TECH NOTE 5

Complementary Forage Systems

Growing maize for silage

FutureDairy investigated options to mitigate the ever-increasing limitations imposed by land, water and labour availability and cost in Australian dairying.

A key strategy for farmers is to increase home-grown forage production and consumption. This, in turn, can improve profitability. FutureDairy has proved that forage yields from complementary forage rotations (CFR) can be more than double those of pasture. This has been demonstrated on both research and commercial farms.

Complementary forage systems (CFS) integrate CFR into pasture-based dairy systems. This can be done in many different ways and tailored to individual farmers' needs.

When using forage crops, FutureDairy's approach is to start by setting goals that are based on what is possible (and then determine what is feasible) rather than constraining goals based on known limits to the current farm situation.

FutureDairy has shown that production of ~30,000L milk/ha or ~2,000kg milksolids/ha from home-grown forages and more than 7,500L/cow (>500 kg milksolids) are achievable with only ~1t of concentrate/cow.

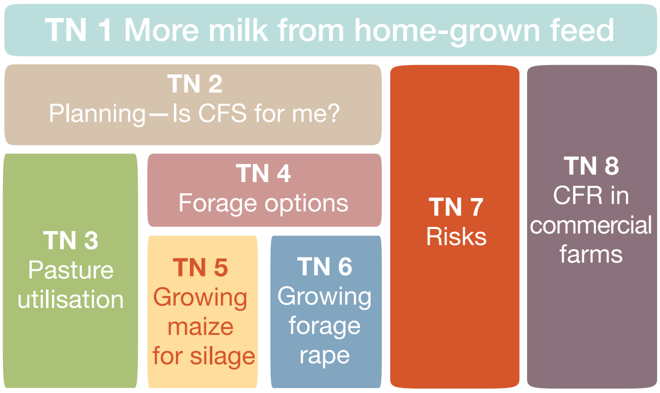
Complementary forage systems may allow you to:

- Increase total forage yield, and therefore milk from home-grown feed, and farm productivity and profitability.
- Replace more expensive bought-in supplements (thus potentially reducing economic risk).
- Increase the efficiency of use of nutrients and water.

This tech note describes:

- Key principles and practices of growing maize for silage.
- Management aspects.
- FutureDairy experimental outputs.

This tech note reports on FutureDairy's findings. Further work/discussion is needed regarding the specific application of these findings in different commercial dairy systems.



The principle

If establishment is adequate and soil nutrient and moisture status are not limiting growth, the total forage yield of a maize crop will be proportional to the amount of radiation (sunshine) captured by the crop. All management practices should be focused on achieving a clean, healthy and well-nourished crop capable of intercepting as much radiation as possible and as early as possible during the growing season.

In practice, to optimise growth we need to get the basics right: establishment, irrigation, fertilisation and harvest.

Establishment

Successful establishment involves:

- Selecting the right hybrid.
- Soil preparation and sowing.
- Density and row spacing.
- Weed and insect control.

Terminology

Complementary Forage System (CFS) refers to the whole farming system; that is the combined pasture and forage cropping area; **Complementary Forage Rotation (CFR)** refers to the area allocated to double or triple cropping.

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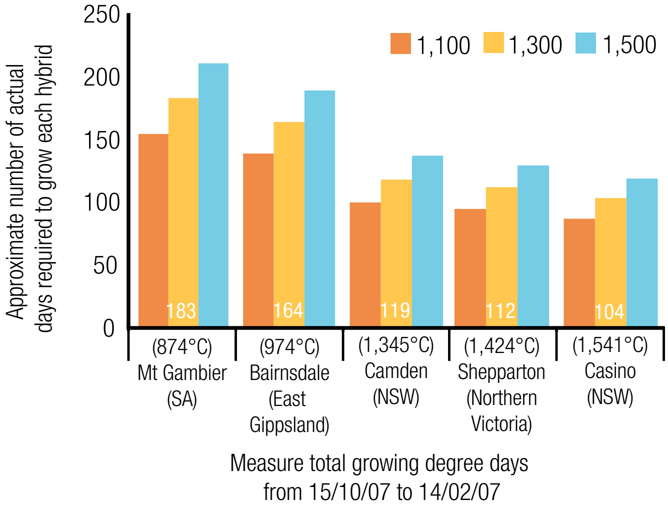

Figure 1. Estimated number of actual days required to grow short (1,100°C), medium (1,300°C) or long (1,500°C) cycle maize crops in different regions of NSW, Victoria and South Australia.

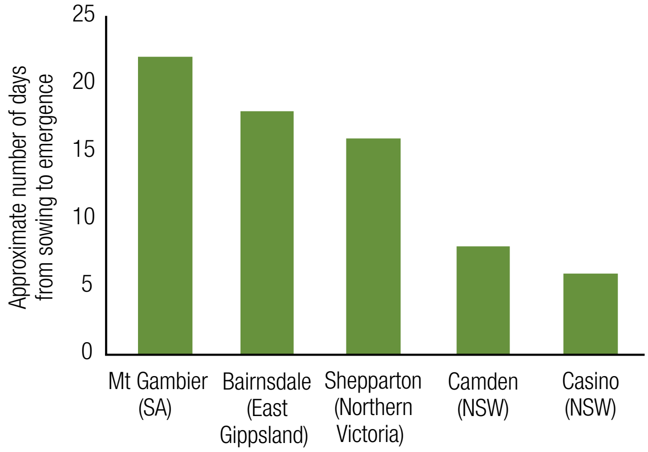

Figure 2. Predicted number of days from sowing to emergence of a maize crop sown in different regions of Australia on 1 October 2007.

Hybrids

The choice of hybrid depends on the intended use. Hybrids for silage production need to be selected for:

- Continued growth during the season (maximum yield DM/ha).
- Retention of a high proportion of green leaf through to harvest.
- Good grain yields that contain 70% more metabolisable energy (ME) and greater carbohydrate levels than the green parts of the plant.
- Tolerance of relatively dense planting.
- High dry matter yield as well as grain yield.

Maize hybrids should be selected for resistance to lodging and root and stalk rot, as well as resistance to the diseases common to the area in which the maize is to be grown. Maize crops should be grown from first-generation seed that has been treated with a fungicide and an insecticide.

Maturity

Selecting an appropriate hybrid in respect to time to maturity depends on the growing season. For example, in Mt Gambier (SA) and East Gippsland (Victoria), the summers are relatively cool. A short-to-medium season hybrid of 95–110 days to cumulative relative maturity (CRM) is most appropriate. Longer season varieties will struggle to finish before late autumn. Maize crops continuing into late autumn pose several risks, including compromising the yield potential of subsequent winter crops (e.g. annual ryegrass, forage rape) and wet weather hampering the harvest.

It is important to note that CRM days are not actual days. A hybrid with a CRM of 95 days will not necessarily be ready to harvest 95 days after sowing. The CRM value relates to the accumulated amount of growing degree days (GDD) required to mature, which is the sum of the temperature degrees above a base temperate. The base temperature is calculated as: (max temp—min temp)—10°.

In practice, maize needs to accumulate 1,000–1,500°C growing degree days to mature, depending on the hybrid.

For example, at Maffra, the long-term average data show a total growing degree days of about 1,000 to 1,100°C from mid-October to late February. The conversion to relative maturity rate CRM is roughly as follows:

- A hybrid classed as 85–100 days CRM needs about 1,100–1,300 growing degree days.
- A hybrid classed as 101–130 days CRM needs about 1,300–1,500 growing degree days.

The impact of cumulative growing degree days is shown in Figure 1, which features actual temperature data from 15 October 2007 to 14 February 2008 for five Australian locations. It shows that a medium-cycle hybrid requiring about 1,300 growing degree days sown on 15 October 2007 would have needed fewer than 120 days to achieve harvest maturity at Camden (NSW), Shepparton (northern Victoria) and Casino (NSW), but more than 160 days at Bairnsdale (East Gippsland, Victoria) and Mt Gambier (SA).

If a maize crop is to be harvested in early March to enable an autumn crop to be sown, short season hybrids would be more appropriate. However, decreasing the CRM also reduces potential yields. For example, a 95-day CMR hybrid may have 2–4 t DM/ha lower potential yield than a 110-day CMR hybrid.

Sowing date

For a given region, the growing season is determined by the 'earliest' sowing date and the 'latest' harvest date. The earliest sowing date depends strictly on soil temperature and the probability of frost events during the early stages of the maize crop. The latest harvest date depends on the forage plan (which crop is planned to be sown after the maize) and the risk (probability) of not harvesting due to climatic conditions (e.g. excess rainfall in early autumn).

Need more details? Use this equation to calculate GDD for your region:

$$\text{GDD} = \sum_{plantingdate}^{maturitydate} Taverage - Tbase\ \Delta t$$

Taverage is the average of daily maximum and minimum temperature and Tbase is the temperature at which growth ceases (usually 10°C) and t is the step time in days.

You will need climate data for your region or just look for the closest weather station data from bom.gov.au

For example, if you want to estimate the GDD between 1 November and 28 February (119 days), for each day do the following:

1. **Average maximum and minimum temperature for each day.**
2. **Take away 10.**
3. **Sum up all the 119 values.**

The critical base temperature for maize germination is 9.8°C and, to emerge, the crop needs to accumulate about 60°C growing degrees. Ideally, this period should not exceed 10–12 days, in order to minimise seed damage and optimise crop establishment.

At Camden this can be achieved by sowing maize in early-mid October, but not until late October-early November in colder regions such as East Gippsland (Victoria).

In practice, the trade-off for individual farmers is in:

1. Sowing as early as temperature allows.
2. Using a shorter hybrid (sacrificing DM yield) the more southerly the farm is located.

Sow as early as possible for your region as this will increase the proportion of grain and increase water use efficiency.

FutureDairy findings

Delaying sowing date can increase tillering and reduce the proportion of grain. Our experiments at Camden showed that delaying sowing for as little as two weeks in spring stimulates a higher vegetative growth of maize mainly through increased tillering. This increase in vegetative growth (and total yield) in late sowing was associated with higher temperatures and radiation use efficiency, but can result in more 'plant' and less 'grain' development, which is undesirable for dairy production systems.

In a trial at Camden, maize was sown on either 20 October or 3 November. The total dry matter (DM) yield was 6% more for the late-sown crop. This was mainly due to higher tillering and developing of cob structure (32% increase) in the late-sown treatments (Table 1).

Table 1. Effect of sowing date on yield and nutrient use efficiency of maize grown for silage.

kg DM/ha or as stated	Early	Late
Total yield (t DM/ha)	28.6	30.3
Grain yield (t DM/ha)	11.0	10.9
Harvest index (%)	38	36
Plant height (cm)	286	270
Tillering (%)	3	30
Total no. of cobs/ha	162,898	161,053
Nitrogen use efficiency (kg DM/kg N)	188	200
Irrigation water use efficiency (kg DM/mm water)	57	53

The proportion of grain decreased slightly with late sowing, which resulted in a 5% decrease in harvest index compared with early sowing. In addition, despite an increase in nitrogen use efficiency, late-sown maize required more irrigation water than early sown maize. This was due to relatively higher temperatures (irrigation water use efficiency decreased by 7% compared with early sowing of maize).

Soil preparation and sowing

Maize can be direct drilled or sown into a cultivated seed bed. Cultivating enables the soil to be deep ripped and the bulk of fertiliser to be incorporated into the soil before sowing. Clay soils may need this every two or three years.

Direct drilling is only recommended with a 'true' direct-drilling machine, to ensure the appropriate depth of the seed (2.5–4 cm), fertiliser placement (about 5 cm deeper and 5 cm to the side of the seed), and an individual compacting wheel for each seed box. It is important that trash in the seedbed is minimised before sowing. This can be done by grazing with dry cows or young stock before sowing or, alternatively, slashing.

If maize is conventionally planted, a typical cultivation could involve:

- Spray out pasture two to three days before deep ripping.
- Deep rip (12" or as deep as possible) every two or three years.
- Apply bulk fertiliser (see section on fertiliser).
- Disc or power-harrow (depending on soil type and conditions).

Planting can begin when the 9 am soil temperature is above 10°C (at sowing depth) or minimum temperature consistently above 10°C and rising over three consecutive days.

Sow with 80–100 kg of mono ammonium phosphate (MAP) as a starter. MAP acidifies the soil around the fertiliser granule less than other sources such di-ammonium phosphate (DAP), thus reducing the risk of damage at germination.

Density and row spacing

Maize plant populations for silage production in irrigated crops should be 80,000–100,000 plants/ha, but allow about 10% more seed for germination and seedling losses.

High plant densities are even more important if maize is sown early when cooler temperatures will slow growth. This is because higher densities can help to achieve canopy closure sooner, minimising opportunities for weeds to establish and maximising radiation solar absorption.

However, high plant densities can have an adverse effect on grain yield if total radiation interception is reduced due to shading. This could be important in regions with continuous heavy cloud cover, such as in the subtropical coastal regions of NSW and Queensland.

The key is to achieve total canopy cover of the soil at an early stage of crop development. Therefore, not only density but also distance between the plants in a row and between rows is important. Reduce the distance between rows as total density increases, to maintain a minimum distance of 15 cm between plants in the same row.

From the harvest point of view, 65 cm is the minimum desirable distance between rows, but avoid going wider than 75 cm. On-farm experience would suggest that narrower row spacing may reduce overall weed burden by achieving canopy closure earlier.

For flood irrigation, it is recommended that maize be grown on raised beds to avoid limiting growth due to water-logging. Experience would suggest that the best beds are approximately 6–8 inches between the top and bottom. To aid in forming beds, it is recommended that the crops grown before maize are such that the number of clods in the subsequent formation of the seedbed is limited, as there is not enough time for these to break down. For example, Persian clover or brassica would be preferred to ryegrass.

Weed and insect control

Weeds compete strongly for sunlight, moisture and nutrients, therefore reducing production and quality. Grass weeds are most competitive and must be controlled early. Shallow inter-row cultivation can destroy young weeds in the first three to four weeks after sowing. Once the maize crop reaches approximately 80 cm the plants will restrict weed growth as it out-competes them for sunlight.

Atrazine and methalochlor are the active constituents most commonly used in pre-emergence herbicides for the control of common summer annual grasses and broad-leaf weeds in maize crops. Metalochlor has a shorter residual effect on the soil, while there is a potential risk of atrazine affecting the following crops (particularly in soils with low organic matter and/or high pH, e.g. the alkaline, sandy soils at Mt Gambier, SA). In practice, this is unlikely to occur in high-yielding crops, where soils are maintained with good moisture over the summer. The advantage of including atrazine as a pre-emergent herbicide is the control of some broad leaf weeds not controlled by metalochlor.

However, if broad leaf weeds are still a problem, there are several post-emergent options such as dicamba (Banvel) with or without 2,4D that can be applied when maize is between 15 cm and 35 cm. There are also post-emergent herbicides to control couch (e.g. primisulfuron).

Herbicide suitability and rates should be checked with your local agronomist or reseller before use, as well as reading the application directions on the label. Some residual chemicals have plant back restrictions for the following crops.

Birds can seriously affect crop establishment, particularly in small paddocks close to trees. At Camden, NSW, attacks are more serious when maize is sown later in November rather than in October.

Check the crop for leaf and plant damage by insects at least twice a week during the first six weeks after emergence. The most dangerous pests to look for are ‘cutworms’, which can be recognised by the irregular damage on the leaves and emerging seedlings dying when they are cut off below ground level. In practice, however, the incidence of cutworms is likely to decrease over time under complementary forage rotations (CFR), as the adult moth prefers to put her eggs on pastures and weeds during winter.

Calculating number of plants/ha

1. Count the number of plants (do not include tillers) on several 4 m linear sections in representative rows.
2. Divide the mean value by 4 to calculate mean number/linear metre.
3. Divide the number of plants/linear metre by distance between rows (e.g. 0.70 m) and multiply by 10,000.

Example:

25 plants in 4 m = 6.25 plants/m

6.25 plants/m ÷ 0.7m = 8.9 plants/m^2 x 10,000

= 89,000 plants/ha

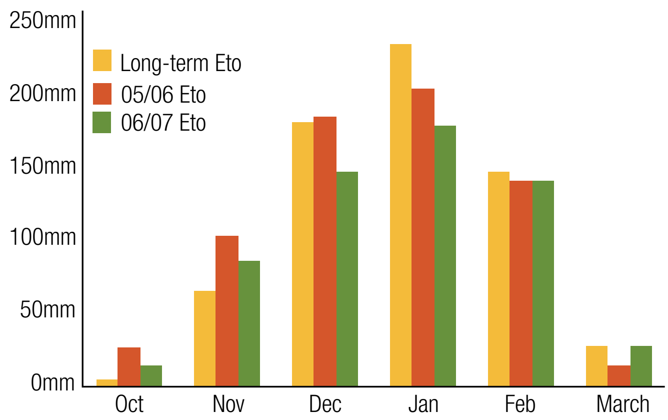

Figure 3. In the Maffra Irrigation District, the long-term average evapotranspiration (Eto) figures suggest that 6.4 ML of water is required per hectare to fully meet the water requirements for maize. However, seasonal variations in Eto in relation to the long-term average Eto can be substantial, as shown above.

Irrigation

When planning irrigation, the key considerations are: the benefits, water requirements and watering at the critical period.

Benefits

Well-watered crops yield more dry matter and are more efficient in using nitrogen. FutureDairy experimental work at Camden showed that increased availability of water through irrigation promotes tillering, taller plants and the number of full grain cobs per plant. But the largest effect of irrigation was on the different fractions of maize plant (Table 2). As irrigation rates increased from nil to 100%, the percentage of grain increased from 9 to 32% but stover (leaf, stem and cob structure) decreased from 91 to 70%.

As a result, nitrogen use efficiency also increased with irrigation rate (from 69 with no irrigation to 161 kg DM/kg N with full irrigation). However, as it can be expected water use efficiency decreased with the increase in irrigation (see Table 2).

Practical message: Define your fertilisation plan according to water availability for irrigation. The highest efficiency will be normally achieved with levels of irrigation close to but lower than, full irrigation.

Water requirements

Maize has a high water requirement due to its high yields (grain and total plant dry matter, see Figures 4, 5, 6 and 7). Because of these high yields, it is one of the most efficient users of water per kilogram of dry matter produced.

A high-yielding crop requires 5–7 megalitres (ML)—or approximately 550–650 mm of water—depending on seasonal conditions. The irrigation system must be able to put out approximately 25 mm/week, and the soil profile kept at, or near, field capacity.

The symptoms of maize plants experiencing water stress are:

- Dull, lifeless leaves.
- Rolled in leaf margins, causing the leaf to 'spike' or stand up.
- Shorter plants with thinner stems.

Critical period

The maize crop uses the majority (70%) of its water requirements in the three weeks either side of tasselling. Therefore, if irrigation is limited, it is absolutely crucial to irrigate during this critical period, from about two to three weeks before tasselling until two to four weeks after tasselling.

Table 2. The effects of irrigation level (% of full irrigation) on water and nitrogen use efficiency and plant fractions of maize at FutureDairy, Camden, NSW.

	Irrigation (%)			
	0	33	66	100
Irrigation water use efficiency (kg DM/mm)	-	96	67	50
Nitrogen use efficiency (kg DM/kg N)	69	103	142	161
Tiller%	7	8	9	14
Full grain cobs (no. cobs/ha)	45,027	75,609	94,185	95,805
Total cobs (no. cobs/ha)	114,120	158,490	175,230	171,180
Plant height at harvest (cm)	165	205	244	264
Plant fractions (%)				
Leaf	44	30	26	27
Stem	25	22	22	21
Cob structure	22	28	23	20
Stover plus cob structure	91	80	71	70
Grain	9	20	29	32

Leaf and cob development

FutureDairy experiments at Camden show how the total number of leaves in a maize plant increases with water availability (see Figure 5). More live leaves mean more food for the plant and also more nutrients to be mobilised for the formation of grain.

The high water content of irrigated maize helps this remobilisation of nutrients, which is key in determining the higher yield of irrigated maize compared with non-irrigated or water stressed maize.

About half of the total number of leaves in maize plants develops between about 45 days (V6) and about 75–80 days (V16) of growth in a 116-day cumulative relative maturity (CRM) hybrid.

Cobs start to initiate at the V8 stage if not limited by water availability. But about 90% of the cob formation occurs between V16 and harvest, in a span of just 30–35 days. This means that water availability is important from early stage of plant development (about V6), but becomes crucial from about V16 (pre-tasselling) to about 2–3 weeks after tasselling.

Practical message: If irrigation water is limited, prioritise irrigation around crop establishment and the four to five week period around tasselling.

An example of irrigation schedule

Table 3 indicates the frequency of irrigation required in each month and amount of water applied for maize grown in the Maffra Irrigation District. For example, you would need to irrigate every four days in January if only 25 mm were applied at each irrigation event, or every eight days if 50 mm were applied. It is based on long-term evapotranspiration (Eto) and assumes no rainfall. It is a guide only. Ideally use in-field moisture monitoring to aid irrigation decisions. If that is not available, use Table 3 as a guide, combined with regular checks on actual evapotranspiration and rainfall (i.e. to offset irrigation), to ensure that the crop is not water stressed. If the soil profile is dry at establishment, more water will be required early on to 'wet up' the soil.

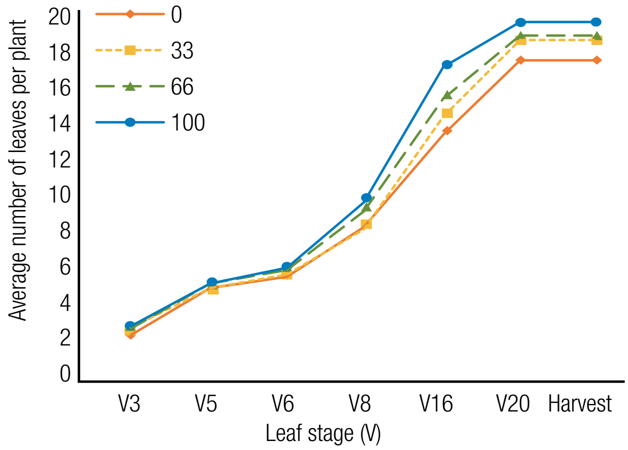

Figure 5. Leaf development of maize plant at different stages of growth of maize depends on rates of irrigation water.

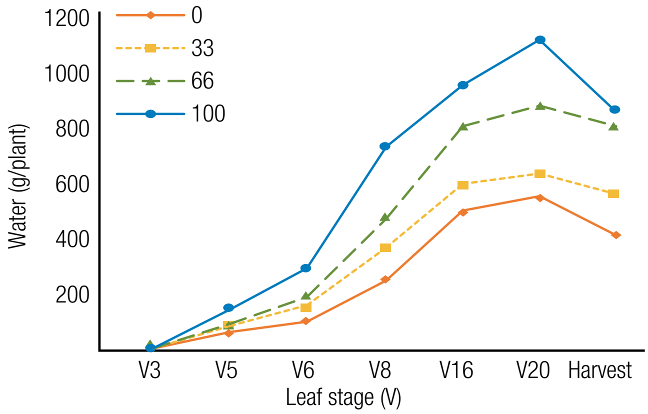

Figure 6. Water content of maize plant at different stages of growth of maize depends on different rates of irrigation.

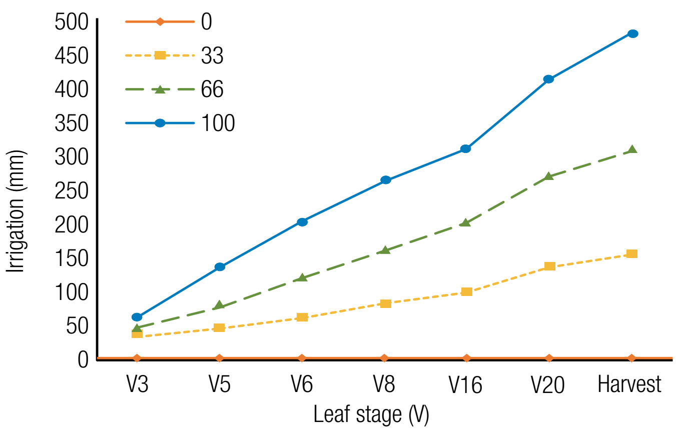

Figure 4. Cumulative irrigation water applied to forage maize at Camden at different stages of crop development and irrigation regimes.

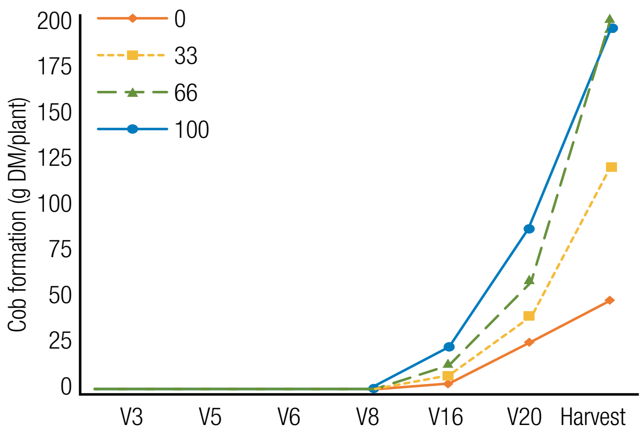

Figure 7. Cob formation initiates at the V8 stage of growth.

Fertilisation

Successful fertilisation involves meeting nutritional requirements and correct timing of application.

Nutritional requirements

Maize prefers well-drained soils with neutral to mildly acidic pH. Because of its high yields, maize is a big user of nutrients. Soil type, coupled with previous cropping and fertiliser history, will affect maize's fertiliser needs. Soil tests should be done before planting and in conjunction with the target yield to determine optimal fertiliser application. For example, a maize silage crop yield of 25 t DM/ha will remove approximately 300–320 kg/ha nitrogen, 250–270 kg/ha potassium and 70–80 kg/ha phosphorus.

This roughly equates to the following amounts of nutrient per tonne of crop grown/ha:

- 10–12 kg nitrogen/ t DM grown.
- 8–10 kg potassium/ t DM grown.
- 2–3 kg phosphorus/ t DM grown.

As a rule of thumb, aim to apply at least 80% of these amounts as fertiliser. For example, for a 25 t DM/ha maize crop that would mean applying:

- 200 kg nitrogen/ha.
- 160 kg potassium/ha.
- 40 kg phosphorus/ha.

Fertiliser can be applied using several methods, such as banding at sowing, side dressings and fertigation. Most precision planters can also apply starter fertiliser, which is placed in a band below the seed.

Fertiliser timing

Maize uses nutrients throughout its growing cycle, with the greatest need when the plant is growing most rapidly, from about 45 cm high to grain fill. To supply the crop's needs, it is best to apply at four stages and to check nutrient adequacy with plant tissue tests.

1. Pre-planting—bulk spread fertiliser before the last cultivation. This may be lime, if needed, as well as two-thirds of the fertiliser planned for sowing. This will have the nutrients in the soil profile ready for the crop.
2. Planting—apply the remaining third of the fertiliser under and to the side of the seed at sowing. This should supply all of the phosphorus and some of the nitrogen requirements of the crop.
3. Apply a side dressing of nitrogen fertiliser at approximately 45 cm high (V6). At this stage the plant is growing rapidly and requires high amounts of nitrogen and potassium.
4. Apply a side dressing at tassel emergence (V12) the final application of nitrogen and potassium. This needs to be delivered via fertigation. If that is not possible, fertiliser needs to be applied in steps 1–3 above.

Although side dressing and/or fertigation are the preferable methods of applying fertilisers, broadcast with simple spreader-type machinery remains the most common and practical way for farmers. FutureDairy results at Camden indicate high yields (>26 t DM/ha for three consecutive years) can be achieved without side-dressing or fertigation.

Table 3. Irrigation required in the Maffra Irrigation District.

Month	Long-term Eto (mm)	Irrigation frequency (days between irrigations)		
		12 mm applied	25mm applied	50mm applied
October	5	30	30	30
November	66	6	11	25
December	183	2	4	8
January	237	2	3	8
February	149	1	3	4
March	29	13	27	30

Table 4. Effects of pre- and post-sown nitrogen fertiliser on grain yield and stover yield, tiller % and nitrogen and water use efficiency.

	Pre-sown nitrogen fertiliser (kg/ha)		Post-sown nitrogen fertiliser (kg/ha)		
	0	135	0	79	158
Grain yield (t DM/ha)	4.1	4.7	3.5	4.3	5.5
Stover plus cob structure yield (t DM/ha)	11.6	13.7	11.5	13.5	12.9
Proportion of grain (%)	22.4	22.8	20.6	21.6	25.5
Irrigation water use efficiency (kg DM/mm water)	66	76	62	73	77
Nitrogen use efficiency		93		151	88
Tiller (%)	6	13	11	9	8

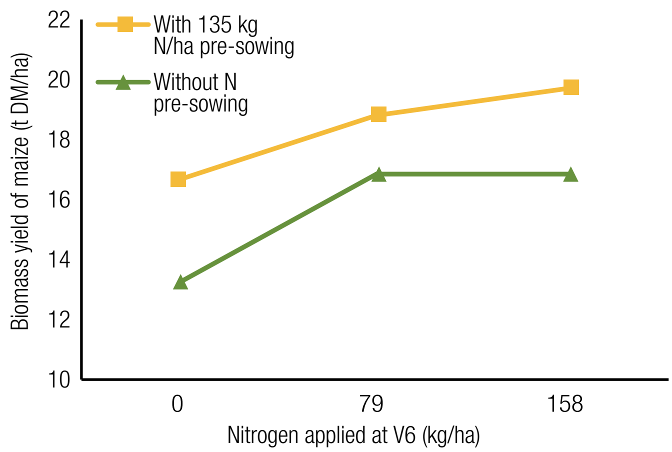

Figure 8. Effects of pre- and post nitrogen application on total maize biomass yield.

Maximising yield

Both pre- and post-sowing nitrogen fertilisations are required to maximise yield.

FutureDairy experiments at Camden showed that both pre-and post-sowing nitrogen fertiliser are required to optimise maize yield (see Figure 8).

Pre-sowing nitrogen fertiliser supports vegetative growth as it increases tillering, stover yield and the number of grainless cobs per hectare. At Camden, applying 135 kg/ha pre-sowing was enough to optimise maize yield with nil or limited irrigation and about 600–700 mm rainfall.

On the other hand, post-sowing nitrogen fertiliser supports reproductive growth as it increases grain yield due to the increase in number of full grain cobs and higher proportion of grain.

Overall, application of pre-sowing nitrogen increased total dry matter yield by 7–16% whereas application post-sowing nitrogen at the V6 stage increased total dry matter yield by 23–34%, compared with the control treatment. On the other hand, application of post-sowing nitrogen increased grain yield by 36% to 57% (for different irrigation treatments), compared to 0 post-sowing nitrogen (Table 4).

At Camden, pre-sowing nitrogen increased irrigation water use efficiency by 8–15%, whilst nitrogen applied at V6 increased irrigation water use efficiency by 24–32% compared to the control treatment with zero nitrogen.

However, application of post-sowing nitrogen must be provided with medium (66%) to high (100%) irrigation water to get high yield response. This is because post-sown nitrogen fertiliser in fact reduces yield when nil to low (33%) irrigation water is applied.

Practical message: If possible and if you don't have 'fertigation' option, split the application of nitrogen into about half pre-planting and about half at V6. This will maximise response, grain yield and nitrogen use efficiency, and minimise risk of wasting nitrogen by leaching.

Nitrogen
Nitrogen stimulates and speeds up growth. The demand for nitrogen increases dramatically from four weeks after seedling emergence. Before that, the plant takes up less than 10% of its total nitrogen requirement. Between V8 and the end of silking (R1), it will take up 78% of its requirements.

Unless fertigation is available, V6 stage is the recommended time to apply nitrogen. The simplest way is to broadcast the nitrogen as urea. Up to about 300 kg/ha urea (135 kg nitrogen) can be applied at V6, providing the crop can be irrigated immediately after to reduce the burning of the leaves and nitrogen losses by volatilisation of ammonia nitrogen. At these high urea levels, burning of the leaf tip will occur, but the crop recovers well and there is no penalty in total yield.

Split nitrogen applications or nitrogen applied in the irrigation water are effective ways to minimise nitrogen loss by leaching or denitrification, or, in the case of urea, volatilisation of ammonia. At the end of the R1 stage it is advisable to do leaf tissue tests to monitor nitrogen content, although corrections at this point can only be made if fertigation is available.

Nitrogen deficiency appears as yellowing of the leaf starting at the tip and extending along the mid rib in a V shape. Young maize that is short of nitrogen is a pale, greenish yellow, is small and has a spindly stalk.

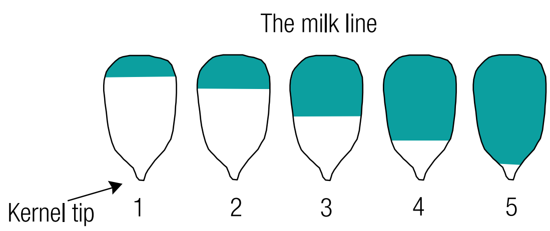

Figure 9. Schematic representation of milk line and stages of corn (Diagram courtesy of Snowy River Seeds: www.hrseeds.com.au).

FutureDairy findings
FutureDairy experimental data showed that nitrogen and water need to be managed together. Both are required to optimize yield (Figure 8).

Practical message: Do not apply the full amount of nitrogen to your crop unless you can ensure water will not be limiting.

Phosphorus
Phosphorus is necessary for early root and seedling development. It also aids photosynthesis by encouraging respiration. The plant needs most of its phosphorus in the early stage of growth to the emergence to R1.

Phosphorus deficiency will appear before the plants are 65 cm tall. It is characterised by slow, stunted growth, plants that are very dark green with reddish purple leaf tips, and stems and margins that show a purplish discolouration. Phosphorus-deficient plants mature slowly and silk emergence is also slow.

Potassium
Potassium is essential for vigorous growth. It is vital to the production and movement of sugars and water within the plant, and flower and fruit production. About 75% of maize's total potassium use is between the V8 and R1 plant stages.

Potassium deficiency appears as yellowing and dying of the leaf margins, beginning at the tips of the leaves. Early appearance of deficiency signs implies low total soil supply or a severely restricted root system.

Other nutrients
Maize is relatively intolerant to zinc deficiency. Zinc is necessary in the first three weeks after emergence. Deficiency manifests with light parallel striping, followed by a white band starting from just inside the leaf margin and extending to the mid rib. The leaf edges, mid rib and leaf tip remain green. Nitrogen and phosphorus uptake may be compromised if zinc levels are low. Zinc is best applied pre-planting, or it can be applied to the crop as a foliar spray.

Sulphur is required for the synthesis of proteins. Deficiency results in interveinal chlorosis and stunting, which are most severe at the seedling stage. Pre-planting fertilisers with sulphur can avert deficiencies.

Magnesium is essential for the plant to create chlorophyll.

Acid sandy soils in high rainfall areas are prone to deficiency, which can be corrected in the pre-planting fertiliser; magnesium sulphate can also be applied as a foliar spray. Signs of magnesium deficiency are yellow streaking of the lower leaves, between the veins, and it is sometimes is associated with dead round spots.

Harvest

Readers are referred to the TopFodder resources, available on Dairy Australia's website.

A practical guide for harvesting maize for silage is to look at the milk line. It is a visual division between the yellowish colour of the seed coat (bottom of kernel) and the whitish colour of the seed towards the tip of the kernel (Figure 9). The milk line can be seen on the opposite side to the embryo (break a cob in half and look at the kernels on the top part of the cob).

In reality, relying only on the milk line can be misleading because the actual moisture content of the plant varies among hybrids. The best way to determine harvest time is by monitoring the dry matter content of the plant. This is not practical on-farm as it involves cutting and chopping a few plants and drying them in an oven.

The exact time will depend on the hybrid and, in practice, the availability of a contractor. High-quality maize silage commonly contains 30–35% DM, so avoid harvesting maize at less than 28–29% DM (whole plant) The loss of nutrient through effluent can be significant, while dry matter of more than 36%, makes compaction of the chopped material more difficult. Keep in mind, that more than half your silage is the stalk without the grain, so maintaining a green plant is important. Some hybrids are not ideal as they dry off quickly after maturity, with an associated loss in quality. In these cases, it would be preferable to harvest sooner rather than later. Ideally, a hybrid should be selected against such 'dry down'.

If you monitor plant moisture, remember that the whole plants dries down at about 0.5% a day, but more than 1% in hot, dry weather. If you measure 75% moisture (25% DM), on average, you should expect to harvest in about 10 days after testing, although this will vary with weather and hybrids.

Nutritive value

Irrigation and nitrogen can affect the nutritive value of maize silage. FutureDairy studies showed that irrigation increased dry matter and fibre (nitrogen detergent fibre, NDF) contents, but decreased crude protein (CP), water soluble carbohydrates (WSC) and metabolisable energy (ME) contents of maize silage despite a higher proportion of grain in the total yield (Table 5). Total metabolisable energy yield of course increased with irrigation as a result of increased total yield.

Nitrogen fertiliser increased sugars (WSC) and ME content of maize silage. Post-sown nitrogen in particular (applied at V6) decreased NDF and lignin, but increased the content of crude protein (17%), water soluble carbohydrates and metabolisable energy (6%) in maize silage compared with the control with no fertiliser (Table 6).

Table 5. Nutritive value of maize silage affected by different rates of irrigation water.

Silage quality (g/kg DM or as stated)	Irrigation (%)			
	0	33	66	100
Dry matter (%)	23	28	29	31
pH	3.80	3.93	3.94	3.89
Neutral detergent fibre	52	55	56	55
Acid detergent fibre	31	30	30	31
Lignin	4.7	4.6	4.7	4.7
Crude protein	7.8	7.2	5.4	5.2
Water soluble carbohydrate	8.8	4.8	2.7	3.1
Metabolisable energy (ME) (MJ/kg DM)	9.82	9.30	9.07	8.81

Table 6. Application of both pre-and post-sown nitrogen fertiliser affects silage quality.

Silage quality (g/kg DM or as stated)	Pre-sown nitrogen fertiliser (kg/ha)		Post-sown nitrogen fertiliser (kg/ha)		
	0	135	0	79	158
Dry matter (g/kg)	273	282	282	267	283
pH	3.89	3.89	3.88	3.87	3.92
Neutral detergent fibre	549	543	551	549	538
Acid detergent fibre	306	305	314	304	298
Lignin	46	47	47	47	46
Crude protein	62	65	57	67	67
Water soluble carbohydrate	43	54	43	52	50
Metabolisable energy (ME) (MJ/kg DM)	9.13	9.38	9.03	9.26	9.47

Practical message: Maximising total forage yield by using full irrigation can result in too much fibre and plant development and decrease the energy content (ME) of the silage. Nitrogen fertilisation can counterbalance this to some extent. In practice aim at about 80–90% of maximum water and nitrogen requirements to reduce the risk of the penalty in quality

More information

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Copies of these articles are available from FutureDairy, ph 02 9351 1631 or the Dairy Australia library ph 1800 824 377, email library@dairyaustralia.com.au.

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- NSW DPI (www.dpi.nsw.gov.au) fact sheets relating to maize production and utilisation www.dpi.nsw.gov.au/agriculture.
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