Growing maize for silage

A guide for dairy farmers

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forages

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Growing a maize crop like this one does not just happen. But is achievable if key management principles are applied. This guide is intended to help farmers identify and apply those principles to grow a succesfull crop for silage

The principles of growing maize for silage outlined in this technical note have been gained through a range of research and development activities over the last five years, in particular work done through the **Future**Dairy project and its partners in the Macallister Irrigation District (MID), south east South Australia and the North Coast of NSW. Through our partner farmers and their support groups, many practical on farm lessons have been learnt, which have been combined with extensive technical research information to produce this technical note.

The **Future**Dairy team

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The principle

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

The practice

In practice to optimise growth we need to get the basics (ABC) right:

The ABC of a successful maize crop for silage

A - Establishment

B - Irrigation

C - Fertilisation

Establisment

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

Hybrids

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; which contains 70% more ME and greater carbohydrate levels than the green parts of the plant.
- Tolerance of relatively dense planting.
- High dry matter yields are as important 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 in the area in which the maize is to be grown. Maize crops should be grown from first generation seed and seed should be treated with a fungicide and insecticide.

Choice hybrids according to available growing window and proven performance on your region.

Cumulative Relative Maturity (CRM) and Growing Degree Days (GDD)

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 and therefore a short to medium season hybrid of 95-110 of cumulative relative maturity (CRM) is most appropriate, with longer season varieties struggling to finish before late autumn. Maize crops continuing into this period pose several risks including compromising yield potential of subsequent winter crops (e.g. annual ryegrass, forage rape) and wet weather hampering harvest.

It is important to note that the CRM days are not actual days. In other words, because a hybrid has a CRM of 95 days, this does not mean it will be ready to harvest 95 days after sowing. The CRM value relates to the accumulated amount of 'growing degree days' required to mature, which is derived from average temperatures. In practice, maize will need to accumulate between 1000 ºC to 1500 ºC 'growing degree days' (GDD) to mature, depending on the hybrid.

Want more details? You can use the equation below to calculate GDD for your region:

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

$T_{average}$ is the average of daily maximum and minimum temperature and T_{base} is the temperature at which growth ceases (usually 10ºC) 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 www.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
2. Take away 10
3. Sum up all the 119 values

For example, at Maffra, the long-term average data show a total GDD of about 1000 to 1100 ºC 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 ~1100-1300 GDD

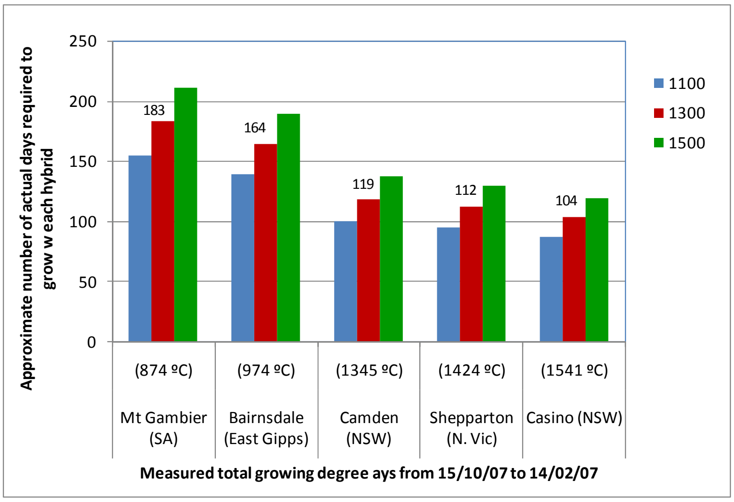
A hybrid classed as 101-130 days CRM needs ~1300-1500 GDD

The impact of cumulative GDD is shown in the graph is exemplified with actual temperature data from 15 October 2007 to 14 February 2008 for five locations in Australia (see bar graph below).

For example, the graph below shows that a medium-cycle hybrid requiring ~1300 GDD sown on 15 October 2007 would have needed less than 120 days to achieve harvest maturity at Camden (NSW), Shepparton (northern Vic) and Casino (NSW), but more than 160 days at Bairnsdale (East Gippsland, Vic) and Mt Gambier (SA).

Therefore, if a maize crop is to be harvested in early March to enable an autumn crop to be planted, short season hybrids would be more appropriate. However, decreasing the CMR 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.

Estimated number of actual days required to grow short (1100ºC), medium (1300ºC) or long (1500ºC) -cycle maize crops in different regions of NSW, Victoria and South Australia



Sowing date

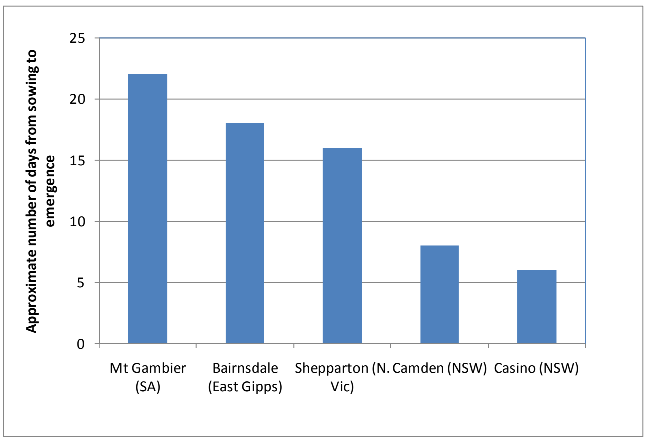
For a given region, the growing season is determined by the 'earliest' sowing date and the 'latest' harvest date. The earliest sowing date depends strictly on soil temperature and the probability of frost events during the early stages of the maize crop. The latest harvest date depends on the forage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

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

In Casino (North Coast of NSW) this can be achieved easily by sowing maize as early as early-mid September; in Camden (west of Sydney, NSW) in early-mid October; in northern Victoria in mid-late October; in East Gippsland (Victoria) in early November; and in the cooler climate of Mt Gambier (SA), in early-mid November.

Using last year actual temperatures, the graph shows the number of days that would have taken a maize crop from sowing to emergence in different regions of Australia had the crop been sown on 1st October 2007.

Predicted number of days from sowing to emergence of a maize crop had it been sown in different regions of Australia on 1st October 2007



Clearly, sowing maize south of Camden NSW before mid October is more risky. But on the other hand delaying the sowing too much will reduce the opportunity for successfully growing a subsequent crop (e.g. annual ryegrass or forage rape), which may be critical to provide quality feed for the cows in autumn and winter. In some areas (e.g. Camden and Casino in NSW), it may increase also the risk of not harvesting the maize crop due to excess rainfall.

In practice, the 'trade-off' for individual farmers is in 1) sowing as early as temperature allows it and 2) using a shorter hybrid (sacrificing DM yield) the more southerly the farm is located.

Soil preparation and sowing

Maize can be direct drilled or sown into a cultivated soil bed. The advantages of cultivating are that it enables the soil to be deep ripped (clay soils may need this every 2 or 3 years) and the bulk of the fertiliser can be incorporated into the soil prior to sowing.

Direct drilling is only recommended with a 'true' direct-drilling machine, to ensure appropriate depth of the seed (2.5-4 cm), with fertiliser placed about 5 cm deeper and 5 cm to the side of the seed, and with an individual compacting wheel for each seed box.It is important that trash in the seedbed is minimized prior to 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 be:

- Spray out pasture 1-3 weeks prior to planting
- Deep rip (12" or as deep as possible; every 2 or 3 years)
- Apply bulk fertiliser (see below)
- Disc or power-harrow (depending on soil type and conditions)

Direct-drilled (zero tillage) maize crop at Camden, NSW.

Conventional cultivation using discs. This soil will be power-harrowed before planting.

- Planting – this can commence when the 9 a.m. soil temperature is above 12° C (at sowing depth) 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-amonium phosphate (DAP), thus reducing the risk of damage at germination).

Air-seeders like this one are the prefered option because they can distribute the seeds very evenly within the row.

Conventional cultivation: soil clods like the ones in this photo will reduce planting uniformity. A good soil preparation is very important.

For flood irrigation, It is recommended that maize be grown on raised beds under flood irrigation to avoid limiting growth due to water-logging. Experience would suggest that best beds are approximately 6-8 inches between the top and bottom. In order to aid in forming beds, it is recommended that crops grown prior to maize are such that the amount of clods in 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.

Density and row spacing

Maize plant populations for silage production in irrigated crops should be 80,000 – 100,000 plants/ha but allow for ~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 weed to establish and maximising radiation absorption.

A well established maize crop sown at 65 cm between rows and ~9.5 plants/m2 (95,000 plants/ha)

However, high plant densities can have an adverse effect on grain yield if total radiation interception is reduced due to shading. This could be of importance 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 plants in a row and between rows is important. It is important to decrease distance between rows as total density increases, in order to maintain a minimum distance of 15 cm between plants in the same row.

A clean, healthy maize crop will achieve canopy-close stage sooner and intercept more incoming radiation

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 through achieving canopy closure earlier.

Calculating number of plants/ha

1. *Count the number of plants (do not include tillers) on several 4-m linear sections in represenative rows.*
2. *Divide the mean vaule by 4 to calculate mean number/linear metre.*
3. *Divide the number of plants/linear metre by distance between rows (eg 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/m2 x 10,000*
- *= 89,000 plants/ha*

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 3-4 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 whilst there is a potential risk of atrazine affecting the following crops (particularly in soils with low organic matter and/or high pH, for example 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 (eg Dicamba [Banvel] with or without 2,4D) when maize is between 15 to 35 cm. There are also post emergent herbicides to control couch (eg primisulfuron). Herbicide suitability and rates should be checked with your local agronomist or reseller prior to use as well as reading application directions on the label as some residual chemicals have plant back restrictions for the following crops.

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

Loss of plants by birds attack

Check crop for leaf and plant damage by insects at least twice a week during the first 6 weeks after emergence. The most dangerous pests to look for are 'cutworms' which can be recognised by the irregular damage on the leaves and also emerging seedlings dying when they are cut off below ground level. In practice, however, the incidence of cutworms is very likely to decrease over time under complementary forage rotations (CFR), as the adult moth prefers to put her eggs on pastures and weeds during the winter.

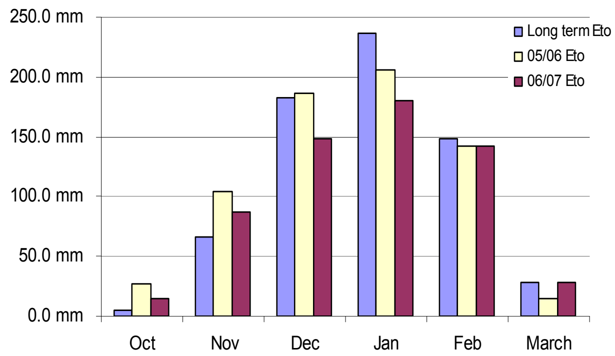
Irrigation

- Requirements
- Critical period

Requirements

Maize has a high requirement for water due to its high yields (grain and total plant dry matter). Because of these high yields it is one of the most efficient users of water per kg dry matter produced. It would require between 5 -7 megalitres (ML) (or approximately 550 - 650mm of water) depending on seasonal conditions, to grow a high yielding crop. The irrigation system must be able to put out approximately 25mm/week, and the soil profile kept at, or near, field capacity.

In the MID, 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 for 2005/6 and 2006/7 in relation to the long-term average Eto can be substantial:



Although not the ideal system, high maize yields can be achieved using traveller-type irrigation

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

Maize plants showing severe water stress and possibly also K defficiency

An example of irrigation schedule

The table below indicates the frequency of irrigation required in each month and amount of water applied for maize grown in the MID. For example, you would need to irrigate every 4 days in January if only 25 mm were applied at each irrigation, or every 8 days if 50 mm were applied. It is based on long term Eto and assumes no rainfall. It is a guide only and, ideally, in-field moisture monitoring would be used to aid in irrigation decisions, but if this is not available, the following guide combined with regular checks on actual Eto and rainfall (ie: to offset irrigation) will 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.

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

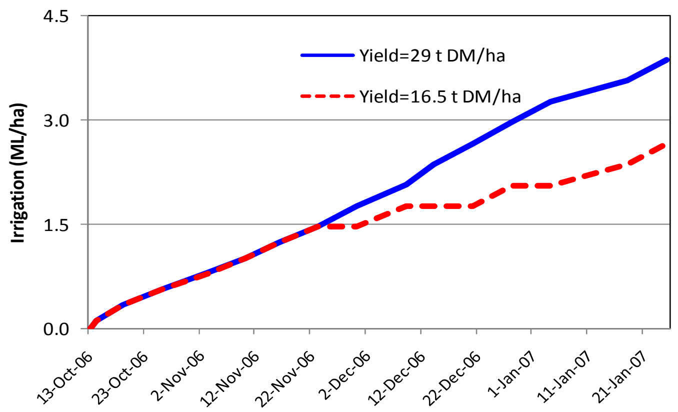
Critical period

The maize crop uses the majority (70%) of its water requirement 3 weeks either side of tasselling (see plant stages of maize below). Therefore if irrigation is limited, it is absolutely crucial to irrigate during the critical period, **from about 2-3 weeks before tasselling until 2-4 weeks after tasselling.**

Our experience during the 2006-2007 severe summer drought at Camden can help to exemplify this.

A decision was made to 'sacrifice' one out of 4 maize crop paddocks to enable adequate irrigation of the other 3 paddocks. The line graph shows the cumulative irrigation in ML/ha for the paddock with less than optimum irrigation (red broken line) and the nearest well irrigated paddock (blue solid line).

Cumulative irrigation (ML/ha) in 2 maize crop paddocks at Camden and total forage yield (t DM/ha). Paddocks were irrigated with adequate (solid line) or less than adequate (broken line) amount of water.



Both paddocks received ~1.5 ML/ha of irrigation water since sowed in mid October until early December but the 'dropped' paddock received 1.2 ML/ha less (4 irrigations of 30 mm each) than the well irrigated paddock from early December until the irrigation was stopped in late January. Although not conclusively because it was only one paddock will less irrigation, total forage yield dropped from 29 t DM/ha in the well irrigated paddock to 16.5 t DM/ha in the paddock with less than optimum irrigation.

Fertilisation

- Nutritional requirements
- Fertiliser timing

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 have an impact on fertiliser requirements for maize crops. Soil tests should be done prior to planting and should be used in conjunction with the target yield to determine optimal fertilizer application. For example, a maize silage crop yield of 25 tDM/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 kg of nutrient per tonne of crop grown:

- 10-12 kg Nitrogen/ t DM grown
- 8-10 kg Potassium/ t DM grown
- 2-3 kg Phosphorus/ t DM grown

A healthy crop with no nutrient deficiencies, water stress or weed problems that will maximise sunshine interception at an early stage. A vigorous and even crop is critical to ensuring high yields.

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

- 200 kg Nitrogen/ha
- 160 kg Potassium/ha
- 40 kg Phosphorus/ha

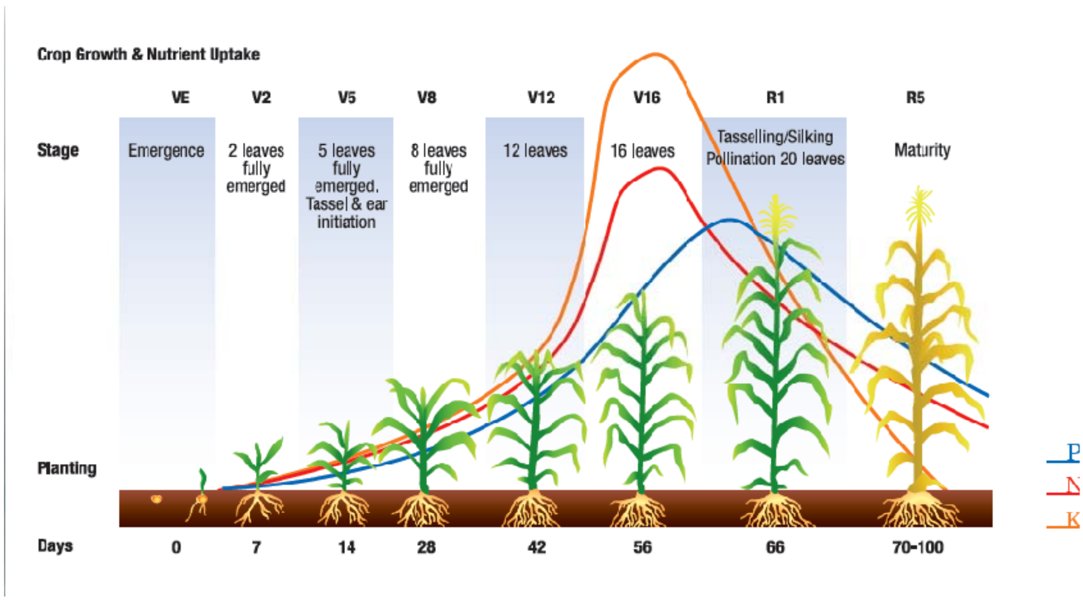
Fertiliser can be applied by several different methods i.e. banding at sowing, side dressings and fertigation. Most precision planters can also apply starter fertiliser, which is placed in a band below the seed.

Fertiliser timing

The maize plant utilises nutrients throughout its growing cycle with the greatest requirement when the plant is growing most rapidly, from about 45 cm high to grain fill (see diagram below). To supply the crop requirements, it is best to apply at 4 stages and to check nutrient adequacy with plant tissue tests.

Crop growth and nutrient uptake. Diagram courtesy of Snowy river seeds: www.hsrseeds.com.au

Urea should be applied at this stage unless fertigation is available



1. Preplanting – bulk spreading of fertiliser prior to the last cultivation. This may be lime if required as well as 2/3 of the fertiliser planned for sowing. This will have the nutrients in the soil profile ready for the crop
2. Planting – apply the remaining 1/3 of fertiliser under and to the side of the seed at sowing. This should supply all of the P and some of the N requirements of the crop.
3. Side dressing at approximately 45 cm high (V6). At this stage the plant is growing very rapidly and requires high amounts of N and K.
4. Side dressing at tassel emergence (V12) the final application of N and K. This application will need to be delivered via fertigation. If fertigation is not possible, fertiliser needs to be applied at 1-3 above.

It is important to note that, although side dressing and/or fertigation are the preferable options to apply fertilisers, broadcast with simple spreader-type machinery remains the most common and practical way for farmers. FutureDairy results at Camden (>26 t DM/ha for 3 consecutive years) indicate that high yields can be achieved without side-dressing or fertigation.

Maize crop near V6 stage. Urea should be applied at this stage unless fertigation is available

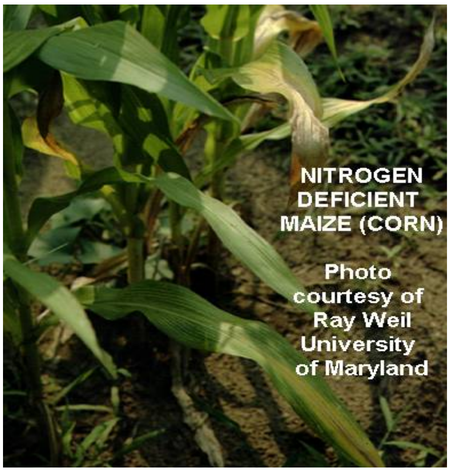
Nitrogen

Nitrogen is the elemet which stimulates and speeds growth. The demand for nitrogen increases dramatically from 4 weeks after seedling emergence (V6 – see photo below). Prior to this, the plant takes up only ≤ 10 % of its total nitrogen requirement. Between V8 and the end of silking (R1), it will take up 78% of its requirements.

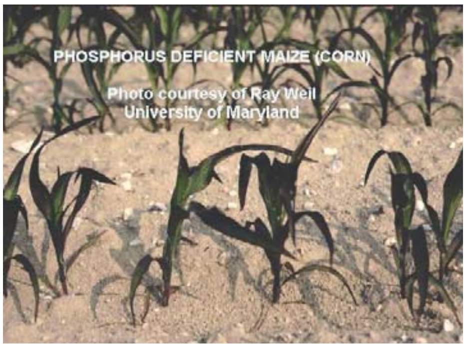
V6 stage is the recommended time to apply nitrogen unless fertigation is available. The simplest form is to broadcast the nitrogen as urea. Up to ~300 kg/ha urea (135 kg nitrogen) can be applied at V6 providing the crop can be irrigated immediately after to reduce burning of the leaves and nitrogen losses by volatilisation of ammonia nitrogen. At these high levels of urea, 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, by 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 manifests as yellowing of the leaf starting at the tip and extending along the mid rib in a V shape. Young maize which is short of nitrogen is a pale, greenish yellow, is small and has a spindly stalk.



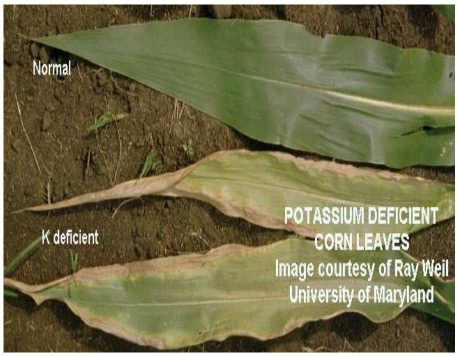
Phosphorus



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

Phosphorus deficiency will show up before the plants are 65cm tall; it is characterised by slow stunted growth, plants which are a very dark green with reddish purple leaf tips and stems and margins which show a purplish discolouration. Phosphorus deficient plants mature slowly and silks emergence is also slow.

Potassium



Potassium is essential for vigorous growth; it is vital to the functioning of the plant for the production and movement of sugars and water within the plant. It is essential for flower and fruit production. Maize uses ≈ 75% of its total Potassium usage between the V8 and R1 plant stages.

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

Other nutrients

Zinc – maize is relatively intolerant to zinc deficiency. Zinc is necessary in the first 3 weeks after emergence and deficiency manifests with light parallel striping followed by a white band starting from just inside the leaf margin and extending in to the mid rib; 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 preplanting, or it can be applied to the crop as a foliar spray.

Sulphur – is a constituent of proteins and vitamins necessary for healthy plants. Deficiency results in interveinal chlorosis and stunting, which are most severe at seedling stage. Preplanting 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 preplanting 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, sometimes associated with dead round spots.

Harvest time

A practical guide for harvesting maize for silage is to look at the milk line. The milk line is a visual division between the yellowish color of the seed coat (bottom of the kernel) and the whitish color of the seed towards the tip of the kernel (see diagram). 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).

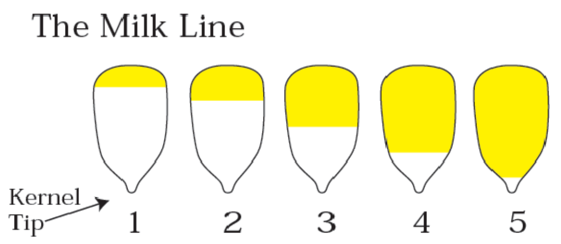


Diagram courtesy of Snowy River Seeds: *www.hrseeds.com.au*

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 DM content of the plant (cutting and chopping a few plants and dry them in an oven), but this is not practical on farm.

Harvesting a maize crop for silage

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

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

The whole plant should be green at harvest

Additional information

- The Victorian DPI www.dpi.vic.gov.au_ has a maize Agfact (Ag1244)
- Pioneer Seeds www.pioneer.com/australia_ has a range of tech notes and info on varieties
- Snowy River seeds www.hrseeds.com.au has a range of tech notes and info on varieties
- NSW DPI (www.dpi.nsw.gov.au) has several fact sheets relating to maize production and utilisation www.dpi.nsw.gov.au/agriculture
- The TopFodder website has resources with regards to making silage www.topfodder.com.au

Acknowledgements

- Amaizing Growers Workshop, printed by Pioneer Seeds (www.pioneer.com/australia)
- NSW DPI Agfact P3.3.3, 1992 (maize growing) ow a corn plant develops, Special Report No. 48, Iowa State University.
- Maize for Forage, Snowy River Seeds, Orbost, Vic.
- Snowy River Seeds Maize Technical Updates.
- Ray Wail (University of Maryland)
- The Potash and Phosphate Institute.