Growth Potential

Corn Growers' Workshop

PIONEER®
BRAND · SEEDS



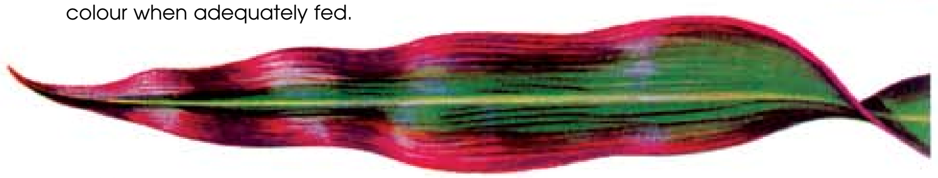

THE BEST CROPS START WITH THE BEST SEEDS

Guide to Nutrient Deficiency Symptoms

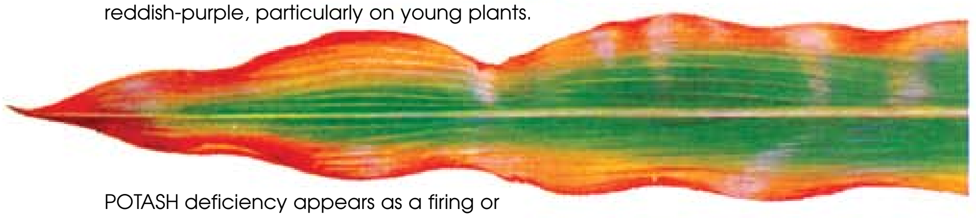
Part 1

(Part 2 located on inside back cover)

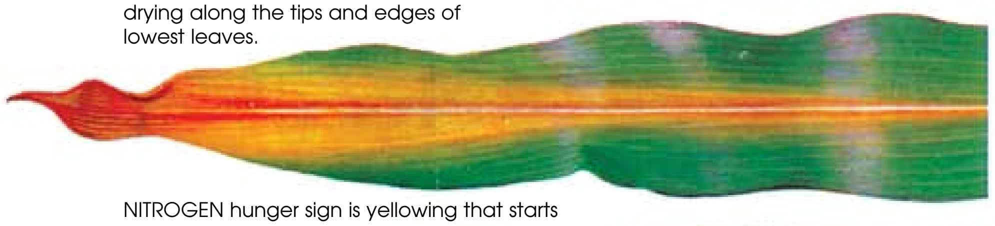
HEALTHY leaves shine with a rich dark green colour when adequately fed.



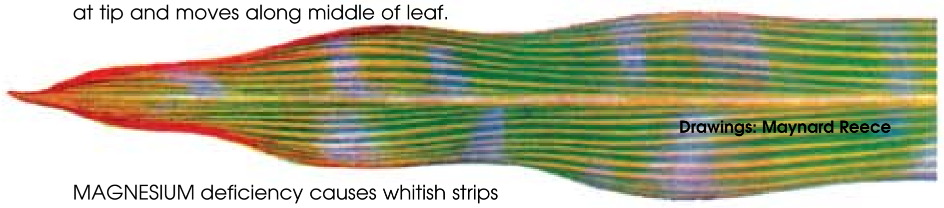
PHOSPHATE shortage marks leaves with reddish-purple, particularly on young plants.



POTASH deficiency appears as a firing or drying along the tips and edges of lowest leaves.



NITROGEN hunger sign is yellowing that starts at tip and moves along middle of leaf.



Drawings: Maynard Reece

MAGNESIUM deficiency causes whitish strips along the veins and often a purplish colour on the underside of the lower leaves.

DROUGHT causes the corn to have a greyish-green colour and the leaves roll up nearly to the size of a pencil.

DISEASE, helminthosporium blight, starts in small spots, gradually spreads across leaf.

CHEMICALS may sometimes burn tips, edges of leaves and at other contacts. Tissue dies, leaf becomes whitecap.

PIONEER®
BRAND · SEEDS

Contents

1. Introduction

This Corn Growers' Workshop aims to provide the essential information any farmer (including those new to corn as a crop) needs to know or understand to be a successful corn grower.

Meet the team of corn specialists that can help with your corn needs.

ROD BIDSTRUP
Dalby, QLD
Ph: (07) 4662 6191
Mob: 0408 717 430
Fax: (07) 4662 1061
Email: rod.bidstrup@pioneer.com

ROB CROTHERS
Toowoomba, QLD
Ph: (07) 4163 6170
Mob: 0408 646 111
Fax: (07) 4163 6089
Email: rob.crothers@pioneer.com

KELVIN SCHWARZ
Toowoomba, QLD
Ph: (07) 4637 2966
Mob: 0408 717 229
Fax: (07) 4637 2977
Email: kelvin.schwarz@pioneer.com

BRETT HANSEN
Biloela, QLD
Ph: (07) 4992 6701
Mob: 0417 713 023
Fax: (07) 4992 6702
Email: brett.hansen@pioneer.com

RICHARD FRASER
Warwick, QLD
Mob: 0427 696 484
Email: Richard.Fraser@pioneer.com

ALEX FORD
Geelong , VIC
Ph: (03) 5243 5277
Mob: 0428 886 727
Fax: (03) 5243 0543
Email: alex.ford@pioneer.com

SAM GALL
Moree, NSW
Ph: (02) 6752 6893
Mob: 0428 729 867
Fax: (02) 6752 6893
Email: sam.gall@pioneer.com

DAVID BURCHAM
Griffith, NSW
Ph: (02) 6929 1166
Mob: 0427 748 348
Fax: (02) 6929 1177
Email: david.burcham@pioneer.com

JOHN DE LYALL
Dubbo, NSW
Ph: (02) 6884 8430
Mob: 0429 061 918
Fax: (02) 6884 8450
Email: john.delyall@pioneer.com

PAUL JENKE
Adelaide, SA
Ph: (08) 8536 4712
Mob: 0408 807 809
Fax: (08) 8536 2546
Email: paul.jenke@pioneer.com

DAVID CODDINGTON
Narrandera
Ph: (02) 6959 1706
Mobile: 0429 995 381
Email: david.coddington@pioneer.com

SIMON NIHILL
Bendigo, VIC
Ph: (03) 5444 1197
Mob: 0427 342 188
Fax: (03) 5444 0355
Email: simon.nihill@pioneer.com

Due to rapid advances in plant breeding technology, plant protection and management expertise over the past decade, there have been significant increases in the yield potential and stress tolerance of corn. For many farmers producing corn as a grain crop or for silage production, the potential exists to increase profits. There are many important factors which will contribute to this. For irrigation farmers, we could also add water management.

The yield potential of corn will vary between districts and farms because of water availability, altitude, sunlight, soil structure and soil fertility. Yield potential will also vary between seasons at the same site depending basically on the season (e.g. heat wave, drought) as well as choice of hybrid, sowing time and other associated management decisions (e.g. type and quantity of fertiliser applied and its timing).

However, good management is a key to economic crop production. Good farmers achieve high corn yields by making sure the plant has access to sufficient plant nutrients and in the right proportions during the whole growing season.

A balanced fertility program is therefore a major step towards obtaining higher yields.

Well-fertilised crops can also have other benefits to the growing plant.

Irrigation experiments in USA have shown that a well fertilised corn crop was 43 percent more efficient in using water than a non-fertilised crop.

2. What is a profitable crop

Many growers assume that the highest yielding crops are also the most profitable. There is a feeling that increasing inputs such as fertiliser and water will automatically lead to bigger yields, and hence more profit per hectare.

Unfortunately, increasing inputs to maximum levels does not always lead to bigger yields and a better profit margin. The highest yielding competition winning crop may attract a lot of interest but it may not be as profitable as a lower yielding crop that is well managed.

The most profitable corn crop is obtained by optimising (rather than maximising) the key inputs such as seed, fertiliser and water, and the timing of these inputs as shown in Figure 1.

Many farmers underestimate the effect of yield on profit, equating a 10 percent increase in yield with a 10 percent increase in profit. The real increase in profit may be 50 percent or even 100 percent. This is because many costs, such as cultivation, planting, spraying etc remain the same for all yield levels.

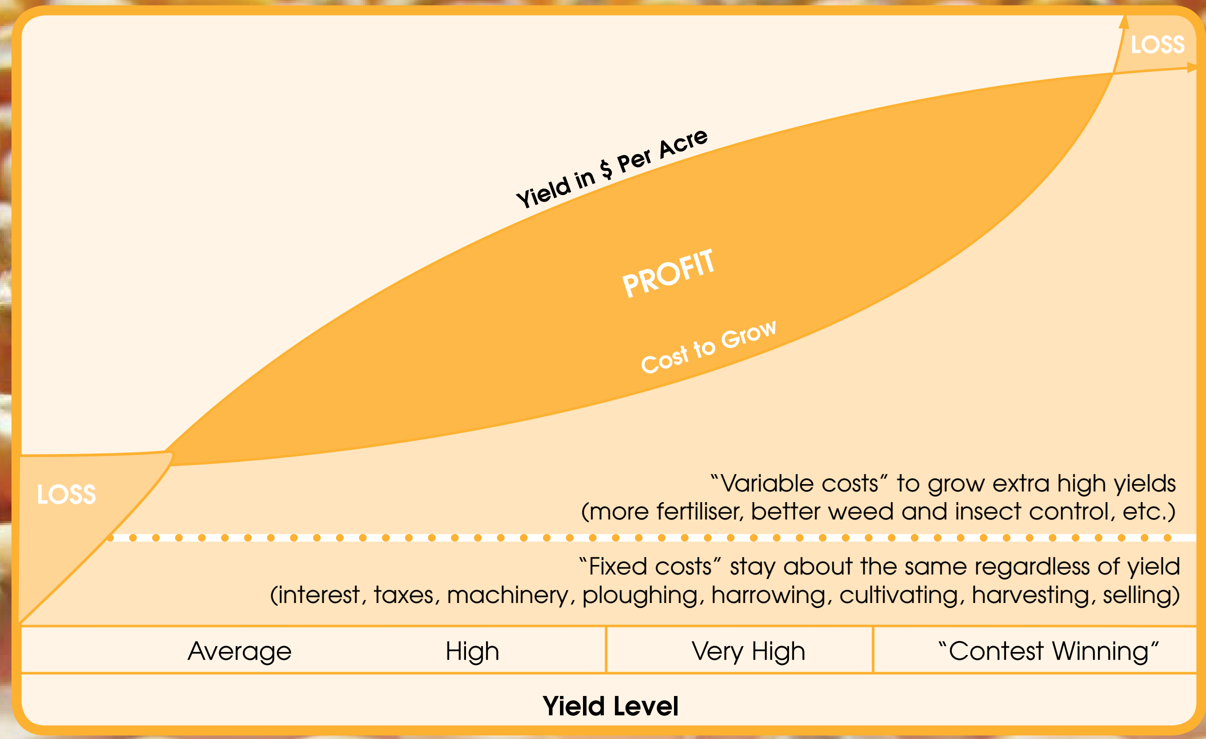


Figure 1.

Unless you overspend on the variable costs such as fertiliser, water, herbicides etc, yield will rise faster then cost giving you both more corn to sell and a greater profit margin per tonne of corn.

The critical factor is to know whether increasing your corn yield (by increasing your inputs) will give an improvement in your profit margin.

Important steps towards a profitable corn crop are:

* Determining the market you intend to supply
* Understanding the requirements of the crop
* Setting a yield goal for each field
* Planting suitable hybrids at the correct plant populations
* Providing adequate fertiliser and water at the critical growing stages
* Only growing an area you can manage

The following sections address each of these aspects of growing a profitable corn crop.

3. How the corn plant grows

A broad understanding of the growth of a corn plant will allow us to look at when the critical growth stages occur and the nutritional and water requirements at those times.

Too often farmers spend a considerable amount of money on fertiliser, cultivation and watering their crop only to end up with an average yield. They have effectively used the optimum level of inputs but have not achieved the optimum high yield - usually because of poor timing of inputs or poor crop management.

This is usually due to a lack of knowledge (or clear understanding) of the growth habits and requirements of a corn crop. Understanding a corn plant's development and its critical growth stages is essential if you are to achieve high yields and obtain maximum profitability.

The development of a corn plant and its requirements are shown in Figure 2 (on page 6).

All corn plants follow the same general pattern of development, but differences in the time various growth stages take depends primarily on the hybrids maturity (given similar conditions). The times, heights and comments indicated in Figure 2 are for a hybrid with a Comparative Relative Maturity (CRM) of approximately 120 days.

Week 0: germination and seedling establishment

This is the first critical stage in the life of the corn plant.

If the soil is too wet, too cold or too dry, germination may be slow or the young seedling may die before establishment.

As the roots begin to take over the job of nourishing the plant, shortages of major elements can seriously slow growth and development.

However many of the troubles which can occur at this stage (including frost) need not have a permanent effect on growth or yield. The young plant is flexible in its requirements and has a high capacity to recover from early setbacks.

Weeks 1-3: vegetative development

This stage creates the root system and leaf structure which will be used later to support the ear and grain formation.

All the leaves the plant will ever have are formed during the first 3 weeks of growth.

They are formed by a single growing point which is actually below the surface of the ground.

If the soil is too wet, too cold or too dry, germination may be slow or the young seedling may die before establishment. Corn plants are susceptible to damage by flooding, especially if temperatures are high.

Although good growth is desirable, this vegetative stage is not as critical in determining yield as earlier or later stages. The corn plant will recover from injury in this stage if later conditions are favourable and use good agronomy practices to assist in that recovery e.g. foliar fertiliser application, inter-row cultivation etc.

Weeks 4-5: tassel and ear initiation

Approximately 30 days after planting (when the corn plant is about knee high) a dramatic change takes place in the function of the growing point.

The growing point is at the soil surface, and having formed all the leaves, develops into an embryonic tassel.

Weeks 5-8: vegetative growth

This stage (including the following flowering stage) is the most critical period in the development of the corn plant.

The plant has a high requirement for nutrients, water and the products of metabolism. Any shortages of nutrient, (especially nitrogen) or water, insect damage or overcrowding will have a serious effect on yield.

Any damage to the pollen or ear structures at this time will be permanent and has little chance of being overcome later.

During this stage the lower internodes elongate rapidly, and the plant undergoes extremely rapid vertical growth.

The roots also grow rapidly and soon fill most of the root zone.

Although ears begin to form shortly after tassel initiation, ear size is determined over a three week period in weeks 6-8.

The numbers of rows per ear are determined first, then kernels per row.

Water or nutrient deficiency at this time will greatly reduce grain yield.

Weeks 9-10: flowering

Having developed the plant structure, the maize plant then directs most of its energy and nutrient towards producing kernels on an ear. This is a critical growth stage because of the heavy demand for water and nutrient (especially nitrogen) caused by the tremendous physiological activity of the flowering plant. These requirements are complicated by the fact that flowering usually occurs in the middle of summer during hot weather.

A shortage of pollen is rarely a problem and a poor seed set is usually the result of nutrient or water shortages that either delay silking or result in kernels aborting after pollination.

"If the soil is too wet, too cold or too dry, germination may be slow or the young seedling may die before establishment."

Weeks 11-18: grain development and maturity

The numbers of ears and kernels have previously been set.

But adverse conditions such as moisture stress will reduce kernel fill.

Exceptionally favourable conditions of moisture and fertility will result in better than usual kernel fill and hence a better grain yield than expected.

This stage chiefly determines kernel size.

Approximately 50-70 days after pollination the corn kernel has reached the greatest dry weight it will have and can be considered physiologically mature.

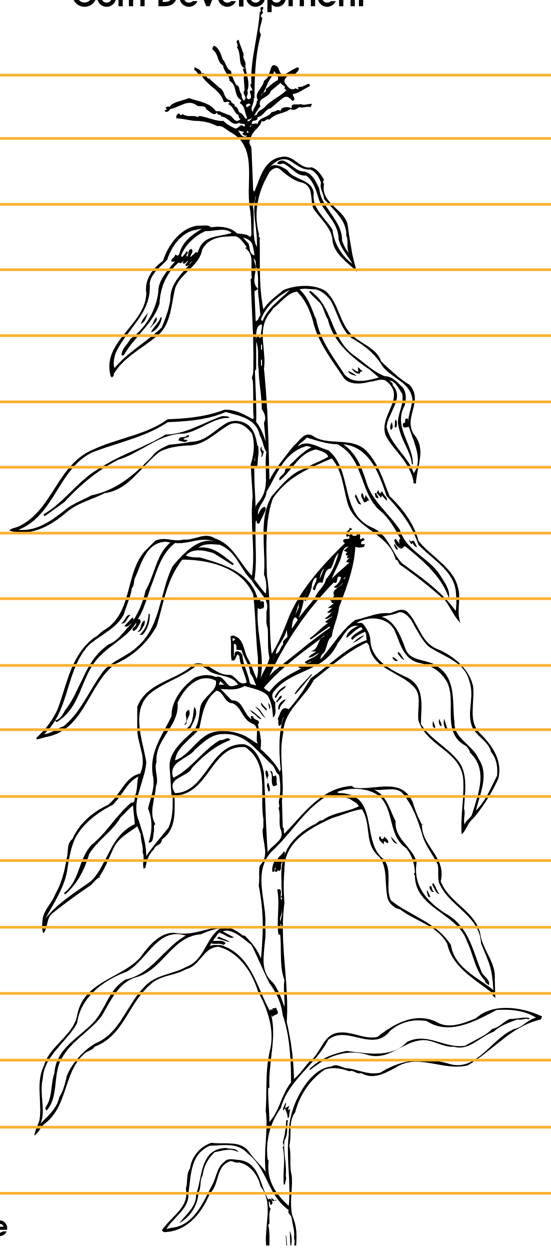
Physiological maturity can be easily determined by the appearance of a 'black layer' at the tip of the grain.

This analysis of the development of the corn plant is obviously very brief, however it does highlight the critical growth stages when a shortage of inputs will have serious effects on the final yield of the crop. This information should be used to develop a crop strategy that will yield a good profit margin based on your environment, financial and farm circumstances, and goals.

It should also be used to analyse the levels of and strategies involved with three of the key inputs in a successful/ profitable corn crop, namely seed, fertiliser and water.

4. Nutrient requirements of corn

Corn Development	Weekly Requirements (as percentage of total need)			
Maturity	% N	% P	% K	% Water
17 weeks	less than 1	less than 1	-K	less than 1
16 weeks	less than 1	1	-K	1
15 weeks	less than 1	2	-K	2
14 weeks	less than 1	5	-K	3
13 weeks	2	8	--	5
12 weeks	4	**9**	--	6
11 weeks	6	**11**	1	**8**
10 weeks	**10**	**13**	5	**11**
Silking	**12**	**15**	8	**12**
Tasseling	**16**	**11**	**16**	**12**
7 weeks	**15**	**10**	**20**	**11**
6 weeks	**14**	7	**21**	**10**
5 weeks	**11**	4	**16**	**7**
4 weeks	7	2	9	5
3 weeks	2	1	3	4
2 weeks	less than 1	less than 1	1	2
1 week	less than 1	less than 1	less than 1	1
Emergence	less than 1	less than 1	less than 1	less than 1



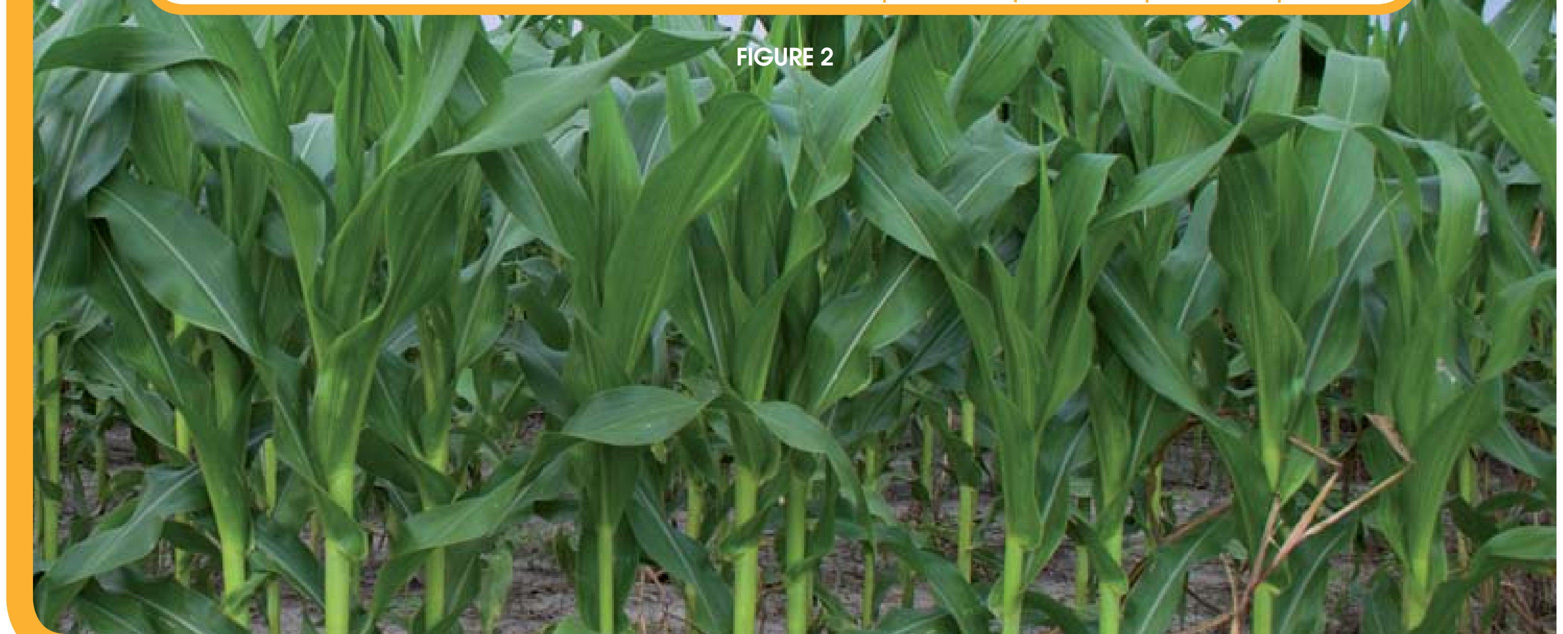


FIGURE 2

Of all the essential nutrients derived from the soil, N, P and K (the primary nutrients) represent 83 percent of the total absorbed. Calcium (Ca), magnesium (Mg) and sulphur (S) are the secondary nutrients and represent another 16 percent leaving only 1 percent for the micronutrients.

The amounts of the micronutrients (boron, chlorine, copper, iron, manganese, molybdenum and zinc) required are very small but are still important to achieving maximum yield and should only be applied when necessary.

Certain soil conditions are more likely to have problems than others e.g. zinc deficiency on high pH soils. Of the secondary nutrients magnesium and sulphur are the most likely to be a problem, and then most likely only on low pH and/or sandy soils.

Once a yield goal has been set, then a fertiliser program can be worked out to provide the necessary nutrients. The yield goal should be set so that it falls in the upper ranges of what is believed attainable, and then calculate what amounts of fertiliser to apply to reach that goal. Figure 3 shows the amounts of N, P, K, S and Mg removed by a corn crop depending on yield and whether the crop is for grain alone or for silage. A crop of 5.5t grain/ha (40t green chop/ha) would be a yield that could be obtained under reasonable dryland conditions. A crop of 11t of grain/ha (65t green crop/ha) would be an achievable yield under irrigated cropping conditions.

The Australian record for a corn crop for grain is 21.5 t/ha and the genetic potential is believed to be around 36 t/ha.

Corn: Grain and Silage		Kilograms per hectare N	P	K	S	Mg
5.5 t/ha grain	Grain	121	19	24	9	11
40 t/ha green chop	Stover	44	7	97	11	20
(12.8t dm/ha)	**Total**	**165**	**26**	**121**	**20**	**31**
7 t/ha grain	Grain	136	24	30	11	13
50 t/ha green chop	Stover	54	10	120	13	25
(16t dm/ha)	**Total**	**190**	**34**	**150**	**24**	**38**
8.5 t/ha grain	Grain	151	28	36	13	15
58 t/ha green chop	Stover	64	12	143	15	30
(18.5t dm/ha)	**Total**	**215**	**40**	**179**	**28**	**45**
10 t/ha grain	Grain	176	32	41	15	17
65 t/ha green chop	Stover	74	14	167	17	35
(20.8t dm/ha)	**Total**	**240**	**46**	**208**	**32**	**52**
11 t/ha grain	Grain	190	35	45	16	18
70 t/ha green chop	Stover	80	15	180	18	35
(22.4t dm/ha)	**Total**	**270**	**50**	**225**	**34**	**56**

It should be noted that these figures are not absolute values. There can be variations up to 10 percent depending on conditions. Of special note is that silage removes more nutrients than grain alone, especially potassium.

FIGURE 3 : Plant nutrients taken up by a corn crop

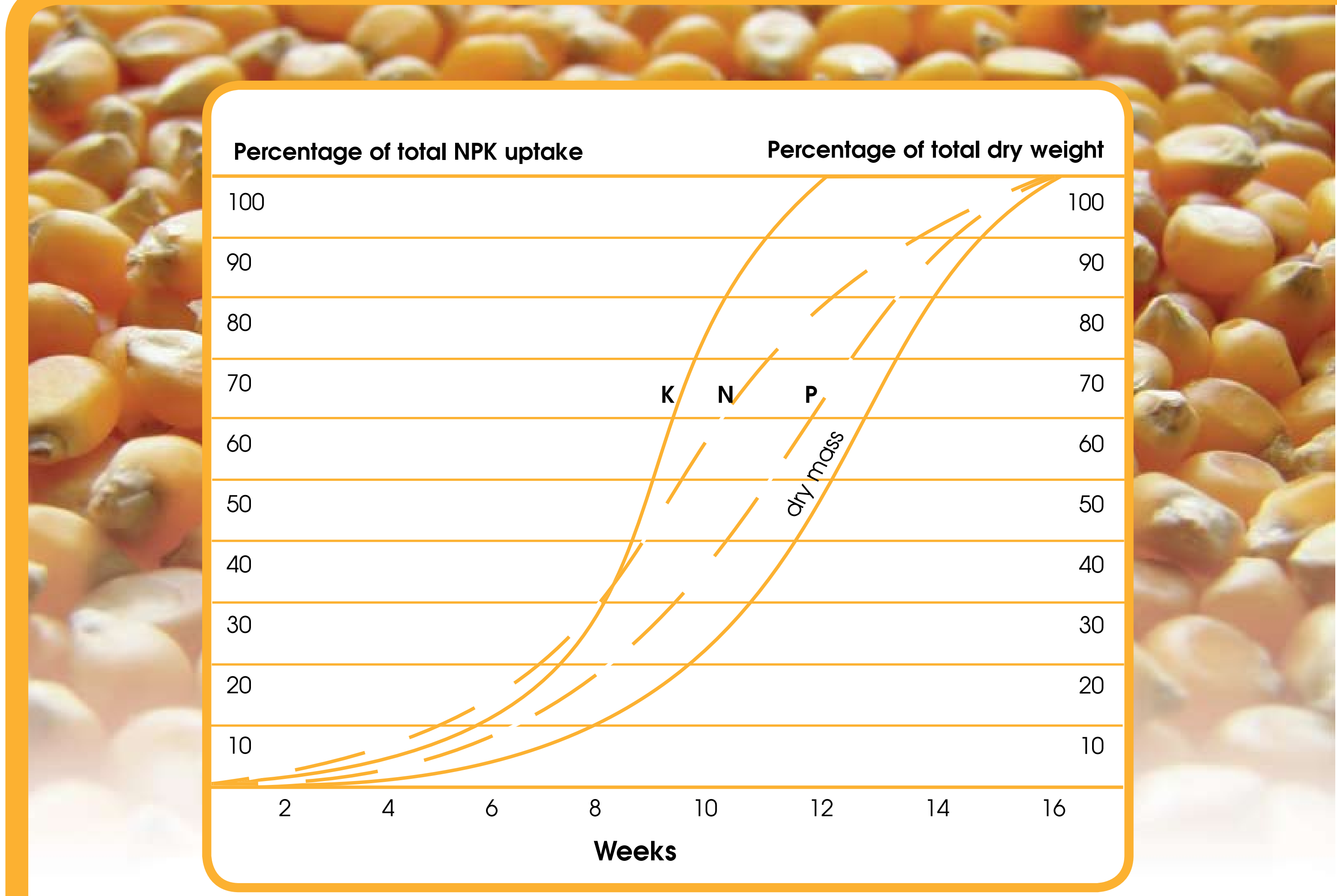


FIGURE 4

While figure 3 showed the total quantity of major nutrients required, the above figure 4 indicates the periods and rates of uptake for N, P and K. By using the two tables in conjunction a calculation of the fertiliser quantities required by the corn crop at each stage of growth can be determined.

4a. The soil - our bank balance

The fertility of a soil is a combination of its physical characteristics (structure, texture, stability, density, organic matter content) and its nutrient status (amount of nitrogen, phosphorus, potassium and other essential nutrients which are readily available to the crop). To grow a profitable crop we should aim for the best combination of both.

The cultural practices employed in the growing of a crop (e.g. no till versus conventional farming) will have the greatest effect on a soil's physical structure. But that is beyond the scope of this paper. Suffice to say however, that the greater the volume of soil the root system can explore, the greater the yield potential will be.

Growers with hard setting soils should implement practices such as deep ripping to break hard pans and permanent beds or zero-till to improve moisture infiltration to the root zone of the crop. Inter-row cultivation can also be used to improve crop growth and water infiltration as well as control weeds.

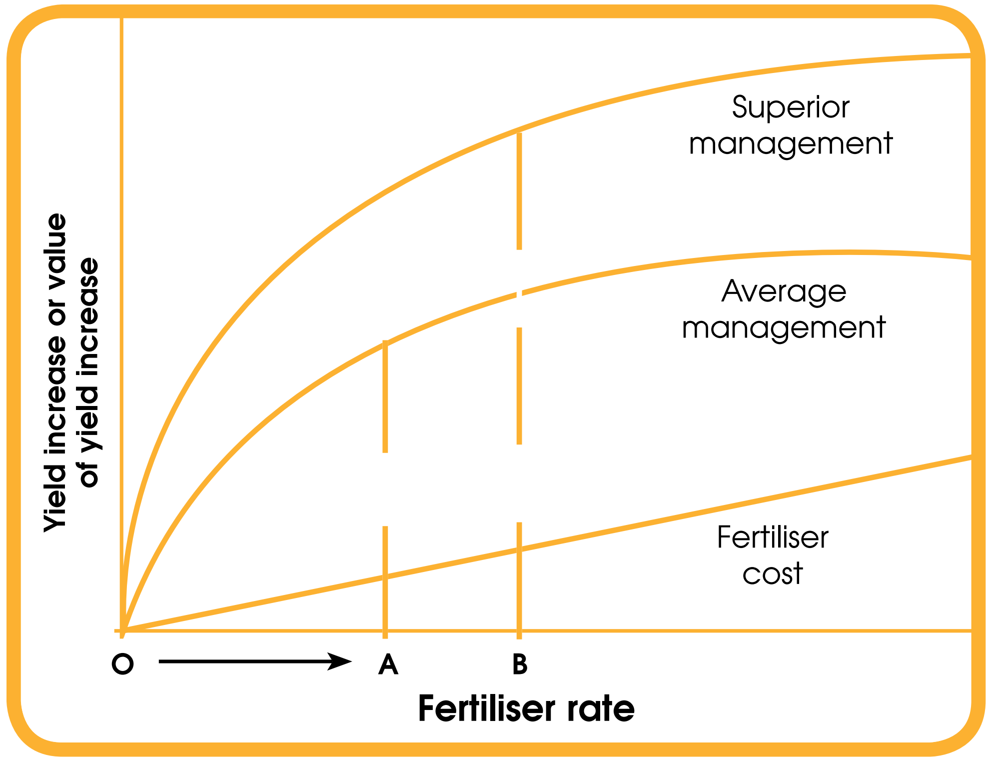


FIGURE 5

Except for some carbon, hydrogen and oxygen derived from the air, the soil is the sole supplier of the plant's nutrient and water requirements (except where foliar fertilisation is used for a specific purpose).

Figure 5: With superior management, higher rates or fertiliser can be profitably used than with average management. With average management rate A is optimal, with superior management rate B is optimal. (From Strizel, 1963).

The soil holds plant nutrients in many forms. Some are readily available to the plant while others have to be changed from an inorganic form to an organic form the plant can use. It is important to note that while the crop nutrient requirements are minimal in the first 6 weeks of growth, the majority of fertiliser should be applied at or prior to planting.

Different soil types hold different amounts of nutrients and water for the plant to use. Sandy soils are usually low in fertility (low organic matter and leach readily) and need small doses of fertiliser and water often (unfortunately this is not always practicable). Clay soils on the other hand are inherently more fertile and hold more water due to the higher level or organic matter in the profile and their greater cation exchange capacity (a result of their clay content).

Not all soils have nutrients in a form available to the plant - some soils have a high fixing capacity (e.g. phosphorus in highly calcareous soils or high pH soils).

The nutrients in the soil can be likened to a savings account. The amount of nutrient available to the plant is like the interest available from a savings account. The larger the nutrient level in the soil (savings account) the larger the amount available to the plant (interest).

Another influence on the availability of nutrients is the soil's pH. Figure 6 shows the changes in plant nutrient availability with changes in the soil pH. The width of the horizontal bar indicates the relative availability of each nutrient. Optimum pH for corn is between pH 6.0 and pH 7.0. Lime will make soils more alkaline and increase the availability of some nutrients when applied to acid soils.

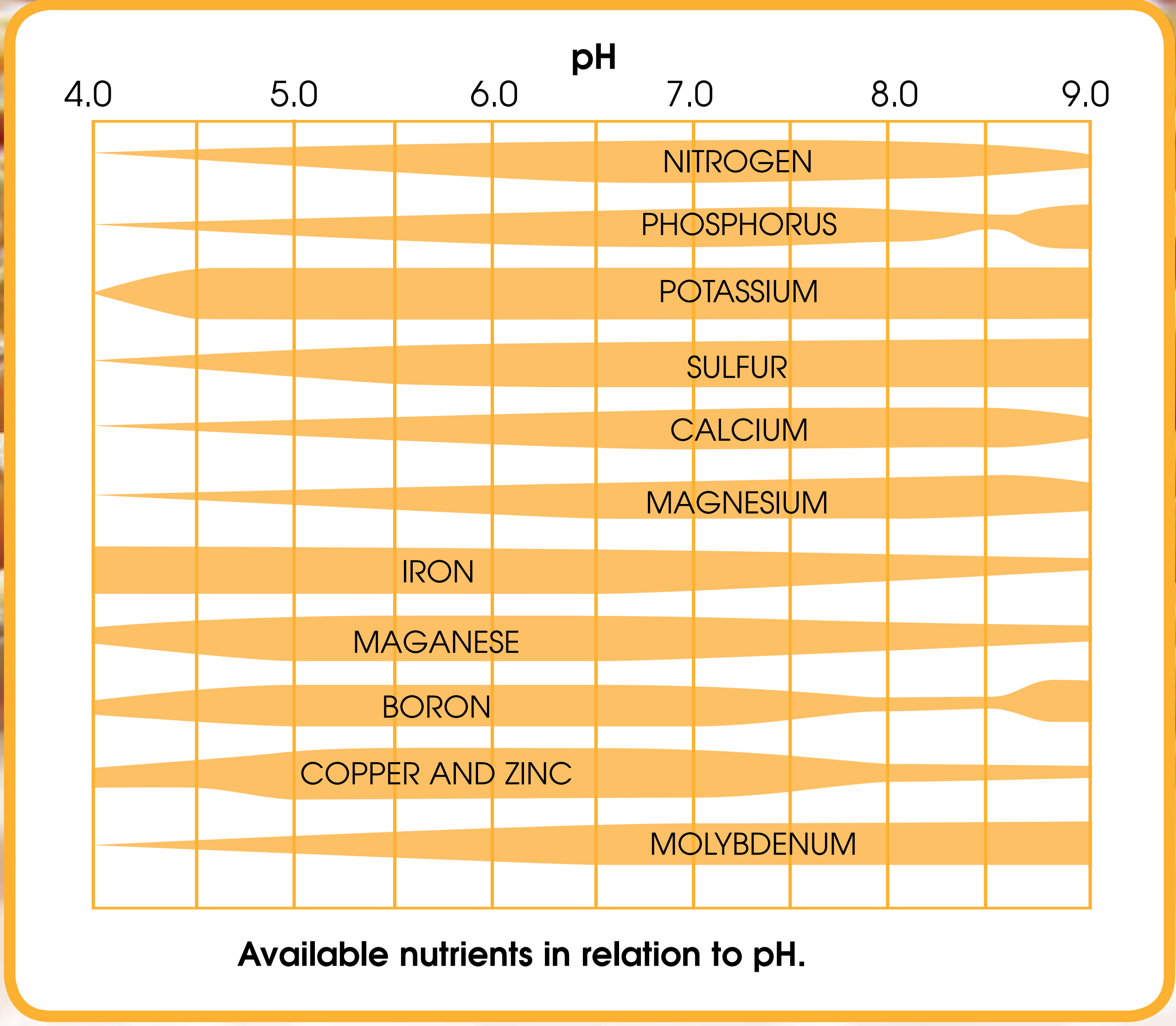


FIGURE 6: Variability of plant nutrients to soil pH

Soil testing and plant tissue analysis are useful tools to help with fertiliser decision making. The results of these tests cannot tell precisely how much fertiliser is required to be applied. They do give an indication of the nutrient levels present and whether the levels are high, medium or low. From this, and experience, an indication of how much fertiliser to apply can be determined.

If the soil is sampled every year or two, the soil's nutrient status and pH can be monitored and an assessment made about whether the levels are rising, falling, or being maintained. The effectiveness of the fertiliser programs can then be assessed by analysing crop yields and the residual effect on soil fertility.

Plant tissue testing is probably a more reliable indicator of the plants need for micronutrients (or trace elements). While this analysis often comes too late to prevent deficiencies, it can be useful for overcoming deficiencies and modifying the fertiliser programs for following crops.

This introduces the concept of maintenance fertilisation. This concept aims to keep the soil at a constant level of fertility by replacing what has been taken out by each crop. In practice however, this applies mainly to the major nutrients of nitrogen, phosphorus and potassium. A deficiency of a micro nutrient can have just as damaging effect on yield as a macro nutrient even though they are only required in small quantities (e.g. zinc).

If a soil's fertility has been allowed to run down it may take several years of high applications of fertiliser (at high cost) to overcome the soil fixing capacity and rebuild the fertility to its original level. Maintenance fertilisation helps to overcome this problem and keep the soil's fertility at a stable level.

4b. Nitrogen (N)

Nitrogen is an essential factor required for producing good yields.

Rates of applied N are very much dependent on the yield potential of a particular soil situation.

A soil test can give a useful guide to available nitrogen for the crop. The nitrogen fertiliser then needed may be pre-applied and/or applied at planting, with side-dressing to fill the total requirements.

Post-emergence applications are useful for irrigated crops or where heavy rain falls after emergence. If the total amount of fertiliser to be applied is side-dressed and application is delayed beyond the first four weeks after sowing, some yield potential may be lost. (Refer to Figure 2.)

Nitrogen is very mobile in the soil and losses through leaching can be substantial. Denitrification losses can also be substantial in wet soils. The techniques of split nitrogen application and/or water run nitrogen can be used to great advantage under these conditions.

There are two other points to consider when determining nitrogen application rates. Firstly the efficiency of uptake of fertiliser-N is often only of the order of 50 percent. Secondly organic (soil) N is approximately 15-20 percent more effective than applied fertiliser N for crop growth. This latter point has important management implications with regards to crop rotations and residual N in the soil.

An 11 t/ha grain chop (70 t/ha green chop) will only take up 35 percent - 95 kg - of its total nitrogen requirement during the first six weeks after emergence. Then the next four weeks (prior to and during silking) will see 53 percent of the total N requirements (145 kg) taken up.

Uptake peaks at 4 kg of N/ha/day, placing huge demands on fertiliser availability and grower management.

Nitrogen deficiencies show in several ways. When young corn is short of nitrogen, the whole plant is pale yellowish green, small, and has spindly stalks. Later, beginning with the bottom leaves, the typical V-shaped yellowing from the tips of the leaves shows. The greater the deficiency the greater the number of bottom leaves affected. Small cobs, often with bare tips, result when nitrogen deficiencies occur during silking and grainfill. Refer symptom pages (see inside cover).

4c. Phosphorous (P)

Soil analysis results are useful when developing a phosphorus fertiliser program. In some soils, phosphorus can react with other soil components and become unavailable to plants. In these soils, when applying the P fertiliser, band application is generally the preferred method (5 cm below and to the side of the seed). This reduces the P fixation and improves the recovery efficiency of the P fertiliser. Recovery is typically seldom more than 15-20 percent of that applied, even under good conditions.

P is vital in early root and seedling development. For normal growth the young plants need a higher percentage of P in their tissues than they will later in the season. Also, P is not mobile (the opposite of N) and does not leach out of soils. This allows all the P to be applied prior to or at planting so that the roots may have access to the fertiliser.

Further, P uptake in plants can be restricted by poor root establishment (e.g. compaction, planting slot smearing) and cold wet conditions, which may occur with early plantings and can result in poor root vigour. Starter fertiliser will help in these situations.

If P deficiency is going to show it 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 margins and stems that can show a purple colouration. As the plant develops, plant maturity will be delayed and silks emerge slowly.

An 11t/ha grain crop (70 t/ha green chop) takes up about 30 percent - 15 kg - of its P requirements during the first 55 days. Peak uptake of 0.75 kg/Ha/day occurs during the 7-10 week period after emergence, with total uptake being about 50 kg. Refer symptom pages (inside cover).

4d. Potassium (K)

Corn requires large amounts of potassium in quantities similar (numerically) to that of nitrogen.

Potassium is essential for vigorous growth, yet never becomes a part of proteins and other organic compounds. It is vital to the structure and efficiency of the functioning of the com plant for the production and movement of sugars to the developing ears.

K does not leach to the same extent as N nor become tied up in unavailable or slowly available forms to the degree that P does. However, like P, it should not be in the surface layer which will regularly dry out and be unavailable to the growing plant.

K applications can be carried out at anytime during land preparation. Some forms of K fertilisers need to be applied well in advance of planting to be available to the growing crop.

An 11 t/ha grain crop (70 t/ha green chop) takes up over 50 percent -117 kg - of its K requirement of 225 kg in the first 55 days. The young seedling does not require much K but the rate of uptake climbs rapidly to a peak in the three weeks leading to tasselling. K uptake peaks at around 4 kg/ha/day during this period and by silking 75 percent of the total K has been taken up.

A deficiency of K shows as yellowing and dying of leaf margins beginning at the tips of the lower leaves. Symptoms appearing at an early stage mean that the total soil supply is low or that the root system is severely restricted - e.g. a compacted soil layer. Refer symptom pages (see inside cover).

4e. Secondary and micronutrients

Zinc (Zn)

Corn plants are rated as having moderate to high susceptibility to Zn deficiency.

Zn is necessary early in the plant's growth during the first three weeks. Responses to applied N and P may be affected if the level of available Zn is low. Soils with a high pH (over 7.0), eroded soils, or land formed soils, are most at risk of Zn deficiency.

As with other nutrients, yield losses can occur before visible symptoms occur. Typical symptoms are light parallel striping followed by a broad whitish band starting slightly in from the leaf edge and extending to the midrib. The leaf edges, midrib and tip of the leaf remain green.

Soil applications of Zn are expected to last several years with rates of 10-20 kg Zn/ha effective for four to five years. Depending on the form of Zn used, applications may need to be made well in advance of the crop.

Foliar applications during water logging periods early in the crop's development can be a useful management tool in helping the crop overcome associated stress.

Water injection and/or foliar (1 percent solution) applications of Zn generally use zinc sulphate heptahydrate or chelated zinc to overcome Zn deficiencies. Foliar applications generally need two sprays about 7-10 days apart, 2-3 weeks after emergence. Refer symptom pages (see inside cover).

Sulfur (S) and magnesium (Mg)

Sulphur originates from organic matter and is normally very mobile in the soil. Typical deficiency symptoms of interveinal chlorosis and stunting are usually most severe in the seedling stage. Using a starter fertiliser containing sulphur should correct any problems.

Magnesium deficiency is usually associated with strongly acid sandy soils in moderate to heavy rainfall areas where the Mg can be leached from the soil. Characteristic symptoms are yellow streaking of the lower leaves between the veins sometimes followed by dead round spots. The older leaves can become reddish purple. Broadcast applications of dolomite should be the most economical long-term treatment. Magnesium sulphate (Epsom salts) is used if a foliar spray is needed. Refer symptom pages (inside cover).

Other nutrients

It is unlikely any other nutrient deficiencies are likely to occur except under very special conditions or circumstances.

4f. Manure

Manure contains valuable nutrients and organic matter. The composition will vary with both the animal and the feeding regime. Micronutrient deficiencies are seldom found on fields that regularly receive applications of manure.

The nutrients contained in manure are not as efficient as chemical fertilisers in stimulating plant growth in the short term, but there is a residual effect which could last up to four years. This is due to the slow release of the nutrients.

As well as having a value in terms of nutrients, manure also acts as a soil improver. Organic matter improves soil structure, helps root penetration and reduces the degree of soil compaction, allowing soils to hold more available water.

Some figures from a Dalby feedlot showed the feedlot manure contained 2.17 percent N, 1.28 percent P and 2.61 percent K. Therefore one tonne of manure (dry matter) would contain 21.7 kg N; 12.8 kg P and 26.1 kg K but only a percentage of this is available in the first year (possibly 35 percent of the N, 60 percent of the P and 90 percent of the K) the rest becoming available in subsequent years. Variations in soil types, climatic conditions and manure used will greatly affect the immediate availability of these nutrients.

Therefore, as N is a critical nutrient for producing maximum yields, it would be recommended that the amount of N from manure is not calculated in the first growing year of application.

When considering using manure, have an analysis done, so that a cost can be put on the nutrients it contains. It can be more difficult to put a cost on the soil improving qualities of manure. Each situation must be taken on its own merits but the usage of manure has many and lasting benefits.

The theory of maintenance fertilisation has a lot of merit. Look upon the soil as a nutrient bank. The healthier it is, the healthier the crop will be and the higher the yields will be.

The likelihood of a response to fertiliser is reduced by any factor that reduces crop growth. Yield increases from the use of fertilisers depends primarily on:

- the potential yield
- the levels of soil nutrient
- soil moisture at planting
- the ability of the plant to take up nutrients
- and the availability of plant nutrients and soil moisture throughout the growth of the crop.

Consideration should be given to crop rotations that influence, amongst other factors, the amount of available soil nitrogen for succeeding crops. Soil nitrogen is more effective than fertiliser nitrogen for crop growth. Nitrogen will generally be (in dollars) the single most expensive fertiliser input in the production of a corn crop.

And finally just as good management is a key to economic crop production, good management is definitely a key to economic fertiliser usage.

5. Water management of corn

When is water needed?

The corn plant's development must not be restricted at any stage of growth if maximum yields are to be achieved. The relationship between a crop's growth and water need can best be shown by drawing the water requirement curve over the weight gain curve. This is done in Figure 7 and it is obvious that the water need increases rapidly from about two weeks prior to tassel and ear appearance until about two weeks after full silk and then decreases rapidly.

It should be noted that Figure 7 only compares water need and dry weight accumulation on a days after emergence basis. The fact that there is no scale on the vertical axis means that there is no comparison between the amount of water and the weight of the plant.

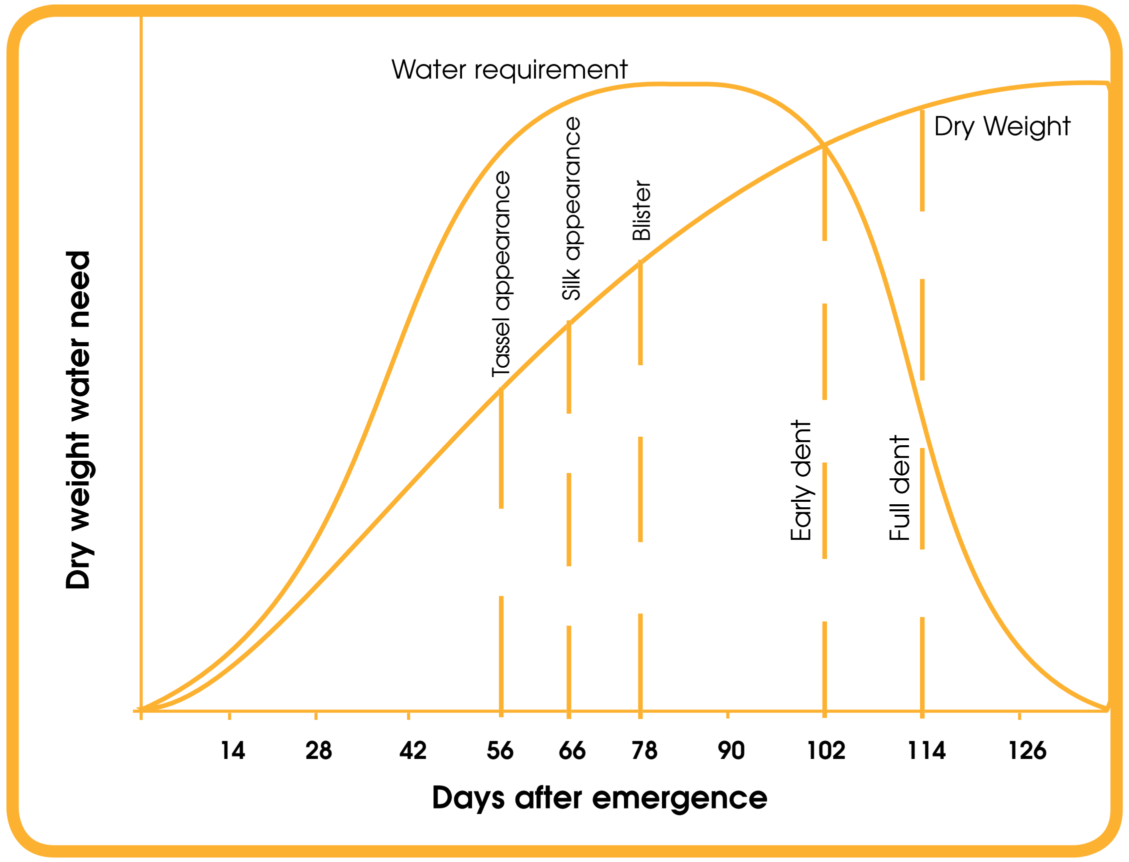


Figure 7: Water requirements of corn (dry weight gain)

An alternative way of indicating water requirement was shown in Figure 2 (refer previous section - how the corn plant develops).

This indicated water requirements each week as a percentage of total water needs, i.e.

- 20 percent in the first five weeks after emergence
- 33 percent in the next three weeks (the three weeks prior to silking)
- 31 percent during the next three weeks during silking and early grainfill

If an irrigated crop of corn in southern Australia uses nine megalitres of water per hectare in a normal season, up to six megalitres are required (and need to be applied) during the six week period from prior to tasselling to early grain fill.

The water available each day, or the rate at which that water can be applied to the crop, becomes very important if timeliness of irrigation is to match the crop requirements and not limit yield.

How much water is required?

Contrary to what is often said, corn is a relatively efficient user of water in terms of dry weight produced for water used. Corn requires approximately 370 kg of water to produce 1 kg of dry weight, compared with approximately 270 for sorghum, 500 for wheat, 560 for cotton, 630 for oats and 860 for lucerne.

However, because there is a lot of weight in a crop of corn, it has a high total water requirement.

If the selection of variety and plant population is adjusted to suit the total amount of water available, and if the water could be metered out in proportion to when it is most needed by the crop, we would have a water:grain yield relationship similar to that shown in Figure 8. Obviously a number of factors such as heat, humidity, wind etc., can influence the shape of this curve, but it is a useful guide on which to base yield goals in relation to the amount of water available.

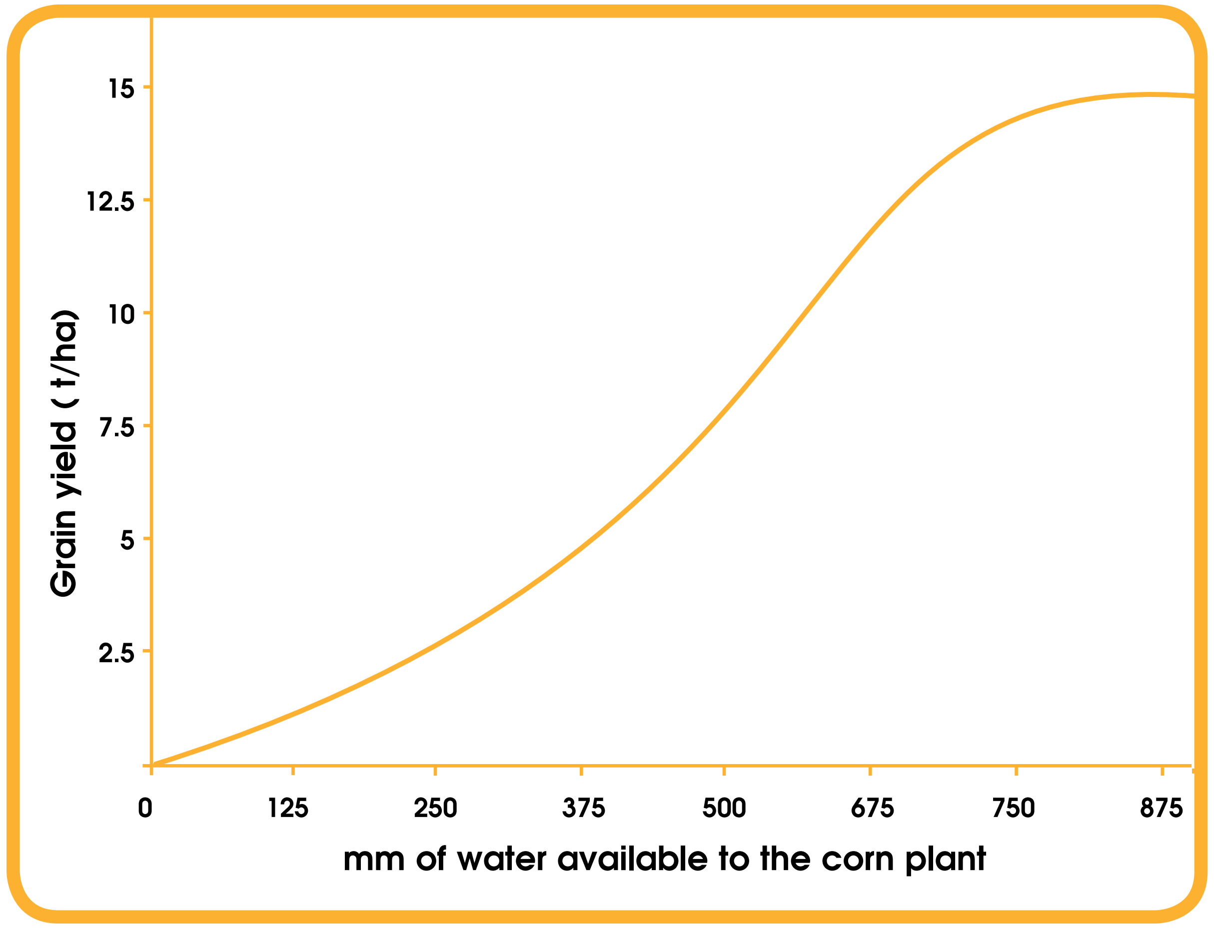


Figure 8 : The relationship between water availability and grain yield

Figure 8 shows that the efficiency of water use increased rapidly as more water was applied (provided population keeps pace) until the hybrid reaches its yield limit.

The soil's capacity to store moisture is a most important factor as it largely determines the amount and frequency of irrigations and is of paramount importance in deciding yield goals under dryland farming. Figure 9 gives the average water storage capacity of various soil types. Work on corn utilising 1.5 m of soil moisture if there are no physical restrictions.

Typical soil water storage capacity of various soil types	
Soil type	**Available water (mm/metre)**
Coarse sand	40
Fine sand	100
Fine sandy-loam	160
Silty-loam	175
Silty-clay	215
Clay	230

FIGURE 9 : Soil water storage capacity of various soil types

A silty-clay soil wet to 1.5 m holds 325 mm of water. If 250 mm of irrigation can be applied, or if a total of 250 mm of rain can be guaranteed at the right time, a yield goal of seven tonne per hectare could be set. (Figure 9).

Getting the maximum efficiency out of water

Research clearly shows that the total amount of water used by high yielding crops is only slightly more than that used to produce low yields. Factors that affect this efficiency are:

(a) Weed control (refer weed control section)

(b) Fertiliser

The old fallacy that fertiliser promotes poor water use is still often heard. To quote one study, yields from 33 irrigation experiments in Nebraska showed than well-fertilised corn averaged approximately 2.5 t/ha more corn than poorly fertilised corn and only used 25 mm extra of water. The well-fertilised corn was 43 percent more efficient in using water.

Surprising as it seems, research proves that the total amount of water used by high yielding corn crops is only slightly more than that used to produce low yields. In other words when you improve your crop management in any way - weed control, hybrid selection, plant population - you grow more corn with a given amount of water.

"More plants do need a bit more water but they also shade the soil and therefore reduce evaporation and also shade themselves and therefore reduce transpiration (water loss from leaf)."

(c) Plant population:

Contrary to popular belief, the need for water does not go up directly with increasing plant population. More plants do need a bit more water but they also shade the soil and therefore reduce evaporation and also shade themselves and therefore reduce transpiration (losses from leaves). Figure 8 showed that yield increased at a faster rate than the extra water needed. However, these higher yields are dependent on higher plant populations and it follows therefore that higher plant populations are more efficient users of water. This aspect is discussed in the section on plant population.

(d) Hybrids:

The Pioneer corn breeding program has placed heavy emphasis on developing hybrids that will yield well in spite of considerable moisture stress. Understanding hybrids ability to handle moisture stress is very important as this can also determine plant populations for different hybrids.

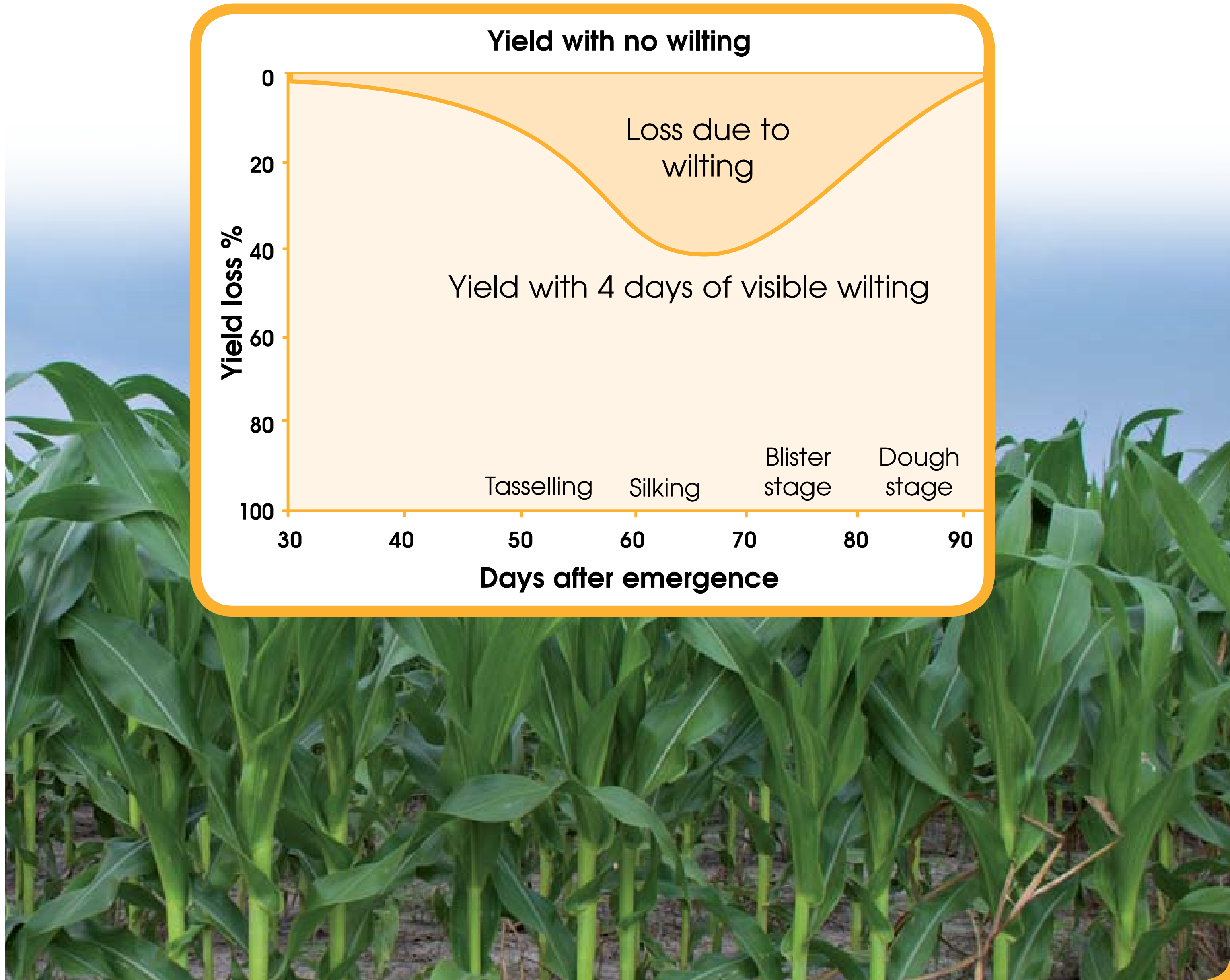
Making the best use of limited water

So far discussion has centred on the corn plant's growth and yield under conditions where water is not limiting. With supplementary irrigation, it is essential to understand the effect of moisture stress at various stages of growth.

It is generally considered that yield is lost when corn is visibly wilted for four consecutive days. Figure 10 shows tasselling to dough stage as being most susceptible to moisture stress and within that period, silking to blister stage is extremely critical. Consequently, if only one watering can be given, it should be applied just prior to tasselling. If a second one can be applied, it should follow the one at tasselling and be timed to prevent wilting. Obviously, water should be applied during the early stages of growth if the crop is in acute stress and then hope for the best at flowering time.

When corn plants become stressed, the lower parts of the plant wilt and suffer damage proportionately more than the upper parts. With some hybrids, this has the serious effect of slowing the development of the silks much more than the tassel. This results in the pollen being finished before the silks emerge and little or no grain is formed on the cobs. Hybrid selection is therefore more important in dryland or limited irrigation situations.

FIGURE 10. Yield lost when corn visibly wilts for four consecutive days at various growth stages. Loss is greatest when moisture stress occurs from tasselling to the blister stage.



6. Weed control in corn crops

Good weed control is very important for high yields in corn, as it is with other summer crops. Weeds compete very strongly for moisture, nutrients and light. Grass weeds are the most competitive and must be eliminated early. However, broadleaf weeds will also compete strongly with corn. Corn is quite sensitive to weed competition in the early stages of growth up until it reaches about 0.8 m in height.

As well as a detrimental effect on your corn crop yield, weeds can create problems at harvest time by blocking harvesting fronts and sieves, or by causing dockage in payments when the grain is delivered. In severe cases they can cause the grain to be rejected for receival by the customer.

Weed control can be carried out by either mechanical or chemical means, or the combination of both.

Mechanical weed control

Corn is usually planted in rows up to one metre apart and therefore inter-row cultivation can be practised. Inter-row cultivation can be done up until the corn crop reaches about 0.75 m in height. After that the crop canopy closes over and the corn competes well with weeds.

Inter-row cultivation must be shallow to prevent root pruning of the crop. Wet conditions may prevent cultivation at critical times and/or cause transplanting of weeds.

Mechanical and chemical weed control

Band spraying of chemicals in the crop row combined with inter-row cultivation is a widely-used practice in all types of summer crops.

Chemical weed control

There are a number of chemicals available which will give very good weed control through the life of the corn crop if used correctly (Always read the label before starting to spray).

Common herbicides registered for post emergent control of various broadleaf weeds in corn

	MCPA formula-tion	picloram +2,4-D amine	atrazine	flumet-sulam	Dicamba not in CQ	fluroxypyr	Tordon 75D	Tordon 75D + atrazine
Mode of action group (1)	I	I	C	B	I	I	I	C+I
Amaranth		R	R		R		R	R
Annual ground cherry				S	R	R	R	R
Anoda Weed				S				
Apple of Peru		R				R		
Bathurst burr		R			R	R	R	
Bellvine					R	R	R	
Billygoat weed		R						
Blackberry nightshade		R	R		R			
Black pigweed		R	R		R		R	R
Bladder ketmia		R	R	S			R	
Caltrop		R		R	R		R	
Cobbler's peg			R		R		R	
Common morning glory							R	
Fat hen		R	R		R		R	
Jute			R					
Mexican poppy		R					R	
Mintweed	R (Sodium salt)	R	R		R		R	R
Noogoora burr		R	R		R	R	R	R
Paddy melon		R	R					
Potato weed		R	R				R	
Red pigweed		R			R	R	R	
Sesbania pea			R			R	R	R
Siratro		R						
Spiny emex		R			R			
Stinking roger							R	
Sunflowers		R	R		R	R		
Thornapples		R	R	S	R	R	R	
Turnip	R	R		R				
Wandering jew							R	R
Wild gooseberry				S		R		R
Wild radish	R (Sodium salt)	R		R				

R -registered S -suppression

Note: these tables are intended as a guide only. Registrations may differ between individual products and change over time. Check the label in all cases before using.

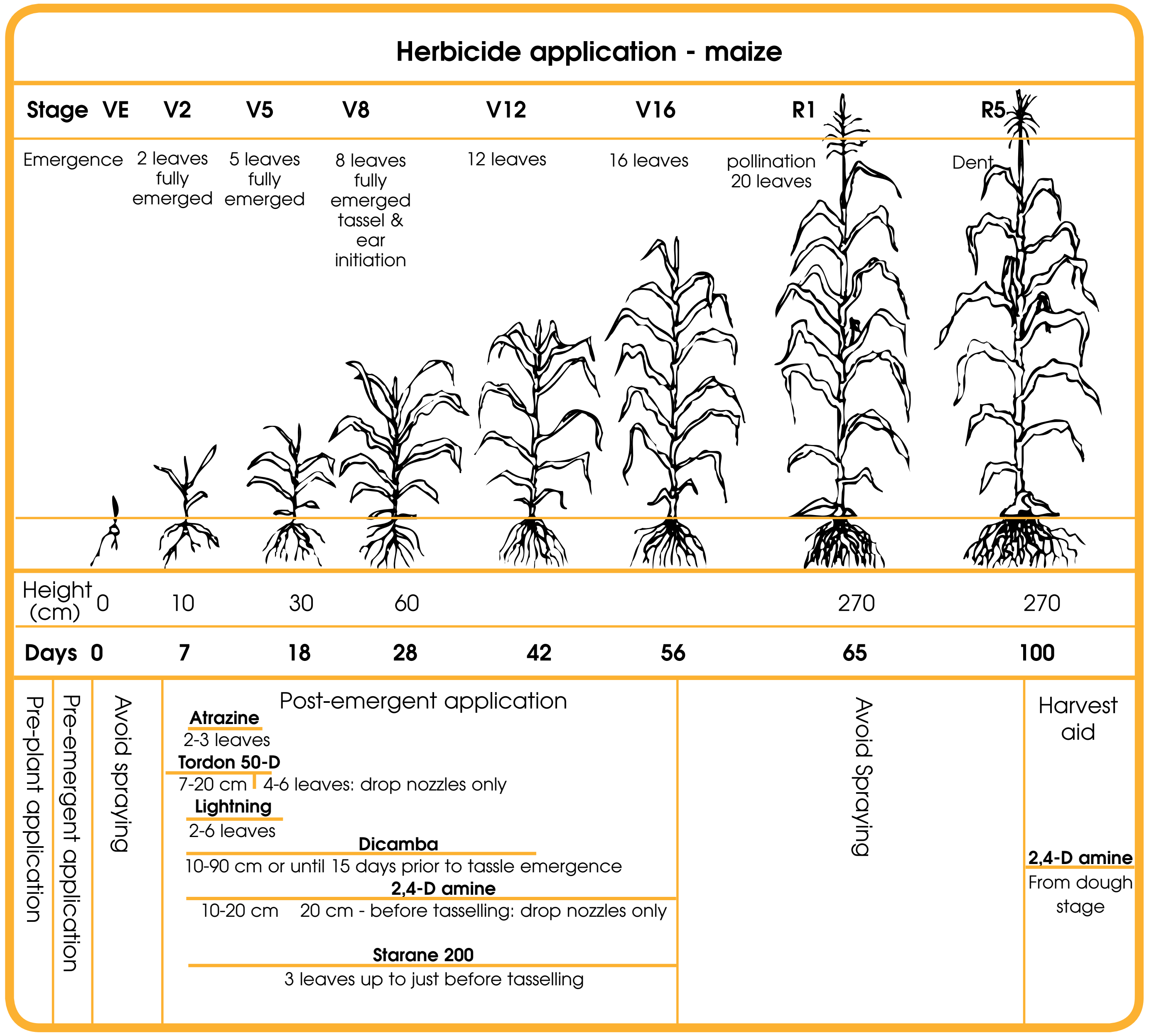


FIGURE 11

"Good weed control is very important for high yields in maize, as it is with other summer crops. Weeds compete very strongly for moisture, nutrients and light."

7. Insect pests of corn

Corn crops are most susceptible to serious damage from insects during establishment (soil insects can be so destructive that resowing is necessary) and from tasselling, silking until harvest.

With the wider use of conservation tillage and stubble mulching, many farmers have noted an increase in insect activity, particularly in the seedling stages. This observation in no way condemns stubble mulching or associated practices, considering the benefits gained in moisture and soil savings, but highlights that these systems are not without pitfalls. Double cropping also has been responsible for building up populations of soil dwellers such as African black beetle, false wire worm and earwigs.

Together with all other good management inputs, a priority requirement is establishing a plant stand to make full use of the fertility and moisture when aiming for the best possible yield goal.

Knowing if insects are prevalent is the first management step - don't be caught unawares on any soil type. There are many cases of damage occurring on soils where soil insects have never been known in numbers before. A corn crops main soil dwelling insect enemies appear with rises of temperature heralding the summer season. In areas that frost frequently, pest populations will be slower to build up, as pupae well down in the ground will be the only survivors from the previous summer. In the northern cropping areas, populations can survive the winter by feeding on crop, crop residue and weeds, though their activity is toned down with the lower temperatures.

From spring, pest activity increases, reaching peak problem proportions with the higher temperatures and humidity of the main planting time. The higher temperatures speed up insect life cycles and, linked with more food availability, all months from September until late February are in the danger period. So, if planting where damage has been suspected in previous years, be prepared to take some precautions.

A thorough check at all periods from ground preparation until harvest enables profit-conscious growers to monitor crop health by simply inspecting their fields.

The importance of seed treatments

Pioneer recommends Betta Strike® seed treatment to enhance the genetic potential of the corn seed sown. Inadequate protection of the emerging seedling leaves the plant exposed to pests and diseases. In fact many symptoms caused by soil borne insects may not be seen visually until much later in the crop development causing significant potential yield loss.

It is important that the application of seed treatments is professionally applied. Research has show that improper application of seed treatments can significantly reduce the effectiveness of the chemical applied.

This will result in poor protection against insect pests and, in extreme circumstances can cause unnecessary stress on seedling vigour.

In recent years, there is evidence to show that some insect seed treatments can improve early plant growth and vigour.

7a. Insect pests

(from Department of Primary Industries, Queensland)

Common soil insects in corn include the following:

© The State of Queensland, Department of Primary Industries and Fisheries, 2007 (D Ironside)

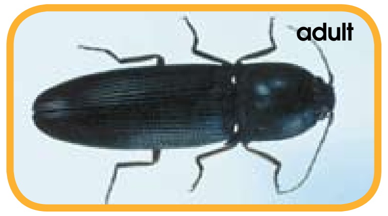
Black field earwigs (*Nala lividipes*) are shiny black insects (up to 15 mm) with a pair of forceps or pincers at the rear end. The immature stages resemble adults but are wingless. They attack seeds, shoots, roots and stems at/or below ground level. Populations are regulated by soil moisture and serious damage is usually confined to soils that retain moisture well. **Note:** There are beneficial earwigs. These are usually larger and light brown in colour.

© The State of Queensland, Department of Primary Industries and Fisheries, 2007 (D Ironside)

False wireworm (*Gonocephalum* spp., *Pterohelaeus* spp.) are cylindrical, yellow-brown beetle larvae with rounded heads. They attack germinating seeds and seedling roots and shoots and are most active in spring. The beetles feed on dry seed in the ground especially in dry soil conditions. They only tend to become a problem if large numbers are present during dry conditions. Control using chemicals at planting, treated seed and insecticidal grain baits.

© The State of Queensland, Department of Primary Industries and Fisheries, 2007 (J Wessels)

Cutworms (*Agrotis* spp.) are caterpillars up to 50 mm in length. Their colour varies greatly. Often they are grey-brown but may range from green or pale yellow to almost black. Cutworms feed on leaves and stems of young plants, with most damage caused by older caterpillars that may cut down plants to eat the leaves. They may also cause the plant to wilt by partially chewing on stems. Cutworms usually feed at night and hide in the soil during the day. Cutworms may be found in any soil type and often move into the crop from adjoining fence lines, pastures or weedy fallows. Spray with chlorpyrifos when caterpillars are feeding (dusk-night). Spot treatments may be successful (refer to the supplier's product label before application of any agricultural pesticide). Keep fallows clean and eliminate weeds from paddock perimeters for at least one month before planting.



© The State of Queensland, Department of Primary Industries and Fisheries, 2007 (J Wessels)

Wireworms (Family Elateridae) are up to 40 mm long and can vary greatly in shape. They may have soft, flat, creamy-white or pale bodies with dark wedge-shaped heads and forked tooth-edged tails, or have hard smooth round yellow to red-brown bodies with flattened, round or cone-shaped tails. Wireworms can feed on seed but usually attack underground stems of young plants, killing the growing points and causing shoots to wilt. Damage is worse when crop growth is retarded by dry, wet or cool conditions. Wireworms generally favour moist areas. Plant treated seed or use in-furrow application of insecticide.

Above-ground pest control baiting

Above ground pests such as African black beetles, false wireworm beetle, field crickets, wingless cockroaches and black field earwigs can be controlled by spreading a bait of Lorsban 500EC and sunflower oil on a base of cracked wheat, sorghum or corn.

Best results can be achieved by broadcasting the bait evenly over the soil surface immediately after planting. This way insects will be controlled before the seedlings emerge. Apply the bait at 2.5 kg/ha to 5 kg/ha for most effective control. You can make your own bait using the following combination: 100ml of lorsban 500EC+ 125ml of sunflower oil on 2-5 kg of cracked wheat, sorghum or maize. Wearing appropriate personal protection equipment, mix the lorsban 500EC and sunflower oil together first, then mix in thoroughly with the cracked grain. Spreading of the bait can be done by a variety of processes; including modified fertiliser spreader, modified granule application and air seeder.

Other insects

Heliothis or corn earworm (*Helicoverpa armigera*) caterpillars are up to 50 mm in length. They can vary in colour from yellow to almost black - often with a broad pale stripe along each side. Eggs tend to be laid anywhere on the top two thirds of the plant. Heliothis are a more serious pest during tasselling and silking. The damage to the silks reduces pollination and grain-set (6-8 larvae per tassel before silk emergence may warrant control). Chemical control should only be aimed at small caterpillars (up to 5 mm), as heliothis have developed resistance to a wide range of chemicals. Before spraying, consider that corn crops often have high levels of beneficial insects (predators and parasitoids) that may be harmed by insecticidal applications. Some biological insecticides with minimal toxicity to beneficials are available.

Corn leafhopper are small, brownish, translucent insects with dark eyes that spring away (hop) rapidly when disturbed. More than 15 per plant can cause a disease-like condition known as wallaby ear. Plant resistant varieties.

Thrip damage of young corn plants.

Thrips may damage crops that are stressed and not growing well. Infected plants may have yellow or silvery patches on the leaves of young plants and a desiccated or wilted appearance. Look in the whorl of the individual corn plants for the presence of very small, brown/black insects measuring 1-2 mm in size. Control with insecticides. Check with your grain buyer as to which chemicals can be used for the particular target market.

Green vegetable bug

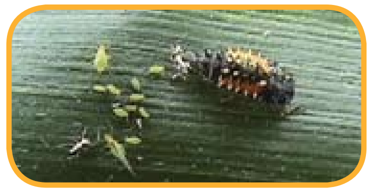
Adult bugs are 12 to 17mm long, shield-shaped and light green or green with three cream-coloured spots on the anterior margin of the large, central, triangular portion of the back. The immature stages are marked with red, green, white, yellow, orange and black.

Adults and late stage **nymphs** may stunt or deform young cobs by feeding at their bases. They may also pierce the husks and puncture the grains. Damaged grains do not develop, or may become dry and shrivel.

Corn aphid

The corn aphid is a minor pest, although it can transmit the virus that caused maize dwarf mosaic. Large colonies sometimes form on the undersides of the leaves, in the funnel or throat of the plant, on the tassels and on the silks and husks of the cob. During dry weather very heavily infested leaves may turn yellow or red and shrivel.

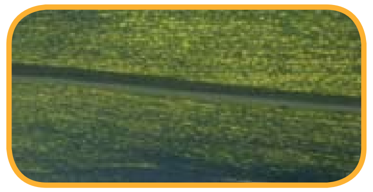
Adult corn aphids are about 1.5 to 2 mm long, winged or wingless, and soft-bodied with greenish abdomens, but the head, the forward portion of the body the legs and antennae are blackish brown. The immature aphids resemble the adults in shape and colour but are wingless.



Corn aphids being predated by a lady bird larvae.

Infestations are normally controlled by natural agencies including the weather, ladybird beetles, parasitic wasps and larvae of hover flies.

Two-spotted spider mite



Spider mite damage.

Adults and nymphs are similar in appearance. Both have a dark spot on each side near the middle of their yellow-green body. Adults are 0.5 mm in length. Infestation generally starts late in the corn crop's vegetative stage, increases after tasselling and dramatically increases after the grain is at the soft dough stage. Hot dry conditions promote rapid population increase. Mites colonise the underside of leaves and can be recognised by the characteristic webbing over the colonised area.

Damaged leaves are chlorotic and brown and senesce prematurely. Mites normally start feeding on lower leaves then move up the stem as new leaves are produced and old leaves senesce. Severe infestations can cause yield loss through reduced cob size, reduced grain size and lodging.

There are no insecticides registered for the control of two-spotted spider mite. Thrips and predatory mites are predators of two-spotted spider mite and insecticides which reduce the number of these predators (eg synthetic pyrethriods) may flare mites leading to higher pest pressure and subsequent crop damage.

8. Choosing a corn hybrid

Selecting a corn hybrid is a very important aspect of all corn production programs. Once a farmer has decided to include corn in the farm program, one of the most important management decisions is to choose the most appropriate hybrid to satisfy the farm and market requirements.

Pioneer is recognised around the world for being the leading provider of corn hybrids. Approximately US$450 million is spent on research annually. This investment combined with a proven testing program enables Pioneer hybrids to be industry leading performers.

In order to minimise any confusion when choosing a hybrid, there are a number of factors to be considered. These are:

8a. Market requirements

In the past, corn was grown primarily as stockfeed. However, the end-use of corn has diversified to such an extent that the market a farmer is trying to satisfy will largely determine the hybrid he chooses. Hybrids differ in texture, varying from soft and floury to hard and flinty.

The market requirements for corn are:

Stockfeed

Any type of corn can be used as a stockfeed but this description is usually applied to the softer, floury grain types. Corn competes in the marketplace with feed wheat and sorghum, and usually commands a premium above sorghum prices.

Processing

Not all corn hybrids are suitable for processing, and the processing companies have lists of hybrids suitable for their particular purposes. Corn chip manufacturers require a semi-flint grain, whereas grit and cornflake manufacturers require a grain with a hard flinty endosperm. Corn flour processors require soft, floury grain. It is very important to confirm with the companies concerned that a particular hybrid is in fact suitable for their requirements, and that they will be buying grain. A premium is often paid for processing corn and growers usually contract with the relevant company prior to planting.

Specialty corns

Waxy and high amylose corn has a different starch ratio than normal corn, and is used in many food products.

White corn has a white endosperm and pericarp and is used to make corn flour (and corn chips) as well as used as a feed in pig and poultry rations.

Popcorn - once again it is very important to check with the end-user before growing these corns.

Silage

With the growth in beef cattle feedlotting, the demand for corn silage is increasing very rapidly in Australia. Generally speaking, the best silage hybrids are those with the highest grain yields, as this has a direct bearing on the yields of metabolisable energy per hectare.

However, traits such as metabolisable energy and digestibility do vary between hybrids, and studies are being undertaken to determine these differences. It is important for silage hybrids to have good standability so that crops not cut for silage can be kept for grain.

Corn silage is also becoming increasingly popular with dairy farmers as a cost effective alternative to grain in dairy cow rations.

Beef and dairy producers often contract with neighbouring farmers to have their silage produced and delivered to the feedlot. This provides an alternative to growing corn for grain.

Earlage

Earlage is an opportunity for livestock producers that want an energy dense feed that has significant fibre content. Earlage is conducted at, or soon after physiological maturity when the grain moisture is approximately 30 percent. Earlage is harvested using the same forage harvesters used in the silage making process but uses a snapper corn front (similar to those used on conventional grain harvesters) to remove the cob portion of the plant.

The grain, the core of the cob and some husk is chopped and processed by the forage harvester and then transported and stored under the same process as whole plant silage would occur. Optimum moisture content for earlage should be 35-40 percent.

It is important that earlage be treated with a proven silage inoculant such as Pioneer® inoculants 11A44 or 1132 to improve the feeding efficiencies of this high quality product.

High moisture corn (HMC)

Firstly, HMC is harvested soon after physiological maturity at a grain moisture content of 24-32 percent. It is harvested by a conventional grain harvester, and then is processed (preferably through a roller mill) and stored in a well designed above ground bunker similar to that used by silage and earlage products.

As the grain is harvested at high moisture, it allows the grower to harvest the crop significantly earlier than would be for dry grain and give the opportunity for crop rotations. By processing the product prior to ensiling, it does not require further processing at feed out time. This is seen by some larger producers to be an advantage if untimely equipment failures occur when trying to feed stock.

Like earlage, HMC is a high quality product and every management tool should be used to minimise losses and maximise feeding efficiencies. Therefore, it should be treated with Pioneer® inoculant 11A44 to assist in its feeding characteristics,

HMC is not a long term stored feed source like whole plant corn silage. While whole plant corn silage can last for many years in a well designed and sealed storage structure, HMC should be used within 12 months of harvest as quality will deteriorate quite rapidly after this time.

8b. Maturity

Corn hybrids are rated for maturity by comparing the moisture at harvest with a standard hybrid. This is called the Comparative Relative Maturity (CRM) and is commonly referred to as the days from planting to physiological maturity (also known as black layer). However the actual number of days taken to reach black layer will vary greatly with location, planting time, and other environmental factors. Black layer refers to the time when the corn kernels have reached their maximum weight, and can be identified by the development of a layer of black cells at the base of each kernel. From this stage on, no further starch is laid down in the kernel, the plant dies and the grain dries down until it reaches harvest moisture.

Under most Australian growing conditions, hybrid maturity is not as critical as in many overseas corn growing areas. Our growing season is very long, and a wide range of maturities can be planted at most planting dates. Maturity becomes more critical in southern growing areas.

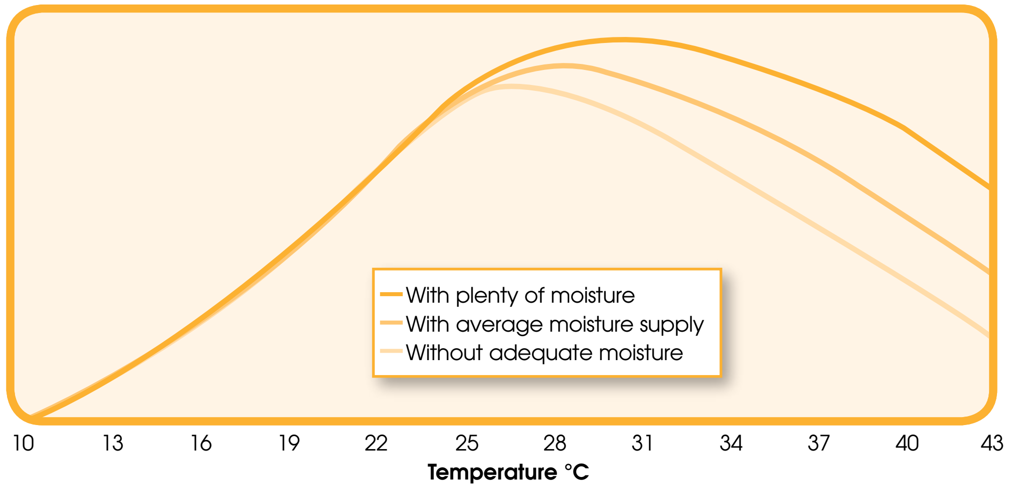
The important points to consider are:

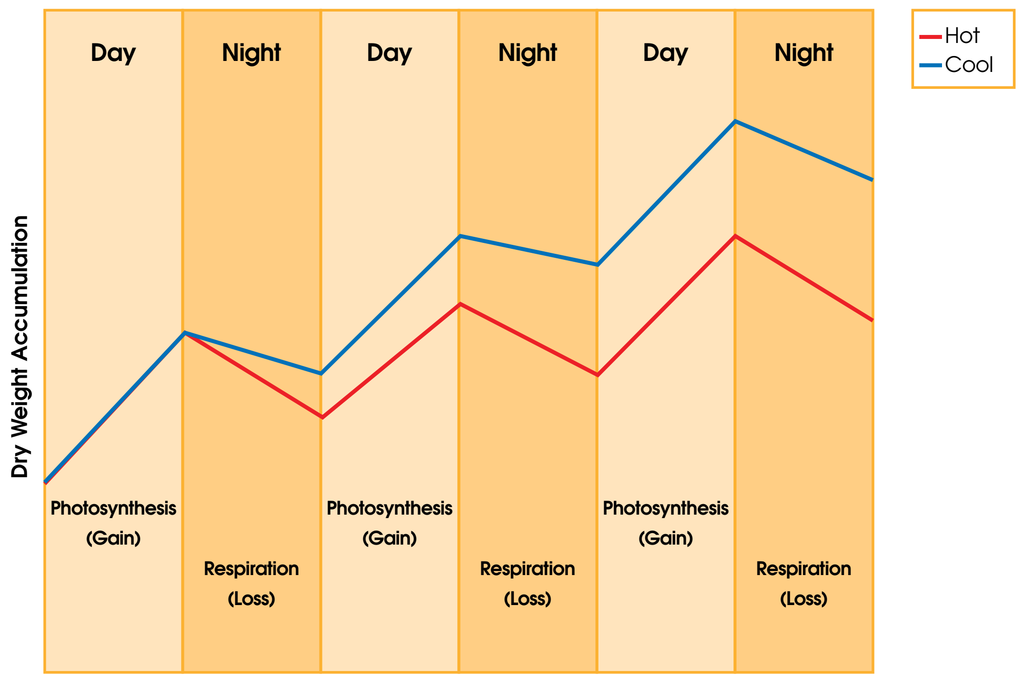
- Try to avoid excess heat at flowering.
- Plant several different maturities to spread risk, to suit water application, and to optimise yield and market opportunities.
- On a late plant it may be necessary to plant a quick maturing hybrid in order to avoid frost damage prior to reaching black layer. However, disease pressure must be carefully considered when selecting quicker maturity hybrids. In some environmental conditions they may be susceptible to leaf and cob diseases.

Generally speaking and especially under ideal growing conditions, a longer maturity hybrid has a higher yield potential than a quick maturity hybrid. However, advances in plant breeding have lifted the yield potential of the quick and mid-season hybrids to such an extent that their yield potential can be comparable to full season hybrids. Obviously each hybrid has to be planted at its optimum plant population.

Another aspect of maturity is the rate of dry down. This is the time taken from black layer to harvest moisture, and is an area where plant breeders have made big gains in recent years. The rate of dry down has been maximised, while at the same time increasing yield and maintaining plant health and standability.

The Relation of Temperature to Rate of Growth





Source: Modern corn and soybean production.

8c. Tolerance to heat and moisture stress

All plants have a range of environmental conditions under which they perform best and corn is no exception.

In the case of corn, plant growth is reduced when temperatures exceed 30 degrees and drop below 10 degrees with an optimum temperature for growth of 22-24 degrees. High temperatures, especially when coupled with low humidity, can seriously affect the reproduction stage of the corn lifecycle and significantly reduce yield.

Breeding efforts in many parts of the world have concentrated on selecting hybrids that can tolerate heat and moisture stress, and current hybrids differ greatly in their ability to handle stress. This is particularly important in dryland environments, and even in irrigated fields the plants can be stressed for short periods.

The most obvious external effect of stress on a corn plant is the delay in silk emergence relative to the onset of pollen shed. Severe silk delay can result in little or no seed-set.

8d. Disease and insect resistance

It is important to choose a hybrid that can tolerate diseases that may be encountered during the growing season. The incidence of disease will depend on many factors including location, environment, cultural practices and planting date.

Rot diseases in corn

Rots in corn can be caused by a wide range of fungal pathogens.

Some of the more common are:

Fusarium stalk rot and Fusarium kernel rot (*Fusarium moniliforme*) (*Fusarium verticilliodes*)

Fusarium is common in many of the corn growing regions of Australia. It can occur as seedling blight but this is not common due to improved seed management.

Affected seedlings have poor root development and growth and may be pale green or purple colour. There is often a poor seedling stand. Mature plants show pink coloured, rotted internal stalk tissues. The pink colour may also be seen on stalk nodes. Stalks are weak and lodge easily. As well as the stalk rot, the kernels may also become infected.

Use resistant hybrids to combat this disease.

Gibberella stalk rot (*Gibberella zeae*)

Very common on the Atherton Tablelands, especially in the wetter parts, where it can cause serious yield loss. The disease is much less serious in southern Queensland. It occurs in wet weather and where there is plant stress during grain fill. It is common where corn monoculture is practised. Plants die prematurely.

The stalk rots, showing internal tissues that are shredded and discoloured (may be pink or quite red). Stalk surfaces show a reddish brown discolouration, particularly around the nodes. Affected stalks are weak and break easily. Later in the season small, round, bluish-black fruiting bodies may be found around the nodes of dead stalks.

Use crop rotation and/or resistant corn hybrids to combat this disease.

Gibberella ear rot or pink ear rot (*Gibberella zeae*)

A disease of tropical and subtropical regions, especially wetter areas. Particularly significant on wetter parts of the Atherton Tablelands. Apart from causing yield loss it can produce a toxin (zearalenone), which is harmful to livestock, especially pigs. Infection is favoured by wet weather, corn monoculture or plant stress during grain fill.

A reddish-pink or whitish-pink fungal growth from the tip of the ear to the base is usual, although infection can occur whenever damage occurs in the ear. Husks tend to bind to the kernels and there may be black fruiting bodies on external husk leaves. Infection is transmitted through windborne spores.

Choose resistant hybrids and control weeds to reduce humidity in the crop canopy (high humidity promotes infection).

This disease has occurred on the Darling Downs in some seasons, especially when summer rainfall has been below average.

There is little information available on the relative susceptibility of different hybrids to this disease. Husk cover and pendulous ears reduce the incidence of this disease.

Losses due to ear rots can also be reduced by prompt harvesting, even if moisture levels are slightly higher and drying is necessary.

Wallaby ear in corn

The physiological condition known as wallaby ear is caused by toxin injected by the leafhopper (*Cicadulina bimaculata*) while feeding. The condition is more common in subtropical coastal areas where it can have a serious effect on yield. Leaves of affected plants are dark green or blue-green in colour. They are short and held at a very upright angle, and veins on the lower leaf surface are thickened. Use tolerant hybrids and control leafhoppers with registered insecticides when plants are young.

Blight in corn

Leaf blight

Turcica/turcicum leaf blight or northern leaf blight (*Exserohilum turcircum*) can be found in all regions and may be serious in susceptible hybrids. Warm wet weather favours infection and disease development.

Leaves show long, spindle-shaped, greyish-green, water-soaked spots (up to 150 mm x 20 mm), which turn light purplish-brown or grey. In favourable conditions the spots may join, blighting almost the entire leaf. The fungus survives on volunteers and residues and is spread by wind and rain.

Choose resistant hybrids and avoid sequential plantings (stops disease build-up) as chemical control is usually not economic.

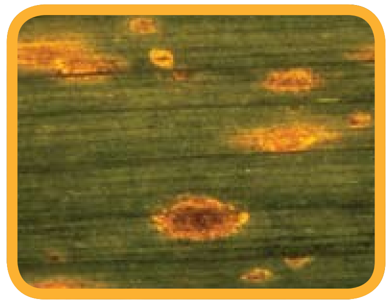
Smut in corn

Smuts are not as common as rusts, and usually attack the plant's reproductive components rather than the leaves or stems.

Boil smut (*Ustilago saydis*) attacks any above-ground growing part of the plant to form blisters or galls containing black spores. Mature galls can grow as large as 20 cm in diameter. Spores can be spread by wind, seed, clothes or farm machinery, and can survive in the soil for many years. Ensure good hygiene and treat seed with registered fungicide.

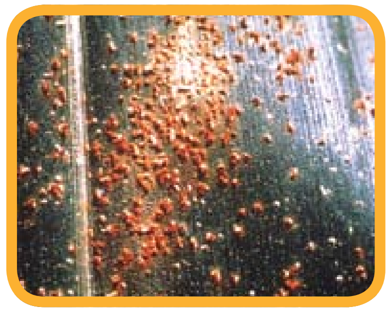
Rust in corn

Common rust



(*Puccinia sorghi*) is commonly found in temperate and sub-tropical regions. Usually only found on lower leaves of resistant hybrids. Tends to be more serious on sweetcorn. Cool-warm humid weather favours disease infection and development. Pustules are oval to elongate on the leaf with a mass of red-brown powdery spores. These sometimes turn black late in the season. Plant resistant hybrids as chemical control is not usually economic.

Polysora rust



or tropical rust or southern corn rust (*Puccinia polysora*) is an important disease in tropical areas. Warm, wet weather favours infection and disease development. Drizzly rain or even heavy dews allow disease formation. Pustules are small circular and orange in colour. They are evenly spread over the leaf surface. Pustules on the midribs, ear husks and tassels may be elongated or irregular in shape. With heavy infections, leaves may die prematurely, and defoliate from the base up. Plant resistant hybrids as chemical control is not economic.

8e. Multiple cobbing

All corn plants have the ability to produce more than one cob. Some hybrids produce multiple cobs more than others. Hybrids that do not produce many double cobs are more likely to have a greater ability to flex the primary ear size. In a high yielding environment, yields will be maximised if farmers aim to produce one good ear per plant.

Therefore, the decision should not be to select a hybrid on its ability to double cob, but rather on its overall yield performance whether this is done by a single cob or more.

8f. Husk cover

Husk cover is important in environments where the maturing grain can be damaged by weather or ear rots.

In some hybrids the ear is borne on a long shank and, as the ear matures, it tends to hang down and thus be protected. In hybrids with a short shank, the ear is held upright and it is important to have good husk cover in order to protect the ear.

8g. Tillering

Some hybrids can produce 1-2 tillers and this is generally considered an undesirable trait in corn hybrids. This does not necessarily mean that hybrids that produce tillers are any less efficient, or will be any lower yielding than hybrids that don't produce tillers. As well as genetic differences between hybrids, the following factors appear to increase the incidence of tillering:

- Cooler temperatures early in the growing season
- Lower plant populations
- High levels of soil fertility relative to the plant population.

In some situations, hermaphrodite ears may form at the top of the tiller. In most cases early formed tillers reflect favourable growing conditions and tend to die off (with nutrients transferred to the main stem) as the season and crop progresses.

Choosing the hybrid

The task of choosing the best hybrid (or hybrids) to plant should be simplified if each of the points discussed above is considered. Unfortunately there never will be a hybrid that will give full protection to every environmental, disease and insect problem that maybe encountered during the growing season, as well as giving the top yield year in year out.

Therefore it is up to the farmer to obtain as much relevant and unbiased information as possible, list his priorities, and decide the best hybrids for his property.

Sources of information include:

1) The research company that developed the hybrid - ask to see Pioneer Product Advancement Trial Data and strip test data from the local area: this is particularly important for new hybrids as they are released onto the market.

2) Local farmer experience.

3) Local seed distributors, many of whom conduct their own hybrid testing programs.

It is a very good idea for farmers to conduct their own strip tests of new hybrids, and obtain their own information before commencing full-scale commercial production. Pioneer is very keen to assist farmers with strip-tests, from planting through to yield testing.

9. Corn plantability and populations

After selecting the corn hybrid, the importance of planting decisions is often under estimated and can often limit the yield potential of the seeds planted. Having a good understanding of all aspects of seed and seed plantability can often lead to increases in yield. Errors at planting are evident throughout the season and can have a permanent effect on yield for the remainder of the season.

Understanding seed sizes

When selecting hybrids, there are many important considerations. Growers should remember that all seed sizes that result from seed production of a specific hybrid are genetically identical. The different combinations of seed size and shape merely reflect the kernels' position on the seed parent ear. The result is that seed from a single ear could fall into many size/shape classes. Large-round classes usually come from the base of the ear, flats from the centre, and small-round seed from the tip.

The harvested seed is graded into different seed sizes. Standard size screens are used each year. However, seed density may change from year to year depending on growing conditions. This results in seed count variations within the different seed sizes as shown in Figure 12. The seed dimensions do not change.

Seed shape	Seed size	Approximate seed counts
R (Round)	1 = Very large	1800 - 2400 seeds/kg
	2 = Large	2200 - 2800 seeds/kg
	3 = Medium	2800 - 3600 seeds/kg
	4 = Small	3500 - 4000 seeds/kg
	5 = Very small	3800 - 4500 seeds/kg
F (Flat)	1 = Very large	1800 - 2400 seeds/kg
	2 = Large	2200 - 2800 seeds/kg
	3 = Medium	2800 - 3600 seeds/kg
	4 = Small	3500 - 4000 seeds/kg
	5 = Very small	3800 - 4500 seeds/kg

FIGURE 12

Seed size performance

Unfortunately, many myths exist when it comes to seed sizes. Some farmers have the concern that differing seed sizes may not have the same performance. That is, some seed sizes are better suited to particular types of planters, and some seed sizes have better vigour than others. Independent studies have found that few differences actually exist in emergence, growth, yield and potential performance between seed sizes.

Corn growers should not be concerned if they cannot acquire their seed size of initial choice. Most modern planters have the ability to plant most seed sizes if they are properly calibrated.

Some moisture studies have noted that small seed has shown an advantage in emergence over larger seed as the larger seed requires more moisture to instigate the germination process.

Farmers should instead focus on the hybrids positioning, genetic potential and seed quality.

The importance of proper seed spacing

Skips and doubles are common form of planting variability in the corn row. Skips result from planter mishandling of seed, or from failure of seed to emerge. Doubles are strictly from planter mishandling. Both skips and doubles result in plant spacing variability, but their effect on yield can be quite different.

The standard deviation of plant to plant spacing is a statistical tool often used for relating field variation to yield losses: the larger the value, the greater the variability among the measurements. The standard deviation can be calculated by hand using formulas available from Pioneer.

In recent years, there has been some research work completed showing yield losses for uneven plant spacing within the row to be as much as 80 kg/ha per centimetre of standard seed deviation.

Planting depth

Proper corn seed planting depth is critical for optimum root and plant development. Shallow planting corn can delay or inhibit the development of brace roots, which are the primary tools for water and nutrient uptake.

Planting seed to a depth of 3.5-5 centimetres (1.5-2 inches) is optimum for brace root development.

If corn is planted too shallow and the topsoil becomes dry, a condition called 'rootless corn syndrome' can develop. Plants can fall over due to the lack of brace root development in the dry soil.

Shallow planting depths of less than 2.5 centimetres can expose corn seedlings to herbicide residues increasing the potential for herbicide injury to corn seedlings.

Planting depth can easily be determined after seedling emergence. The brace root area (growing point) typically develops about 20 millimetres beneath the soil surface regardless of the seed depth. Measure the mesocotyl length (the area between the seed and growing point) then add 20 millimetres to determine planting depth.

Symptoms of irregular planting depth can be:

- Uneven emergence
- Non-uniform mesocotyl length
- Varying plant height

Slower planting speeds and well maintained units will help to achieve more uniform planting depths.

Planter calibration and maintenance

Of all production variables that affect profitability, planter condition is one of the most controllable.

Agronomy and planter equipment need to work together to maximise yield. A systems approach to precision farming:

- Clearly fine tuning planters to achieve the best possible stands should be the goal of every corn grower.
- Planter maintenance should begin when the last paddock is planted. Proper cleaning and storage at that point can save hours of time and effort later.
- Pre-season checks of the seed meters, monitors, drop tubes, row units and drive train should all be carefully examined.

Finger pick-up

- Look for fractures or cracks on the cover lid.
- Clean the unit out regularly.
- Check springs - look for stretched or lazy springs, which may cause doubles and skips.
- **Finger wear** - flat areas may cause drag on the backing plate, which may in turn cause the flag to vibrate and drop the captured seed.
- **Backing plate** - Pitting or rust may cause vibration.
- If the bump is worn down, replace the backing plate.
- Replace worn brushes, especially when using small seed.
- **Back housing** - cleaning the back housing will help reduce vibration.
- **Belts** - Look for cracks and brittleness in belts.

Fit correctly as per manufacturer manual instructions

Seed distribution units must align correctly with seed tubes.

Store planter units under cover to prevent rusting and pitting.

Vacuum planters

- Disassemble the planter units and wash the seed meters in soapy water.
- To prevent warping, hang plates on a peg in your shed away from any excessive heat created by corrugated iron walls (to prevent warping).
- Look for warped or cracked plates.
- Check vacuum seals and hoses for cracks.
- Remove any seed treatment build up.
- Brushes must be in good condition.
- Seals must be pliable and be crack free.
- Some units require graphite.
- Check the condition of your seed tube - where lips can affect distribution and seed depth.

Vacuum planter seed size calibration

- Matching your seed plate with your seed size and air pressure is essential.
- Doubles indicate the plate hole size is too large or the air pressure is too high.
- Increase the air pressure if skips appear. If this is ineffective, change your plates to a larger hole size.
- Decrease the air pressure if doubles appear. If this is ineffective, change your plates to a smaller hole size.
- If air humidity is high, talcum powder mixed with seed may help to avoid doubles.

Disc checks and settings

- It is important that the disc groove, within the soil profile is shaped as a 'V'. Anything shaped as a 'W' is incorrect.
- Set disc angle according to your planter manual to avoid damage to planter tubes.
- Ensure your press wheel assemblies are centred - adequate down pressure is required to exhume air pockets from around the seed.

Seed monitors and drop tubes

- Seed monitors should be cleaned and checked thoroughly.
- A bottle brush may be the best tool to rid sensors of dirt and seed treatment build-up.
- Check drop tubes for obstructions, and adverse wear from disc openers.
- If the seed tubes are worn they may need replacing as any bumps or obstructions will hinder an accurate seed drop.

Drive system and depth wheels

- Replace worn chains, sprockets and bearing in the drive system.
- Check for worn insect boxes.
- Avoid air in hydraulic systems.
- Must be snug against the disc opener to prevent soil prematurely falling into the seed trench.
- Use factory supplied spacers when adjusting.
- Avoid mud build up on wheels affect planting depth.

Planter unit set up

- Ensure your row units are centred
- Planter units must be level
- Ensure the planter is level - refer to owner's manual
- Planter beam should be approximately 50cm from the ground - Refer owners manual
- Preset the units so they sit level - this will assist in gaining good soil contact and even planting depth.
- Coulters should be used to remove clods and stubble from in front of the planter unit where applicable, to ensure even planting depth and reduced vibration.
- Avoid leaving a planter furrow where possible - rain may wash soil into the furrow which in turn may increase the seed depth to an unacceptable level.
- Drive at the correct planter speed
- Apply correct down pressure on the planter unit
- Parallel linkage not bent or worn
- Avoid mud building up on the depth wheels
- Zero tillage - increased pressure may be needed to achieve correct planting depth. You may have to add weight to the planter bar to achieve the correct planter depth.

Stand uniformity, distribution and depth

- Fine tune your planter to maximise yield.
- Uniform stand equals uniform ear size
- Irregular stalk thickness may indicate a difference in emergence uniformity - this may be caused by soil compaction, uneven seed depth, seed soil contact, moisture availability, open planter trench or insect damage etc.
- Even emergence - when plants emerge simultaneously, the roots join up within the row. They detect the same enzyme: therefore no adverse competition between plants is detected. Plants must emerge within 48 hours of one another to avoid irregular enzyme detection resulting in irregular stalk thickness and cob size.

Planting time

The four major aspects to consider at planting time

1. Adequate soil moisture to germinate the seeds - a full profile is desirable when planting in dryland conditions.
2. Soil temperature - corn will germinate at 10 degrees Celcius but preferably wait until temperature reaches 12 degrees Celcius and is rising. A soil thermometer is a worthwhile investment.
   - Under cool soil conditions (10-12 °C), deep plantings could cause significant emergence delays, hence placing the young plant under stress.
   - Under warmer soil conditions (15-25 °C), planting corn at 2.5, 5, and 7.5 cm deep has little effect on emergence rates.
   - However if planting early (cool season, lower than ideal soil temperatures, adequate soil moisture), growers should consider that shallow planting (approx. 4cm) is warranted, as germination is assured along with the positioning of the growing point & the brace roots.
3. Heat stress - if possible, plant so that your crop is not flowering during the high heat stress period in mid-summer.
4. Disease and insect pressure - generally speaking, later planted crops have a greater possibility of yield loss due to insect and disease pressure.

It is important to set yield goals. While these goals should be realistic, the majority of Australian corn growers are sacrificing yield by setting their targets too low. The following goals are suggested.

a) Good soil and climate; plenty of water with quick application - 10 to 18 tonnes/ha.

b) Good soil and climate and can apply supplementary water quickly - 7 to 15 tonnes/ha.

Plant populations

Choosing the right plant population is a very important decision. For the purpose of this discussion, it is assumed that weeds and insects are fully controlled and that sufficient fertiliser is applied to achieve the yield goal set.

The main factors influencing yield goal and therefore plant population are:

- Water availability
- Speed of application of water
- Soil type
- Hybrid used
- Planting time
- Planter considerations
- Market requirements (grain or silage).

It is important to understand how these factors influence planting rates.

Row spacing

In most Australian situations, row spacing is not the limiting factor in producing high yields. Hybrid selection, plant spacing and good agronomy practices have more impact on achieving high yields. Yields in excess of 15 t/ha (30 DM t/ha silage) and combined with high plant populations (>90,000 plants per hectare). Row spacings as narrow as 37cm have been used.

Hybrid used

While consideration should be given to the above factors we believe that the major consideration in deciding plant population is your selection of hybrid.

Plant breeders in recent years have been successful in breeding hybrids with higher yield potential and the ability to handle higher plant populations. This has been achieved primarily by selecting plants with more erect leaves and better stress tolerance. This enables crops to intercept more sunlight and cope with stress over longer periods.

Because of the change in plant structure and higher plant population the yields per hectare have increased dramatically although the actual increase in yield per plant has not increased significantly.

While many new hybrids can handle the inter-plant competition generated by higher plant populations, the genetic make-up of the hybrid will dictate the range of plant population recommended for each environment at which that hybrid will give optimum yield and profit responses.

As a rule of thumb, longer season hybrids (longer CRM) require less plants to achieve a given yield than hybrids which mature earlier.

This is because of the longer growing period which allows more sunlight, nutrients, water and oxygen to be converted into starch and grain, thereby developing a larger plant with greater grain yield potential.

The relationship between plant populations and yield for various Pioneer® brand hybrids under irrigated conditions is shown in Figure 13. From this the appropriate populations can be calculated for various yield goals. It should be noted that these yield curves are based on actual yield data collected by our research division and should be used as a guide only.

Pioneer plant breeders are continually breaking yield barriers by developing elite hybrids such as 31G66, 34N43, 33V15 and many others which can continue to yield and stand at much higher populations.

For those not familiar with reading graphs, the following examples will assist:

a) To achieve the peak yield for 31G66, the estimated population should be approximately 60-80,000 plants per hectare.

b) 36B08, a quick hybrid, has a peak at a population of approximately 70-100,000 plants per hectare.

Market requirements

In almost all situations it is not recommended to increase your plant population above that which will give peak yield production.

Excessive plant populations will give smaller grain size (even if total grain yield does not decrease significantly) and this will reduce mill yields of starch or flinty endosperm for grit production.

If processors offer bonuses for large grain size it may be profitable to reduce plant population by two to five percent under those normally recommended for that hybrid to ensure the optimum combination of yield and grain size, i.e. profit per hectare.

Plant the correct number of seeds

Care must be taken to plant the correct number of seeds to achieve the desired population. Very briefly, final stand depends on the following:

a) Number of seeds planted.

b) Germination and vigour of the seed.

c) Seed bed conditions (moisture, temperature, tilth etc.)

d) Machinery

e) Soil insect control

Don't forget: It is the final population that matters, so increase your desired population by the expected loss of establishment to get the number of seeds that have to be planted.

Example: If you are wishing to establish 60,000 plants/hectare then it is our recommendation to allow for a field loss of an extra 10-15 percent below the actual seed germination. For example, 92 percent germination indicated on the tag in the bag then it would be necessary to plant approximately 72,000 seeds/hectare.

FIGURE 13

FIGURE 13: A guide to the relationship between plant population and yield for various Pioneer® brand corn hybrids under practical irrigation conditions.

10. Maize silage

The recommendations for growing a maize silage crop are similar to those provided in this publication for growing a conventional corn crop. If the crop is planted into a previous pasture paddock insect numbers are likely to be high and use of Betta Strike® seed treatment is recommended. As well as using Betta Strike® consider applying an insecticide when the pasture is sprayed out.

Harvesting maize silage

The timing of maize harvest and harvest management factors, such as chop length and compaction, have a major impact on the quality and quantity of the resulting silage. Most farmers rely on contractors to harvest their crops. Choice of contractor is an important step in ensuring a quality product.

Contractors

Choose a reliable contractor with well maintained equipment. Ensure that the contractor is prepared to vary chop length if crops are too wet or too dry. Book your harvest contractor as soon as your crop is in the ground. Make sure that he can apply Pioneer® brand maize silage inoculant to your crop as it is harvested. Keep in touch with your contractor as your crop nears maturity.

Timing of harvest

The ideal time to harvest your maize silage crop is when the whole plant dry matter is between 30-35 percent. Harvesting a crop too early will result in a yield loss. High losses will occur as plant fluids run from the stack or bunker taking away valuable sugars. Late harvest may result in a loss of quality as plant stover (leaf and stalk) increase in fibre and becomes less digestible. Dry crops are also difficult to compact properly.

In a crop that is still green (i.e. not frosted or drought stressed), the first sign that harvest is approaching is the husk covers turn slightly yellow-brown. There are several ways in which you can determine when your crop is between 30-35 percent whole plant dry matter.

Milk line

The whole plant dry matter can be estimated by looking at the milk line of the grain. To check whether your crop is in the range of 30-35 percent dry matter:

a. Take a cob from a plant that is at least 20 rows into the crop. The plant that you take the cob from must be in a uniformly-planted row.

b. Break the cob in half and discard the end of the cob that was attached to the plant.

c. Hold the point of the cob downwards and remove a kernel from the snapped end.

d. Keep the kernel the same way up as when you removed it from the cob. Slide your fingernail along the length of the kernel starting at the flat (dented) end of the kernel. On a 1-5 scale, with 1 being containing no hard starch and 5 being black layer, the optimum chopping time is when the milk line is between position two and three on the kernel.

Frosted maize

The common mistake made after a maize crop suffers frost damage is harvesting too soon. Even though the leaves are scalded and appear dry, the total plant moisture is often too high for successful storage which can create effluent run-off from the storage structure. Depending on the stage of maturity of the crop when it was frosted, the severity of the frost and subsequent weather conditions after the frost, harvesting could occur 4 to 8 days later.

Laboratory analysis

Many commercial laboratories can measure the dry matter content of chopped whole plant maize samples. Remember that the result of a drymatter test will only be accurate if a good representative sample is submitted. Note that grain moisture meters cannot be used to determine whether a crop is ready to be harvested for silage.

Chop length

The ideal chop length is 10-15 mm. This is an average chop length and you will find some particles that are shorter or longer in your silage. When feeding predominant silage rations, some longer particles are beneficial as they stimulate the rumen of the animal that is being fed. If your silage is very dry (greater than 35 percent dry matter), decrease the chop length to 5-9 mm. In the case of very wet crops (less than 30 percent drymatter) chop length may be increased up to 20 mm.

A good method of testing whether the chop length that you are using is correct for the moisture level is to take a handful of the maize silage and squeeze it. The palm of your hand should feel moist. If you can wring water out of the silage, you are almost certain to have runoff from your stack. Either increase the chop length or delay the harvest. On the other hand, if the maize silage does not stay compressed after squeezing, the maize is too dry. Chop length should be shortened.

Knives

Keep the chopper knives sharp to ensure a clean cut. Excessive bruising caused by blunt knives will result in more runoff.

Kernel processors

The use of kernel processors is more prevalent these days but kernel processors should not be used as a tool to deliberately delay harvest.

Silage inoculants

Pioneer® brand 1132 maize silage inoculant

Silage ferments faster and more effectively with this maize-specific inoculant. Pioneer® 1132 contains bacteria that are specially selected to give a faster, more efficient fermentation. As a result you get more milk or meat per tonne of forage ensiled.

Pioneer® brand 11C33 maize silage inoculant

A new maize-specific inoculant that helps improve forage quality. Pioneer® 11C33 contains *Lactobacillus buchneri*, a proprietary and novel bacteria that reduces the risk of heating during storage and at feedout. 11C33 also speeds up fermentation and lowers pH.

Storing a maize silage crop

Once maize silage harvest commences it is important that the chopped material is compacted into a stack or bunker and covered as rapidly as possible.

Storage facilities

Maize silage can be stored in a bunker or an above ground silage stack. The average density of a maize silage stack is approximately 200 kg of dry matter (DM) per cubic metre with a range of 150-275 kg DM per cubic metre. The average density of a maize silage bunker is approximately 225 kg DM with a range of 175-300 kg DM.

Building new bunkers and stacks

Build your bunker or stack on a firm base away from hedges, trees and major drains. Choose a site that you will have access to all year round and is near where you intend to feed. Where possible, stacks should be built away from areas where rats, wild cats, ducks or any other wildlife that could make holes in the cover congregate. Feed-out costs will be reduced if the bunker or stack is built close to where the maize silage will be fed. The size of the face of the stack or bunker should match the rate of feed-out. Ensure the stack is built so that you can feed across the face of the stack every three days taking at least half metre from the face. A long and narrow stack or bunker is the most desirable.

New bunkers

Ensure there is a drain around the top side so that surface water cannot run in from surrounding land. If you are planning to concrete the walls of your bunker it is a good idea to make the top slightly wider than the base. This allows easier compaction right up to the walls. Maize silage can be stored in bunkers that have dirt walls. However, in some soil types when the water table rises a large amount of water can enter the bunker through the walls. Water then accumulates at the bottom of the bunker wetting the silage and destroying its quality. To avoid this happening, it is a good idea to dig a ditch around the base of the wall and put in some form of drainage (clay tiles or plastic pipe). Backfill with gravel.

Permanent bunker or stack sites

Plan to carry out any maintenance of permanent bunker or stack sites well before harvest. Crumbling dirt walls should be re-cut to give a straight, clean edge. If you have a permanent bunker or stack site that you use each year, clean out residues of last year's silage. This should be done at least a week before the new silage is put into the stack.

Old residues left on the walls or floors will contain large numbers of undesirable bacteria.

Prior to harvest

Order necessary silage making supplies such as covers, tape and tyres. Check that your preferred contractor is using Pioneer® brand inoculant because not all inoculants are the same and Pioneer is the only company in Australia that provides maize-specific inoculants. Contact your local Pioneer area manager for more information.

Discuss with your contractor where you plan to put your silage and who will do the stack work. Where necessary widen gateways and/or races to allow easy access for the silage harvester.

Stacks

Often it is difficult to keep the sides of silage stacks parallel. In addition, stacks tend to spread width-ways until they look like flat 'pancakes'. To avoid this happening mark out two parallel lines prior to the commencement of harvest and build the stack between the lines.

Compaction equipment

Good compaction is the key to making top quality silage. Take into account the rate at which the silage is being harvested when planning machinery requirements for compaction. Compaction is a function of vehicle weight and rolling time. Remember that wheeled vehicles have a higher weight per surface area and achieve better compaction than tracked vehicles of an equal size. If a tractor that you plan to use has duals, remove the outside tyres, increase the tyre pressure and put on weights.

Silage covers

A new cover is preferable but if you have an old cover that has no holes, it may be used. Lay it in the sunlight or spray with disinfectant to kill any undesirable micro-organisms. If you are buying a new cover, ensure that it is at least 125 micron thickness. If birds are a problem in your area consider using a silage cover with a white surface.

The first load

Spreading loads

Fill the bunker or stack as quickly as possible to minimise exposure to the air. Where possible, fill in a wedge shape. This will give good compaction and minimise the amount of time that the maize silage is exposed to the air. Spread each load into a 150-200 mm layer so that it can be compacted properly. If large loads are being delivered to a stack site, dump the loads in front of the stack. Build the stack by taking small loads to the stack layering as you go to achieve the desired shaping.

Compaction

Continue compacting for up to two hours after the final load has arrived at the stack.

Straightening the stack

Make sure stack sides are straight and parallel. Ensure that all loose material is removed from the sides and ends and is compacted on the top before covering. This is best done by hand using a rake and/or a wide mouthed shovel. If the sides of the stack are not smooth, it will be difficult to lay the cover without creases and folds occurring.

Smoothing and covering

The stack or bunker should have a smooth surface. Remember to roll and compress any material that was moved by hand. The cover should be flat with no bumps or hollows so that the entire surface of the plastic is touching the silage material. Seal around the base of silage stacks by placing a layer of sand or lime on top of the cover. If the cover must be overlapped, ensure that the joins are sealed well. Where possible, avoid a large overlap as condensation can form between layers of plastic and run into the silage causing spoilage. Weigh down your silage cover firmly with tyres or sand bags placed closely together.

Feed-out management

Aim to keep the face of the maize silage stack tight throughout the feed-out period. You should not be able to push your fingers into the stack any further than the depth of your finger nails. Maize silage that is loose allows air to penetrate into the stack. Aerobic (oxygen-loving) bacteria break down plant material producing waste products including carbon dioxide, heat and water. Silage quantity and quality are decreased.

Maize silage that is well compacted and sealed will not contain moulds. Moulds grow once the silage has been exposed to the air for a few days or more. Although not all moulds are harmful, some can cause animal health problems and even death. Never feed mouldy or rotten silage to your animals.

Careful use of the tractor bucket at feed-out time will minimise loosening of silage. If possible, use the bucket to chip down silage then scoop it up from the ground. Avoid digging into the stack as this loosens silage that will not be fed for several days. The first step is to work out how far into the face you need to feed. Next, scoop out the lowest section of silage. Then using the bucket blade, chip down the silage one section at a time starting at the bottom.

Another alternative is to move sideways across the bunker face removing small amounts of silage from the whole face.

Silage grabs and block cutters will assist in keeping the face of the stack or bunker tight.

It is not necessary to lower the silage cover if maize is being fed on a daily basis since it will be impossible to seal the stack. The air that is trapped under the stack tends to heat creating an ideal environment for the growth of mould. Lowering the cover may be advisable during periods of heavy rain or if birds are a problem.

Heating and the subsequent growth of mould when silage is exposed to air can be reduced by using a Pioneer® brand inoculant containing *L. buchneri* such as 11C33. Contact your local Pioneer area manager for more information.

"A slow introduction will allow starch-digesting bacteria levels to increase and will improve utilisation and minimise the risk of gastric disturbances. Animals that have not been fed maize silage previously may take a few days to acquire a taste for it."

Starting to feed maize silage

Introduce maize silage into the diet over a period of 5-10 days. Start by allocating each animal 1-2 kg drymatter and increase the amount that you feed each day. The reasons for gradually introducing maize silage into the diet are numerous.

The rumen of a cow will contain cellulose-digesting and also starch-digesting bacteria. Most of the

sugars in grass are stored as cellulose whereas the grain in maize silage contains high levels of starch. Animals that have been fed totally on grass will have relatively low levels of the starch-digesting and high levels of the cellulose-digesting bacteria. Feeding large amounts of maize silage to cattle that have low levels of starch-digesting bacteria will result in the inefficient use of the maize grain resulting in large amounts appearing in the dung. A slow introduction will allow starch-digesting bacteria levels to increase and will improve utilisation and minimise the risk of gastric disturbances.

Animals that have not been fed maize silage previously may take a few days to acquire a taste for it. Feeding out large quantities of maize silage in the first few days may result in wastage.

Daily feeding

Once maize silage has been introduced to the diet, feed it on a daily basis. No feed will be efficiently used by an animal if it is being added to and removed from the diet at frequent intervals.

Do not feed maize silage in advance. The best time to fill your feedout wagon or bins is immediately prior to the time that you will feed the silage to your cows. Once silage is removed from the stack and loosened, aerobic (air present) spoilage begins.

Heating when silage is exposed to air can be reduced by using a Pioneer® brand inoculant containing *L. buchneri* such as 11C33. Contact your local Pioneer area manager for more information.

Methods of feeding

Farmers are increasingly using feed pads for maize silage feeding. Where a feed pad is not available maize silage can be fed out using a feed-out wagon. The maize silage can be dumped in piles (by remaining stationary and allowing the silage to feed-out), in a line in the centre of the paddock or against a fence line.

The metabolisable energy content of maize silage is largely determined by the percentage of grain present since grain contains 70 percent more energy than stover (the green part of the plant). Time of harvest, fermentation quality and feed-out management will also have an effect on energy content. Some well fermented, high grain content maize silages have metabolisable energy levels in excess of 11.5 MJME /kg DM, i.e. MJ of metabolisable energy per kg of dry matter.

Buying in maize silage

Purchase price

Maize silage is normally traded on a standing basis with the purchaser paying for the harvesting and all subsequent costs. There are two main methods of purchasing a standing crop.

1. On a per kilogram drymatter basis

In this case the grower and purchaser agree upon a standing price (cents per kg of dry matter). Legally, crops that are sold on a weight basis must be weighed on a 'weights and measures approved' weigh bridge. Every load of the crop must be weighed to determine the wet weight. Drymatter samples are collected throughout the harvest period and analysed to determine the drymatter percentage.

Crop wet weight (tonnes) x drymatter (percent) = crop drymatter yield (tonnes)

The advantage of buying a crop on a per kilogram drymatter basis is that you know exactly how much you will be paying for each kilogram of drymatter that you feed. The main disadvantage is that cartage costs may be increased if trucks need to detour to be weighed. Care must be taken to ensure that a representative drymatter sample is collected.

2. On a per hectare basis

The grower and purchaser agree upon a price per hectare prior to crop harvest time. The actual maize silage cost (cents per kg of dry matter) will vary greatly depending on the per hectare price paid and the crop yield.

When a crop is purchased on a per hectare basis, the purchaser gains the advantage of a high dry matter yield and the risk of a poor dry matter yield. Selling on a per hectare basis means that there is no requirement to weigh the crop or to take dry matter samples to determine yield.

Subsequent costs

If a crop is purchased standing the grower is required to pay for further costs such as harvesting, inoculants, cartage, stacking, covering.

11. Summary

The input most frequently found to be deficient in low yielding or unprofitable corn crops is grower management. Every corn grower must learn to set a yield goal at the start of the season before he begins planting. Without a yield goal it is impossible to calculate the correct plant population needed, the amount of fertiliser required, or whether the intended crop will be profitable.

Corn is a crop that offers farmers the prospect of good profit margins provided they are prepared to -

1. Understand the requirements of the crop
2. Plant suitable hybrids at the correct plant population
3. Provide adequate fertiliser inputs
4. Supply the crop with water at the critical growth stages
5. Only grow a manageable area

- Timeliness is an essential element of corn crop management, and most corn crop failures, can be traced back to poor timing of inputs or farming operations associated with that crop.
- Early preparation is another important element of successful corn crops, including ground preparation, fertiliser and water application to ensure yield is not lost.
- Early planting usually gives the highest yields in any area each year because of the longer growing period available to accumulate sugars and starches in early spring.
- A combination of early planting is almost always involved in all high-yielding crops produced by Australia's leading corn growers.
- Corn is a crop that responds to good management, so time and effort spent learning how to grow and manager the crop will result in improved yields and profitability.

It is hoped that the information provided by Pioneer Hi-Bred Australia in this booklet will assist our farmer customers to become better and more profitable corn growers.

NOTES

PIONEER HI-BRED AUSTRALIA PTY LTD

Locked Mail Bag 9001
204 Wyreema Road TOOWOOMBA QLD 4352
Ph: (07) 4637 2966 Fax: (07) 4637 2977

PO Box 104
323 Tullamore Road NARROMINE NSW 2821
Ph: (02) 6889 2299 Fax: (02) 6889 2490