 3030 Project has a focus on increasing production and utilisation of home-grown feed, so the potential and some management aspects of millet and sorghum were evaluated in different plot studies, on-farm experiments and partner farms.

This Information Sheet summarises the key findings and discusses the role of millet (*Echinochloa utilis*) and sorghum (*Sorghum bicolor*) in pasture-based dairy systems.

Key features

- Sorghum and millet perform better than most other annual summer crops when soil water is limiting.
- Sorghum and millet normally have high water use efficiency.
- Nutritive characteristics [estimated ME (metabolisable energy) and CP (crude protein)] of millet and sorghum are normally poorer than for other summer crop options (forage Brassicas or chicory).
- Millet and sorghum have a potential role in double-cropping following late-cut winter cereals.
- Millet and sorghum have minimal disease or pest threats compared to spring sown Brassicas.
- Yields can be restricted by low summer temperatures.

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Where do millet and sorghum fit into your feed plan?

Reliable quantity of summer feed

In the typical southern Australian dryland perennial ryegrass-based dairy system, there is a summer feed gap when ryegrass growth declines due to high temperatures and frequent water stress. Sorghum and millet have been used in some parts of Victoria as a grazed crop to fill this gap.

The main characteristic that makes species like millet or sorghum stand out is their fast growth and adaptation to water stress conditions, although their feeding value is inferior to other summer forage options such as Brassicas or chicory (see Feeding value). Sowing millet or sorghum for the summer is an option to reduce the risk of crop failure from moisture stress (although they do not eliminate this risk) and increase DM production at the expense of feed quality.

Millet and sorghum have also been used as a back-up plan when summer crops to be sown in late spring (October to early November) such as turnips or forage Brassicas are not sown earlier due to insufficient soil moisture or rainfall. Millet and sorghum can adapt better than Brassica species to both late sowing and limited soil moisture content. Millet and sorghum are also easy to establish but they require a high soil temperature to germinate (from 14 to 16°C, depending on the hybrid).

Renovation programs

Millet and sorghum can be used as summer crops between the cultivation and/or spraying of an old permanent pasture sward and the sowing of a new pasture in autumn. They are chosen to play this role more for their ease of establishment and freedom from insect damage than for benefits to the soil or the subsequent pasture to be sown.

As with all forage options, there are advantages and disadvantages of using millet and sorghum as break crops.

The advantages are:

- **Lower risk of crop failure:** Because of their higher tolerance to water stress and low risk of insect attack, they are more likely to attain a minimum amount of feed than most other broad-leaf summer crop options.
- **Efficient N users:** Millet and sorghum have higher N use efficiency (kg DM/kg N) than most broad-leaf summer forage crops. This means that they can effectively utilise the N released from the mineralisation of organic matter that occurs after cultivation of permanent pastures.
- **Control of broad-leaf summer weeds:** In paddocks with high infestation of problematic broad-leaf weeds, using millet and sorghum ensures that selective sprays can be used as many times as necessary to secure their control.
- **Absence of serious/severe pest threats.**
- **Ability to be conserved as hay or silage.**
- **Can have a role as a 'speculative crop'** (e.g. millet can be cheap to sow after an early turnip crop or similar).

The disadvantages of sorghum and millet as break crops are:

- **Poor control of grass weeds:** Weeds such as couch or barley grass are common in old pasture swards and their elimination is crucial before sowing new pastures. There are no selective herbicides to effectively control these species in millet and sorghum. If these weeds grow with the crop, they can set seed and reappear the next season in the pasture sward, where they are difficult to eliminate.
- **Poor nutritive value of summer diet for lactating cows:** The high fibre content of millet and sorghum does not improve the normally low nutritive value of summer pastures. In the case of grazeable millet and sorghum, if managed properly (grazed at the right height; see Figure 1) they can have moderate metabolisable energy (ME) but they rapidly lose quality once they progress past the ideal grazing height. Brassicas or herbs such as chicory or plantain are a better alternative in this regard.
- **Later sowing times:** Due to higher minimum soil temperatures for germination, they often cannot be sown until late spring-early summer, missing out on growth potential under good growing conditions.
- **Toxicity risks:** Sorghum especially has the risk of prussic acid poisoning of stock if grazed at certain stages of growth.
- **Poor growth under cool conditions:** In some years in southern Victoria, cool summer conditions can restrict the growth of these crops.

Figure 1. Millet crop grazed at vegetative stage in 3030 Project trials at Terang (21 February 2011).

In heavy infestations of problematic grass weeds (bent grass, barley or couch grass), millet and sorghum are more suitable for 12 or 18-month renovation programs than as single summer break-crops. These longer renovation programs include double-cropping with an autumn-sown crop (forage Brassica or winter cereals) and could be combined with a different crop in the following summer. With these crop combinations there are more chances to control problematic weeds before sowing the next pasture (see example in Figure 2).

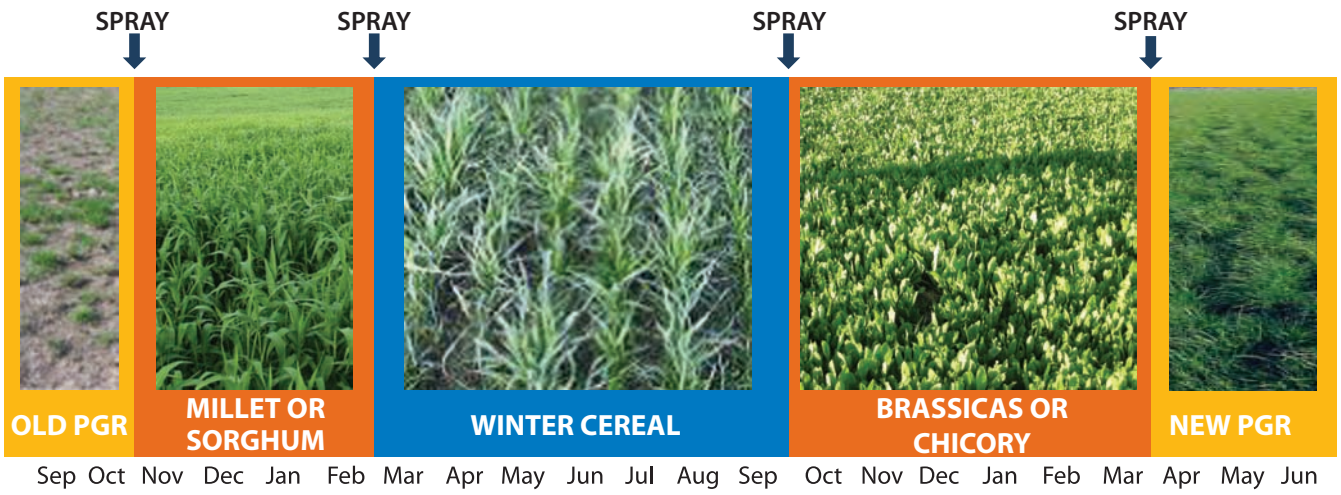

Figure 2. Diagram of an 18-month renovation program including millet and sorghum in summer.

The double cropping of cereals with summer crops was the focus of extensive research within the 3030 Project, involving plot studies, farmlet evaluation and commercial farm experiences.

Most of the double-cropping options included winter cereals. Millet suited the farm systems where the winter cereals were cut later (soft dough stage) rather than earlier (boot stage), whereas Brassica crops were more suitable to be sown after the early harvested cereals. This was due to two reasons:

1) millet needs soil temperatures of 16°C or above at sowing to germinate, which is not reached when the cereals are cut early (around mid-October); and

2) the harvesting date of the cereals has an impact on the level of conserved soil moisture and millet has a better chance to establish successfully with limited soil moisture than most Brassica crops.

An additional benefit of the millet is to almost eliminate the risk of insect damage. On the other hand, it is likely that the nutritive value of millet forage will be lower than that of Brassica forage.

Yields of millet and sorghum

With no limitations of water and nutrients, sorghum can produce 17–20 t DM/ha and millet 7–10 t DM/ha). However, under dryland conditions yields of millet and sorghum can be extremely variable and on commercial farms in southern Victoria these potential yields are rarely achieved.

The main factors that influence yield are variable summer temperatures and summer rainfall. In this way, millet and sorghum are more tolerant to water stress than maize. A plot study of the 3030 Project compared the yield of forage Brassicas to the yield of a millet crop during two consecutive summers (Jacobs et al., 2006). Although the yield differences with full irrigation were not large, the incomplete irrigation treatments had a larger impact in the forage Brassicas than in the millet, which was able to reach more than 80% of the potential yield with only 25% of the irrigation requirements met (Table 1).

Table 1. Yields of millet and forage Brassica under contrasting irrigation regimes at Terang (adapted from Jacobs et al., 2006).

		Irrigation level			
		100%	50%	25%	Dry
		(t DM/ha)			
Millet (cv. Shirohie)	Year 1	14.4	14.1	12.7	11.5
	Year 2	13.8	13.5	11.2	8.04
Forage Brassica (cv. Hunter)	Year 1	12.3	10.2	8.3	7.9
	Year 2	14.3	11.9	10.3	8.4

A series of replicated trials of the 3030 Project at DemoDairy in Terang, Victoria (Jacobs et al., 2008; Jacobs et al., 2011) compared the most common summer crops used in dairy farms of southern Australia. Dry matter yields of sorghum and millet were very similar to the ones of regrowth Brassica crops (Hunter and Winfred), and the herbs chicory and plantain. The main difference between them was the time required for crops to reach grazing maturity. Yields of all different crop species were highly variable depending on summer rainfall, ranging between 3 and 9 t DM consumed per ha. In the same trials, the yield of DM consumed from bulb turnips (single grazing) was also variable but generally higher, up to 11 t DM/ha, reflecting the stronger growth potential of this single grazed crop.

Although they do not have the same yield potential, one of the main advantages of sorghum and millet over maize is that they can be direct grazed (Figure 2), which reduces the cost per tonne of DM consumed and adds flexibility to the system (requirements of machinery, contractors, feeding out facilities, etc).

Figure 3. Paddock of millet strip grazed at 3030 Project farmlets at Terang (21 February 2011).

In comparison to Brassica forage crops, sorghum and millet do not show higher yields but have the advantage of a higher tolerance to dry conditions. Their main disadvantage is the nutritive value.

An important point, confirmed by the 3030 studies, is that none of these annual summer crop species can remove completely the risk of crop failure in dryland conditions. Their inclusion in the forage plan of non-irrigated dairy farms has to account for this risk.

Feeding value of millet and sorghum

Compared to perennial ryegrass or other annual summer forages, millet and sorghum have a relatively poor nutritive value as a feed for lactating cows. They are characterised by high fibre content and moderate ME levels.

A lower energy content of forage sorghum compared to other summer crop options was seen in grazing trials by the 3030 Project at Terang (Table 2, Jacobs et al., 2008). Although the ME values of sorghum in the second year were higher than in the first year, they were consistently below chicory and forage Brassicas in both years.

Table 2. Metabolisable energy content of grazed summer forage crops at Terang (adapted from Jacobs et al., 2008).

	Year 1		Year 2	
	First Grazing	Second Grazing	First Grazing	Second Grazing
	(MJ ME/kg DM)			
Chicory (cv. Grouse)	10.2	11.0	10.9	11.5
Forage Brassica (cv. Hunter)	13.2	12.8	12.9	12.9
Sorghum (cv. Sweet Jumbo)	8.9	9.0	10.2	10.2
Forage Brassica (cv. Winfred)	13.0	13.3	13.2	12.2

Sorghum silage can be used in the diet of dry cows during the transition period (15 days before calving). These feeds have a moderate to low risk level for milk fever due to their low Dietary Cation Anion Diference (DCAD) as shown in Table 3 (Lean and DeGaris, 2010). The DCAD measures the levels of four macrominerals in the diet: positively charged cations (K+ and Na+) and negatively charged anions (Cl- and S-). By adding these charges together, the ration DCAD is determined. The DCAD affects cows' blood buffering capacity and acidity. Diets containing low or negative DCAD can reduce risk of milk fever.

Responses to N application in millet and sorghum

A study evaluated the response to dairy second pond effluent in summer crops. Chicory, regrowth Brassicas and sorghum responded linearly to effluent application when applied at rates up to 100 mm split across two equal applications. The study also found that:

- When there was some summer rain, chicory and regrowth Brassicas responded better (around 50 kg DM/mm) than sorghum (around 30 kg DM/mm).
- When there was no summer rain, there was a low and similar response in all crop species (15 kg DM/mm applied).

Table 3. Mineral composition and DCAD of some feeds used in pre-calving diets (adapted from Lean and De Garis, 2010).

Feed	Ca %	Mg %	Cl %	S %	Na %	K %	DCAD (mEq/kg DM)	
							Typical	Range
Rye/clover pasture	0.63	0.23	2.00	0.28	0.53	3.40	+390	+10 to +750
Kikuyu pasture	0.34	0.37	4.50	0.10	0.33	1.96	+680	+10 to +750
Lucerne	1.53	0.31	0.61	0.30	0.14	2.57	+360	+10 to +750
Oat hay	0.35	0.16	1.02	0.14	0.42	1.87	+280	0 to +750
Pasture hay	0.47	0.18	0.66	0.17	0.02	2.00	+230	+10 to +750
Wheat hay	0.35	0.16	0.53	0.16	0.08	1.77	+240	0 to +750
Grass silage	0.57	0.22	0.76	0.20	0.05	2.78	+390	+10 to +750
Maize silage	0.31	0.22	0.32	0.12	0.01	1.22	+150	+5 to +300
Sorghum silage	0.49	0.28	0.60	0.12	0.02	1.72	+200	+10 to +750
Trit silage	0.52	0.17	0.75	0.20	0.08	2.90	+440	+10 to +750

In the same study, the main effects on herbage protein and mineral content were:

- Linear increases in crude protein content of up to 0.08% DM per mm applied for regrowth turnips and sorghum.
- Linear increase in K content of all crops (which can sometimes lead to a decrease in Mg content).

Another 3030 study looked at the response to urea application on summer crops over two summer periods (Jacobs et al., 2011). Nitrogen was applied at 0, 40, 80, 120, 160 and 200 kg N/ha with half of the N being applied 5–6 weeks after sowing and the remainder immediately after the first grazing. Yield responses of chicory, plantain, turnips, regrowth Brassicas, sorghum, millet, and a millet/regrowth Brassica mixture were generally poor (0 to 4 kg DM per kg N applied). There was some response in the crude protein content of forages, ranging from 0.02 to 0.1% increase per kg N applied.

However, these results should be understood within the particular context of the experiment. First, both trials were undertaken in permanent pasture areas that had been cultivated as part of the seedbed preparation for the summer crops. Subsequent soil N mineralisation may have masked the magnitude of any responses to applied N. Second, the very limited summer rainfalls in the second year resulted in no responses in DM yield to N applications.

This research confirmed that very low responses to N application should be expected when sowing summer forage crops on soil being cultivated after a permanent pasture. In addition, it was clear that N should only be applied when there is sufficient soil moisture to secure growth.

Millet and sorghum mixtures

Millet + forage rape

This mix has been tried in several commercial farms in Gippsland with the objective of increasing the nutritive value of the millet crop. The practice involved including ~1 kg/ha of a forage Brassica seed with the millet seed drill.

Visual observation of the crops at the time of grazing indicated that the plant density and proportion of the DM of the Brassica was low. This suggests that there was not likely to be an increase in the nutritive value of the crop.

Sowing technique and densities might need to be revised. The two species have different optimum sowing depths (the common practice is to aim for less than 10 mm for Brassicas and 20 mm or more for millet) and this is likely to have an impact on early competition between the seedlings of both species. More work is needed to test if this mix is feasible as an alternative to increase the feeding value of millet crops.

Millet + chicory

On-farm experience is that where herbs such as chicory or plantain are sown with a summer forage crop (Brassica or millet), nutritive values improve in some cases, with no adverse effect on summer DM yield.

Increases in forage production have been observed during the following autumn when these crop/herb mixtures are used instead of monoculture crops. Both chicory and plantain can produce significant amounts of feed over the first autumn after sowing, a period when it is often very difficult to produce home-grown feed. Probably the most significant advantage of this mixture is that the presence of chicory and plantain ensures a more seamless transition from the summer forage crop into the perennial sward, reducing the feed gap until the new pasture is established and fully productive. It could also be suitable for the autumn oversowing of an annual or short rotation ryegrass. This is only true if the establishment of the chicory/plantain was successful and their plant density is still acceptable after the millet crop has been grazed.

Another advantage of this mix was that there were fewer weeds in the newly sown pastures during the first year of the new pasture, due to the presence of chicory/plantain plants covering the ground and reducing germination of unwanted species during the establishment phase.

Additional agronomic information

- More information on agronomy of millet and sorghum can be found at the DPI Victoria Dairy Services website (http://new.dpi.vic.gov.au/dairyservices/multimedia-library/newsletters/target-10-communicator/october/which-summer-crop-should-i-grow).
- A complete factsheet about millet agronomy has been produced by the Western Australian Agriculture Department (http://www.agric.wa.gov.au/objtwr/imported_assets/content/past/f09301.pdf)
- More information on sorghum agronomy can be found in the Pacific Seeds Forage Sorghum Agronomy Guide (http://www.pacificseeds.com/products/forage/documents/forageagronomy08.pdf) and the HSR Seeds Forage Sorghum Agronomy (http://www.hsrseeds.com.au/pdf/HSR%20Seeds%20Forage%20Sorghum%20Production.pdf; http://hylan.com.au/pdf/HSR_SummerCropGuide_SouthernRegion.pdf).

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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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