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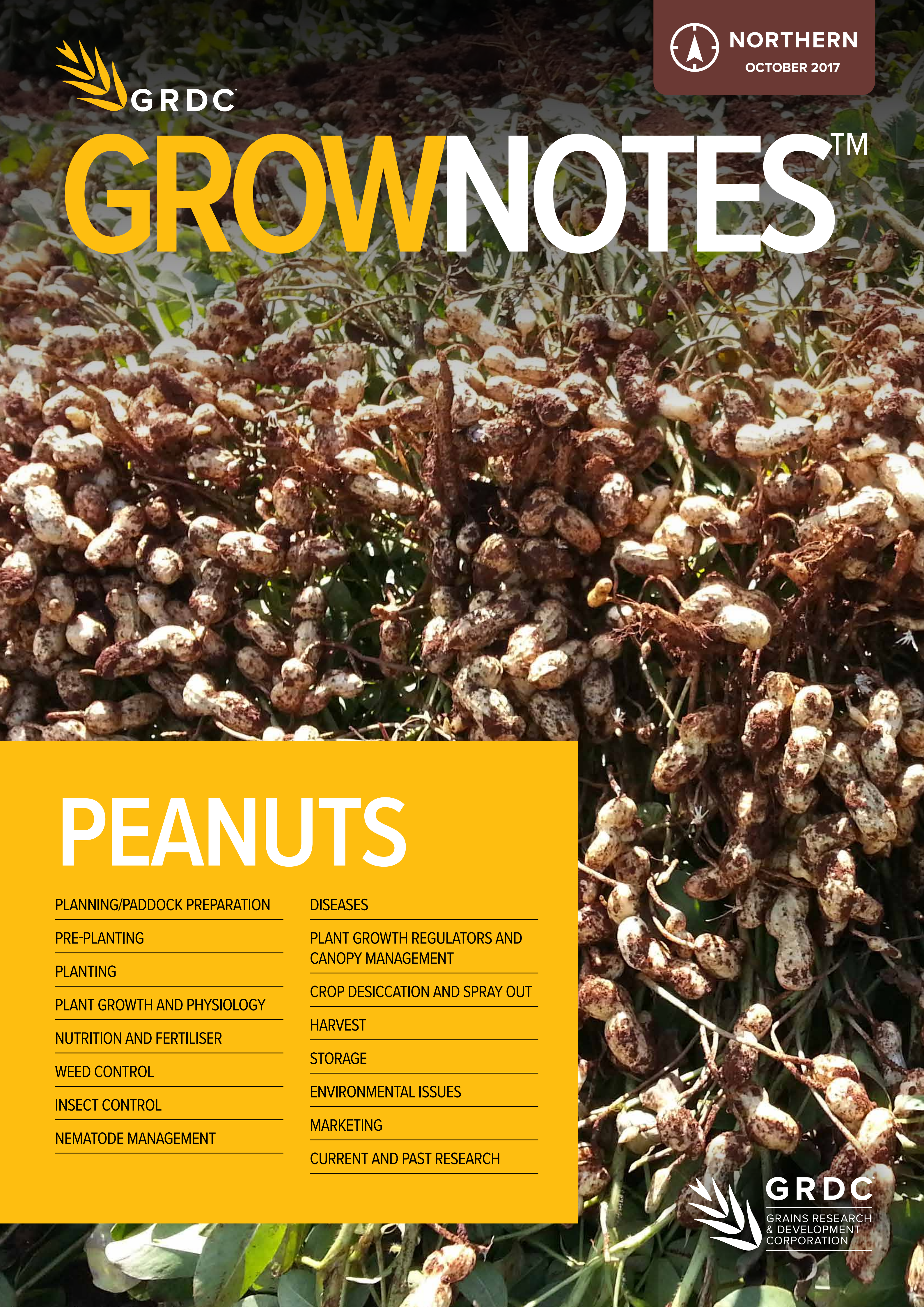
GRDC

GROWNOTES™



PEANUTS

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What's New

The GRDC GrowNotes are dynamic documents that are updated according to user feedback and newly available information.

This version of the GRDC Peanuts GrowNotes (updated October 2017) contains the following updates on original content published in December 2014:

Section Section A – Introduction

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- New link: Research paper: A Greijdanus, M Kragt (2014) The grains industry: An overview of the Australian broad-acre cropping: http://ageconsearch.umn.edu/bitstream/164256/2/WP1400002.pdf
- New link: Agronomy packages take on northern pulse challenge: https://grdc.com.au/resources-and-publications/groundcover/ground-cover-supplements/ground-cover-issue-115-profitable-pulses-and-pastures/agronomy-packages-take-on-northern-pulse-challenge

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- New link: 2017 Australian Nut Conference: http://www.nutindustry.org.au/events.html

Section Section 1 – Planning/paddock preparation

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- New link: Legumes make cane more able: https://grdc.com.au/resources-and-publications/groundcover/ground-cover-issue-115-marapr-2015/legumes-make-cane-more-able
- New link: Rotation cuts the high cost of nematodes: https://grdc.com.au/resources-and-publications/groundcover/ground-cover-issue-119-nov-dec-2015/rotation-cuts-the-high-cost-of-nematodes
- Updated reference: Peanut production guide, August 2015. Peanut Company of Australia: http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

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- New link: SoilWaterApp – a new tool to measure and monitor soil water: https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/SoilWaterApp-a-new-tool-to-measure-and-monitor-soil-water

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- New podcast: Summer cropping: https://grdc.com.au/Media-Centre/GRDC-Podcasts/Northern-Weekly-Update/2014/11/63-north
- New link: Better profits from good soil water decisions (Goondiwindi): https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Better-profits-from-good-soil-water-decisions-Goondiwindi

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- New text: GRDC (2016) Pre-breeding gains lift peanut fortunes: https://grdc.com.au/resources-and-publications/groundcover/ground-cover-issue-122-may-jun-2016/prebreeding-gains-lift-peanut-fortunes

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- New text: Peanut Company of Australia (2016) Annual report 2016: http://www.pca.com.au/wp-content/uploads/2016/11/annualreport2016.pdf

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- New text: GRDC (2017) Commercial inoculants compatible with new varieties: https://grdc.com.au/resources-and-publications/groundcover/groundcover-issue-127-marchapril-2017/commercial-inoculants-compatible-with-new-varieties

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- New section: Declining soil fertility

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- New link: The what where and why of soil testing in the northern region: https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/The-what-where-and-why-of-soil-testing-in-the-northern-region

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- New link: The want and waste of the nitrogen economy: https://grdc.com.au/resources-and-publications/groundcover/ground-cover-supplements/ground-cover-issue-123-more-profit-from-crop-nutrition-2/the-want-and-waste-of-the-nitrogen-economy

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- New text: GRDC (2017) Lost nitrogen and what you can do: https://grdc.com.au/resources-and-publications/groundcover/ground-cover-issue-123-julyaugust-2016/lost-nitrogen-and-what-you-can-do

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- New link: Phosphorus and potassium nutrition: https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/02/phosphorus-and-potassium-nutrition

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- New link: The what where and why of soil testing in the northern region: https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/The-what-where-and-why-of-soil-testing-in-the-northern-region

Section Section 6 – Weed control

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- New link: GRDC Fact Sheet: Pre-harvest herbicide use: http://www.grdc.com.au/GRDC-FS-PreHarvestHerbicide
- New link: GRDC Tips and Tactics: Reducing herbicide damage: https://grdc.com.au/resources-and-publications/all-publications/factsheets/2017/02/reducing-herbicide-damage

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- New text: Weekly trap catch data for *H. punctigera* and *H. armigera* from locations across all states: https://jamesmaino.shinyapps.io/MothTrapVis/

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- New link: Mungbean and soybean insects: https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/06/mungbean-and-soybean-insects

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- New link: GRDC Tips and Tactics: Root-lesion nematodes: https://grdc.com.au/TT-RootLesionNematodes

Section Section 9 – Diseases

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- New video: GCTV14: Peanut disease resistance: https://www.youtube.com/watch?v=a53hM-cGJYE

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- New link: New research investment to tackle peanut disease: https://grdc.com.au/resources-and-publications/groundcover/ground-cover-issue-115-marapr-2015/new-research-investment-to-tackle-peanut-disease
- New text and photos: AM Rago, LI Cazón, JA Paredes, JPE Molina, EC Conforto, EM Bisonard, C Oddino (2017) Peanut smut: from an emerging disease to an actual threat to Argentine peanut production: http://apsjournals.apsnet.org/doi/pdf/10.1094/PDIS-09-16-1248-FE

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- New link: Stored Grain Information Hub: http://storedgrain.com.au/
- New link: Part I Achieving great aeration results and Part II Silo recirculation as an aid to fumigation: https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/07/Part-I-Achieving-great-aeration-results-and-Part-II-Silo-recirculation-as-an-aid-to-fumigation

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- New contact: Grain Storage Information Hotline: 1800 WEEVIL (1800 933 845)
- New link: Grain Storage Fact Sheet: Stored grain pests identification: https://grdc.com.au/resources-and-publications/all-publications/factsheets/2013/06/grain-storage-fact-sheet-stored-grain-pests-identification

Section Section 14 – Environmental issues

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- New text: GRDC (2016) Managing frost risk. Northern, Southern and Western Regions: https://grdc.com.au/resources-and-publications/all-publications/factsheets/2016/02/managingfrostrisk
- New text: J Christopher, B Zheng, S Chapman, A Borrell, T Frederiks, K Chenu (2016) An analysis of frost impact plus guidelines to reduce frost risk and assess frost damage: https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/07/An-analysis-of-frost-impact-plus-guidelines-to-reduce-frost-risk-and-assess-frost-damage

Section Section 15 – Marketing

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- New trading standards: Australian Oilseeds Federation. Quality Standards, Technical Information & Typical Analysis 2017–18: http://www.graintrade.org.au/sites/default/files/file/Commodity Standards/2017-2018/2017-18 AOF Standards V16_1 August 2017 (FINAL).pdf

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MORE INFORMATION

A general summary of the Australian grain growing regions is available at A Greijdanus, M Kragt (2014) The grains industry: An overview of the Australian broad-acre cropping

Agronomy packages take on northern pulse challenge

Introduction

A.1 Agronomy at a glance

- Returns for peanuts depend on yield and quality. Best returns are obtained under reliable rainfall or irrigation with intensive management. Most types of irrigation can be used, including sprinkler systems and furrow irrigation. Successful furrow irrigation requires good land levels and raised beds.
- Peanuts prefer sands, sandy loams and light clay loams (Photo 1); pod losses can be high in heavy or sticky soils.
- In high risk areas, all new paddocks must be assessed for pesticide and heavy metal residues prior to planting.
- Planting usually occurs from October to January in Queensland and New South Wales (NSW). In the Northern Territory, winter plantings occur in March–April, while summer plantings are also possible from October–January. Crops take about 5 months to grow; however, early-maturing varieties taking about 4 months to grow are also available. Planting should be timed so that harvesting is conducted in relatively dry conditions.
- The minimum soil temperature required for germination is 18°C, measured at 50 mm depth at 9 a.m.
- The crop's maturity is assessed to determine harvesting time. Harvesting is a two-part operation. First, the taproot is cut and the plant shoots and peanut pods are inverted to partially dry in the field for several days before a separate threshing operation is done.
- Optimum threshing occurs at a pod moisture content of 12–16%. Controlled drying brings the peanuts slowly to a safe storage moisture content and ensures optimum quality. Extended periods of paddock drying can cause higher losses, more splits, poorer quality and increased risk of rain damage.
- Peanuts should form part of a sustainable farming system in rotation with a grass or cereal crop. [1]

1 PCA. Are you interested in growing peanuts? Peanut Company of Australia, http://www.pca.com.au/interested-in-growing-peanuts/

MORE INFORMATION

[Are you interested in growing peanuts?]

Photo 1: *Growers are advised to research best practice management to maximise peanut production.*

Photo: Graeme Wright, PCA)

A.2 Crop overview

The peanut or groundnut (*Arachis hypogaea*) is an annual legume crop originating from South America. Peanuts grow on a small bush or vine. The crop takes 4–6 months to grow, depending on the variety and region planted.

The Australian peanut industry has about 160 growers including North, Central and southern Queensland, and northern NSW (Figure 1).

Australia produces about 40,000 tonnes (t) of farmer stock peanuts annually, which represents only about 0.2% of the world's peanut production. More than 90% of Australia's peanuts are grown in Queensland. The industry is based on the large-seeded Virginia varieties and medium to large seeded Runner varieties. Plantings are ~one-third Virginia and two-thirds Runner types. Some new ultra-early varieties with Runner-type kernels are also planted.

The size of the domestic market for peanuts is ~50,000 t of pods annually.

Australia is one of the few peanut-producing countries where imports are freely permitted. The price that growers receive for their crop is therefore significantly influenced by world prices. [2]

An 'off' flavour problem was detected in peanuts from North Queensland's Tolga region in 2008 and 2009. The cost to the Australian peanut industry was more than $1 million in downgraded product. This musty, earthy taste had never been detected in peanuts anywhere, and Australian peanut exports were affected.

The exact cause of the taste has yet to be confirmed, but changes resulting from research supported by the Grains Research and Development Corporation (GRDC) to the way peanuts are delivered, shelled and stored appear to have largely resolved the issue.

A raft of changes were implemented in response to the problem, including a 0.5% lower kernel moisture content at delivery, and better overall harvesting management

2 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

on-farm have reduced the severity of the problem. The GRDC-funded study has wider implications for farmers in northern Queensland, because the growing of potatoes and peanuts in rotation could also be a factor. [3]

Figure 1: *Peanut production areas of Australia . (Note, there is no current production in the Ord region.)*

A.3 Executive summary

Peanuts are a robust and drought-tolerant plant, but they will not return a healthy profit to the grower unless they receive adequate water and nutrition, and protection from weeds and diseases. Growers are paid on the weight and quality of peanut kernels.

Peanuts can be grown on a wide range of soils, provided the surface soil (the top 15–20 cm) is reasonably friable. Suitable soil types include sands, sandy loams and silty loams. In Australia, peanuts have traditionally been grown as high-value crops on the red clay loams (Krasnozems) of the South Burnett and Atherton Tableland in Queensland. Peanuts can be grown in a wide range of tropical and sub-tropical environments in Australia, and contribute favorably as a nitrogen (N)-fixer in rotation with sugarcane, cotton and cereals.

The GRDC also supports the peanut industry by funding research and extension projects. [4]

MORE INFORMATION

2017 Australian Nut Conference

VIDEOS

GCTV14: Coastal Grower Solutions Group

3 C Collis (2012) Peanuts back in flavour but mystery lingers. Ground Cover, Issue 97, March–April 2012, GRDC, http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-97-March-April-2012/Peanuts-back-in-flavour-but-mystery-lingers

4 GRDC (2013) Peanut off-flavour. GRDC Fact Sheet, www.grdc.com.au/GRDC-FS-PeanutOffFlavour

Planning/Paddock preparation

1.1.1 Peanut production season plan

A crop management table is a valuable tool for planning the peanut cropping season (Figure 1).

Crop stage-weeks			0	2	4	6	8	10	12	14	16	18	20	22
Ground preparation	Deep ripping													
Fertiliser	Soil test	Lime and/ or pre-plant fertiliser			Gypsum									
Planting			Plant											
Weed control		Pre-plant incorporated	Pre-emergent	Post-emergent applications										
Foliar disease control					Regular scheduled applications of foliar fungicides for leafspot, rust, net blotch									
Sclerotinia control														
Irrigation requirement			HIGH	LOW		HIGH							MODERATE	
Digging										Digging				
Threshing											Threshing			
Growth stage for a 20 to 22 week variety			Emerge	Vegetative growth										
					Flowering and pegging									
							Pod development							
													Wheeler	
													Middleton	
													Menzies	
													Holt	
										Redvale		Page		

Figure 1: *Peanut crop management table.*

Source: PCA [1]

Use the following checklist to ensure that you complete each of the operations at the correct time.

1 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

VIDEOS

Planter calibration

2010 Peanut Planting

Boomspray calibration

Pre-season

- Carry out soil tests and have results interpreted by a qualified agronomist.
- Determine whether a soil ameliorant such as gypsum or lime is required.
- Forecast likely input requirements (pesticides, fungicides, inoculants, seed) and plan procurement.
- Determine your desired planting date based on the seasonal forecast and risk.
- Determine your deadline for planting. If this deadline is reached and it has not rained, pre-water your paddock.
- Plan and budget an irrigation schedule.
- Calculate and plan machinery requirements.
- Calibrate planter and fertiliser equipment and plan for recalibration between paddocks.
- Calibrate boom spray and check nozzles.
- Determine which variety best suits your conditions and order seed.

Ground preparation

- Deep-rip your paddock.
- Prepare an even seedbed to ensure that it has good tilth.
- If soil ameliorants are required, they should be applied 1–3 months before planting.
- If granular magnesium or zinc is required, apply at least 2 weeks before planting.

Week 0: planting

- Ensure good moisture for planting and germination.
- If using peat inoculants, ensure that they are kept in a cool place (Esky or fridge).
- If using dry inoculant, sprinkle some into the planter box. Half-fill the box with seed (gently) and sprinkle some more inoculant over the seed. Fill the box with seed and sprinkle with some more inoculant.
- Seed placement, depth and calibration should be checked at regular intervals during planting.
- Applications of S-metolachlor (Dual®) are recommended as a post-plant pre-emergent herbicide in most situations. Application needs to be finished as soon as possible after planting (1–2 days) prior to seedling emergence.
- In irrigation systems, S-metolachlor needs to be watered in within 10 days of application, although 5 days is preferred to help ensure good crop emergence.
- Irrigation scheduling plan should be in place.

Week 1: cracking

- Cracking describes when the peanuts are just about to emerge. They start to push through the soil and the rows become visible.
- If the soil is dry or there is a hard crust, irrigation at this time can be beneficial to ensure good emergence.
- If weeds have emerged before the peanuts emerge, consider an application of a knockdown herbicide with no residual, such as paraquat.

Weeks 2 and 3: crop establishment

- Crop should be fully emerged.
- Scout for soil insects and foliar insects, especially *Helicoverpa*. Scout for cutworms (*Agrotis* sp.)
- Generally, no irrigation is recommended at this stage. It may be beneficial to stress the crop.

Weeks 4 and 5: flowering

- Flowering has started.

- Spray any weeds with post-emergent herbicides as recommended by your agronomist.
- Do not irrigate when the very first few flowers appear because it will stress the crop, reducing potential yield.
- Apply protective fungicide applications as recommended by your agronomist.
- If required, apply foliar fertilisers, especially copper (on very sandy soils) and zinc.
- If required, apply gypsum at 1–2 t/ha. Consult your agronomist for more information.
- Scout for foliar insects, especially jassids, leafhoppers, mites and *Helicoverpa*.

Weeks 6 and 7: main flowering

- This is the start of the main flowering and the start of the logarithmic (fastest) growth phase when the peanuts begin to grow very rapidly.
- In irrigation systems, irrigation is essential at this stage because it is when the crop's yield potential is set.
- Use your irrigation to try to fill the soil profile. This may involve two waterings in quick succession.
- Scout for foliar insects and foliar disease.
- Spray appropriate fungicide as needed.
- If inter-row cultivation is needed (e.g. hardsetting soil, weeds), it is best performed no later than at this stage.

Weeks 8 and 9: pegging

- Ensure that you follow your irrigation schedule (crop stress during pegging and podset can be detrimental to yield).
- Pull up two or three bushes to check the pegging and development.
- Scout for foliar insects and diseases.
- Spray appropriate fungicide as needed.
- Spray with foliar fertilisers.
- If Sclerotinia blight could be a problem, spray a protectant fungicide at this time.

Weeks 10 and 11: pegging and pod-setting

- Check schedule if growing peanuts under irrigation.
- Pull up some bushes to check development.
- Scout for diseases and insects.
- Make sure harvesting equipment is properly repaired and maintained.

Weeks 12 and 13: canopy closure and pod-setting

- The crop should reach full canopy closure by week 12, and it should now be setting its peak yield potential.
- The crop factor in your irrigation schedule should now increase to 1.0 (this means the crop will lose as much water as an open pan of water placed in the sun and wind).
- Scout for diseases and insects and spray as necessary.
- Spray with foliar fertilisers as required.

Weeks 14 and 15: pod-filling

- Keep the water up to the crop. Check your irrigation schedule.
- Pull up some bushes to check pod development.
- Scout for insects, especially armyworms (*Spodoptera sp.*), which stay at or just below ground level during the day but feed on pegs during the night.
- Scout for disease, especially rust. Look carefully for raised coppery pustules on the back of leaves.

Weeks 16 and 17: pod-filling and early maturity

- Keep the water up to the crop.
- Scout for disease.
- At the end of week 17, check for signs of maturity. Pull up some bushes up to check for maturity.
- Early-maturing varieties may be fully mature by this time in some environments.

Weeks 18 and 19: maturity and digging

- Water use of the crop may start to lessen during this phase, but dig around under some plants and check the moisture status.
- You still need to keep the crop moist to avoid aflatoxin and to help fill out any later setting pods.
- Check for maturity.
- Scout for any signs of disease.

Weeks 20 and 21

- Check maturity using the hull scrape test and double-check any pods you are unsure of by using the shell-out technique.
- Test maturity in the paddock by running some strips with the digger. Check for losses and maturity.
- Make sure the digger is working properly. The elevator chain speed should be slightly faster than the forward speed of the digger.
- Step down from the tractor regularly to check under the windrow for losses. Try to get good inversion.
- If you are dealing with large areas, it may be best to dig initially a portion that you can comfortably harvest with the thresher.

Harvest

- To avoid aflatoxin contamination, peanuts should remain in the windrow for no more than 3 days.
- Ideal moisture content for threshing, to avoid losses and damage to the kernels, is 12–16%.
- Take samples from the windrow and check the moisture content.
- The speed of the pickup head should match the forward speed. This allows the windrow to be picked up without separating or over-running the inverted bushes.
- Check cylinder speeds regularly; they may have to be adjusted as windrow conditions change during the day.

Pre-cleaning

- Pre-clean your peanuts to remove dirt, sticks, weeds and other extraneous matter.
- Pre-cleaning will also remove many loose shell kernels and immature pods and so decrease the risk of aflatoxin contamination.

Curing

- Ensure that peanuts are adequately pre-cleaned.
- Start drying within 3 h of threshing to prevent aflatoxin development.
- Make sure air temperature in the plenum does not exceed 11°C above ambient temperatures (up to a maximum of 35°C).
- Check that the moisture removal rate does not exceed 0.5% per h.
- The relative humidity of the drying air should be 50–65%.
- Regularly check the temperature and relative humidity in the air tunnel.

MORE INFORMATION

PCA. Peanut production season plan—checklist.

VIDEOS

Soils and challenges

- Regularly check the moisture content of the peanuts. [2]

1.2 Paddock selection

1.2.1 Rotations

When choosing paddocks, rotations past and future should be considered. Peanuts preferably should be rotated with a grass or cereal crop [3] to increase sustainability, reduce disease and make the most use of excess nitrogen (N).

A good crop rotation, avoiding a peanut monoculture, will lower disease levels, which can increase dramatically when peanuts follow peanuts. There is some evidence that peanuts following potatoes have a higher risk of contamination with off-flavour volatile compounds. A genus of actinomycete, *Streptomyces*, is known to produce the volatile compounds associated with off-flavour; these bacteria are present in immature and/or decomposing potatoes, which can lead to a high number of actinomycete spores in the soil. Immature potatoes left after harvest can be roughly the same size as mature peanut pods, and are sometimes harvested with the peanuts. *Streptomyces* on these immature potatoes can be transferred to storage bins, along with the potatoes, during harvesting. [4]

1.2.2 Soils

Peanuts require well-drained, friable soils such as sandy loam, silty loams, and friable clay loam. The preferred soil types for growing peanuts are sands, sandy loams and light clay loams. Peanuts will grow on heavier soils, but harvest losses tend to be high in heavy or sticky soils. [5]

The history of all paddocks new to peanut cropping should be considered; there may be a need to test for heavy metals and pesticides prior to planting (see *Pesticide history* below).

In Australia, peanuts have traditionally been grown on the red clay loams (Ferrosols) of the South Burnett and Atherton Tableland. These soils are naturally friable and have a good water-holding capacity. However, peanuts can be grown on a wide range of soils, provided the surface soil (top 15–20 cm) is reasonably friable.

Soils prone to waterlogging should be avoided because peanuts do not tolerate long periods of waterlogging. Planting on raised beds can help to alleviate minor waterlogging problems.

Heavy clay soils or hardsetting soils that break into large clods should be avoided because pods may be torn off the bush at digging. These loose pods cannot be recovered by the harvester. Heavy soil conditions may lead to high levels of extraneous material in the load, which will incur penalties.

Heavy clays may also become non-trafficable for long periods because of wet weather. This can cause harvesting delays and potential yield losses. [6]

1.3 Paddock history

To be successful, peanuts must form part of a sustainable farming system. New paddocks that have never grown peanuts may be able to produce two consecutive peanut crops. However, the best system involves growing peanuts once every 2 or 3 years on the one paddock with a grass or cereal crop as the rotation species. Good

2 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

3 Peanut Company of Australia, http://www.pca.com.au

4 GRDC (2013) Peanut off-flavour. GRDC Fact Sheet, www.grdc.com.au/GRDC-FS-PeanutOffFlavour

5 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

6 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

rotation crops for peanuts include sugarcane, maize, Rhodes grass (*Chloris gayana*) and sorghum. [7]

Peanut yields are maximised by rotating with other crops over a 3-year period. Peanuts fix N into the soil; however, they also remove other essential nutrients, which need to be replaced to ensure that yield potential is achieved.

Some farmers grow peanuts for two seasons in one paddock and then rotate out to other crops for three to five seasons.

Another reason why growers are encouraged to adopt a regular rotation of crops with peanuts is to avoid build-up of weed, disease and insect problems, which occur under any system of monoculture.

Crops such as potatoes, navy beans or soybeans are not ideal in long-term sustainable rotations with peanuts because they tend to host many of the same pest and disease problems.

1.3.1 Paddock history trials

Between 1983 and 1996, a trial at the Redvale, in the Kingaroy region, examined effects of various crop rotations and ley pastures on peanut productivity and crop value, and on the incidence of known peanut pathogens. On average, peanut crops yielded 25% higher in rotations than in a monoculture, but the quality of harvested pods was unaffected by rotation. There was no additional yield response to rotation breaks longer than a single year, and no additional response to grass leys over alternate crops. Incidence of known peanut pathogens was significantly affected by rotation, but the impact of these pathogens on crop yield was strongly related to in-crop rainfall and resultant seasonal yield potential. Gross returns from peanut crops in a monoculture were $177 per ha lower per tonne of potential yield than in crop rotations. The findings have been used as a basis for optimising rainfed peanut farming systems for long-term viability and sustainability. [8]

The relatively high yield potential of the crop (up to 5 t dry pods/ha in good seasons) and the excellent prices for quality produce (up to $850/t dry pods) have made peanuts very attractive to farm managers. Often, however, this results in the crop being grown too frequently in the crop rotation in an effort to maximise returns, with a consequent increase in soil-borne pathogens and relatively poor crop performance.

Several overseas studies have demonstrated the need for substantial breaks between peanut crops grown in the same field. In Georgia, USA, for example, increasing periods without peanuts from 1 to 3 years resulted in commercial peanut yields 11–25% (dryland) and 7–36% (irrigated) higher than under peanut monoculture. However, studies have also shown that rotations, particularly under irrigation, were often shorter than optimal because the most successful rotation crops (e.g. cereals and grass leys) were generally of much lower economic value. As Australian farmers face increasing economic pressures, peanut producers face similar temptations to shorten the peanut rotation.

The initial study at Redvale compared a peanut monoculture with peanuts grown after 1 or 2 years of cropping maize, or after 1, 2, 3 or 4 years of grass pasture ley (Rhodes grass). Two replicate plots of each treatment were sown in each of three consecutive seasons. The repeated treatment series was used to sample the response across a range of climatic conditions. In the initial peanut crop after the rotation breaks, plots were split with treatments of either 0 or 4 kg carbofuran/ha to quantify the role of nematodes (*Pratylenchus brachyurus*, root-lesion nematode; and *Meloidogyne hapla*, root-knot nematode) in crop productivity responses. Soil was conventionally tilled prior to sowing each crop and basal nutrients (N, phosphorus, potassium) were applied to meet crop requirements.

7 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

8 M Bell, G Harch, J Tatnell, K Middleton (2003) The impact of crop rotation on peanut productivity in rainfed cropping systems. Australian Agronomy Conference, http://www.regional.org.au/au/asa/2003/c/5/bell.htm

Once returned to peanuts, plots were maintained in monoculture for three successive seasons to quantify residual effects of breaks. After the third peanut crop, subplots were either continued in peanut monoculture or sown to a crop rotation comprising soybeans, maize and peanuts. Opportunity sowings of winter oats (*Avena sativa*) were made after each legume crop in this rotation whenever rainfall permitted, with biomass incorporated as a green manure at the early boot stage. The peanut monoculture plots were split to treatment with and without winter oats.

Soil (0–30 cm, in 10-cm increments) was collected from subsets of plots immediately prior to planting in each season, to assess nematode numbers and soil chemical properties. Plant establishment and mortality data were recorded during most seasons, numbers of nematodes in peanut roots were determined ~6 weeks after planting, and plots were scored for the incidence and severity of symptoms caused by known soil-borne pathogens midseason and at maturity. Gross returns from peanut cropping were determined using commercial grading standards and current crop values. Crop rotations (peanuts following 1 or 2 years of grass ley or maize, or following a rotation with soybeans, oats and maize) were compared with monoculture peanuts in terms of pod yields and gross margins (derived using average costs of production from each crop and current input costs).

Peanut yields and crop value varied markedly between growing seasons (Figure 2). Yield was more responsive than crop value to breaking the monoculture. The results demonstrated that average gross returns ($/ha) were 30% higher in the break treatments than in the peanut monoculture. No aflatoxin was recorded in any year, and this was reflected in consistently high crop values.

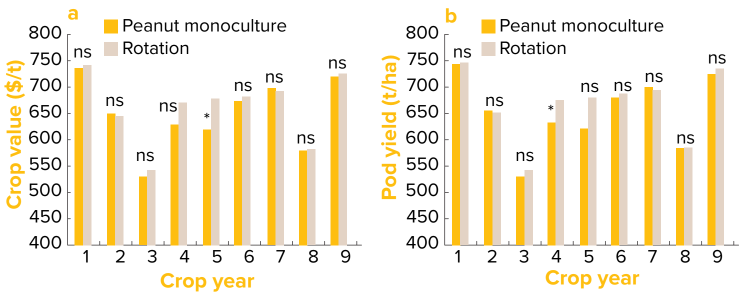

Figure 2: *(a) Crop value ($/t) and (b) pod yield (kg/ha) for peanut crops in the study at Redvale, Kingaroy. * Indicates statistical significance (P<0.05); ns, no significant differences.*

This study produced no evidence that breaks of longer than one summer season (i.e. peanuts grown every second year) were necessary to maximise crop yields and crop value (initial study phase, Table 1). Grass leys were no more effective in raising peanut productivity than rotating to maize cropping. The alternate rotation in the second phase of the study (peanuts–oats–soybeans–oats–maize–fallow–peanuts) produced significant increases in crop productivity compared with continuous peanut cropping (Table 1). Comparisons were limited by the wider range of break durations in the ley treatments than in the maize cropping (1–4 years *v.* 1–2 years). However, this limited sampling indicated that grass leys >2 years produced no additional benefits in terms of peanut yield or crop value.

Data clearly showed that introducing a winter green manure crop (oats) into a continuous summer peanut cropping pattern, as practiced in some of the newer production areas under irrigation, had no positive effect on yields or crop value. Yields were significantly lower than in the peanuts–oats–soybeans–oats–maize rotation (Table 1).

Table 1: *Effect of break duration and break type on peanut yield (t pods/ha) and crop value ($/t).*

Rotation	Years out of peanuts	Peanut yield (kg/ha)	Crop quality ($/t)
Initial phase of study			
Continuous peanut	0	1.53	$643.2
Maize	1	1.86	$630.0
Maize	2	1.98	$635.9
Grass ley	1	1.88	$648.2
Grass ley	2	1.84	$653.2
l.s.d. (P = 0.05)		0.21	ns
Second phase of study			
Continuous peanuts, winter fallow	0	2.28	$650.9
Continuous peanuts, winter oats	0	2.28	$659.7
Crop rotation (peanuts, oats, soybeans, oats, maize)	3	3.07	$670.4
l.s.d. (P = 0.05)		0.25	ns

Because there was no differentiation between break types (grass or maize) in terms of subsequent peanut productivity, data were pooled within years and an assessment was made of the residual effect of the breaks upon return to peanut monoculture. This is an important issue, because growers recognise the need to grow break crops but also want to maximise the frequency of the high-value peanut crop in the rotation. The analysis (Figure 3) clearly shows that the maximum benefit of a break was captured in the first peanut crop, with an average yield increase of 26%. Significant residual benefits persisted for only the second and third peanut crops after the break; these benefits were reduced to less than half those recorded in the initial peanut crop.

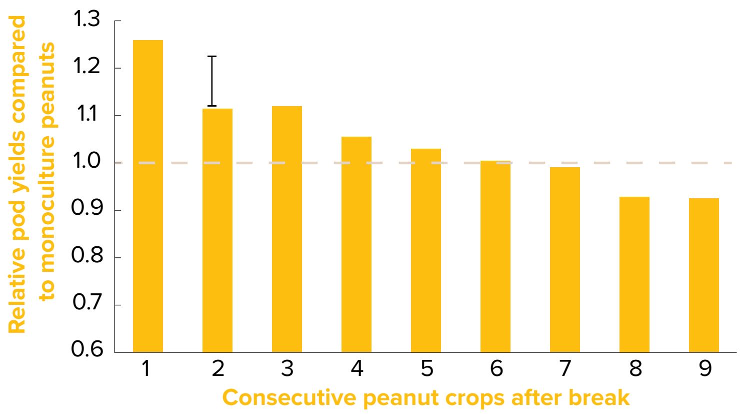

Figure 3: *Combined analysis of the residual effect of crop rotations on pod yields after a return to peanut monoculture. Length of capped line indicates significant differences (P < 0.05).*

Relationships between the potential yields in each season (yields in rotated plots) and the loss in yield or gross returns (yield × crop value) resulting from employing a monoculture were derived using regression techniques. These relationships suggested that 0.24 t pods/ha or $177 gross return/ha would be lost for each tonne of peanut yield potential in a monoculture compared with adequate rotations (R^2 = 0.81 and 0.80 for yield and gross return loss relationships, respectively). Losses in gross returns would obviously increase where crop values were greater than the average $640/t recorded during this study (e.g. under irrigation).

There was no evidence of any rotation responses resulting from changes in soil chemical fertility, as evidenced by plant nutrient status. This was not surprising considering the generous fertiliser applications used during the study. Grass leys were shown to affect soil physical fertility, in particular the ability of soils to resist crusting and allow rainfall to infiltrate. However, these changes had little impact on soil water during subsequent growing seasons and resultant yields of the peanut crops. This was due to a combination of intensive tillage after the ley minimising differences in soil structure, and the high rates of internal drainage and low plant-available water storage in these soils. Therefore, the measured peanut rotation responses were more likely due to impacts on soil health, in particular to the incidence of soil-borne peanut pathogens.

Several known soil-borne peanut pathogens were present at the experimental site during the study, including root-lesion and root-knot nematodes, crown rot (causal organism *Aspergillus niger*), Verticillium wilt (causal organism *Verticillium dahliae*), collar rot (causal organism *Lasiodiplodia theobromae*) and Sclerotinia blight (causal organism *Sclerotinia minor*). The incidence and severity of all of these organisms varied with season (e.g. Sclerotinia blight was evident only in the relatively wet 1993–94 season). The incidence of several of these organisms was affected by crop rotation (e.g. Table 2), and the combined contribution of all of the known pathogens to variation in peanut yield within any one season ranged from 5% to 50%. The smallest contribution to yield variation by these organisms occurred in the poor seasons (years 2, 5 and 8 in Figure 2b), when the predominant yield-limiting factor was water deficit.

Table 2: *Effect of crop rotation on the incidence of selected pathogens in the following peanut crop in crop years 7 and 9 (from Figure 2).*

	Continuous peanut, winter fallow		Continuous peanut, winter oats		Peanut rotated with soybean, oats, maize	
Pathogen or disease	**Year 7**	**Year 9**	**Year 7**	**Year 9**	**Year 7**	**Year 9**
Root-knot nematodes (/g DW root)	465a	1580a	690a	1775a	32b	29b
Root-lesion lesion nematode (/g DW root)	480	215	668	63	376	201
Verticillium wilt at harvest (% plants)	16.5a	47.8a	4.4b	37.8ab	3.7b	23.1b
Sclerotinia blight at harvest (% plants)	0	5.8a	0	3.6a	0	15.9b
Plant mortality due to crown rot (% plants)	23.7a	20.7a	24.6a	17.8a	1.6b	6.3b

Between rotations for the particular pathogen and growing season, means followed by the same letters are not significantly different

Seasonal rainfall conditions have the greatest impact on productivity of rainfed peanut crops in the inland Burnett. However, crop rotations involving a year without peanuts in each field will consistently result in greater peanut yields and gross returns than in peanut monocultures, with residual benefits persisting for a further two peanut crops. Rotations significantly reduced the incidence of known peanut pathogens, with the greatest benefits in terms of yield and returns occurring in high-yielding seasons.

VIDEOS

Legumes in cane

Rotations and benefits

MORE INFORMATION

Legumes make cane more able

Rotation cuts the high cost of nematodes

Peanut Company of Australia.

Australian Pesticides and Veterinary Medicines Authority.

These findings will form the basis of economic analyses to determine the optimum peanut frequency in the cropping systems of this region. [9]

1.3.2 Pesticide history

Organochloride residues in the soil and heavy metals can be a major problem for growing peanuts. The peanut fruit or pod grows directly in the soil and takes up many of its own nutrients through the pod wall. Consequently, pesticide residues and heavy metals are often taken directly into the peanut as it grows. This may then render the peanut unfit for human consumption. All new paddocks should be tested for pesticide residues prior to planting peanuts. [10] For more information, check with your processor.

1.4 Benefits of peanuts as a rotation crop

Peanuts have been shown to have beneficial effects on follow-up crops of sugarcane and cotton.

In sugarcane, peanuts can provide a break in cane monoculture, resulting in a reduction of pathogens and healthier cane stools, as well as boosting N available to the follow-up crop and improving soil structure. Peanuts also have the potential to lengthen ratoons in the follow-up cane crop. According to 2006 data from the (then) Queensland Department of Primary Industries and Fisheries, cane yields were boosted by at least 20% over the whole crop cycle. [11]

In 2005–06, peanuts were found to fix 60–90 kg N/ha in a rotation that included cotton and wheat, at Bonshaw in northern NSW. Peanuts were also thought to assist with control of nutgrass. [12]

1.5 Disadvantages of peanuts as a rotation crop

Peanuts require significant soil disturbance to reduce harvest losses (deep ripping, inter row-cultivation), making them unsuitable as a rotation crop in a full no-till situation.

Peanuts have limited herbicide options both pre- and post-emergent, so where herbicide-resistant weeds are present, peanuts may not be suitable.

As a legume, peanuts are unsuitable as a rotation with other legume crops because of the likelihood of shared pest and disease build-up.

1.6 Pre-plant weed control

Depending on the weed spectrum, weed control pre-planting can be achieved by using trifluralin or pendimethalin incorporated. [13]

1.7 Potential crop contaminants

PCA requires that all new paddocks be tested for pesticide and heavy metal residues prior to planting. These tests can be carried out at PCA's Innovation and Technical Centre. [14]

Please check the requirements of your chosen processor.

9 M Bell, G Harch, J Tatnell, K Middleton (2003) The impact of crop rotation on peanut productivity in rainfed cropping systems. Australian Agronomy Conference, http://www.regional.org.au/au/asa/2003/c/5/bell.htm

10 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

11 PCA. Benefits of peanuts in cane rotation. Peanut Fact Sheet. Peanut Company of Australia.

12 PCA. Cotton growers: have you considered peanuts? Peanut Fact Sheet. Peanut Company of Australia.

13 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

14 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

1.8 Seedbed requirements

Carefully preparing the soil is an important part of successfully growing peanuts. Peanuts prefer a weed-free, moderately fine seedbed. Because they develop an extensive root system, deep ripping to break up soil compaction may be necessary. Peanuts also require loose soil in which to peg (i.e. re-enter the soil to develop underground nuts). [15]

Peanuts produce a deep taproot capable of exploiting moisture and nutrient reserves deep in the profile. Consequently, soils prepared for peanuts should be free of any hard pans or compaction layers. Deep ripping is recommended to at least 30 cm depth in heavier soils.

Peanuts have large seed and do not require a particularly fine seedbed, but good soil–seed contact is essential to encourage rapid and even germination. Press-wheels on the planter are essential.

To encourage good crop establishment, the seedbed should be relatively even and free from weeds and excess stubble. Some growers are adopting minimum tillage practices to protect the soil surface from erosion and to improve soil structure. Discuss the implications of minimum tillage with your agronomist.

Peanuts have been traditionally planted in rows 90 cm apart, as the standard row configuration and preferred spacing to minimise losses during harvesting. Most harvesting equipment is designed to handle rows 90 cm apart; despite this, some growers have planted row spacings ranging from 65 to 100 cm. Some growers have used a twin-row planting configuration for plantings. Four rows are planted with the two outside rows 90 cm apart, and the two inside rows 70 cm apart. This configuration leads to faster canopy cover, reducing weed pressure, and generally improving yields. Twin row is particularly appropriate for ultra-early varieties.

Peanuts are normally planted on flat ground, but planting single rows on a hill or two rows on a bed can assist the digging process and improve drainage in wet areas. [16]

VIDEOS

Crop modelling and Aquaman

Water use and efficiency

1.9 Soil moisture

Peanuts are considered a relatively drought-tolerant crop. They have various physiological mechanisms for avoiding the effects of drought and an extensive root system able to exploit moisture reserves at depth. Even in drought seasons, peanuts will nearly always produce some yield. However, few growers can afford mediocre yields because of the high input costs. Peanuts are best grown where the rainfall is reliable or where access to irrigation is available.

1.9.1 Dryland

Peanuts produce a yield even during dry seasons; however, in a dryland situation they need to be grown in a summer-dominant rainfall area of ~500 mm/season to reduce risk of negative gross margins.

Even during drought, peanuts will nearly always produce some yield, but few growers can afford mediocre yields because of the input costs.

To reduce risk in dryland situations, seasonal forecasts must be taken into account, and the option of supplementary irrigation is preferable as a backup. [17] Peanuts need 600–700 mm of water over the season for a high-yielding crop.

MORE INFORMATION

SoilWaterApp – a new tool to measure and monitor soil water

Gross margin assessment for dryland peanut production in northern Queensland. Agbiz tools, Queensland Government.

15 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

16 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

17 PCA. Irrigation versus dryland cropping. Peanut Company of Australia.

VIDEOS

Irrigation systems and design

1.9.2 Irrigation

What will irrigation do?

Irrigation may be used to manipulate the soil conditions, especially at pegging and at harvest. The crop uses 2–6 ML/ha, depending on rainfall and soil type. Consult an agronomist to determine an appropriate irrigation schedule. If water is limited, strategic or supplementary irrigation is recommended.

Peanuts can be watered with sprinklers such as centre pivots or travelers or by flood irrigation (depending upon soil type). Trickle (tape) irrigation can be used in some circumstances. [18]

Irrigators should avoid holding off watering in favour of possible rain to minimise crop stress. Prior to planting, budget for total crop water use at 5–7 ML/ha. Peanuts are very sensitive to water stress, despite their hardiness as a crop. Minimise water stress during the critical flowering–podfill stages. Stress can increase the incidence of disease and ultimately affect kernel quality. Lack of uniformity of water application is a major issue often arising from inadequate equipment or poor system design. Soils most suited to peanuts generally have very low water-holding capacity, so water use must be carefully monitored. Know the required irrigation intervals to maintain adequate soil water. [19]

The 600–700 mm of water required over the season for a high-yielding crop can come from rain, irrigation or stored soil moisture. However, the total amount of moisture that the crop receives is not as important as the timing of rainfall or irrigation, which can have a dramatic effect on both crop yield and quality (Table 3).

Table 3: *Growth stages and irrigation needs of peanuts.*

Growth stage	Irrigation requirements
Germination and emergence	Good moisture conditions required; irrigation can ensure crop is planted on time
Vegetative	Peanuts can tolerate mild water stress at this stage; stress may be beneficial.
Peg initiation	No water stress at this stage, very sensitive; use irrigation
Pod formation and filling	No water stress; use irrigation
Maturity	Decreasing water use as the crop matures

Irrigation scheduling using a system of pan evaporation measurements and crop factors has been found very effective. Devices including tensiometers, gypsum blocks and EnviroSCAN probes, which provide indirect measurements of soil water, can also be very useful.

Irrigation systems

If water is available, it may be used to improve peanut yields and returns. The main systems used for irrigating peanuts include: furrow irrigation, or various forms of sprinkler irrigation including centre pivot, lateral moves, travelling irrigators or solid-set sprinklers. [20]

Irrigation systems include surface flow, sprinklers or various forms of micro- or drip irrigation. Each has its own uses and relative suitability.

18 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

19 G Mills, R Rachaputi, G Wright, Y Chauhan, J Barnes (2004) Yield potential of peanuts at Mackay—What are the key barriers to obtaining it? GRDC Update Papers, February 2004, http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2004/02/Yield-potential-of-peanuts-at-Mackay-What-are-the-key-barriers-to-obtaining-it

20 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

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Irrigation system selection and design guidelines. Victorian Resources Online.

ME Qureshi *et al.* (2002) Profitability of growing sugarcane under alternative irrigation systems in the Burdekin delta.

Jeremy Whish CSIRO discusses target yield and stored soil moisture. GRDC Radio (Northern Update) 063: Summer cropping

Better profits from good soil water decisions (Goondiwindi)

Surface (e.g. flood or furrow) irrigation is suited to heavy soils with limited deep drainage, and to the application of large volumes of water to large areas. Energy costs are low, usually relying on gravity to move water. Surface irrigation is unsuitable for porous soils or 'fussy' crops whose water requirements are quite narrow.

Sprinkler systems range from under-tree to fixed overheads, rain guns, linear move and centre pivots. These systems can water large areas and are reasonably precise in water delivery. They require water under pressure to operate, and thus have high energy costs. They have high infrastructure costs and can be an obstacle to flexible crop husbandry. In some regions, remnant native trees may pose problems for use of centre-pivots.

Micro-irrigation systems include mini-sprinklers, drip or trickle, and subsurface irrigation. They allow precise water delivery to plants and their roots. They can be used in a variety of conditions and can maintain high-value crops in various soils. They require a pressurised water supply and can be relatively expensive to install but also provide high levels of Water Use Efficiency.

Systems with increased technology and pressurised water delivery have underpinned improvements in Water Use Efficiency in many regions. They give irrigators much more control over where water goes, how much is applied, and how much is lost to runoff, drainage or evaporation. [21]

1.10 Yield and targets

Yield expectations vary between regions (Table 4).

Table 4: *Yield expectations for Queensland crops.* [22]

Region	Expected yield
Southern Queensland dryland	1.5–4.0 t/ha (average 2.5 t/ha)
North Queensland (high rainfall) dryland	2.5 – 6.0 t/ha (average 4.0 t/ha)
Irrigated	4.0 to 8.0 t/ha (average 5.0 t/ha)

At the Douglas Daly Research Farm in the Northern Territory, results suggest that 3–4.75 t/ha of peanuts can be achieved with correct management techniques. [23]

Australian peanut producers are commonly achieving only 50–70% of the genetic yield potential of commercial peanut varieties. [24]

21 National Program for Sustainable Irrigation (2012) Irrigation essentials updated. Research and innovation for Australian irrigators 2012. National Program for Sustainable Irrigation, http://npsi.gov.au/products/npsi06121

22 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

23 C Ham (2004) Growing peanuts in the Top End of the NT (*Arachis hypogaea* L.). NT Department of Primary Industry, Fisheries and Mines, https://dpir.nt.gov.au/__data/assets/pdf_file/0008/232928/177.pdf

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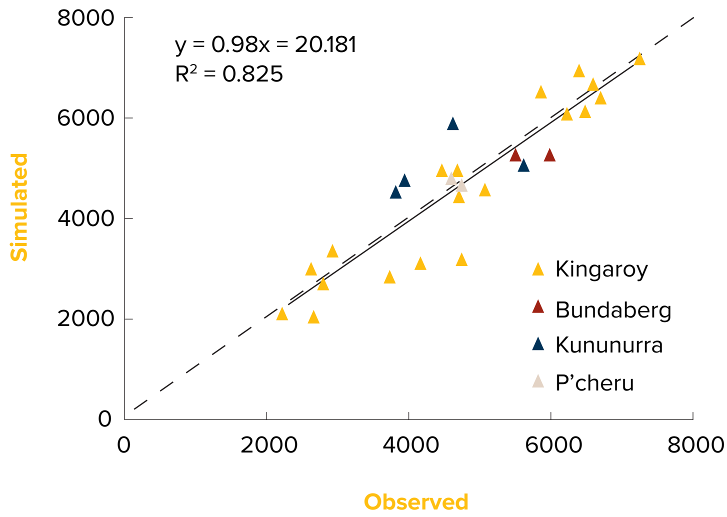

Figure 4: *Peanut pod yield (kg/ha).*

Generally growers using better practices are achieving yields in the range 4.5–7.0 t/ha, with some farmers having reported up to 8.0 t/ha (Figure 4). Frequently yields do not exceed 6.0 t/ha. Failure to align with the essential elements of best management practices (BMP) in peanut production generally results in either failure to achieve target yields or a consistent decline in yields over ensuing years (Table 5). BMP relates both to the management factors employed in the overall farming system and to the specific management techniques applied to peanut crop agronomy and management operations. New peanut growers have an excellent opportunity to implement BMP from start-up because of the collective experience of researchers and agronomists and the valuable practical knowledge of fellow peanut producers.

A GRDC-QDAF project 'Best management practices in the production of high input peanuts', Queensland Department of Agriculture and Fisheries (QDAF) has documented successful and sustainable peanut production methods.

Table 5: *Factors causing production loss in peanuts.*

Factor causing production loss	Approx. loss (%)
Inadequate/poor irrigation management	20%
Poor rotations yield decline	20%
Poor harvest management (losses wet harvests)	15%
Diseases (Cylindrocladium black rot, soil-borne and foliar diseases)	10%
Inadequate plant stands or plant populations	15%
Poor weed management	10%
Poor nutrition (micro- + macro-nutrient deficiency)	10%
Total	**100%**

Importantly, new production environments such as Mackay and the Burdekin will present new challenges for defining BMP given the specific conditions that apply in each region, particularly in relation to optimum planting and harvesting windows. However, the essential rules for successful production remain the same across regions. BMP focuses on sustainable yield in a profitable framework involving the whole farming system. [25]

1.10.1 Seasonal outlook

For more information, visit the Bureau of Meteorology, Climate outlooks.

1.10.2 Fallow moisture and double-cropping

The Agricultural Production Systems Simulator model (APSIM) was used to simulate the relative benefits of double-cropping (wheat and peanuts) over peanuts with a winter fallow in the Burnett district of Queensland. Simulation results demonstrated that, in general, double-cropping could be practiced successfully in the South Burnett. [26]

Background

Double-cropping is frequently practiced on Red Ferrosols in the Burnett district. Wheat is commonly planted after peanuts with very little stored water at planting. In some instances, wheat is planted almost immediately after a peanut crop if planting rainfall (25 mm) has occurred. In many cases, the resulting wheat crop is not viable. Questions have been raised about the validity of this double-cropping practice: how often does the wheat crop jeopardise the following peanut crop, and what are the long-term yields for wheat and peanuts planted in this way?

One way to address this issue is with simulation models. APSIM is a cropping system model capable of integrating the effects of weather, soil and cropping management. We used APSIM to investigate the viability of double-cropping in the Burnett.

APSIM was parameterised for a typical Red Ferrosol soil near Kingaroy. Two cropping systems were simulated: peanut following wheat, and peanut with a winter fallow. Plant-available water (PAW) capacity for the soil simulated was 110 mm to a depth of 1.8 m. The lower limit of water extraction for the two crops was derived from experimental data. In the model, wheat was planted between 1 May and 31 July when available water in the top 0.50 m was >25 mm. Peanuts were planted between 15 October and 31 December on ≥55 mm or more PAW in the top 0.50 m. A 90-year weather record for Kingaroy was used.

Outcomes

Simulated median peanut yields were 2.8 t/ha in the peanut–wheat rotation and 2.9 t/ha in the peanut-only system. The distributions of peanut yields from the peanut–wheat and peanut-only systems were similar. This indicated that, on average, wheat did not reduce planting soil moisture or yield of the following peanut crop. This was because the peanut crop commonly received adequate soil water after planting to maintain yields. Even if soil water at planting was high, low in-crop rain could result in low peanut yields. In general, a winter fallow did not result in improved utilisation of rainfall for peanut growth, or increased yields. [27]

1.10.3 Water Use Efficiency

Peanuts and other tropical legumes often face water stress, but planting cultivars with high Water Use Efficiency can minimise the yield losses in times of stress.

Go 'on-farm' to hear Queensland peanut growers discuss Water Use Efficiency.

MORE INFORMATION

RD Connolly *et al.* (1998) Simulating peanut/wheat cropping in the Burnett with APSIM. Australian Agronomy Conference.

PCA/DPIF. Managing weeds.

VIDEOS

Water use and efficiency

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D Rowland *et al.* (2012) Variation in carbon isotope ratio and its relation to other traits in peanut breeding lines and cultivars from U.S. trials. *Journal of Plant Breeding and Crop Science* 4.

KT Hubick *et al.* (1986) Correlation between Water Use Efficiency and carbon isotope discrimination in diverse peanut (*Arachis*) germplasm. *Australian Journal of Plant Physiology* 13.

P Songsri *et al.* (2013) Association of stomatal conductance and root distribution with Water Use Efficiency of peanut under different soil water regimes. *Australian Journal of Crop Science* 7.

Research shows that remote-sensing imagery of irrigated peanut crops with simple airborne digital video camera systems offers growers and consultants a cost-effective technique for the assessment of spatial variability in crop performance. Images of near-infrared reflectance (NIR) taken from irrigated peanut crops (pivots) in southern Queensland showed major variability arising from crop stress, most likely a result of poor irrigation distribution and/or poor water infiltration (Figure 5).

The NIR from peanut crops taken ~4–6 weeks before harvest was highly correlated with final pod yield, and this offers a potential yield-forecasting technique for growers and industry. The close association also allows an assessment of the magnitude of the yield deficit resulting from spatial variability (or 'yield gap'). This provides growers and consultants with a useful method to calculate the economic impact of reducing the yield gap in their own fields and has potential for use as a strategic tool to identify problems and improve various aspects of crop management.

The research has shown that NIR images can provide growers with indicative yield maps and the likely yield gap and resulting reduction in gross income prior to harvest. The imagery can direct crop inspection and hence the detection and early warning of water, disease, nutrient and other stresses for potential in-season management. The strong relationship between NIR and pod yield in peanut crops also suggests potential for using the technology as a yield-forecasting tool for regional irrigated and rainfed production, with a significant potential role in other field crops. [28]

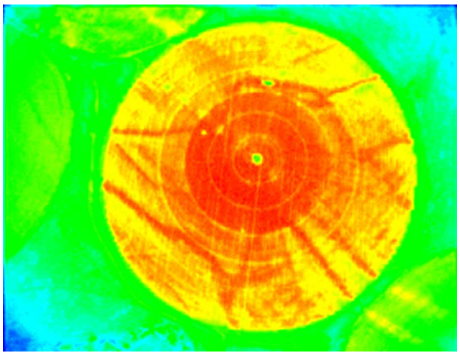


Figure 5: *Peanut pivot in the Texas region, Queensland, showing extreme crop variability associated with poor soil infiltration and distribution in the outer pivot.*

1.10.4 Nitrogen-use efficiency

Like other legumes, peanuts are able to produce their own N via a symbiotic relationship with a strain of the soil bacteria rhizobia. These beneficial bacteria infect the peanut root system and forms characteristic nodules, from which N_2 gas is 'fixed' from the atmosphere. The N is then available to the plant for growth and development. For peanuts, use Group P rhizobial inoculum.

Not all legumes grown by Australian farmers have the same capacity for N_2 fixation (Table 6). Of the crop legumes, navy beans are weak, fixing only ~20% of their needs with the remainder supplied from soil and fertiliser sources. On the other hand, faba beans, lupins and soybeans that have good capacity for N_2 fixation. Peanuts, field peas, lentils, mungbeans and chickpeas are in between. [29]

28 G Wright, A Robson, G Mills (2004) Application of remote sensing technologies to improve yield and Water Use Efficiency in irrigated peanuts. 12th Australian Agronomy Conference, Australian Society of Agronomy, http://www.regional.org.au/au/asa/2004/poster/1/5/698_wrightg.htm

29 D Herridge (2013) Managing legume and fertiliser N for northern grains cropping. GRDC, https://www.researchgate.net/publication/293958450_Managing_Legume_and_Fertiliser_N_for_Northern_Grains_Cropping

MORE INFORMATION

DEEDI Qld. Rhizobium inoculation. Get the best from your legume crop.

D Herridge (2013) Managing legume and fertiliser N for northern grains cropping. GRDC.

GC Wright, GL Hammer (1994) Distribution of nitrogen and radiation use efficiency in peanut. *Australian Journal of Agricultural Research* 45.

Table 6: *Estimates of the amounts of N_2 fixed annually by crop legumes in Australia.*

Legume	%Ndfa	Shoot DM (t/ha)	Shoot N	Root N	Total crop N	Total N
			(kg/ha)			
Soybeans	48	10.8	250	123	373	180
Lupins	75	5.0	125	51	176	130
Faba beans	65	4.3	122	50	172	110
Field peas	66	4.8	115	47	162	105
Peanuts	36	6.8	190	78	268	95
Chickpeas	41	5.0	85	85	170	70
Lentils	60	2.6	68	28	96	58
Mungbeans	31	3.5	77	32	109	34
Navy beans	20	4.2	105	43	148	30

Source: primarily Unkovich et al. 2010

%Ndfa, Percentage of legume N derived from N_2 fixation; DM, dry matter; root N = shoot N × 0.5 (soybeans), 1.0 (chickpeas) or 0.4 (remainder); total N fixed = %Ndfa × total crop N

1.11 Disease status of paddock

Peanuts are susceptible to several soil-borne diseases, especially Sclerotinia blight, white mould and Cylindrocladium black rot. Good rotational practices, crop management and hygiene are the best defences against these diseases. Limited fungicide options are available to combat peanut soil diseases.

Soil-borne diseases can lead to substantial yield and quality loss. Although some products are available to lessen the effects of these diseases, the best policy is to follow a recommended rotational program (involving grass or cereal crops) and practice good cultural management. In particular, excessively aggressive cultivation should be avoided, especially where soil is pushed against the plant.

Sclerotinia blight can be particularly devastating in some areas. It is recommended that a registered fungicide spray be used and applied as a protectant before symptoms appear. This may be as early as when the crop is 6–8 weeks old, or when the first flower petals drop. One or two follow-up fungicide applications may be required if symptoms develop. [30]

1.12 Insect status of paddock

Peanuts can tolerate higher insect thresholds than other, more determinate crops, because they compensate growth following damage.

Peanuts are indeterminate in vegetative and reproductive development. This means the plants do not stop growing in order to flower and produce a crop. They continue to grow leaves and stems while also flowering and setting pods. The pods must therefore compete with the shoots for carbohydrate and nutrients.

In traditional peanut-growing areas (e.g. the South Burnett), soil pests can cause major economic damage. Foliar pests rarely cause economic damage. The worst soil-insect damage usually occurs where there is a long history of peanut growing with few non-legume crops in the rotation.

In drought years, *Etiella* is a major problem in dryland crops. *Etiella* larvae are able to reach the pods in dry soil, and damaged pods are at greatly increased risk of aflatoxin contamination. Most other pest problems occur only occasionally.

As peanuts expand into newer areas, some pests, such as *Helicoverpa*, mites and mirids, will be a more constant problem. Soil pests are likely to become important in

30 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

MORE INFORMATION

QDAF (2010) Soil insects in Queensland.

H Brier *et al.* (2012) Good bug? Bad bug? An identification guide for pests and beneficial insects in summer pulses, soybeans, peanuts and chickpeas.

newer areas as more peanuts are grown, and new species may be encountered that are specific to the soil type in question. Pest damage to peanuts can start as soon as the crop is planted and it continues until maturity. Under intensive production, a number of pests will warrant control. [31]

31 QDAF (2010) Insect pest management in peanuts. Department of Agriculture, Fisheries and Forestry Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/peanuts

VIDEOS

Varieties

Pre-planting

2.1 Varietal performance and ratings yield

In 2014, a 5-year license agreement was implemented between the processors Peanut Company of Australia (PCA) and G. Crumpton and Son, and PCA and Clifton Farming.

The agreement allows access to all current and future PCA varieties (Table 1). The only exclusion will be for a 2-year period for any 'introduced' variety commercially released that was part of the PCA program prior to 1 July 2007.

All growers need a Sub-License Agreement to grow any PBR variety.

Table 1: *Peanut variety summary 2015–16.*

						Generally recommended for:			Susceptible to:	
Variety	**Type**	**Weeks (days) to maturity South Qld (approx)**	**Growth habit**	**Peg strength**	**Seed size**	**Dryland – South Qld**	**North Qld irrigated & high rainfall dryland**	**Irrigated Central & South Qld**	**Leaf diseases**	**Soilborne diseases**
Wheeler	Virginia	20 (140)	Erect	Medium	Large	Yes	No	Yes	Yes (Highly susceptible to net blotch)	Yes, maybe some tolerance to CBR
Middleton	Virginia	19 (135)	Semi-erect	Medium	Large	Yes	No	Yes	Yes (Highly susceptible to net blotch)	Some tolerance to Aflatoxin incidence
Fisher	Virginia	20 (140)	Semi-erect	Medium	Large	Yes	No	South Qld only CQ – No	Yes (Some tolerance to net blotch and leafspot)	Some resistance to CBR. Tolerance to Sclerotinia
Menzies	Runner	20 (140)	Semi-prostrate	High	Medium	No	Yes	No	Yes	Some tolerance to CBR and White mould
Holt	Runner	20 (140)	Semi-prostrate	High	Medium –large	Yes (consult agronomist)	Yes	Yes	Yes	Some resistance to CBR. Some tolerance to Sclerotinia and White mould
Page	Runner	19 (135)	Semi-prostrate	High	Medium	Yes (consult agronomist)	Yes (consult agronomist)	Yes	Yes	Some resistance to CBR. Tolerance to Sclerotinia, White mould & Fusarium
Redvale	Ultra Early	15 (105)	Erect	High	Medium	Yes (consult agronomist)	Yes (consult agronomist)	Yes (consult agronomist)	Yes. Limited tolerance to rust (susceptible to net blotch)	Susceptible to CBR

This table is a guide to varietal selection. Consult your local peanut agronomist for specific recommendation on varieties for your farm. PBR, Plant Breeder's Rights: these varieties are protected under the Australian Plant Breeders Rights Act 1994 and the regulation therein

MORE INFORMATION

GCTV Extension Files: Redvale in a Nutshell

MORE INFORMATION

Hi Oleic peanuts are simply the best peanuts yet!

New peanut showcases 'speed breeding'. GRDC Ground Cover Issue 92.

Seed is not a part of the license agreement. When a variety is commercially released, PCA will provide pure seed to the other processors based on their share of the crop. Each party will then be responsible for the provision of seed to their contracted growers.

Redvale is a valuable variety option for growers in all regions. In dryland areas in southern Queensland, Redvale can avoid end-of-season drought and hence aflatoxin risk, yet can still produce a high-yielding crop with good grades in above-average seasons.

In coastal regions, Redvale offers an early-maturing option for early or late planting to allow a legume break-crop to better fit into a cane system. It will use up to 30% less water and fungicides than other varieties, yet still yield >5 t/ha if managed properly.

In North Queensland, Redvale has performed very well under wet conditions. It is worth considering where a grower wants to minimise crop inputs (irrigation, fungicides) yet still have the potential for yields of >4.5 t/ha. [1]

2.1.1 Hi Oleic varieties

'Hi Oleic' is a reference to the relative levels of oleic and linoleic acid (or O/L ratio) in the peanut kernels. The balance of these two oils determines the increase in rancidity over time, i.e. keeping-quality or shelf life. Older peanut varieties have an O/L ratio in the range 1–2. Newer varieties have an O/L ratio in the range 20–40. This greatly improves their shelf life and flavour. All varieties available from PCA are Hi Oleic. [2]

2.1.2 Short-season (early maturing) varieties

A succession of short-season peanut varieties through the Australian peanut-breeding program has recast the legume as a profitable sequencing option that allows growers to avoid late-season drought.

Advances in peanut pre-breeding over the past 18 years have seen short-season varieties achieve about 90% yield parity with their long-season counterparts. This yield lift is significant because in the past the benefit that early maturing varieties provided in helping growers avoid severe yield losses due to drought late in the growing season also meant reduced overall pod yields compared with full-season varieties.

Short-season peanut varieties have shown they can sprint through the growing season, maturing about 30 days earlier, and still compete with both the yield and quality of traditional, long-season cultivars.

Trials at five Queensland sites have shown the potential for a new short-season variety, to be released in 2018, to outperform full-season peanut lines. In these long-term trials (2008–15), the new variety, Taabinga, had a pod yield potential of up to 6 tonnes per hectare, which is nearing the yield potential of 'elite' full-season lines.

Quality and grade improvements have seen the new Taabinga variety yield large, flavoursome kernels with a large proportion of 'Jumbo' grade peanut kernels. Better kernel grades in the Taabinga variety should further increase gross returns from the crop, estimated at more than $3,000/ha (for irrigated crops in central and coastal Queensland).

Compared with the first early maturing Australian peanut variety, Walter, released in 2007, trials have shown Taabinga can return an extra $1,000/ha.

Other short-season genetic gains that have implications for processing efficiency and market acceptance are a lower ratio of shell to peanut and high blanchability (cooking to remove kernel skin).

1 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

2 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

Australia produces about 35,000 t of peanut pods per year, which is just 0.1% of the global crop, estimated at 35,000 million tonnes, indicating the potential to increase Australia's market share.

The varietal improvements have also extended the planting window for about 30% of the Australian crop grown under dryland conditions in the Burnett region of Central Queensland.

In dryland situations when opening rains do not arrive in time for the traditional sowing window from November to December, early maturing varieties can be late-sown in January. The ability to plant the crop very early and harvest in early autumn opens up new opportunities to grow peanuts in sequence with sugarcane planted in autumn instead of spring.

Fast-maturing varieties could also benefit the other 70% of the national crop grown under irrigation in Queensland, northern NSW and the Northern Territory. Where irrigation water is limited, early maturing crops help increase water use efficiency, lifting the crop's overall productivity and profitability in dry seasonal conditions. [3]

2.1.3 Yielding ability

A peanut grower's income is determined largely by the yield and quality achieved. Like many crops, substantial variations in yield may exist. Climatically, some areas may have different yield potential, and differences do exist among varieties. However, management factors are often a major determinant of final yield, so care must be taken with all aspects of growing the crop.

Similarly, kernel quality can be influenced by management factors. Growers are directly paid on kernel quality; therefore, it is important that they understand which management factors can directly affect kernel quality.

These include:

- good crop rotation and freedom from disease
- good nutrition, especially calcium (Ca) and boron
- good irrigation/moisture management
- optimum maturity determination
- good harvesting conditions
- controlled drying.

On-farm yield is normally measured in tonnes per hectare (t/ha) of farmers' stock peanuts, which means unshelled pods (in-shell) cleaned of extraneous matter and at the moisture content used for grower payment calculation.

Under excellent conditions, the Runner and Virginia varieties are capable of yields >7 t/ha. The ultra-early varieties tend to yield less, but are still capable of yields of 5 t/ha.

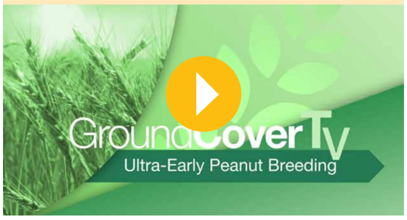
The different varieties produce different levels of shell; growers should be aware of this because they are not paid for their shell. Runner types produce 19–22% shell and Virginia types, 22–25% shell. Well-grown, irrigated crops will be at the lower end of shell percentage, whereas immature and drought-affected crops generally exhibit higher shell percentages. [4]

Ultra-early varieties, such as Tingoora, can escape end-of-season droughts and give reliable yield. Ultra-early maturity also provides a short-rotation option for high-input growers (i.e. irrigated regions in southern and North Queensland) where commercial pod yields of >5 t/ha have been achieved.

VIDEOS

GCTV4: Peanuts 'Tingoora'

GCTV14: Ultra Early Peanut Breeding



3 GRDC (2016) Pre-breeding gains lift peanut fortunes. Ground Cover Issue 122, May–June 2016, https://grdc.com.au/resources-and-publications/groundcover/ground-cover-issue-122-may-jun-2016/prebreeding-gains-lift-peanut-fortunes

4 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

2.1.4 Peanut breeding

The need for productivity and efficiency gains in any industry is essential and growing peanuts is no different. In the 2015–16 year PCA and GRDC signed a new 5 year agreement to continue the development of new peanut cultivars for the Australian industry. This breeding program has also been supported by another 5 year agreement with QDAF.

The breeding program continues to target two different maturity groups: full-season types (20 to 22 weeks) and ultra-early types (approximately 16 to 18 weeks). Varieties are selected within these groups based on their ability to meet a market need, Hi Oleic oil composition, high yield, low shell and high blanchability traits and enhanced resistance to a range of foliar and soil borne diseases.

Over the next few years PCA plans to have the following varieties commercially released to Australian peanut growers.

Kairi

The new full-season maturity line (D281-p40-236A, to be called 'Kairi') performed very well again during 2015–16 and is highly likely to progress to commercial release in 2017–18. Kairi has 5–15% higher kernel yield than Holt, Middleton and Fisher, a larger Runner grade out superior to Holt and enhanced foliar disease tolerance (leaf spot, leaf rust and net blotch). It has shown very good broad adaptation with consistent superior performance against commercial checks in dryland (Burnett) and irrigated (North Queensland, Brisbane Valley, Bundaberg, Central Queensland) environments. [5]

Taabinga

The first early maturity line developed by PCA in the joint breeding program ('P' lines) for potential commercial release is P23-p153-63 (to be called 'Taabinga'). This line has continued to perform very well in all regional variety trials over the past 3 years, with superior kernel yield performance (20% higher than Redvale), kernel size (>50% runner Jumbos) and excellent foliar disease tolerance (leaf spot, leaf rust, net blotch). [6]

However, ultra-early varieties will have lower yield potential than full-season varieties in seasons with good rainfall.

The peanut variety Sutherland has demonstrated significantly higher levels of resistance to rust (caused by *Puccinia arachidis*) and late leaf spot (caused by *Cercosporidium personatum*) than currently grown varieties such as Menzies and Holt. It gives growers another method of managing leaf disease in peanut crops. [7]

2.2 Quality of planting seed

Peanut seed is easily damaged and must be treated as gently as possible. Once a seed is split, the two halves will not germinate.

Seed is treated with fungicide before planting to reduce seedling diseases. It is not worthwhile for farmers to plant untreated seed, because germination rates will drop to <40%.

Planting can start any time after the soil temperature reaches 18°C at planting depth (50–70 mm). This is measured at 9 a.m. for 3 days in a row. Planting is delayed if rain is expected within 3–4 days. Planting is also timed to ensure that the crop is ready for harvest before frosts begin and when there is a low risk of rain.

In high-rainfall areas, formation of raised beds prior to planting may be necessary. [8]

5 Peanut Company of Australia (2016) Annual report 2016. PCA, http://www.pca.com.au/wp-content/uploads/2016/11/annualreport2016.pdf

6 Peanut Company of Australia (2016) Annual report 2016. PCA, http://www.pca.com.au/wp-content/uploads/2016/11/annualreport2016.pdf

7 GRDC (2010) Managing leaf disease in peanuts. GRDC Fact Sheet, https://grdc.com.au/__data/assets/pdf_file/0030/207687/managing-leaf-disease-in-peanuts.pdf.pdf

8 PCA. Soil preparation. Peanut Company of Australia.

2.2.1 Growing peanuts for seed

Peanut seed is more delicate than most other seed and needs care and attention from planting of the seed crop through harvesting, drying, shelling and seed preparation.

Growing peanuts for seed is a specialist activity because high-quality seed is essential to ensure optimum plant populations. The industry requires quality seed with high germination rates, vigour and purity.

Peanut germination and vigour can be affected any time through the growing season. Particular attention must be paid to crop nutrition, management of weeds and diseases, minimising moisture stress, and correct harvesting and drying techniques.

Clean land

Land must be free of weeds and volunteer peanuts. Preferred paddocks have not grown peanuts for at least 3 years and do not have a history of soil-borne diseases. Contamination of seed crops from peanut volunteers of a different variety is a major concern.

Good rotations are needed to achieve clean land status. Preferred rotations include pastures, sugarcane, and grain crops such as maize, sorghum, wheat and barley.

Clean machinery

Peanut seed must be kept separate from all other peanuts. All handling equipment should be cleaned to avoid contamination.

All machinery must be free of kernels and pods. This includes planters, diggers, threshers, elevators, drying bins, silos and trucks.

Irrigation

If water is available, irrigation can ensure good yields and dramatically improve seed quality but needs to be considered in terms of budget and risk.

Supplementary calcium

Peanuts, especially seed crops, have a high requirement for Ca. Low seed Ca results in poor germination.

Supplementary Ca can be applied as lime or gypsum, and in combination with irrigation, it can make a big difference to germination.

Lime is preferred if the soils are acidic. Ideally, the lime should be applied and lightly incorporated before planting. Rates are usually 2.5–3.5 t/ha.

Gypsum is the preferred option for applying Ca because it is more soluble and more available than lime. Gypsum is best applied close to flowering at 1 t/ha over the whole crop or banded over the row at 400–600 kg/ha. Lime can also be applied over the row where soils are acidic, but it must be applied soon after emergence.

Maturity

Check crops regularly as harvest nears. The hull scrape method will help to determine the best time to dig. Slightly immature kernels give better physical quality than over-mature ones.

Digging and threshing

Diggers that invert peanuts are preferred for seed crops because inverted peanuts dry uniformly and quickly.

Threshing is one of the most critical aspects of seed production. The impact received during improper threshing may damage peanuts, making them unsuitable for seed. Mechanical injury causes broken or bruised seed tissue. Such damage leads to seed deterioration in storage, increasing the chance of fungal invasion of the seed.

MORE INFORMATION

QDPI/CSIRO. Managing cadmium in summer grain legumes for premium quality produce.

Cadmium. Nuts2u.

Incitec Pivot Fertilisers. Gypsum.

Physical damage to the seed is one of the causes of the 'J-shaped' root system that can develop when peanuts are trying to establish. Plants with deformed root systems do not yield as well as those with a normal root system.

Slow cylinder speeds are essential. As conditions change throughout the day, the harvested crop should be checked for loose shell kernel and hull damage.

Allow the peanut bush to dry sufficiently in the windrow before threshing. Green bushes are tough and require aggressive threshing action to separate the pods from the bush. Moisture content of 18–22% is ideal (Table 2).

Table 2: *Effect of seed moisture at threshing on germination.*

Threshing moisture	Average germination
<20%	89%
20–25%	84%
>26%	75%

Source: Six steps to high quality peanut seed. North Carolina Agricultural Extension Service

Drying

Peanuts for seed should generally be pre-cleaned before drying.

Seed can be easily damaged by over-drying, rapid drying and/or drying at overly high temperatures. Drying damage can result in poor germination and poor shelling quality, with an increase in splits and skin slippage.

Peanuts for seed should be dried at a maximum of 35°C, and no more than 7°C above ambient air temperature. The minimum relative humidity for seed is 65%, compared with 50% for commercial crops. Moisture should not be removed faster than 0.5% per hour.

Peanut seed contracts

PCA has a program to produce seed peanuts. This aims to provide the industry with quality seed with high germination rate and varietal purity. Growers are contracted to produce this seed and must meet specific conditions including paddock and machinery clean-down inspections, calcium application and preferably irrigation. [9]

9 PCA/DPIF (2007) Peanut seed production. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/7a_other_seed.pdf

Planting

Peanuts in northern NSW and Queensland are usually grown through summer, planted anywhere from September to early January. In the Northern Territory, irrigated peanuts can also be planted in March and harvested in September. The crop usually takes 18–24 weeks from planting to digging. Growing through the summer months means that the crop can take advantage of available rainfall.

Planning for the harvest is essential when determining when to plant. Planting should be timed to avoid rain at harvest and the likelihood of frosts.

Soil temperatures should be monitored regularly as planting approaches. Keep track of the soil temperature at the desired planting depth (e.g. 50 mm). Measure the soil temperature at 9 a.m.

A minimum soil temperature of 18°C is required for germination (measured at 50 mm depth at 9 a.m.). Soil temperatures can be measured using a probe thermometer, or likely soil temperatures can be found at the Bureau of Meteorology (Agricultural observations bulletins: NSW, Northern Territory, Queensland).

Temperature has a major influence on peanut growth and development. Peanut growth is favoured by warm temperatures >25°C. Dry matter production drops by ~25% when night temperatures reach 15°C and by 50% when night temperatures drop to 9°C.

Care should always be taken when handling peanut seed. The seed is large and fragile and easily damaged. Never drop or walk on bags of peanut seed and do not leave the seed in direct sunlight. [1] Once a seed is split, the two halves will not germinate. [2]

3.1 Seed dressings

Seed must be treated with a recommended fungicide seed dressing (check registrations at APVMA) to reduce the incidence of seedling diseases. It is not worth planting untreated peanut seed because germination is often <20%. [3]

3.2 Inoculation

Peanuts are a legume. They are able to fix nitrogen (N_2) from the atmosphere via nodules on their root system. These nodules are caused by a type of bacteria called rhizobia, which infect the plant's root system. Failure of the plants to nodulate will reduce N-fixing ability and lower yields.

Native rhizobia exist in many soils, but it is recommended that growers inoculate their peanuts to ensure good nodulation and an adequate supply of N. The rhizobial strain used in the inoculant is an improved strain, designed specifically for peanuts (Group P), and is regarded as more effective than the native strains in the soil.

Growers striving for maximum yields should inoculate their peanuts every season.

Water injection is the best method for applying the peat inoculant. Do not mix the inoculant into a slurry and apply to the seed; this will damage the seed.

Granular inoculant (when available) can be applied via granular application boxes, commonly used for applying granular soil pesticides, etc. However, the application of granular inoculant and granular pesticides together is not recommended. [4]

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1 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

2 PCA. Soil preparation. Peanut Company of Australia.

3 PCA/DPIF (2007) Crop establishment. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3d_establish.pdf

4 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

3.2.1 Treat inoculum well

When it comes to improving the nitrogen-fixing capacity of pulse crops, the best approach is to treat inoculum well by transporting, storing and applying it according to the manufacturer's recommendations.

Rhizobia are living organisms that need to be kept cool before application and mixed with good-quality water to ensure maximum rhizobia survival.

The more rhizobia in the inoculum, the greater the chance that effective nodules will be formed and the greater the chance that more nitrogen will be fixed.

As part of ongoing QDAF research, different inoculation methods and forms have been compared for soybeans and peanuts. Peat-based inoculum applied as a seed coating or as a liquid injected into the soil, freeze-dried inoculum either applied as a seed coating or liquid-injected, and granules were all tested.

For soybeans and peanuts, researchers found that plants responded positively to all forms of inoculum equally, when applied according to label recommendations.

Inoculated seed needs to be planted within hours into moist soil to ensure adequate numbers of rhizobia are still alive when the seed germinates. Rhizobia survival will be compromised if crops are sown into hot, dry soil.

Care needs to be taken when mixing rhizobia inoculum with products such as liquid fertilisers or pesticides. For example, zinc and other heavy metals can be detrimental to rhizobia when the two are in direct contact. [5]

3.3 Germination

In Queensland, certified peanut seed must have a minimum germination rate of 80%. [6]

3.4 Reduced tillage

Peanuts are more difficult to grow using reduced tillage or no-tillage methods than most other crops. Peanuts need loose soil for the crop to peg into and to make digging easier. This is generally achieved through deep ripping prior to planting.

Field trials of no-till peanuts planted into wheat stubble in the Burnett area of Queensland have yielded mixed results. On sandier soils, outcomes are likely to be better, particularly if the soil is hardsetting with poor water infiltration. Commercial evaluation of no-till planting into sugarcane residue shows little or no difference in yield compared with conventional planting. No-till in the sugarcane rotation will become more beneficial as controlled traffic practices increase.

Weed control is often more costly in terms of chemical use under a minimum-tillage system because inter-row cultivation is not used. However, this can be offset by reduced machinery and fuel costs.

On the lighter red scrub and forest soils of the Burnett region, pod losses from cutting and pulling the crop from reduced-till and no-till blocks were much less than expected.

Some growers use strip tillage, where the plant bed is cultivated and the inter-row is left uncultivated. GPS-controlled machinery enables the operator to maintain the beds in the same position from one season to the next. [7]

MORE INFORMATION

R Mason *et al.* Using minimum tillage and controlled traffic to reduce the risk of cropping in the Burnett.

Y Dang *et al.* (2013) Tillage impact in long term no-till GRDC Update Paper.

GRDC (2007) Why Australia has the world's greatest herbicide resistance problem. GRDC Ground Cover Issue 68.

EA Roesner (1998) Minimum tillage effects on soil structure measured using image analysis. Australian Agronomy Conference.

5 GRDC (2017) Commercial inoculants compatible with new varieties. Ground Cover Issue 127, March–April 2017, https://grdc.com.au/resources-and-publications/groundcover/groundcover-issue-127-marchapril-2017/commercial-inoculants-compatible-with-new-varieties

6 PCA/DPIF (2007) Crop establishment. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3d_establish.pdf

7 PCA/DPIF (2007) Crop establishment. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3d_establish.pdf

Considering that water is the most limiting resource in the rainfed environment of the Burnett, minimum till reduces the amount of rainfall required to prepare a seedbed. [8]

3.5 Time of planting

Planting can start any time after the soil temperatures at planting depth reach 18–20°C at 9 a.m. for 3 days in a row. Delay planting if the soil is cool or if rain is expected within 3–4 days.

Planting should be timed to ensure that the crop is ready for harvest at the end of the wet season and before the first frost (Table 1). Spanish and ultra-early types mature earlier than Virginia and Runner types, so they can be planted 2–3 weeks later. In some parts of coastal and northern Queensland (near Cairns), and the Northern Territory, peanuts can grow over the winter months but growth is limited. [9]

Table 1: *Preferred and possible planting times for Virginia and Runner peanuts.*

Region	Preferred	Possible
Northern NSW and southern Qld	Mid Oct–late Nov	Start Oct–mid Dec
Central Qld	Mid Nov–mid Dec	Mid Sept–early Jan
Atherton Tableland and Lakeland	Mid Nov–mid Dec	Mid Nov–late Jan
Bundaberg	Early Sept–mid Dec	Mid Sept–end Dec
Mackay	Sept (ultra-early varieties) mid Nov–mid Dec	Sept–Jan

3.6 Seeding rate

Although peanuts can compensate for suboptimal plant populations, the crop cannot make up for poor plant stands or large gaps.

To achieve the correct plant density, calculate the required seeding rate to ensure that adequate numbers of seeds are planted regardless of seed size (Table 2). For Virginia and Runner types, an acceptable plant population under full irrigation is 130,000–150,000 plants/ha. Aim for populations of up to 180,000 plants/ha for Spanish or ultra-early varieties under full irrigation. Table 3 provides the seed numbers per metre of row needed to achieve the desired plant population.

Under dryland conditions, Virginia and Runner types require rates of 50,000–60,000 plants/ha in southern Queensland and 80,000–90,000 plants/ha in North Queensland. Plant Spanish or ultra-early types at a rate to give 120,000–150,000 plants/ha in North Queensland and 80,000 plants/ha in southern Queensland.

A field establishment of <80% is typical. There are several reasons for this low establishment rate, including peanut susceptibility to seedling diseases despite seed dressings, soil insect damage to seed during production and planting, and the difficulty of producing good-quality seed. [10]

8 R Mason, J Page, M Cloete. Using minimum tillage and controlled traffic to reduce the risk of cropping in the Burnett, http://actfa.net/wp-content/uploads/2014/07/Using-minimum-tillage-and-controlled-traffic-to-reduce-the-risk-of-cropping-in-the-Burnett-R-Mason-et.-al..pdf

9 PCA/DPIF (2007) Crop establishment. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3d_establish.pdf

10 PCA/DPIF (2007) Crop establishment. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3d_establish.pdf

Table 2: *Planting rates (kg/ha) required for different-sized peanut seed to achieve desired plant populations, assuming 80% field establishment.*

Plant population (no. of plants/ha)	No. of seeds per kg					
	750	1060	1300	1400	1600	1800
60,000	100	71	58	54	47	42
80,000	133	94	77	71	63	56
100,000	167	118	96	89	78	69
120,000	200	142	116	108	94	84
140,000	233	165	135	125	109	97
160,000	266	188	154	142	126	112

Table 3: *Seed numbers per metre of row required to achieve desired plant populations.*

Plant population (no. of plants/ha)	Row spacing (cm)			
	86	91	96	102
60,000	5	5.5	6	6
80,000	7	7	8	8
100,000	9	9	10	10
120,000	10	11	12	12
140,000	12	13	14	14
160,000	14	15	15	16

3.7 Sowing depth

Depth of planting is not as critical for peanuts as it is for most other crops. The ideal is 50–70 mm deep, but planting depths may range from 35 to 100 mm. Where peanuts are to be planted into dry soil and then furrow-irrigated, plant at 25–35 mm depth to avoid waterlogging the seed.

The peanut seed is large, and in order to germinate, it must absorb 35% of its weight in water. Large-seeded varieties such as Wheeler and Middleton need better soil moisture at planting than small-seeded varieties such as the Spanish and ultra-early types. All seed must be placed into moist soil, with no dry bands of soil in the profile.

If moisture and temperature are acceptable, the emerging seedling is very strong and can break through soil surface crusts. [11]

3.8 Row configuration

Field trials have shown that growing ultra-early varieties in twin-row configurations and at increased plant populations can lead to yields comparable to those of full-season varieties.

Trials have shown that with irrigation, or in good rainfall years, twin-row planting can result in significant improvement in pod yield and kernel grades compared with single-row planting, due to better synchronisation of flowering and podding, and more even crop development (Photos 1–3, Figure 1). [12]

11 PCA/DPIF (2007) Crop establishment. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3d_establish.pdf

12 RCN Rachaputi, S Krosch, G Wright. Optimising row spacing for the ultra-early Tingoora. GRDC, Peanut Company of Australia, the Queensland Government.

Photo 1: *Single rows (conventional practice) of peanuts are planted with 90-cm spacing between the rows.*

Photo: PCA

Photo 2: *Twin rows of peanuts are planted 20–30 cm apart under a 90-cm arrangement.*

Photo: PCA

Photo 3: *A field trial with peanuts, comparing a single-row (foreground) and twin-row (background) configurations.*

Photo: PCA

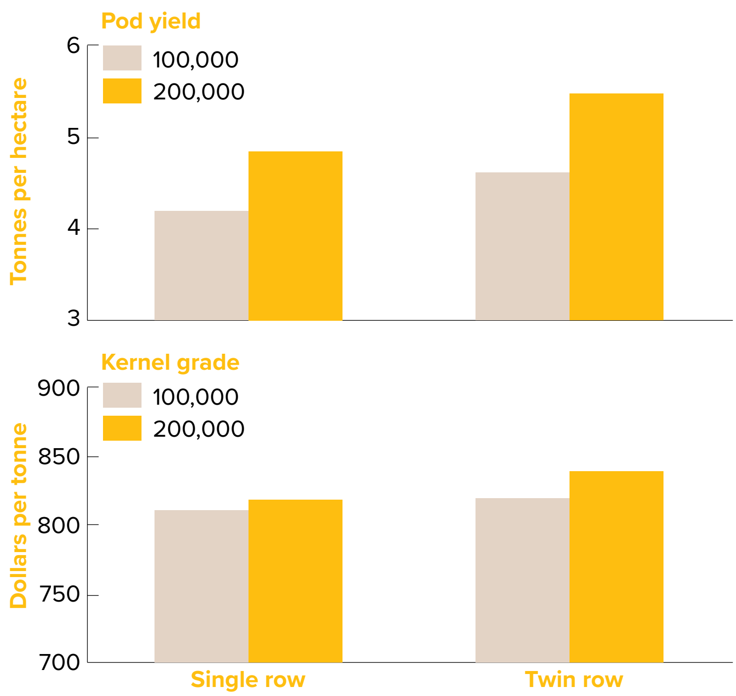

Figure 1: *Pod yield and kernel grade of peanuts at Tingoora grown under single- and twin-row configurations under irrigated conditions (Bundaberg, 2009–10 season).*

In 2002, researchers from the University of Georgia in the United States released the results of 6 years of study on twin-row planting patterns. Work in the 1970s in

Alabama by E Hauser and G Buchanan had already shown that twin rows allowed for better weed control.

The Georgia research was carried out from 1996 to 2001 on numerous small plots and on-farm demonstration sites throughout the state, comparing 17.5–35.5-cm twin rows with 1-m single-row patterns. Seeding rates were kept constant: 3 seeds/30 cm on each twin row or 6 seeds/30 cm on single-row planting patterns.

Several positive conclusions were drawn:

- twin rows result in quicker canopy coverage than single rows.
- yields increased by 549 kg/ha, averaged over early to late plantings.
- grades increased an average of 1–2%.

The researchers estimated that if 50% of the Georgia peanut acreage was planted to twin-row patterns, there was a potential economic return of US$28 million in increased yield and another $4 million in increased grade value to producers.

In 1999, ~35% of the Georgia peanut acreage was in twin-row patterns; by 2002, 50% was in twin-row patterns.

Trials on planting twin rows under strip-tillage methods showed that a major factor for success was to centre the subsoiler between each set of twin rows. The yield response was not as great as with conventionally tilled twin rows it but was still positive compared with single rows.

With strip tillage, it was difficult to achieve an adequate plant stand and avoid excessive digging losses due to planting on level soil and lack of good row definition for digging efficiency.

For twin rows, it was important to use a 76-cm cut-frog on the digger to avoid pulling peanuts off the inside twin rows.

Since 2000, the University of Georgia has recommended planting 6 seeds/30 cm on single rows and 3 seeds/30-cm row on twin rows. Their research indicated no advantage to exceeding 6 seeds/30 cm on single rows or 3 seeds/30 cm on twin rows, and that 2 seeds/30 cm was insufficient. [13]

3.9 Sowing equipment

Peanuts must be planted with a row-crop planter (Photo 4). Combine planters are not suitable. The peanut seed is large and fragile. Plate planters such as the Covington and Janke are commonly used, as well as rotary cone and finger pick-up planters (e.g. Mason Deere and KMC). Vacuum precision planters such as John Deere and Monosem are gentle and well suited for peanuts. Nodet and Gaspardo vacuum planters must be modified to plant peanuts. Kinze planters with 'edible bean' cups are not suitable.

Recommended planting equipment includes:

- John Deere MaxEmerge vacuum precision planter; Mason Deere-type planter with rotary cones
- Nodet and Gaspardo pneumatic planters, with modifications
- Covington box or some inclined plate planters, or flat plate planters such as the International 186 and 184 series
- Monosem vacuum precision planter. [14]

13 PCA. Twin rows boost yields and grades. Peanut Company of Australia.

14 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

Photo 4: *A 4-row planter modified to plant two twin rows.*

3.9.1 Press-wheels

The use of press-wheels is essential (Photo 5). They give better seed–soil contact, which promotes faster and more uniform emergence. Soft-centred or twin-inclined press-wheels are preferred, particularly on soils that form surface crusts. Hard-centred press-wheels can be used on some soils that do not crust, although the pressure may have to be reduced.[15]

Photo 5: *Press-wheels on the planter are essential for good seed–soil contact.*

15 PCA/DPIF (2007) Crop establishment. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3d_establish.pdf

3.9.2 Planters

The soft-skinned peanut seed is easily damaged. Therefore, the seed-metering mechanism of the planter must accurately distribute the seed without excessive agitation or shearing action. Many different seed-metering mechanisms are available. None of the combine planters has acceptable seed meters but row-crop planters have more suitable metering methods (Table 4).

Correct-sized plates will minimise damage to seed, and nylon (or similar) plates generally accumulate less seed dressing than do metal plates.

On all peanut planters, maintain an accurate planting rate even if placement depth varies, because the peanut plant can only compensate for small gaps.

The horizontal or flat plate planter is renowned for its tendency to shear off kernels. This destroys seed and causes missed plant spaces where a non-viable portion of seed filled the plate cell. Precision is not high.

The inclined plate planter (e.g. Covington) is very reliable for planting peanuts, even the larger seed sizes. Although seed placement is often not precise, planting rates are usually reasonably accurate. These planters are not suitable for rough seedbeds or operating at high speed (maximum speed 6 km/h).

Rotary cone planters are reasonably reliable and provide accurate seed placement. However, very large kernels can cause bridging—a blockage in the chute opening.

Vacuum planters (e.g. John Deere MaxEmerge) are widely used for planting peanuts. These planters can make skin slippage worse on over-dried kernels, leaving a ‘bald’ kernel exposed with no fungicide treatment. Loose skins can also block the air-holes. This mechanism gives accurate seed placement, and adaptation to peanut planting is reasonably straightforward.

Brush meters have been developed by Kinze but are not suitable for peanuts because of the size of peanut seed. Combine planters should not be used. [16]

Table 4: *Seed-metering mechanisms for row-crop planters.*

Metering	Precision	Agitation	Suitability	Comments
Horizontal plate	Low	High	Low	High potential to shear peanut kernels (IHC 184 and IHC 186)
Inclined plate	Low	Med	High	Commonly used (Covington, Janke)
Rotary cone	Medium	Medium	Medium–high	Suitable for peanuts (Mason Deere, KMC)
Finger pickup	High	Low	Low	Not easily adapted to large peanuts (Mason Deere finger pickup)
Vacuum pneumatic plate	High	Low	High	Very accurate. High potential to remove kernel skins (Nodet, John Deere, Gaspardo, Monosem)
Brush meter	High	Low	Low	Available models not readily adaptable
Combine planters	–	–	None	Unacceptable, will not work

16 PCA/DPIF (2007) Crop establishment. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3d_establish.pdf

Plant growth and physiology

The peanut (*Arachis hypogaea*) is a summer-growing legume that originated in South America and is well adapted to warmer regions of Australia. If conditions allow, it can show perennial characteristics and survive for several years.

Like other legumes, peanuts do not rely on soluble N in the soil to supply the plant's N requirements. Rather, rhizobial bacteria 'infect' the roots and take N_2 from the atmosphere, making it available to the plant. Unlike other legumes, the mature fruit develops into a legume pod underground (Photo 1) and the plant has four leaflets per leaf, not three.

Photo 1: *Inverted peanut bush.*

Peanut pods are made up of an outer shell that usually contains two kernels. About 70% of the pod's weight is kernel. The kernels are high in oil (44–56%) and protein (22–30%). Depending on variety and conditions, the peanut plant can grow to a height of ~60 cm and can spread up to 100 cm. The plant is unique in that it flowers aboveground and then, once pollinated, produces its fruit below the soil surface.

The flowers, which are small, yellow and pea-shaped, are produced in the axils of the leaves. The flowers are self-pollinated, usually at night. After the ovary is fertilised it begins to elongate and grow towards the soil.

This 'peg' (as it is called) reaches the soil about 7–10 days after pollination. The ovary is carried in the tip of the peg and starts to grow into a pod after it pushes into the soil. Pods will not develop unless there is darkness, mechanical resistance and moisture. [1]

4.1 Botanical types

Peanuts are divided into two broad botanical types based on the following differences:

- the branching pattern of the plant
- the dormancy of the seed
- the maturity of the plant.

The Virginia group does not produce flowers on the central branch, only on the lateral branches. The seeds show some dormancy and the crop is relatively late maturing (130–170 days). Within the Virginia group, there are both erect and Runner (prostrate) types (Photo 2).

1 PCA/DPIF (2007) The peanut plant. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/2a_peanut_plant.pdf

Photo 2: *Some varieties have runner, or prostrate, growth habit.*

The Spanish group produces erect plants with flowers on both the central and lateral branches. The seeds of the Spanish group show little dormancy and the crop is early-maturing (100–130 days).

The crop matures in about 18–24 weeks depending on variety and season temperatures (Photo 3). [2]

Forage peanuts are used for grazing and for groundcover in orchards. These are different species from the varieties grown for their edible kernels. One species, Pinto's peanut (*Arachis pintoi*), is grown in areas of Queensland and NSW with average annual rainfall >1,000 mm. The kernels are much smaller than the cultivated types and are not suitable for the edible trade. [3]

MORE INFORMATION

GC Wright *et al.* (1991) Physiological analysis of peanut cultivar response to timing and duration of drought stress. *Australian Journal of Agricultural Research* 42.

RCN Rachaputi. More efficient breeding of drought-resistant peanuts in India and Australia. Adoption of ACIAR Project outputs 2003–2004.

2 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

3 PCA/DPIF (2007) The peanut plant. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/2a_peanut_plant.pdf

MORE INFORMATION

KJ Boote (1982) Growth stages of peanut (*Arachis hypogaea* L.). *Peanut Science* 9.

BE Warrick. Plant growth and development of peanuts. Soil, Crop and More Information.

Photo 3: *Trials such as this help plant breeders to assess the qualities of new varieties under field conditions.*

4.2 Growth and development

The length of each growth stage depends mainly on temperature. Peanuts are not as sensitive to daylength as soybeans; however, long days and high night temperatures can alter the balance between growth of the bush and the pods. A typical growth cycle for a Virginia variety in both south and north Queensland is shown in Table 1. [4]

Table 1: *Growth stages of a Virginia peanut variety in southern and northern Queensland.*

	Days after planting	
Growth stage	**Southern Qld**	**Northern Qld**
Planting to emergence	6–14	6–12
Emergence to first flower	20–40	28–38
Flowering	35–65	28–65
Pegging	45–75	36–75
Pod-filling	60–130	55–130
Harvest maturity	140–150	125–150

4.2.1 Germination and emergence

A peanut seed has two cotyledons, or seed leaves, and an embryo. After emergence, the cotyledons unfold above the ground. The embryo is not totally protected by the cotyledons and can easily be physically damaged during the harvesting, storage, shelling and planting operations.

A damaged embryo will not develop properly, and although it may germinate and establish, yield will be much lower than from undamaged seed. Plants growing from

4 PCA/DPIF (2007) The peanut plant. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/2a_peanut_plant.pdf

damaged seed often have a curled or J-shaped root system. This defect can also be a symptom of pre-emergence herbicide damage.

It is recommended that peanut seed is planted at soil temperatures of at least 18–20°C, but seed will germinate best at soil temperatures of 20–35°C. The radicle, or root, takes 1–2 days to emerge from the seed.

After 5 days, the taproot is 10–15 cm long. Lateral roots then start to develop and secondary roots grow from the laterals. After 5–10 days, the root is supplying minerals from the soil to the plant.

Photo 4: *Peanuts take 7–14 days to emerge.*

Effective rooting depth of the peanut plant is ~100–120 cm. Where there are no soil restrictions, the peanut plant has a long, spike-shaped root up to 150 cm long, with the primary root system branching to a depth of 60–80 cm.

Emergence through the soil, known as 'cracking', begins 6–14 days after planting (Photo 4). Dry or cool soils can delay emergence for up to 3 weeks, often resulting in poor establishment due to soil-borne disease.

Emerging peanut seedlings can push through quite hard and crusted soil, hence the term 'cracking', but very crusted soil will restrict emergence. [5]

4.2.2 Vegetative growth

After 20 days, there may be 8–10 fully expanded leaves. Unlike most legumes, peanuts have 4 leaflets per leaf, which partially fold up at night.

Peanut foliage can grow at a daily rate of 150–200 kg/ha once full canopy cover is reached.

Peanuts are indeterminate in vegetative and reproductive development. This means the plant does not stop growing in order to flower and produce a crop. Plants continue to grow leaves and stems while flowering and setting pods. The pods must, therefore, compete with the shoots for carbohydrate and nutrients. Indeterminate crops are more likely to be able to compensate for low levels of insect damage.

There are differences in determinacy between varieties. The Virginia types are more determinate than Spanish types. Newer varieties achieve higher pod yields than older

5 PCA/DPIF (2007) The peanut plant. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/2a_peanut_plant.pdf

varieties, because a larger portion of the newer varieties' growth goes into pods than to vegetation.

4.2.3 Flowering

Virginia types, including the Runner types typically grown today, start flowering about 28–40 days after emergence and continue for 25–30 days. Flowers can appear throughout the season.

The yellow flowers open at night, self-pollinate in the early morning and wither by evening of the same day (Photo 5). Flowers grow along the branches and each node can produce several flowers. Generally, only ~15–20% of flowers successfully produce a pod. A plant may have 200 pods.

Drought and temperatures >35°C will reduce the number of flowers produced. If water stress reduces flower number, the plant can recover by producing a flush of flowers when adequate water is received.

Low humidity and high temperatures at flowering can cause short-term plant water stress. This results in flowers with pistils that are too short and adversely affects the vitality of the pollen grains, reducing the chances of fertilisation.

Peanuts are self-pollinated; therefore, bees are not needed and different varieties can be grown side by side with little contamination. [6]

Photo 5: *The small yellow flowers open at night, self-pollinate in the early morning and wither by evening.*

4.2.4 Pegging

After the ovary is fertilised, it begins to elongate and bend towards the soil. The peg, or strings, can be seen about 1 week after fertilisation. The pegs hang down from the stems and continue to grow until they have penetrated the soil (Photo 6). Because one node can produce several flowers, several pegs can develop from a single node.

Pegs may be 2–15 cm long. However, those longer than ~7 cm often do not reach the ground or penetrate the soil adequately. If these long pegs develop a pod, it is more likely to be immature and lost at harvest.

6 PCA/DPIF (2007) The peanut plant. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/2a_peanut_plant.pdf

Pegs enter the soil 8–12 days after pollination. The tip of the peg is sharp, allowing it to penetrate the soil to a depth of 1–7 cm under cool, moist conditions. Most of the pegs that only penetrate 1–1.5 cm develop a pod, but the rate of development is slower.

As soils become harder, it is more difficult for the pegs to penetrate. The pegs are more sensitive to soil compaction than are the roots, so soil moisture, which 'softens' hard soils, can be critical at this stage.

The fertilised embryo is in the tip of the peg and begins to develop and enlarge soon after entering the soil. After the tip of the peg enlarges underground, it is called a pod. [7]

Photo 6: *The peg forms at the base of the flower and grows down into the soil before the pods begin to develop*

4.2.5 Pod development

The period between the peg entering the soil and the shell reaching full size is called pod development. Pod development lasts ~30 days and relies on the soil surface being kept moist. This is a critical time for irrigators. [8]

4.2.6 Podfill

From about 60 days onwards, pods are formed and filled. Pods are full size about 3–4 weeks after peg burial, even though seed growth inside the pod has barely begun. The shell reaches maximum dry weight well before the kernels.

Peanut pod numbers can increase at a daily rate of 100,000–500,000 pods/ha over a 15–25-day period, and pod weight can increase at a daily rate of up to 100 kg/ha for the 75–150 days after emergence.

7 PCA/DPIF (2007) The peanut plant. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/2a_peanut_plant.pdf

8 PCA/DPIF (2007) The peanut plant. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/2a_peanut_plant.pdf

Some nutrients, particularly Ca and boron, are absorbed through minute hairs on the peg and shell. This method of nutrient uptake is relatively inefficient, which means that peanuts have a much higher soil Ca requirement in the top 5–10 cm of soil than other plants.

When soil Ca levels are very low, the developing kernels abort and the empty shell is called a 'pop' (Photo 7). [9]

Photo 7: *Pops (shells without a kernel or with a shrivelled kernel) of Virginia or Runner types are typical of low soil calcium levels. A mild deficiency may cause the embryo to turn dark.*

4.2.7 Maturity

Crops may take 110–170 days (16–24 weeks) to reach harvest maturity, depending on variety, planting time, seasonal conditions and location. Temperature largely controls the time to harvest.

As peanuts mature, the inside layer of the shell changes colour from white, through yellow, orange, brown to black. This gives an indication of harvest maturity.

Once the pods mature, the pegs begin to deteriorate, particularly if foliar diseases have affected the crop. Yield loss begins to occur if peanuts are not harvested within 7–10 days of peak maturity, because the pegs weaken and the pods fall off the plant.

Peanuts often produce a very uneven crop, with a range of mature and immature kernels present at harvest. The relative proportion of mature and immature kernels is assessed and will affect the quality grading of the crop (Photo 8). The payment systems are based on grading the crop into different-sized kernels, each with a different value. Immature or small kernels receive a lower price. [10]

9 PCA/DPIF (2007) The peanut plant. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/2a_peanut_plant.pdf

10 PCA/DPIF (2007) The peanut plant. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/2a_peanut_plant.pdf

Photo 8: *Inspect the kernels to determine the best time to harvest.*

4.3 Seed dormancy

Mature peanut kernels are dormant to some degree. Interestingly, seeds that develop at the peg end of the pod have a longer dormant period than those at the opposite end.

The period of dormancy depends on variety and storage conditions.

Spanish types have virtually no dormancy (5–50 days), whereas Virginia types can be dormant for 100–120 days.

If sufficient moisture is available, seeds with little or no dormancy period can sprout in the field before harvest. Currently grown Spanish varieties can have this problem, but pre-harvest sprouting is generally not problem with Virginia or Runner types. [11]

11 PCA/DPIF (2007) The peanut plant. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/2a_peanut_plant.pdf

Nutrition and fertiliser

5.1 Declining soil fertility

The natural fertility of cropped agricultural soils is declining over time, and so growers must continually review their management programs to ensure the long-term sustainability of high quality grain production. Paddock records, including yield and protein levels, fertiliser test strips, crop monitoring, and soil and plant tissue tests all assist in the formulation of an efficient nutrition program.

Pasture leys, legume rotations and fertilisers all play an important role in maintaining and improving the chemical, biological and physical fertility of soils, fertilisers remain the major source of nutrients to replace those removed by grain production. Fertiliser programs must supply a balance of the required nutrients in amounts needed to achieve a crop's yield potential. The higher yielding the crop, the greater the amount of nutrient removed. Increasing fertiliser costs means growers are increasing pulses within their crop rotation and even the use of ley pastures to complement their fertiliser programs and possibly boost soil organic matter. [1]

5.1.1 Soil organic matter

Soil organic matter (SOM) is a critical component of healthy soils and sustainable agricultural production. Growers understand that crops grown in healthy soils perform better and are easier to manage. Soil organic matter is *'all of the organic materials found in soils irrespective of its origin or state of decomposition'* [2] that is anything in or on the soil of biological origin, alive or dead. It is composed mainly of carbon (C; approximately 60%) as well as a variety of nutrients (including N, P and sulfur). It is difficult to actually measure the SOM content of soil directly so we measure the soil organic carbon (SOC) content and estimate SOM through a conversion factor:

Soil organic matter (%) = organic carbon (%) × 1.72

It is important to understand the role of plants in the SOM cycle. Photosynthesis is the process by which plants take in carbon dioxide (CO_2) from the atmosphere, combine with water taken up from the soil, and utilising the energy from the sun, form carbohydrate (organic matter) and release oxygen (O_2). This is the start of the SOM cycle. When the leaves and roots (carbohydrate) die they enter the soil and become SOM. These residues are decomposed by soil organisms which provides them with the energy to grow and reproduce. The SOM cycle is a continuum of different forms (or fractions) with different time frames under which decomposition takes place. Over time SOM moves through these fractions; particulate, humic and resistant fractions. As SOM decomposes C is released from the system along with any nutrients that are not utilised by the microorganisms. These nutrients are then available for plants to utilise. Eventually a component of these residues will become resistant to further decomposition (resistant fraction Figure 1).

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1 QDAF (2010) Nutrition management. Overview. Department of Agriculture, Fisheries and Forestry Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/nutrition-management/overview

2 JA Baldock, JO Skjemstad (1999) Soil organic carbon/Soil organic matter. In KI Peverill, LA Sparrow, DJ Reuter (eds). Soil analysis: An interpretation manual. CSIRO Publishing, Collingwood Australia.

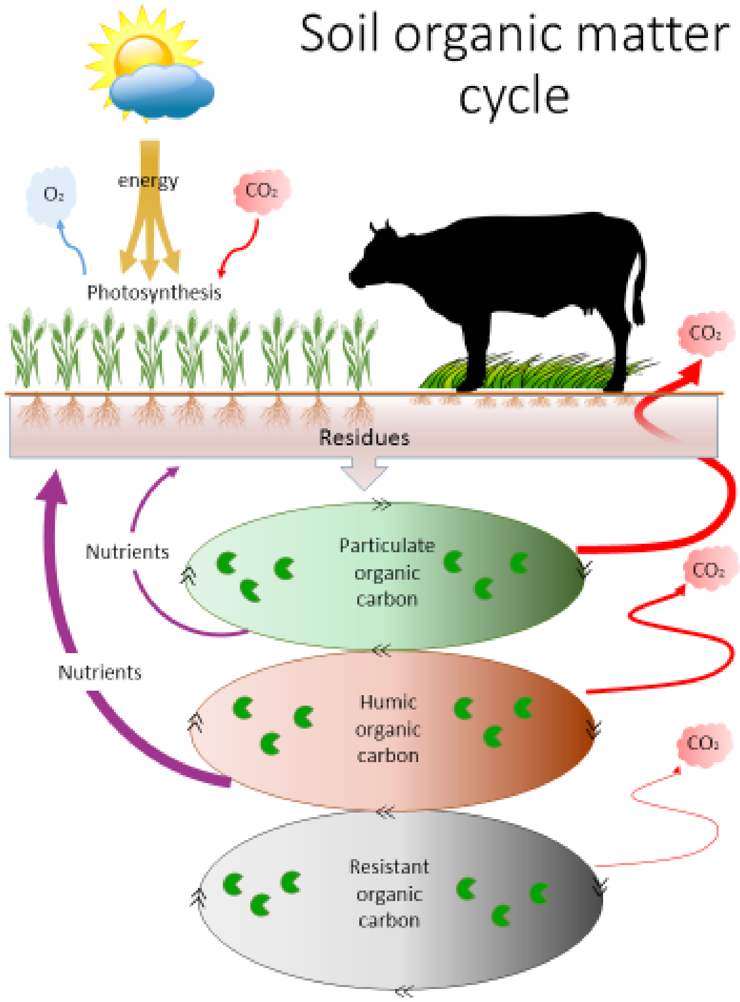


Figure 1: *Organic matter cycle.*

Source: J Gentry, QDAF

Organic matter is fundamental to several of the physical, chemical and biological functions of the soil. It helps to ameliorate or buffer the harmful effects of plant pathogens and chemical toxicities. It enhances surface and deeper soil structure, with positive effects on infiltration and exchange of water and gases, and for keeping the soil in place. It improves soil water-holding capacity and, through its high cation-exchange capacity, prevents the leaching of essential cations such as calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na). Most importantly, it is a major repository for the cycling of N and other nutrients and their delivery to crops and pastures.

Australian soils are generally low in SOM. Initial SOM levels are limited by dry matter production (and so climate) for each land type/location. SOM levels have declined under traditional cropping practices. On-farm measures (sampled 2012–15) from over 500 sites in Queensland and northern NSW confirm that SOM, measured as soil organic carbon, declines dramatically when land is cleared and continuously cropped. This decline affects all soils and land types but is most dramatic for the brigalow–belah soils because their starting organic C levels are so high (Figure 2). [3]

3 QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112–117, http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf

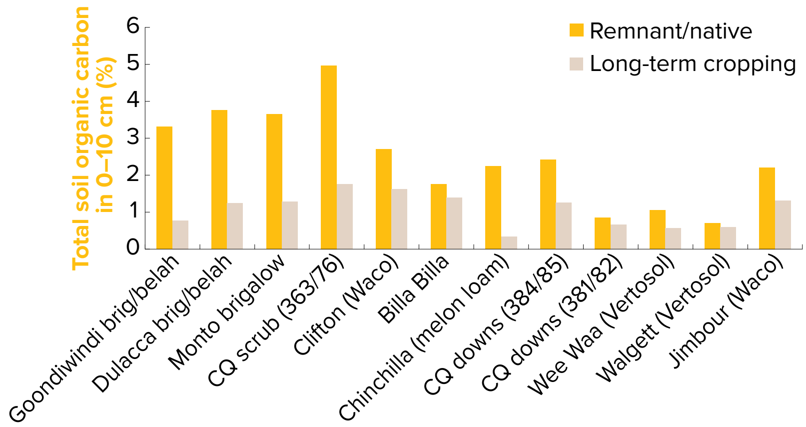


Figure 2: *The decline of soil organic carbon in long-term cropping systems.* [4]

Declining levels of SOM have implications for soil structure, soil moisture retention, nutrient delivery and microbial activity. However, probably the single most important effect is the decline in the soil's capacity to mineralise organic N to plant-available N. Past research (1983) has shown that N mineralisation capacity was reduced by 39–57%, with an overall average decline of 52% (Figure 3). [5] This translated into reduced wheat yields when crops were grown without fertiliser N.

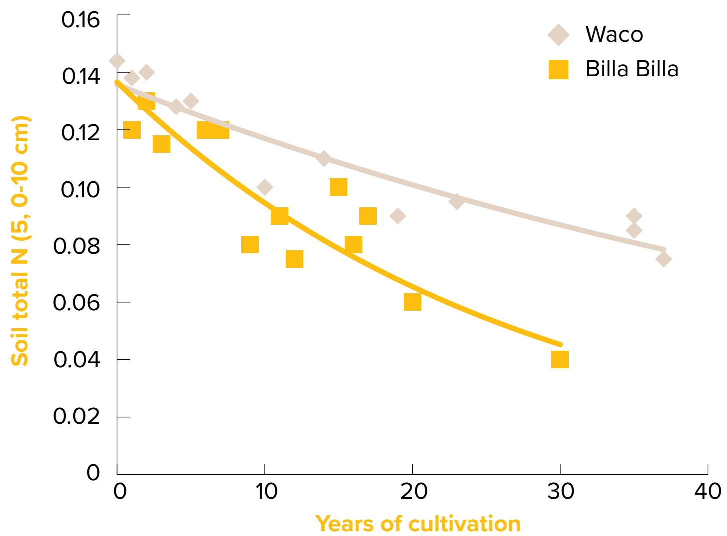


Figure 3: *Graph of decline in soil total N with years of cropping. The decline was greater for the Billa Billa soil (clay content 34%) than the Waco soil (clay content 74%).* [6]

Source: based on Dalal & Mayer (1986a,b)

4 QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112–117, http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf

5 RC Dalal, RJ Mayer (1986) Long term trends in fertility of soils under continuous cultivation and cereal cropping in southern Queensland. II. Total organic carbon and its rate of loss from the soil profile. Australian Journal of Soil Research 24, 281–292.

6 RC Dalal, RJ Mayer (1986) Long term trends in fertility of soils under continuous cultivation and cereal cropping in southern Queensland. II. Total organic carbon and its rate of loss from the soil profile. Australian Journal of Soil Research 24, 281–292.

5.1.2 Current situation

Soil organic carbon levels are simply a snapshot of the current balance between inputs (e.g. plant residues and other organic inputs) and losses (e.g. erosion, decomposition) constantly happening in each soil and farming system. The decline over time is overwhelmingly driven by the extent of fallowing in our farming systems. Most fallow rain in the northern region (as much as 75–80% in a summer fallow) is lost as runoff or evaporation. This wasted rain does not grow dry matter to replenish the organic matter reserves in the soil. However, increasing moisture in the fallowed soil continues to support microbial decomposition. This helps accumulate available N for the next crop, but reduces SOC. The SOM and C levels will continue to decline until they reach a new lower level that the dry matter produced by the new farming system can sustain. Put simply,

'Crops may make more money than trees and pastures, but do not return as much dry matter to the soil.'

Total SOC levels vary within a paddock, from paddock to paddock and from region to region. Comprehensive sampling was under taken throughout the northern region, with over 900 sites sampled and analysed for total organic C at 0–10 cm depth. These results varied enormously across sites. The average was 1.46% however it varied from under 0.5% to over 5% (Figure 4). [7] A selection of these data from representative soil types throughout the northern grains region clearly indicates how soil C levels can be significantly different due to soil type (Figure 5). [8]

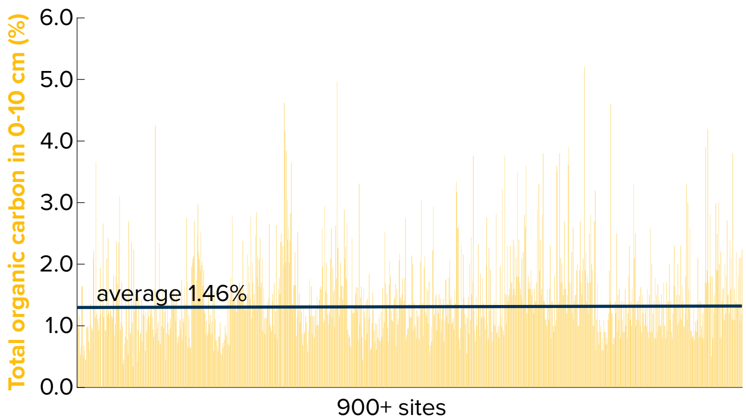


Figure 4: *Soil organic C levels on mixed farms within the GRDC Northern Region.* [9]

7 QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112 – 117, http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf

8 QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112–117, http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf

9 QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112–117, http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf

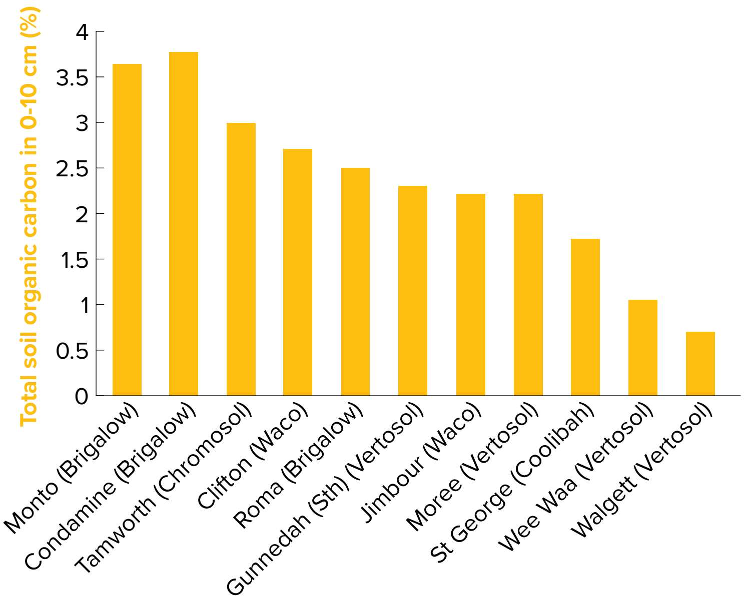


Figure 5: *Impact of land-type on total soil C levels (0–10 cm) across the northern region.* [10]

5.1.3 Options for reversing the decline in soil organic matter

Soil organic matter is an under-valued capital resource that needs informed management. Levels of SOC are the result of the balance between inputs (e.g. plant residues and other organic inputs) and losses (e.g. erosion, decomposition, harvested material) in each soil and farming. [11] So maximising total dry matter production will encourage higher SOC levels, and clearing native vegetation for grain cropping will typically reduce SOC and SOM levels. [12]

Modern farming practices that maximise Water Use Efficiency for extra dry matter production are integral in protecting SOM. Greater cropping frequency, crops with higher yields and associated higher stubble loads, pasture rotations and avoiding burning or baling will all help growers in the northern region to maintain SOM.

Research in the past has shown the most direct, effective means of increasing SOM levels is through the use of pastures, however these pasture have to be productive. A grass only pasture will run out of N especially in older paddocks, which is normally the reason why these paddocks are retired from cropping. As a result, a source of N is required to maximise dry matter production, this can be supplied via a legume or N fertiliser. The rotation experiments of I. Holford and colleagues at Tamworth, NSW and R. Dalal and colleagues in southeast Queensland provide good evidence of this (Table 1).

The greatest gains in soil C and N, relative to the wheat monoculture, were made in the 4-year grass–legume ley, with increases of 550 kg total N/ha and 4.2 t organic C/ha. The chickpea–wheat rotation fared no better than the continuous wheat system. The shorter (1–2-year) lucerne and annual medic leys resulted in marginal increases in SOC and N (Table 1).

10 QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112–117, http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf

11 FC Hoyle, JA Baldock, DV Murphy (2011) Soil organic carbon: Role in rainfed farming systems. In PG Tow, I Cooper, I Partridge, C Birch (eds). Rainfed farming systems. Springer, pp. 339–361.

12 RC Dalal, RJ Mayer (1986) Long term trends in fertility of soils under continuous cultivation and cereal cropping in southern Queensland. II. Total organic carbon and its rate of loss from the soil profile. Australian Journal of Soil Research 24, 281–292.

Clearly, time and good sources of both C and N are required to build up SOM, which is exactly what the 4-year grass–legume ley provided. Nitrogen was supplied via N_2 fixation by the lucerne and annual medic in the pasture, with most of the carbon supplied by the grasses, purple pigeon grass and Rhodes grass. There were no inputs of fertiliser N in any of the treatments in Table 1. [13]

Table 1: *Effects of different rotations on soil total N and organic C (t/ha) to 30 cm and as gain relative to continuous wheat.*

Rotation	Wheat crops	Soil total N		Organic C	
		0–30 cm	Gain	0–30 cm	Gain
Grass/ legume ley 4 years	0	2.91	0.55	26.5	4.2
Lucerne ley (1–2 years)	2-3	2.56	0.20	23.5	1.2
Annual medic ley (1–2 years)	2-3	2.49	0.13	23.1	0.8
Chickpeas (2 years)	2	2.35	0.00	22.0	0.0
Continuous wheat 4 years	4	2.36	-	22.3	-

Further research was initiated in 2012 to identify cropping practices that have the potential to increase or maintain SOC and SOM levels at the highest levels possible in a productive cropping system. Paired sampling has shown that returning cropping country to pasture will increase soil C levels (Figure 6). However, there were large variations in C level increases detected, indicating not all soil types or pastures preform the same. Soil type influences the speed by which C levels change, i.e. a sandy soil will lose and store C faster than a soil high in clay. As too does the quality and productivity of the pasture, maximising dry matter production by ensuring adequate nutrition (especially in terms of N and P) will maximise increases in soil C over time. Current research in Queensland being undertaken by the Department of Agriculture, Fisheries and Forestry (QDAF) is indicating that the most promising practice to date to rebuild soil C stocks, in the shortest time frame, is the establishment of a highly productive pasture rotation with annual applications of N fertiliser, however, adding an adapted legume is also effective. [14]

13 D Herridge (2011) Managing legume and fertiliser N for northern grains cropping. Revised 2013. GRDC, https://www.researchgate.net/publication/293958450_Managing_Legume_and_Fertiliser_N_for_Northern_Grains_Cropping

14 QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112–117, http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf

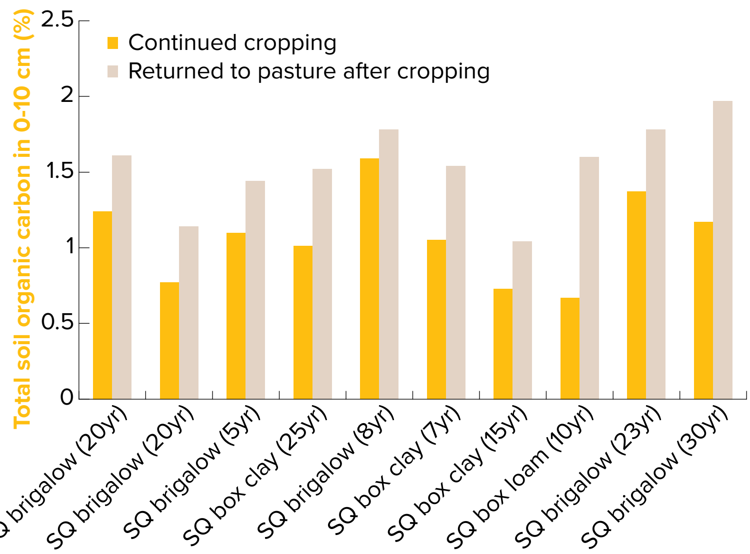


Figure 6: *Total organic carbon comparisons for croplands resown to pasture.* [15]

Impact of fertiliser N inputs on soil

If the rates of fertiliser N are sufficiently high, the effects can be positive. In the Warra experiments, both soil organic C and total N increased marginally (3–4%) over an 8-year period when no-till, continuous wheat, fertilised at a rate of 75 kg N/ha, was grown. This is in contrast with decreases of 10–12% in soil organic C and N in the non-fertilised, continuous wheat and chickpea–wheat plots. The result was much the same in NSW Department of Primary Industries experiments in northern NSW. At the Warialda site, for example, SOM increased during 5 years of cropping but only where fertiliser N had been applied to the cereals.

It is clear from the above examples that building SOM requires N. It works in two ways. First, the fertiliser or legume N produces higher crop/pasture yields and creates more residues that are returned to the soil. Then, these residues are decomposed by the soil microbes, with some eventually becoming stable organic matter or humus. The humus has a C/N ratio of about 10:1, i.e. 10 atoms of C to 1 atom of N. If there are good amounts of mineral N in the soil where the residues are decomposing, the C is efficiently locked into microbial biomass and then into humus.

If, on the other hand, the soil is deficient in mineral N, then more of the C is respired by the soil microbes and less is locked into the stable organic matter. [16]

5.2 Nutritional requirements

Peanuts differ from other crop in some of their nutritional needs. Most of the pod's Ca and boron (B) is taken directly from the soil rather than via the roots. Calcium is often applied to the crop before flowering. Peanut roots depend on arbuscular mycorrhizal (AM) fungi (previously known as vesicular arbuscular mycorrhizal, or VAM) and are very effective at utilising residual phosphorus (P) from previous crops in the rotation. [17]

VIDEOS

Crop nutrition

15 QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112–117, http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf

16 D Herridge (2011) Managing legume and fertiliser N for northern grains cropping. Revised 2013. GRDC, https://www.researchgate.net/publication/293958450_Managing_Legume_and_Fertiliser_N_for_Northern_Grains_Cropping

17 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

Peanuts have special nutritional needs because the fruit grows under the ground. The fertility of the soil where pegs and pods develop is important because the pod absorbs most of its required Ca and B through the shell, rather than through the roots, and then through the peg. This influences the method and timing of some fertiliser applications, which may differ considerably from those of other crops.

Soils naturally contain beneficial fungi that help the crop to access nutrients such as P and zinc (Zn). The combination of the fungus and crop root is known as arbuscular mycorrhiza(e) (AM). Many different species of fungi can have this association with the roots of crops. Many that are associated with crops also form structures called vesicles in the roots.

The severe reduction or lack of AM shows up as long-fallow disorder—the failure of crops to thrive despite adequate moisture. Ongoing drought in the 1990s and beyond has highlighted long-fallow disorder where AM fungi have died out through lack of host plant roots during periods of long fallow. As cropping programs restart after dry years, a yield drop is likely from reduced AM levels, making it difficult for the crop to access nutrients.

Long-fallow disorder is usually typified by poor crop growth. Plants seem to remain in their seedling stages for weeks and development is very slow.

Benefits of good AM levels are:

- improved uptake of P and Zn
- improved crop growth
- greater drought tolerance
- improved soil structure
- greater disease tolerance.

In general, the benefits of AM are greater at lower levels of soil P because AM increase a plant's ability to access this nutrient. [18]

Peanuts have an exceptional ability to extract some nutrients from the soil, particularly P and Zn. This is why peanuts have a reputation for being able to respond better to fertiliser left after previous crops than to fertiliser directly applied to the peanut crop. AM fungi are one reason for this phenomenon. These fungi occur naturally in most soils and readily infect peanut root systems.

The AM fungi assist the plant's roots to extract P and Zn from the soil. So dependent are peanuts on AM fungi for uptake of P that if the fungi are not present, the crop needs soil P levels up to 10 times higher than normally required.

In the South Burnett, Queensland, peanuts are commonly fertilised with P by over-fertilising the previous maize crop. Some growers also apply P before or at planting. Similarly, on the Atherton Tableland, peanuts are often grown on the residual fertiliser following a potato crop.

Different fertiliser programs are needed on other soil types. Iron (Fe) deficiency is a particular problem on heavier clay soils with pH >8.0, because peanut roots are not very efficient at accumulating Fe.

Copper (Cu), magnesium (Mg) and Zn responses have also been recorded on lighter sands in coastal and inland areas, and Zn deficiency can also be a problem on soils with pH >7.5.

Other factors can cause symptoms similar to those of nutrient deficiencies. For example, night temperatures <9°C cause leaf yellowing and a slight interveinal chlorosis (Photo 1), and Verticillium wilt shows as a pale-green colour around the leaf margins.

18 QDAF (2010) Nutrition—VAM and long fallow disorder. Department of Agriculture, Fisheries and Forestry Queensland, 14 Sept. 2010, http://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/nutrition-management/nutrition-vam

Photo 1: *Yellowing between veins is typical of cool temperatures, <9°C.*

Table 1 presents the essential nutrients for peanuts and the concentrations found in the youngest fully expanded leaves. Use these values as a guide only. Nutrient levels vary depending on the part of plant that is sampled. Levels also change as the plant matures and nutrients are relocated into the pods as the kernels develop. A soil test for Ca provides the only reliable guide for pod development. [19]

19 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

Table 2: *Classification of nutrient status of peanut crops by analysis of the youngest fully expanded leaves.*

Nutrient	Severely deficient	Deficient	Marginally adequate	Adequate	High
N (% DM)	<3.2	3.2–3.7	3.8–4.1	4.2–4.5	>4.5
P (% DM)	<0.19	0.19–0.23	0.24–0.26	0.27–0.40	>0.40
K (% DM)	<0.7	0.7–1.3	1.4–1.7	1.8–2.5	>2.6
S (% DM)	<0.15	0.16–0.20	0.21–0.25	0.26–0.30	>0.3
B (mg/kg DM)	<13	13–23	24–30	30–50	>50
Mo (mg/kg DM)	<0.02	0.02–0.05	0.05–0.13	0.13–1.0	>1.0
Cu (mg/kg DM)	<1.3	1.3–1.7	1.8–2.1	2.2–5.0	>5.0
Mg (% DM)	<0.2	0.2–0.25	0.25–0.3	0.30–0.80	–
Ca (% DM)	–	<1.0	1.0–1.2	1.4–2.0	–
Mn (mg/kg DM)	–	<10	–	50–350	600–800
Zn (mg/kg DM)	<12	15–18	18–20	20–50	>200
Fe (mg/kg DM)	<25	25–35	35–50	50–300	–

Note: these values apply only before the crop starts to fill pods. Sources: Bell et al. 1990; Reuter and Robinson 1986; Reuter and Robinson 1997

5.3 Soil fertility

Soil fertility is very important for peanuts. During the growing of the peanut pod, Ca and B are absorbed through the shell rather than through the plant's roots. This has implications for the method and timing of fertiliser applications.

Peanuts tolerate a wide range of soil acidity levels; however, the ideal pH is 6.0–7.0. Soils that are more acidic (pH <6.0) should be limed. Ensure your soil test is properly interpreted by a qualified agronomist. [20]

Potassium (K), P, Ca and sulfur (S) are the nutrients most commonly applied to peanuts, but growers should also check Mg levels, which are becoming depleted in some Australian soils.

Micronutrients must not be ignored—deficiency can sometimes lead to major yield losses. Zinc (Zn), B and molybdenum (Mo) are commonly applied. Copper (Cu) is often deficient on very sandy soils. Some soils also have manganese (Mn) deficiency.

Foliar applications of micronutrients are common; however, soil applications are also suitable for some nutrients. [21] Your agronomist can provide advice.

MORE INFORMATION

[The what where and why of soil testing in the northern region]

5.4 Crop removal rates

Nutrient management needs to take into account the removal from the farm of nutrients contained in crop products such as grain and hay (Table 2). Peanuts have a high K content compared with most grain crops (although only half the K concentration of soybean seed), and when hay is taken from the paddock, even more K is removed.

20 PCA. Soil preparation. Peanut Company of Australia.

21 PCA. Peanuts and fertilisers. Peanut Company of Australia.

Table 3: *Mineral content of peanut kernel, shell and hay.*

Mineral element content (%)				Nutrients removed (kg/t)	
	Kernel	Shell	Hay	Hay	Nut-in-shell
N	4.6	1.3	1.5	15	40
P	0.4	0.03	0.15	1.5	3
K	1.0	0.9	2	20	8
S	0.2	n.a.	0.2	2	2+
Ca	0.07	0.2	0.8	8	1.3
Mg	0.2	0.1	0.3	3	2
Fe	0. 001	0.15	n.a.	n.a.	0.5
Cu	0.001	0.001	0.0005	0.005	0.01
Zn	0.006	0.002	0.001	0.01	0.05
Mn	0.002	0.004	n.a.	n.a.	0.02
B	0.03	0.001	0.003	0.03	0.2

Source: This table has been compiled from a range of sources; there is a great deal of variation between samples and sources and these values provide a general guide only; n.a., not available

Table 2 provides values indicating the quantity of each element removed at harvest. This is a guide to what must be replaced to maintain soil fertility. For example, each tonne of hay will contain about 20 kg K, requiring 40 kg of muriate of potash (or equivalent) to replace it. [22]

5.5 Soil testing

Soil testing is essential. As well as tests to the traditional depth of 0–1 cm, deeper tests should be considered to check nutrient levels at depth. Many soils have reasonable levels of nutrients in the topsoil but nutrients are very low deeper in the profile. Consider 10–20 and 20–30 cm tests.

It is recommended that growers obtain a complete nutrient analysis or soil test prior to planting peanuts. Peanuts are regarded as good scavengers for nutrients, but if any nutrients are lacking in the soil, including micronutrients, then yield potential may be limited. Your soil test should be analysed through an ASPAC-accredited laboratory and properly interpreted by a qualified agronomist.

Once you have analysed soil test results you can plan a fertiliser program based on available nutrients and, most importantly, your budget or expected yield. If the hay is to be baled after harvest, you will need a different fertiliser program.

Replacements rates will need to be adjusted based on removal of both peanuts and hay.

5.6 Nutrient availability and soil pH

All pH levels presented here refer to the soil acidity testing method using 1 part soil : 5 parts water (pH_{H2O}). Soil acidity, or pH, affects the plant's ability to take up nutrients from the soil. If the pH is not within the range required for optimal plant growth, the plant is not able to make the best use of the nutrients in the soil, even if the correct amounts are present in the soil. It is important to correct soil pH so that the investment in nutrient applications is not wasted.

Peanuts tolerate a wide range of soil acidity levels. The ideal soil pH range is 5.5 (slightly acidic) to 7.0 (neutral). If the soil is more acidic (i.e. pH <5.5), nodulation and N_2 fixation can be reduced and trace element imbalances can occur, potentially causing

MORE INFORMATION

PCA/QDPIF. Crop nutrition.

C Guppy *et al.* Interpreting soil tests in the light of P, K and S research.

M Bell, C Guppy. Interpreting soil test results for the northern region.

22 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

aluminium (Al) and Mn toxicity. If the soil is more alkaline (i.e. pH >7.0), deficiencies in Zn, and possibly Fe, can develop.

A soil test will show whether the pH needs adjusting with products such as agricultural lime. The amount of lime needed to correct low pH depends on the buffering capacity of the soil and the extent to which it is necessary to raise pH. The buffering capacity of a soil is its ability to 'absorb' Ca without causing a change in soil pH.

Clay soils and soils with higher organic matter, such as the red volcanic soils around Kingaroy, Queensland, generally have a higher buffering capacity than sandy soils. Although more lime may be needed to correct the pH in highly buffered soils, these soils are able to 'hold' the pH at the new level for longer than poorly buffered soils.

When you have your soils analysed, ask for a 'lime requirement' figure, which represents the lime required to reach, say, pH 6.5. This is based on well-researched data that take into account the buffering of the soil and the amount the pH is to be raised. The calculation used gives the amount of lime required to treat a 10-cm layer of soil only, so if the lime is mixed into the top 20 cm of soil, the recommended rate must be doubled to treat the extra soil.

There is an important distinction between correcting pH and correcting Ca deficiency. Once the pH is correct, Ca applications may still be needed to feed the crop (Photo 2). Calcium nutrition is particularly important for growers on sandy soils. [23]

Photo 2: *Lime or gypsum banded over the row will provide Ca to the plant.*

MORE INFORMATION

Incitec Pivot Fertiliser. Nutrient advantage.

23 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

5.7 Calcium

Because of their underground fruiting habit, peanuts have a relatively high requirement for Ca. Calcium is not very mobile within the plant, and the peanut pod takes up its own Ca directly from the soil. Consequently, available Ca must be present in the podding zone (the top 2–10 cm of soil). Growers should check that applications of Ca post-plant are available to the crop.

Adequate Ca is essential for ensuring high-quality kernels. Insufficient Ca may lead to smaller kernels and kernels with hollow hearts (not completely filled). Low Ca will also reduce the germination of seed peanuts. In larger seeded peanuts (Virginia types), low Ca can lead to kernel abortion, causing empty pods or 'pops' [24] as well as splits and poor germination. [25]

To provide an adequate supply of Ca in the podding zone, natural gypsum (calcium sulfate) is usually applied at early flowering over the peanut row. Gypsum is a relatively soluble source of Ca that is easily absorbed by the pods. Gypsum contains 23% Ca and is applied at rates of 600–1,000 kg/ha. [26]

Gypsum may be used as a Ca fertiliser, but it may not be the product of choice. Lime should be used on acid soils that are low in Ca. Not only does lime supply Ca, it also corrects acidity (raises the soil pH). However, it is ineffective in neutral and alkaline soils.

Typically, gypsum is applied during the fallow period. The rate at which gypsum is applied as a Ca fertiliser where the pH does not need amending is 1–2.5 t/ha. This can remain effective for several years. [27]

Dolomite contains Ca and Mg. It can correct soil acidity and supply some Ca. However, you should find out the ratio of Ca to Mg in the soil before using dolomite. The Ca level should be at least double that of Mg. Otherwise, the Mg can interfere with the pod's uptake of Ca.

Alternatively, fine lime can be applied 4–6 weeks prior to planting (if soil pH is <6.0) and lightly incorporated. Lime is less soluble than gypsum. It is usually applied at rates of 2.5–5 t/ha and contains 35–40% Ca. [28]

Note that peanuts need much higher Ca levels in the surface soil (top 5–10 cm) than other crops. It is a major factor in kernel development and quality.

Deficiency symptoms are likely where soil surface Ca levels are low, large kernel varieties are being grown, and the soil surface is dry. Sandy soils generally have low Ca levels.

A severe lack of Ca in the podding zone will cause pops (full size pods with no kernels inside) or pods with only one kernel (Photo 3). A mild deficiency may cause the embryo to turn dark, reducing germination and vigour.

Low soil moisture can limit the uptake of Ca because soil Ca can only move through the soil when it is dissolved in water; therefore, pops are always worse in a dry season. It is common to have paddocks where no pops are recorded in wet seasons and quite a few in drier seasons.

Foliar symptoms of Ca deficiency include yellowing, multiple branching (rosetting), death of the growing point and petiole collapse. Such symptoms are rare in field conditions.

24 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

25 PCA. Peanuts and fertilisers. Peanut Company of Australia.

26 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

27 Incitec Pivot. Gypsum. Fertfacts. Incitec Pivot Ltd, http://www.incitecpivotfertilisers.com.au/en/Soil%20,-a-,%20Plant%20Tests/~/media/Gypsum%20Fact%20Sheet.ashx

28 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

Photo 3: *Pops (shells without a kernel or a shrivelled kernel) of Virginia or Runner types are typical of low soil Ca. A mild deficiency may cause the embryo to turn dark.*

Calcium deficiency in the podding zone can be overcome with applications of gypsum or lime. Liming will generally correct Ca deficiency for several years. However, in some very sandy soils, the ability to hold a large amount of Ca in the shallow pod-zone is limited and some Ca may be leached from the zone within a season. Annual applications of a Ca source may then be required. Choose pH-neutral and more soluble sources of Ca, such as gypsum, rather than lime in this situation.

Where soil pH is acceptable but Ca is low, gypsum applied in bands over the row (i.e. into the pegging zone) is more economical and more effective over the relatively short period of pod-filling.

A rate of 400–600 kg/ha applied in bands 30–40 cm wide is usually adequate, although soils with very low Ca or high Mg may need a higher rate.

Choose Spanish and Runner types for soils with a low ability to hold positively charged nutrients such as Ca (i.e. soils with a cation exchange capacity, or CEC, of <4 cmol/kg or meq/100 g). In these situations (e.g. on sandy soils), the soil cannot hold enough Ca to adequately fill pods in the larger Virginia types, which are less efficient at accumulating Ca. In these soils, the 'exchangeable' Ca needs to be ~70% of the total CEC, i.e. the desired cation balance is Ca 70%, Mg 15%, K 5%, and others, including sodium (Na) 10%.

In red and brown forest soils of the inland Burnett, the CEC and Ca levels are usually adequate, but extra Ca is sometimes applied because the topsoil is dry, reducing the efficiency of Ca uptake. Normal liming practices (to maintain pH) usually meet this requirement.

Only 10–14% of the Ca taken up by the crop ends up in the pods; most is in the foliage (66%) and roots. The shells and kernels extract their Ca directly from the soil in the podding zone, whereas Ca absorbed by the roots is carried to the stems and leaves but not down the peg to the pod.

Larger kernel varieties of peanuts need higher soil levels of Ca. Small-seeded Spanish types are much less susceptible to low soil Ca than Runner types, which in turn are less susceptible than Virginia types.

For large-seeded varieties, the need for Ca also depends on the level of soil K. Pops can result from low Ca in the podding zone and/or inhibited Ca uptake because of high levels of other nutrients, particularly K.

Apply Ca if a soil test shows any of the following:

- Ca <70% of the CEC and CEC <6 cmol/kg
- Ca >70% of the CEC and CEC 6–10 cmol/kg, but soils likely to be quite dry during pod-filling

- CEC <4 cmol/kg, regardless of the proportion of CEC as Ca.

Low Ca can affect the germination of seed, as well as the peanut's ability to resist pathogens such as *Aspergillus flavus* (the cause of aflatoxin), *Rhizoctonia* and some fungi causing pod rots.

Analysis of peanut foliage will not show whether sufficient Ca is available for kernel development. A soil test in the pod-zone will give a better indication.

Seed peanuts from crops grown under marginal to low Ca have poor germination. The level of Ca in the kernel needs to be ≥420 mg/kg for satisfactory germination. As a precaution, apply extra Ca to all seed crops.

Gypsum is more soluble than lime and is preferable for over-the-row applications, particularly if timing is close to flowering. Gypsum also corrects deficiency of S and should be used on alkaline soils (pH >7) instead of lime.

A drawback of the relatively high solubility of gypsum is that very heavy rain may leach it from the pegging zone in sandy soils. When using gypsum on these soils, time application as close as practical to flowering.

Because lime is less soluble, it is best applied at least 1 month before planting to ensure that the Ca has become available. Calcium is needed in the pod-zone, so do not incorporate the lime deep into the soil. Lime applied to soils with a pH >6.5 may cause Zn or Mg deficiency. [29]

5.8 Nitrogen

MORE INFORMATION

The want and waste of the nitrogen economy

High levels of N are needed for high-yielding peanut crops. However, like other legumes, peanuts fix N_2 from the air via symbiotic bacteria (rhizobia) living in nodules formed on the peanut plant roots (Photo 4).

Nitrogen is required for growth and is taken up throughout the season. It is sourced from the soil or from N fixation. Growers must inoculate peanut seed with efficient strains of rhizobia prior to planting to ensure optimum N fixation. When the suitable rhizobia become established in fields, farmers may not need to add N fertilisers to peanut crops. [30]

Photo 4: *Many nodules, like those on these roots, are needed to fix sufficient N. Inoculating the soil with rhizobia at planting is essential.*

29 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

30 PCA. Peanuts and fertilisers. Peanut Company of Australia.

Poor nodulation, waterlogging or a lack of other nutrients essential for N fixation, such as P and Mo, can cause N deficiency. Generally, plants recover quickly from temporary waterlogging. A shallow cultivation will allow the soil to aerate and will hasten recovery from waterlogging.

Symptoms of N deficiency include stunting of the plant and yellowing of the leaves, frequently with a reddish discoloration of stems (Photo 5).

Photo 5: *Pale plants and leaves are typical of low N levels, often associated with poor nodulation or wet soils.*

Rates of N up to 50 kg/ha may be useful where waterlogging has killed rhizobia or where nodulation is slow or has failed. Greatest benefit will come from applying N when the crop is podding; however, 20–30 kg/ha of early (starter) N may be warranted in situations where soil N is very low prior to nodules becoming established and functional (after about 1 month). This can happen when a sugarcane trash blanket is incorporated before planting the peanut crop.

To avoid these problems, inoculate seed carefully, do not plant in areas prone to waterlogging, and provide the nutrients essential for successful nodulation.

Excessive soil N, from either natural fertility or fertiliser, can delay nodulation, can cause excessive vegetative growth, and lead to fewer flowers producing mature fruit.

Nitrogen fixation can provide up to 70% of the total N uptake of the plant, often ≥200 kg N/ha. The remainder is obtained from the soil. High-yielding crops will fix more N than low-yielding ones.

Check the plant roots for signs of nodulation. Slice through the nodule and note the colour inside. Reddish colour indicates that N is being fixed; green, the nodule is mature but not fixing N; white, the nodule is immature; and brown, old nodules.

Nitrogen fixation of 100 kg/ha under dryland conditions has been recorded at Kingaroy, and 200 kg/ha under irrigation at Bundaberg.

Total N uptake from soil reserves and symbiotic fixation under high-density, irrigated conditions may reach 300–350 kg/ha (excluding N in the roots) and under dryland conditions 100–200 kg/ha. Commonly, an additional 30–40% of the N is stored in the roots and pods (i.e. 100–120 kg N/ha under irrigation and 40–80 kg N/ha in dryland situations). About 25% of the total crop N remains in the roots after harvest and 30–50% is removed in the harvested pods, with the remaining 25–45% left as stubble or removed as hay.

Peanut crops generally do not add N to the total soil N store, although they will contribute soluble N to the next crop. Peanut residues typically contain 2% N by weight and, if left in the paddock, release N quite quickly to a following crop.

It is possible to gain up to 100 kg N/ha in the soil store from the peanut crop, but only if a crop of large, healthy plants does not yield as well as expected. With the new, high-yielding varieties, the net N balance after the peanut crop is more likely to be negative, because the peanut crop has put more N into the pods than what remains in the plant residues. [31]

5.8.1 Nitrogen loss

Key points

- Nitrogen is a mobile nutrient and can be lost downwards (leaching), sidewards (erosion) and upwards (gas emissions).
- To reduce losses, avoid unnecessarily high N rates.
- Delay or split N fertiliser application so that peak N availability coincides with peak crop demand.
- Using legumes in crop rotations will also reduce N losses.

N fertiliser is one of the most significant input costs for northern grain growers, so understandably growers want to minimise applied N losses through better management to maximise return on investment.

N for crop production can come from SOM, crop residues (especially legumes), manure and fertiliser. The amount of plant-available N (mineral N) released from microbial breakdown of SOM, crop residues and manure depends on the amount of organic matter in the soil, the amount of crop residue remaining and its N concentration, and the amount and type of manure applied and how it is applied. However, as the N release process is undertaken by microbes, temperature and moisture availability can also influence the rate of release.

In the north, growers either measure this 'mineralised' N in the soil profile towards the end of a fallow period using soil testing or estimate it from SOM levels, fallow rainfall and rotation histories.

They then derive a fertiliser N requirement based on the difference between this soil mineral N and the likely crop demand based on expected yields. N fertilisers such as urea are then applied either directly into the soil (banding), or broadcast onto the soil surface and then incorporated.

In contrast to the soil organic N reserves, fertiliser N is either immediately available for plant use (in ammonium or nitrate forms) or soon available after conversion in soil (for example, from urea to ammonium and nitrate).

Any loss of N will reduce the pool of N that a crop can use to produce biomass and grain yield. [32]

How nitrogen is lost

Essentially, cropping systems are 'leaky' and N (especially when in the nitrate form) can be lost via downward, sideward or upward movement.

Downward movement via leaching (the drainage of water through the soil profile) is a greater problem in lighter textured soils than the medium–heavy clay soils dominating the northern grains zone, but previous research has demonstrated some losses can occur this way.

31 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

32 GRDC (2017) Lost N and what you can do. Ground Cover Issue 123, July–August 2016, https://grdc.com.au/resources-and-publications/groundcover/ground-cover-issue-123-julyaugust-2016/lost-N-and-what-you-can-do

Sideways movement can occur rapidly through erosion of organic matter-rich topsoil during intense rain events, or more slowly through lateral movement of nitrate in soil water.

The main upwards N loss pathways consist of gaseous losses through ammonia volatilisation or denitrification of nitrate (a biological process occurring within the soil profile wherever there is sufficient available nitrate, labile C substrate and low oxygen conditions, such as in slowly draining soils).

Understanding N-loss pathways and how they are influenced by seasonal conditions and management strategies is a critical first step in optimising the efficiency and profitability of applied N use. [33]

Case study: One management strategy to reduce nitrogen losses

A trial at Kingaroy in southern Queensland explored the impact of crop rotation (grain or grain-legume pre-histories) on fertiliser N requirements and N use efficiency during a subsequent sorghum crop in 2014–15. The pre-histories were sorghum/peanuts/soybeans in the 2013–14 summer, all harvested for grain.

In the second summer crop year when sorghum was planted, the fertiliser N rate required to achieve a sorghum grain yield of 6.3 t/ha was reduced by 50% after the peanut rotation and the need removed entirely after soybeans. Specifically, sorghum following sorghum needed 120 kilograms of N/ha, sorghum following peanuts needed 60 kg of N/ha and sorghum following soybeans required no N fertiliser at all.

Fertiliser N losses were negligible at the optimum N rate in the peanut or sorghum histories on this friable soil, with each history recovering 65 to 70% of the applied N in crop biomass in these high-yielding crops.

Fertiliser is a major input cost for northern growers and will continue to be so as the region's soil organic matter and associated mineralisable N reserves continue to decline. This will continue to be the case unless legume frequency in crop rotations increases substantially. [34]

5.9 Phosphorus

MORE INFORMATION

Phosphorus and potassium nutrition

Peanuts also require relatively large amounts of P but the presence of arbuscular mycorrhizal (AM) fungi on their roots makes them very efficient at absorbing any reserves in the soil.

QDAF experiments at Kingaroy, showed that very high levels of P were needed when no AM fungi were present. Soils that had been sterilised required ~240 kg P/ha to achieve full growth potential, but when the AM fungi were not destroyed, the rate was just 30 kg P/ha.

Peanut growers have traditionally used high rates of P on alternate crops (e.g. maize) during crop rotation. Peanuts respond better to fertiliser left over from the previous crop than to fertiliser directly applied to the latest crop. [35]

Peanut plants require moderate amounts of P. When AM fungi are present in the soil, peanut plants become very efficient at extracting soil P. Phosphorus is required for general plant growth and plays an important role in root development and crop maturation.

Deficiency symptoms show when soil P levels are <20 mg/kg of soil (Colwell or bicarbonate P tests) or where AM fungi are not present. Many Australian soils are naturally low in P, but many cropped soils have a considerable P bank because of residual phosphate fertilisers applied over the years.

33 GRDC (2017) Lost nitrogen and what you can do. Ground Cover Issue 123, July–August 2016, https://grdc.com.au/resources-and-publications/groundcover/ground-cover-issue-123-julyaugust-2016/lost-nitrogen-and-what-you-can-do

34 GRDC (2017) Lost nitrogen and what you can do. Ground Cover Issue 123, July–August 2016, https://grdc.com.au/resources-and-publications/groundcover/ground-cover-issue-123-julyaugust-2016/lost-nitrogen-and-what-you-can-do

35 PCA. Peanuts and fertilisers. Peanut Company of Australia.

The first sign of P deficiency is a light flecking, gradually becoming more yellow until parts of the leaf die (Photo 6). Severely P-deficient plants are stunted, with small leaflets, often bluish green in colour and later developing pale spots between the veins before turning yellow and falling off. The stems may be purplish. Severe deficiency symptoms may only appear when growth has already been depressed by 70–80%.

Photo 6: *Top: light flecking gradually becoming more yellow until parts of the leaf die indicates P deficiency. Bottom: leaves folded together can also indicate a lack of P.*

Peanut growers traditionally applied high rates of P on other crops in the rotation, rather than directly applying P to the peanut crops.

Direct applications of P are necessary when soil levels are <20 mg/kg of soil (bicarbonate P). For irrigated crops and crops on the red soils of the Atherton Tableland, P rates of 30 kg/ha, and occasionally higher, may be needed. This contrasts with rates of ~10 kg P/ha for dryland crops on many red soils in southern Queensland. In the South Burnett, where soil test levels are <10 mg/kg, apply 10 kg P/ha broadcast before planting and a further 10 kg P/ha at planting.

The total P taken up by a peanut crop may range from 5 kg/ha to >30 kg/ha. AM fungi help peanut plants to exploit residual P from earlier fertiliser applications and soil P reserves that are unavailable to many other crops. Peanuts extract some P from relatively deep in the soil, but most is extracted from the top 40 cm.

Activity of AM fungal is reduced at high soil P concentrations; therefore, banded applications of fertiliser do not achieve the best uptake of P (unlike for most other crops). The maximum rate of uptake of P starts at flowering. About 65% of the P taken up by the plant is translocated to the pods and removed from the peanut field at harvest. [36]

MORE INFORMATION

The what where and why of soil testing in the northern region

36 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

5.10 Sulfur

Peanuts require S, along with N, to form proteins. Soil reserves of S decline where soils are cropped for many years without applications of S-containing fertilisers.

Sulfur deficiency in peanuts is difficult to diagnose from foliar symptoms. The symptoms can include pale yellowing of young leaves, while older leaves remain darker green (Photo 7). This is similar to the appearance of other nutrient disorders, such as the early stages of N and Fe deficiency, and to some non-nutrient disorders.

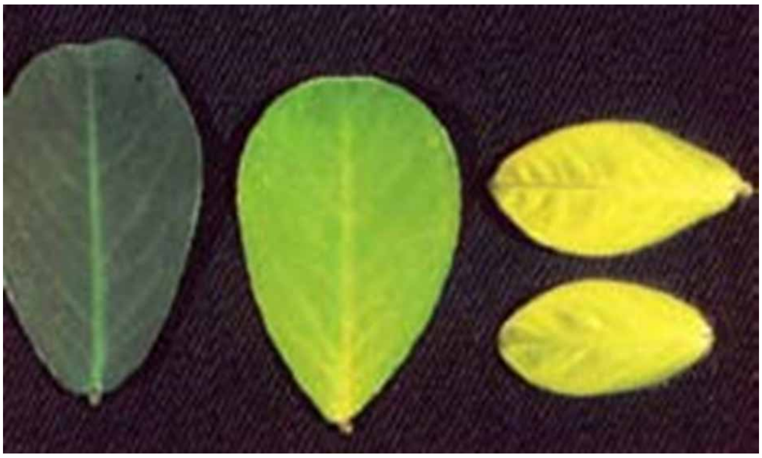


Photo 7: *Pale yellow leaves on the top of the plant are typical of S deficiency. Sulfur deficiency is unlikely where gypsum is used to supply Ca.*

Applications of 10–20 kg S/ha are generally adequate unless a very high yield potential exists. Total S taken up by peanut crops can be up to 60 kg/ha, with very high-yielding crops expected to require more.

Sources of S include some N (sulfate of ammonia) and K (sulfate of potash) fertilisers, as well as superphosphates.

High-analysis P fertilisers such as triple superphosphate (20% P) contain less S than single superphosphate (1% S *v.* 11% S), which means that S inputs may become necessary as the use of single superphosphate declines. If gypsum is used (see *Calcium* above) no other source of S should be needed.

Use of superphosphate (with ~11% S content) on light-textured soils has often masked S deficiency. The form of soil S taken up by plants (sulfate-S) is soluble and can be leached down the soil profile. Therefore, soil tests that take account of the S in deeper soil layers will better guide fertiliser requirements. [37]

5.11 Potassium

Peanuts require large amounts of K to grow the crop canopy, although only 20–30% of the total crop K is removed in the harvested product.

Deficiencies are most likely in sandy soils and are also common in long-term cropping areas on the red and brown forest soils in the South Burnett. Deficiencies are more likely on soils with a history of hay-making.

Soil K content is often highest in the topsoil layers, because most of the plant's K is stored in the crop residues and K does not leach easily through the profile (except in light sands).

Under direct drill, the K accumulates in just the top 5–10 cm. This layer is often dry when the peanut crop needs to take up K for later growth, and despite a high soil-test value, the crop can still become K-deficient.

37 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

Potassium deficiency in peanuts causes tip and margin (and sometimes interveinal) yellowing, followed by early leaf drop and death of tissue (Photo 8). Symptoms first appear on older leaves. Stems may also show some dead spotting and are shorter and thinner than in adequately supplied plants.

Photo 8: *Potassium deficiency typically showing yellowing then browning of the tips and leaf edges.*

In deficient situations, an application of 50–100 kg K/ha may be needed and should be placed below the pod-zone.

Where soil levels are <0.15 cmol/kg, apply 50–100 kg K/ha for a few crops until soil levels increase. Annual applications of ~15 kg/ha will maintain satisfactory soil K levels. Peanuts remove ~10 kg K for each tonne of pods harvested.

Occasional sampling of the subsoil (30–40 cm deep) will help you to develop the best strategy for K fertiliser application.

Peanuts can extract K from the soil faster than they need it, especially in the seedling stage. As a result, the K concentration in the plant can be high in the early growth stages until flowering, when it starts to be redistributed from leaves to pods.

High levels of K in the pod-zone will inhibit the Ca uptake of developing pods if the supply of Ca is limited. Although the shell will develop, only one kernel or even no kernels will form. High levels of K in the pod-zone can also lead to reduced shelf life of peanut kernels by causing an increased incidence of breakdown. Try to avoid large applications of K to the soil surface just before planting. If possible, apply K deeper than 5 cm.

Removing peanut hay will rapidly deplete soil K levels, because there is ~20 kg K in each tonne of peanut hay. [38]

5.12 Boron

Boron deficiency can have severe effects on peanut yields and quality. Boron, like Ca, must be taken up directly from the soil by the developing pod. Even though no foliar symptoms of deficiency occur, the developing pods may be deficient.

Boron is highly soluble and readily leached from sandy and sandy-loam soils. These light-textured soils and calcareous soils of high pH are most likely to be deficient in B. Some red soils of the Atherton Tableland are also deficient.

The kernel develops a 'hollow heart' and the embryo of the kernel may go dark (Photo 9). These effects reduce kernel weight and lower the likelihood of germination. Hollow heart is the classic symptom of B deficiency and it will show up long before leaf symptoms.

Peanut plants seem to tolerate low levels of B better than many other plants. Foliar symptoms of B deficiency include stubby, rosetted branches (similar to the symptoms of Ca deficiency), cracking of branches, discoloration of nodal areas, and leaves with a yellow–green mosaic appearance. Deficiencies also cause shell deformity and random shell cracking (other conditions also cause cracking).

Photo 9: *Kernels with 'hollow heart' are classic symptoms of low soil B. Hollow hearts will form well before deficiency symptoms on the foliage.*

Boron deficiency can be corrected with soil applications of B fertilisers, such a borax or regular liquid applications to the soil under a growing crop. Boron applied to the leaves can be taken into the plant but cannot be moved to the pod to supply the developing kernels.

Limit applications to 0.5 kg B/ha, which is ~5 kg/ha of borax applied to the soil or Solubor® sprayed at 2.5 kg/ha. Do not apply more B unless there has been leaching rain.

Soil tests using hot-water-extractable B can help determine the need for B, but are not very reliable.

Exercise caution when applying B because it is easy to change deficiency into toxicity, even using low rates of B fertiliser. Rates of only 4 kg B/ha have produced symptoms of B toxicity in peanuts. Boron toxicity looks like K deficiency, with

38 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

yellowing at the margins and between the veins and, eventually, browning of the margins. [39]

5.13 Copper

Low soil Cu is not common; it would mainly be expected on light sandy soils.

Copper deficiency has been seen on some of the coarse sandy soils of the Mareeba–Dimbulah Irrigation Area, and in some of the coastal sands near Bundaberg.

Plants are severely stunted and they can die if the deficiency is not corrected. Leaves show an interveinal chlorosis, with the tips and leaf margins dying. The leaves eventually wither and drop off. The pinched and 'burnt' leaf tips can be very distinctive (Photo 10).

Three or four applications of copper sulfate or copper oxychloride will usually correct the deficiency. Be sure that there is sufficient leaf area for foliar applications to be effective. Copper sulfate can be corrosive to brass boom-spray fittings.

Photo 10: *Top: leaf symptoms of low Cu levels—distorted leaf tips. Bottom: Cu deficiency in the field showing yellowing and browning leaf tips.*

With micronutrient applications, some phytotoxicity can occur; however, this damage does not affect the crop. [40] During flowering in weeks 4 and 5, apply foliar fertilisers (1% solution), especially Cu (on very sandy soils) and Zn. [41]

5.14 Iron

Lack of Fe is an important factor to consider when growing peanuts on alkaline soils. Peanut plants require Fe early in the crop growth to help establish functioning nodules to start N fixation.

39 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

40 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

41 PCA. Peanut production season plan. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/checklist.pdf

Iron deficiency is most likely on calcareous soils or other soils of pH ≥8.0. Waterlogging or too much lime in some soils can induce Fe deficiency. Even temporary waterlogging from flood irrigation can be enough to induce deficiency if supplies of plant-available Fe are already marginal.

Iron deficiency has been seen on some of the heavy soils of the Burdekin and Mareeba irrigation areas, and on parts of the Darling Downs. It has also been confirmed on some heavy soils around Biloela, where the upper leaves turn a very light yellow after rain or irrigation. Iron deficiency is common on the alkaline soils in the Northern Territory.

Plants are usually stunted and pale, with leaves showing interveinal chlorosis (yellowing), eventually becoming very pale yellow and almost white (Photo 11).

Photo 11: *Top: Fe deficiency, showing the pale leaves with the veins staying green and eventually losing most of their colour. Bottom: Fe deficiency at Jandowae on a high pH soil.*

There is some debate over the best way to treat Fe deficiency. Foliar sprays with 3% Fe solution as ferrous ammonium sulfate are used in the USA. This generally corrects the deficiency for a few weeks; three sprays may be needed. Urea helps the uptake of Fe.

Chelated Fe (Fe-EDDHA) can be used in both soil and foliar applications, but ferrous (Fe^{2+}) sources are not useful as soil applications. In Israel, Fe is placed in a band at planting to supply both the plant and rhizobia.

Iron deficiency can prevent the formation of healthy rhizobial nodules. As a result, low Fe levels can cause N deficiency because the rhizobia are unable to supply N to the plant.

Some varieties are more tolerant to low levels of Fe. [42]

42 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

5.15 Magnesium

Peanuts are less susceptible to Mg deficiency than other crops. At levels of soil Mg where a response would be seen in maize and soybeans, peanuts do not show symptoms of deficiency or respond to Mg fertiliser. It appears that peanuts are more efficient at extracting Mg from soil, just as they have a greater ability to extract P, although the mechanisms are probably different.

Sandy soils are often Mg-deficient, for example, Innot Hot Springs in North Queensland, the tobacco soils of the Mareeba–Dimbulah Irrigation Area and some of the soils around Bundaberg. High levels of K can induce Mg deficiency.

Magnesium deficiency shows as yellowing (beginning at the margins and moving towards the midrib) followed by orange discoloration and finally necrosis (death) of older leaves. Veins often show a brown discoloration on the underside of the leaf (Photo 12). Younger leaves remain relatively normal in appearance. Magnesium deficiency symptoms are generally seen on leaves in the middle of the plant; both the oldest and youngest leaves can look normal.

Dolomite will supply both Mg and Ca but can raise the pH, so should be used with care on high-pH soils. Foliar fertilisers are available to treat Mg deficiency.

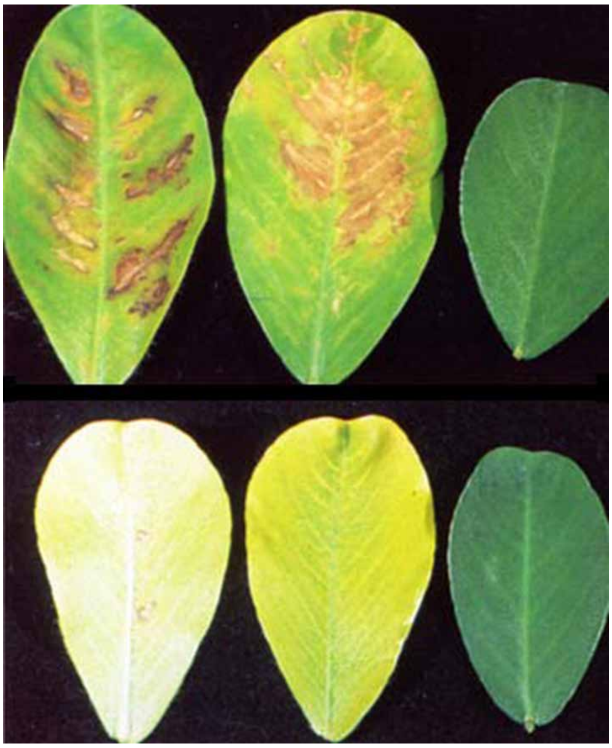


Photo 12: *Top: typical symptoms of Mg deficiency with browning patches on the leaf. Bottom: in the early stages, the veins on the top of the leaf are slightly lighter yellow than the rest of the leaf and the veins underneath the leaf are a darker colour.*

Uptake of Mg is closely related to dry matter accumulation. Thus, the concentration of Mg in the plant tissue remains relatively constant throughout the life of the crop.

High levels of soil Mg can reduce kernel quality. Magnesium can move from the foliage to the pod and can partially replace Ca under Ca-deficient conditions, reducing kernel quality. Adding Mg to the pod-zone can also reduce the uptake of Ca and therefore increase the incidence of pops and pod rots.

The soil test level for Mg is not well defined for peanuts. Crop responses have been obtained in other crops if exchangeable Mg is <0.2 cmol/kg. If a soil test is at or below this value, apply a test strip to determine whether there is a crop response to Mg.[43]

5.16 Manganese

Manganese deficiency or toxicity is unlikely, except in very high or very low pH soils, respectively. However, short periods of Mn toxicity can occur during periods of low oxygen availability (waterlogging, or wet soil with a lot of incorporated organic matter) in soils otherwise adequate for peanut production.

Deficiencies are most likely on alkaline soils, due to the insolubility of Mn at high pH, and on some very sandy soils.

Manganese toxicity may occur under wet conditions on very acid soils; however, in these soils, other limiting factors such as Ca deficiency or Al toxicity are also likely. Rhizobia are often more sensitive than the plant itself to Mn toxicity. As a result, short-term waterlogging or wet periods, combined with buried 'lumps' of organic matter such as cane trash, can result in death of rhizobia and short-term N deficiency. If this happens early in the season, the plants may re-nodulate, but if it occurs during podfill, re-nodulation may not occur and fertiliser N topdressings may be needed for the crop to mature.

With Mn deficiency, the older leaves turn yellow and the veins stay green (Photo 13). Younger leaves are green and distorted.

Photo 13: *Laboratory symptoms of Mn deficiency (field symptoms may be slightly different). Older leaves turn yellow with green veins, and young leaves are green and distorted.*

Lime will correct Mn toxicity by raising soil pH. Inter-row cultivation may help to restore soil oxygen levels quickly and reduce toxic levels of Mn after a very wet period.[44]

5.17 Molybdenum

Molybdenum is essential for protein synthesis and N fixation. Molybdenum deficiency is most likely where peanuts are grown on acidic soils (pH <5.5). Soil tests over time will show whether the soil is becoming more acidic and is more likely to respond to Mo.

If the level of Mo is too low for N fixation, symptoms of N deficiency will appear. The same symptoms will show if nodulation has failed or the rhizobia have died following waterlogging.

43 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

44 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

Molybdenum can be supplied by mixing with other fertiliser or as a foliar spray. Mo-superphosphate with 0.04% Mo or a foliar spray of sodium molybdate at 300 g/ha will supply 100 g/ha of Mo.

In most situations where Mo is low, it will need to be applied to each crop. In some cases, Mo deficiency can be corrected indirectly with lime or dolomite raising soil pH to ~6. Often the problem is one of unavailability at low pH, rather than actual low Mo.[45]

5.18 Zinc

Peanuts appear to tolerate lower levels of Zn than many other legumes because AM fungi help to extract this nutrient. However, growers in Israel suggest that peanuts can be more sensitive than maize or cotton to low levels of Zn.

Zinc deficiency can occur in soils with a pH >7 but is unlikely in acid soils, except for the very light sands and wallum areas in the coastal Burnett.

Zinc deficiency appears as interveinal yellowing with a browning around the midrib of the leaf (Photo 14).

Photo 14: *Top: leaf symptoms of zinc deficiency in the laboratory (note the browning around the midrib of the leaf). Bottom: field symptoms may be slightly different.*

Zinc deficiency can be corrected with foliar or soil Zn fertiliser applications.

Peanuts are very sensitive to Zn toxicity, which may build up after continual applications on other crops, such as irrigated maize. Symptoms of Zn toxicity include stunting 4 weeks after germination, leaf chlorosis, and flattened stems that develop

45 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

a characteristic vertical split at soil level. See *Cadmium management* below for more information on Zn toxicity.[46]

5.19 Cadmium management

Soils with a long history of superphosphate applications can have problems with cadmium (Cd) accumulation in the peanut kernel.

Cadmium is a heavy metal that accumulates in the human body and can cause health problems. It is therefore imperative that Cd in peanut kernels is minimised.

Cadmium in Australian soils has primarily been introduced as a contaminant of phosphatic fertilisers from marine deposits of phosphate rock from nearby sources (e.g. Nauru and Christmas Islands). The high use of phosphate (and other) fertilisers has added Cd to soils that now grow peanuts.

Not all Cd in a soil is available for uptake by plants. Cadmium uptake is greatest when the soil has low pH (i.e. acidic soils), low clay content (i.e. sands) and low organic matter levels. Marketing companies such as the Peanut Company of Australia (PCA) require soil tests before planting if Cd contamination is likely in a soil.

Growers can manage Cd uptake by the peanut plant, and subsequent movement of the Cd into the developing kernel.

Lime applications to keep soil pH ≥6 will reduce the amount of plant-available Cd, as will incorporation of organic matter (e.g. a cane trash blanket). However, both of these strategies require a few months of time and soil moisture to have a significant impact. Placement must occur wherever there is Cd in the soil profile (mostly the top 40 cm, or to the depth of previous cultivation or ploughings) to be effective. Remember that to lime the top 30 cm of the soil profile to a target pH (e.g. 6.5), lime must be applied at the required rate to treat each 10 cm layer.

Peanut varieties differ substantially in their ability to move Cd from the leaves down into the developing kernel. Low Cd-accumulating varieties should be grown on high-risk soils. Seek advice on the varieties best suited to your situation as new varieties become available.

The peanut plant also seems to move Zn preferentially, instead of Cd, to the kernel, so strategic applications of foliar Zn will help to reduce Cd in the kernels to acceptable levels. To do this, regular applications of up to 1 kg/ha of elemental Zn (4 kg/ha zinc hepta-hydrate) are required throughout the pod-filling phase. Be careful not to over-fertilise with Zn—toxicity can occur. Conduct soil tests and consult your local agronomist.

Zinc applications to the soil can reduce kernel Cd, but increased Cd uptake by the plant and Zn toxicity can occur; therefore, soil applications involve more risks than do foliar applications. The best solution is to build soil Zn levels slowly over time and conduct regular soil tests to avoid over-application.[47]

MORE INFORMATION

QDPI/CSIRO. Managing cadmium in summer grain legumes for premium quality produce.

Cadmium. Nuts2u.

Incitec Pivot Fertilisers. Gypsum.

46 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

47 PCA/DPIF (2007) Crop nutrition. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3b_nutrition.pdf

VIDEOS

Weed control

MORE INFORMATION

Australian Pesticides and Veterinary Medicines Authority.

Weed control

Weeds compete with the peanut crop for moisture, nutrients and light. They cause major problems at harvest time, and reduce the quality of the crop.

Peanuts do not grow very tall and consequently do not compete very well with weeds. Early control of weeds during the crop's first 6 weeks is critical. Yields will be slashed if weeds are allowed to compete unchecked at this stage.

The presence of weeds also causes losses during digging, threshing and drying—entangling machinery, knocking peanuts off the bush, and leading to mould damage by causing uneven drying in the windrow.

Weeds can also restrict airflow during the drying process, creating pockets of moisture, which have the potential to cause aflatoxin.

A combination of cultivation, herbicides and hand-chipping is usually required to control weeds. [1]

Many herbicides are registered for use in peanuts. Correct use of herbicides has proved relatively safe and very effective against a diversity of both grass and broadleaf weeds. However, growers should avoid spraying broadleaf herbicides during the main flowering period if possible.

Mechanical cultivation is still used in many areas; however, growers need to be careful of root pruning and especially of throwing dirt up against the plant stem during cultivation. These activities have been shown to exacerbate several soil-borne diseases, such as white mould. [2]

Control of weeds is one of the major factors involved in successfully growing peanuts. Because the peanut crop grows underground, weeds make digging and threshing operations very difficult, resulting in high losses. Peanut plants themselves can also be a problem weed when growing in fallows and other crops.

A weed management program in peanuts requires the timely use of cultural, mechanical and chemical practices (Photo 1).

Weed management is a whole-of-farm, whole-of-year concern. Weeds should never be allowed to seed in fallows, peanut crops or rotation crops. Preventing weeds from seeding will reduce weed populations in the long-term and reduce the risk of weeds developing resistance to herbicides.

Weeds reduce the effectiveness of fungicide applications because some of the fungicide falls on the weed instead of on the peanut foliage.

Photo 1: *The weed on the left is at the 2-leaf stage and requires less herbicide to control than the more mature weed on the right.*

Weed control in the crop starts with the seedbed preparation. Do not plant peanuts unless weeds are under control at the time of planting.

1 PCA. Soil preparation. Peanut Company of Australia.

2 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

Studies of weeds in many crops show that weeds start to compete with the crop as soon as they have germinated. For peanut crops, it is especially important to have weeds under control early, because the peanut plants do not compete well with weeds, particularly in the first 6 weeks of the crop cycle.

Peanuts usually maintain yield potential if the grower eradicates weeds within the first 3–4 weeks after planting and the peanut crop remains weed-free for the rest of the season. Yields will generally suffer if weeds remain in the crop during the 4–8 weeks after planting.

Some weeds can only be controlled with herbicides that also have an adverse effect on peanuts. These weeds must be controlled before planting peanuts.

Weeds in peanuts are a major problem at harvest time. Losses occur during digging, threshing and drying. Some peanut farmers have lost fingers trying to free a peanut puller choked with weeds. [3]

6.1 Digging

During digging, the peanut plant is removed from the ground with machines such as a digger-inverter, to place the peanuts upside-down for drying.

Weeds become entangled with the peanut crop, causing peanuts to be lost from the bush and making inversion difficult. They also cause uneven drying and more dirt to be retained in the windrow. Grasses with extensive root systems or creeping growth habits, such as couch grass and crowsfoot grass, can cause major problems.

Digging is affected by the drag or baulking, which occurs over the blades when trying to cut through these grasses.

Diggers require coulter blades to break up bellvine and convolvulus vine, allowing them to flow through the blade section. Despite the coulters, the vine will drag over the cutter section and cause poor inversion. The windrow will also be far less open and considerable mould damage can occur to peanuts in a poorly inverted, tight windrow if it rains.

Other weeds with strong taproots, such as Sida, drag and cause the bunching of peanuts and soil in the inverter section of the digger.

Large broadleaf weeds with thick stems, such as thornapple, cause poor inversion and result in dragging and choking in the cutter section.

Growers often use a rotary hoe or discs to loosen the soil on the headlands, to allow the cutter blades to penetrate before reaching the peanut plants. This practice also helps to control weeds that may otherwise invade the crop area. [4]

6.2 Threshing

Weeds also affect the threshing operation. Binding weeds such as convolvulus and bellvine produce large volumes of leaf matter, which the harvester must separate from the pods in the sieving process.

Taprooted and thick-stemmed weeds become caught in sieves, further reducing the capacity and efficiency of the harvester.

Soil left on weed roots reduces the separation efficiency, resulting in higher levels of leaf and trash remaining in the harvested product. This contamination reduces the crop value. [5]

3 PCA/DPIF (2007) Managing weeds. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4c_weed.pdf

4 PCA/DPIF (2007) Managing weeds. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4c_weed.pdf

5 PCA/DPIF (2007) Managing weeds. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4c_weed.pdf

6.3 Drying

Efficient curing relies on a clean peanut sample. Weeds may cause high levels of extraneous matter (leaf material, sticks and dirt), which reduces air-flow through the peanuts. This causes pockets of moisture to remain and can result in mould and aflatoxin development.

The fruit of wild gooseberries, wild cucumber and wild gherkins can also cause curing problems. The pod or fruit is a storehouse of moisture and it will not dry as quickly as the peanuts. This can lead to the development of mould and, potentially, aflatoxin, despite correct curing practices. Pre-cleaning before curing will help, but it is not always possible to remove the fruit completely. [6]

6.4 Management options

A combination of cultivation and herbicides is usually needed to control weeds in peanuts, although in irrigated crops, weeds are usually controlled using only herbicides.

MORE INFORMATION

GRDC Fact Sheet: Pre-harvest herbicide use

GRDC Tips and Tactics: Reducing herbicide damage

6.4.1 Cultivation

In dryland crops, growers may use two inter-row cultivations to control weeds, to loosen the soil for the pegs to penetrate, and to make cutting easier. In very loose, friable soils, inter-row cultivation may not be necessary. After heavy rain or prolonged wet periods or on soils that crust, an inter-row cultivation to aerate the soil may benefit the crop even if very few weeds are present.

Cultivators should be set so to avoid throwing soil onto the peanut plant; this can cause damage and disease. Move soil up to, but not onto the plant. If a late cultivation is unavoidable, do not disturb pegs that have entered the soil. Avoid late inter-row cultivations in situations where Sclerotinia blight is a known problem.

Hand-chipping can still be very cost-effective to control 'escaped' weeds before harvesting the crop.

6.4.2 Herbicides

The following information regarding herbicides and their use relates to Queensland registrations. Check the label for use in other states.

Grass weeds

Grasses are usually controlled before planting by using an incorporated herbicide such as trifluralin or pendimethalin. Imazethapyr (e.g. Spinnaker®) or imazapic (e.g. Flame®) applied post-emergence can give good suppression of nutgrass.

S-Metolachlor (Dual®) applied post-plant pre-emergence controls some grasses.

Fluazifop-p (e.g. Fusilade®), sethoxydim (Sertin®), quizalofop-p-ethyl (e.g. Targa®) and haloxyfop (e.g. Verdict™) will control grass 'escapes' after crop emergence and are also effective on Johnson grass (*Sorghum halepense*) and volunteer sugarcane.

Paraquat will control only very small grasses.

Glyphosate provides useful fallow weed control.

Broadleaf weeds

Bentazon (Basagran®), acifluorfen (Blazer®), 2,4-DB (Buttress®), paraquat, imazapic (e.g. Flame®) and imazethapyr (e.g. Spinnaker®) are the main controls available for broadleaf weeds.

6 PCA/DPIF (2007) Managing weeds. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4c_weed.pdf

Basagran® will control many broadleaf weeds; however, it will not control wild gooseberry or Sesbania. Use Blazer® if these weeds are present. Using Basagran® or Blazer® under conditions of high temperature and low humidity may result in poor weed control. Spraying may need to cease by 9 a.m. to 10 a.m. Even irrigated crops can have stressed weeds in the middle of the day depending on the evaporative demand on that day.

Paraquat gives cheap, effective control of several common weeds. It can scorch peanut leaves; however, they do recover rapidly. The peanut crop should be sprayed before the 7–8-leaf stage. Good coverage is essential. Unlike Basagran® and Blazer®, paraquat will control stressed weeds, but usually, they must be younger than the 4-leaf stage. Many growers mix Basagran® with paraquat to reduce the burn on the peanuts that can result from using paraquat on its own. This mix will also reduce control of legume weeds.

Dual® is sometimes banded over the row at planting to control *Commelina benghalensis*. Unlike trifluralin, Dual® does not require mechanical incorporation, but it does need rain or irrigation within 10 days of application.

Prometryn provides good control of many weeds in irrigated peanuts. Its cost and the need for moisture make it unsuitable for dryland peanuts, except in high-rainfall areas. Some damage to peanuts has occurred where a tank mix of Dual® and prometryn was used on heavy soils. Growers should consult their peanut agronomist before applying prometryn.

Rope wick weeders with glyphosate are used to control large broadleaf weeds, Johnson grass and volunteer maize and sorghum.

Weed peanuts

Volunteer peanut plants growing in other crops and in the fallow between crops are very difficult to control.

Many herbicides and combinations of herbicides will severely distort peanuts, but may not reliably kill them. Research at Kingaroy has identified several products that will control volunteer peanuts, but they are not yet registered.

Fallow sprays of glyphosate at up to 2 L/ha and Spray.Seed® (paraquat + diquat) have not killed all volunteer peanuts even when used in combination with other herbicides such as 2,4-D amine, dicamba and atrazine.

Herbicides used in rotation crops of sorghum and maize do not always give reliable control of volunteer peanuts. Combinations of atrazine and Starane™ (fluroxypyr) have proven the most effective. Contact your local agronomist to find out the latest information on controlling volunteer peanuts.

For conservation cropping fallow management, in fallow paddocks use glyphosate, 2,4-D amine, dicamba, atrazine and Starane™ to control grasses, broadleaf and woody weeds.

VIDEOS

Insect management

Insect control

Various insect pests attack peanuts; however, compared with horticultural crops and cotton, insects are not considered a major problem for peanuts. Regular scouting for insect pests is still warranted. Growers should budget on at least one spray for *Helicoverpa*.

Peanut crops in cotton- and lucerne-growing areas may have more aboveground pests than crops that are more isolated. Soil pests such as white grubs and whitefringed weevil (*Graphognathus leucoloma*) are significant pests in established peanut-growing areas.

In traditional peanut-growing areas, foliar insect pests have not been a major problem. However, this has changed recently as peanuts have moved into new production areas, especially areas that have predominantly grown cotton or horticultural. [1]

7.1 Types of insect pests

Foliage feeders

The main foliage feeders tend to be *Helicoverpa* sp. and cluster caterpillar (*Spodoptera* sp.). Large numbers of these larvae (>6 larvae/m) can be damaging when the plants are very small; control measures may be warranted.

Growers also need to check crops carefully during the main flowering and pegging period. These insects will attack both flowers and pegs and can reduce yield potential. Control may be warranted where there are >2 larvae/m of row.

In North Queensland, redshouldered leaf beetle (*Monolepta australis*) can be a regional pest of significance. They have a short life cycle, and two populations generally occur throughout the season. Expect heaviest pressure in paddocks adjacent to avocadoes and other tree crops. A preventative approach to management is recommended; manage the pest in the tree crop (where many registered control options exist). Effective insecticide options in peanuts are few; however, for latest information please consult your agronomist.

Sucking insects

Several sucking insects will attack peanuts and are often responsible for the spread of viruses. The most commonly observed are the vegetable jassid and the lucerne leafhopper. These can attack the crop at any stage and often build up to huge numbers. Growers often overlook these pests because they are not easily seen, but in large numbers, they can cause significant crop damage. If ≥25% of the crop's leaves have small yellow spots or stippling, and or the leaves are turning yellow at the tips and margins, then chemical control measures may be warranted.

Thrips, mirids and mites can also be a problem in some areas. Regular scouting of the crop is essential to determine whether control measures are warranted. [2]

1 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

2 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

7.2 Growth stages

7.2.1 Pre-emergence

Pest damage to peanuts can start as soon as the seed is planted, but this is not common. Where pre-emergence damage occurs, it is usually from larvae of the whitefringed weevil. False wireworm larvae, whitefringed weevil, large white grubs ('canegrubs') and mole crickets all can occasionally damage germinating seeds.

7.2.2 Emergence to first flowering

During vegetative growth, damage is mainly to foliage by either leaf-chewing or sap-feeding pests. Sap-feeding pests include lucerne and vegetable leafhoppers (jassids), peanut mites and cowpea aphids, and may occur any time after crop emergence.

Peanut mites can damage peanuts during prolonged dry periods (Photo 1). The mite disappears with rain and the plant outgrows the damage.

The two-spotted mite is not usually a pest of peanuts. However, if peanuts are sprayed heavily with non-selective (hard) pesticides, or are grown in areas where adjacent crops are heavily sprayed, then two-spotted mite infestations may occur. In the vegetative stage, control may be required if the mite is still present and >10 plants out of 30 have >30% reduction in leaf area.

Leaf-chewing pests that affect peanuts include *Helicoverpa* and the cluster caterpillar. Redshouldered leaf beetle occasionally damage isolated patches of a crop.

Almost every peanut crop will contain some *Helicoverpa* larvae. Control is rarely needed, as peanuts are very tolerant of defoliation. Naturally occurring outbreaks of Nuclear polyhedrosis virus (NPV) will often kill larvae before they damage the crop.

Cluster caterpillars are less common than *Helicoverpa* and rarely need control.

In North Queensland, whitefringed weevils can cause severe damage. Larvae chew the taproots, which can cause plants to die, and adults can defoliate young plants when present in large numbers.

The larvae of the peanut whitegrub, *Heteronyx piceus*, and related species can inflict damage similar to that caused by whitefringed weevil larvae, but this seldom results in plant death. Adult peanut whitegrubs can cause severe defoliation in young plants.[3]

Photo 1: *Peanut mites cause damage like this only in dry years.*

3 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.2.3 Flowering, pegging and podfill

Sap-sucking pests present during the vegetative stage can continue into flowering, pegging and podfill. Mirids may also affect the crop, feeding on buds and flowers and causing them to abort.

Helicoverpa, usually *H. armigera*, sometimes feed on flowers and pegs. If significant numbers of flowers and pegs are being chewed off, some control may be needed. Cluster caterpillars also attack peanut pegs. This pest is more common in coastal regions and the tropics.

Root-chewing larvae of whitefringed weevil and whitegrubs can cause significant plant losses and pod damage.

Heavy infestations silverleaf whitefly (SLW, *Bemisia tabaci*) at flowering and podding can greatly reduce plant vigour and yield. However, peanuts are not favoured hosts for this exotic pest, and populations in most years are usually low.

Western flower thrips (*Frankliniella occidentalis*) are another exotic pest and a potential threat to peanuts, mainly because they transmit Tomato spotted wilt virus (TSWV). Although TSWV infections are often initiated by western flower thrips feeding during the vegetative stage, severe TSWV symptoms are usually not manifested until flowering. However, the incidence of TSWV in Australian peanuts has not yet reached the damaging levels reported in other crops or in peanut crops overseas. [4]

7.2.4 Mature crops

The lucerne seed web moth (*Etiella*) may leave holes in pods and appear close to harvest, particularly during dry seasons. Damage is less common in irrigated crops and Runner types seem most affected. [5]

7.3 Damage caused by pests

Soil insects and pod damage

In some parts of Queensland, whitefringed weevils can cause severe damage. Larvae of the weevil attack the taproot of the plant. This may cause direct death of the plant or indirectly lead to its demise by providing an entry site for diseases such as Cylindrocladium black rot (CBR). The larvae will also chew pegs and developing pods. The best strategy for managing this pest appears to be to control the adults before they lay eggs.

Various whitegrubs and canegrubs will also feed on roots, pegs and developing pods. Mechanical cultivation can be useful in controlling some of these pests and some soil-applied insecticides may also be warranted.

Etiella moths and larvae may be common on some of the sandier soil types and are often especially active against the Runner types pf peanuts. The adult moth lays its eggs on the peanut plant. The larvae hatch and move down the plant into the soil to feed on the pods. Growers should check crops at least 1 month prior to harvest. In extreme cases, the crop may have to be dug early. Irrigation is the best form of defence against this pest. [6]

7.4 Management of insect pests

In weeks 2 and 3 during crop establishment, check for soil and foliar insects, especially *Helicoverpa* and cutworms (*Agrotis* sp.).

4 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

5 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

6 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

MORE INFORMATION

[Australian Pesticides and Veterinary Medicines Authority.](#)

In weeks 4–7 during flowering, check for foliar insects, especially jassids, leafhoppers, mites and *Helicoverpa*. Continue to scout for foliar insects during weeks 8 and 9, when pegging occurs, and through to canopy closure and pod-setting in weeks 12 and 13.

In weeks 14 and 15 when pod-filling is under way, check for insects, especially armyworms (*Spodoptera* sp.), which stay at or just below ground level during the day but feed on pegs during the night. [7]

Weekly trap catch data for *H. punctigera* and *H. armigera* from locations across all states can now be viewed online. The adjustable bar below the map allows selection of a time period (1 wk, 2 wks, 1 mth, etc). https://jamesmaino.shinyapps.io/MothTrapVis/

7.5 Major insect pests of peanuts

7.5.1 Aphids (Aphididae)

Importance: Cowpea aphids (*Aphis craccivora*) are common (Photo 2). They are not considered a pest; however, they are vectors of the Peanut mottle virus (PMV). Peanut mottle virus is usually not a problem in peanuts, but can be a major concern in navy beans growing nearby.

Registered chemical: Check current registrations on the APVMA website. [8]

Photo 2: *Cowpea aphids.*

7 PCA. Peanut production season plan. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/checklist.pdf

8 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.2 Cluster caterpillar (*Spodoptera litura*)

Importance: Cluster caterpillars (Photo 3) are significant but infrequent in traditional growing regions such as the South Burnett. They are more abundant in coastal regions and the tropics, where serious damage has been reported.

Damage: Cluster caterpillars are foliage and peg feeders. Young larvae feed in groups, leaving the bigger veins. Larger larvae are solitary, chewing large pieces of leaf and attacking and severing pegs, causing pod death.

Action level: Sample weekly during the vegetative stage and from flowering to the end of podfill. Examine five plants at six widely spaced locations (i.e. 30 plants).

Control: Rarely a problem if insecticides are used to control *Helicoverpa*. [9]

Registered chemical: Check current registrations on the APVMA website.

Photo 3: *Cluster caterpillar (top left), eggs (top right), and moth (bottom).*

9 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.3 Cutworms (*Agrotis* spp.)

Importance: Minor and sporadic.

Damage: Seedlings are chewed off around ground level (Photo 4). Damage is usually patchy and tends to progress outwards from the initial damage site.

Action level: Not determined. Check presence with germinating seed baits.

Registered chemical: Check current registrations on the APVMA website. [10]

Photo 4: *Cutworms.*

10 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

MORE INFORMATION

Mungbean and soybean insects

7.5.4 Lucerne seed web moth (*Etiella behrii*)

Importance: Major but sporadic. Can be severe in drought years. Infestations are worse on lighter, sandier soils and in dry seasons. Crops of variety Florunner tend to be more affected by *Etiella* than other varieties. Can also be a problem in irrigated crops when soils are drying down before harvest. *Etiella* damage is a major risk factor for aflatoxin.

Damage: In dry seasons when soils are dry and cracked, newly hatched larvae are able to reach the underground pods (Photo 5). Larvae bore straight into pods and feed within them until ready to pupate. Larvae then emerge from the pods and sometimes produce webbing around the pods. Note that other, less damaging caterpillars (e.g. *Endotricha* sp.) commonly make webbing at the base of plants.

Etiella exit holes are 2–3 mm in diameter and these allow the aflatoxin-producing fungus *Aspergillus flavus* to enter pods. Aflatoxin levels in *Etiella*-damaged pods can be >4 times greater than in undamaged pods containing aflatoxin. *Etiella* damage is not obvious until harvest. *Etiella* larvae are frequently still inside pods at harvest and can be driven out in their thousands when pods are dried postharvest.

Action level: If it has been a dry season, check the crop regularly, starting at least 1 month prior to harvest. Sample five plants at six positions all over the paddock (i.e. 30 plants). If pods have much webbing and frass, pull early and dry. Light traps are being trialled to monitor *Etiella* moth activity and predict pod damage.

Photo 5: *Left: lucerne seed web moth—a problem in dry seasons, particularly on light sandy soils. Right: the blue green larvae tunnel into pods and destroy the kernel. It is difficult to separate damaged and sound pods at harvest.*

Registered chemical: None registered.

Cultural control: Pull crop early and dry. Eliminate alternative hosts such as *Sesbania* and rattlepod (*Crotolaria* spp.). [11]

11 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.5 False wireworms (*Gonocephalum* spp. and *Pteroheleaus* spp.)

Importance: Minor and sporadic.

Damage: Larvae feed on decaying vegetable matter, crop residues in the soil and newly germinated seed (Photo 6). Both the seed and the growing point of the plant are damaged, resulting in patchy stands. During summer, adults ring-bark or cut off young plants at or just below ground level.

Action level: Not determined. Check presence with germinating seed baits.

Control: Seed treatment will reduce but not eliminate the problem.

Registered chemical: None registered. [12]

Photo 6: *False wireworm.*

12 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.6 *Helicoverpa punctigera* and *H. armigera*

Importance: Minor and frequent. Can cause damage from emergence to pegging.

Damage: Most crops will contain some *Helicoverpa* larvae (Photo 7). *Heliothis punctigera* mainly attacks the leaves and growing points whereas *H. armigera* usually damages flowers and pegs. Peanuts are tolerant of defoliation, and even quite high populations (e.g. 5 larvae/m^2) have little impact on yield in well-grown crops. However, severe defoliation or flower and peg damage during podding can reduce crop potential. Usually, naturally occurring outbreaks of NPV kill larvae before they damage the crop.

Action level: Sample weekly during vegetative, flowering and pegging stages. Sample five 1-m lengths of row at six positions across the paddock. During the vegetative stage, spray if there are >12 larvae/m of row. During flowering and pegging stages, spray if >3–5 larvae/m are present and larvae are feeding on flowers and pegs.

Registered chemical: Check current registrations on the APVMA website.

Biological control: NPV products, e.g. ViVUS. [13]

Photo 7: *Helicoverpa larvae mainly eat leaves, but can chew flowers and pegs.*

13 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.7 Lucerne leafhopper (*Austroasca alfalfae*)

Importance: Minor to significant and frequent. Lucerne leafhopper is yellow-green and more damaging than the emerald green or blue-green vegetable leafhopper. This pest is more common in tropical regions.

Damage: Nymphs and adults feed on the sap-conducting system and inject a toxin. Leaves turn yellow and die from the tip (hopper burn) and plant growth is stunted (Photo 8). Damage is worse when plants are stressed.

Action level: Sample weekly during the vegetative, flowering and pegging stages (30 leaves/week). Sample five leaves halfway up the plant at six positions across the paddock. Spray if >7 of 30 leaves have yellowing or burn in the vegetative crop stage.

Registered chemical: Check current registrations on the APVMA website. [14]

Photo 8: *Top: lucerne leafhopper. Bottom: 'hopper burn', typical yellow leaf tips caused by lucerne leafhoppers.*

14 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.8 Vegetable leafhopper (*Austroasca viridigrisea*)

Importance: Minor and frequent. Vegetable leafhopper is emerald (blue-green) in colour and less damaging than the yellow-green lucerne leafhopper (Photo 9). It is very common in most peanut crops.

Damage: Nymphs and adults suck the contents of leaf cells. The leaf cell dies, leaving a white spot. Adjacent spots form the stipple pattern characteristic of vegetable jassid damage. Damage is worse when plants are stressed.

Action level: Usually does not need control, except where there are extremely high populations during hot, dry weather. Sample weekly during vegetative, flowering and pegging stages.

Registered chemical: Check current registrations on the APVMA website. [15]

Photo 9: *Vegetable leafhopper.*

15 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.9 Pineapple mealybug (*Dysmicoccus neobrevipes*)

Importance: Minor and sporadic. Its importance may increase in irrigated crops.

Damage: Infested plants are stunted. Nuts often collapse and assume a blackish colour when the waxy, fluffy, white mealybugs are present in large numbers (Photo 10). Damage is usually in poorly drained sites.

Action level: None determined.

Registered chemical: No registrations. Pesticide control is not feasible for this pest.

Cultural control: Avoid planting in poorly drained areas.[16]

Photo 10: *Mealybug.*

16 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.10 Mirids (Miridae), green and brown (*Creontiades* sp.)

Importance: Widespread but probably not as damaging as in mungbeans. Peanuts in lucerne-growing areas are at most risk.

Damage: Mirids infesting caged peanut plants have been shown to reduce the number of pods produced (Photo 11). Mirid attack may result in uneven crop maturity.

Action level: A provisional threshold of 3–4 mirids/m^2 has been set for peanuts.

Registered chemical: None registered. [17]

Photo 11: *Mirids are widespread and suspected of damaging peanuts in the field.*

17 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.11 Peanut mite (*Paraplonobia* spp.)

Importance: Minor and infrequent; should not be a problem in overhead or spray-irrigated crops.

Damage: A general yellowing and silvering of the leaves will show up in patches of the crop during prolonged dry periods. As damage becomes more severe, lower leaves are shed and plants die. Mites jump off the plant at the least disturbance (even a shadow across a leaf), so care is needed to find the relatively large, dark green–black mites (0.5 mm long) on the under-surface of the lower leaves (Photo 12).

The mites disappear after rain and plants usually outgrow the damage.

Action level: Sample weekly if the weather has been dry for a prolonged period. Only spray the patches with obvious silvering if rain is not expected.

Registered chemical: Check current registrations on the APVMA website. [18]

Photo 12: *Peanut mite damage to a leaf.*

18 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.12 Two-spotted mite (*Tetranychus urticae*)

Importance: Minor and sporadic. A problem where peanuts grow next to cotton.

Damage: Sucking of the tissue causes leaf mottling and yellowing. In severe cases, leaves will die (Photo 13).

Action level: Not determined.

Registered chemical: Check current registrations on the APVMA website. [19]

Photo 13: *Two-spotted mites are usually a problem only in cotton districts.*

19 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.13 Redshouldered leaf beetle (*Monolepta australis*)

Importance: Minor and sporadic. Most common in coastal regions where the larvae feed on sugarcane roots.

Damage: Adult swarms feed on foliage and flowers. Overall damage in inland regions is generally minor; adults usually occur in isolated patches in a crop (Photo 14). However, very high populations across whole crops have caused major damage in coastal regions, shredding leaves and flowers. Larval damage to roots is not significant, as peanuts are not a preferred larval host.

Action level: Not determined.

Registered chemical: None registered. [20]

Photo 14: *Redshouldered leaf beetle.*

20 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.14 Silverleaf whitefly (*Bemisia tabaci*, type B)

Importance: Potentially a serious pest in coastal and tropical regions (Photo 15). Heavy SLW populations severely damaged many peanut crops in central Queensland in 2002. However, this was an exceptionally bad season, and in most seasons, SLW is not a problem because peanuts are not a preferred host.

Damage: Severe SLW damage can reduce plant vigour and yield. Severe SLW infestations in young plants can stunt plant growth and greatly reduce a crop's yield potential. Later infestations at flowering and podding can reduce podset and pod yield. Generally, the impact of SLW is more severe in drought-stressed crops.

Action level: Not determined.

Registered chemical: No pesticides registered for SLW management in peanuts. In the long term, sole reliance on pesticides for SLW is not sustainable and the integrate pest management (IPM)-friendly options available in cotton are too expensive for peanuts. Avoid the use of non-selective pesticides against other pests, to help conserve SLW parasites.

Cultural control: Avoid planting peanuts close to earlier maturing susceptible hosts such as cotton, cucurbits and sweet potatoes.

Biological control: SLW are parasitised by a number of small native and introduced wasps. Ladybirds and hoverfly larvae have also predated on SLW. Therefore, use of non-selective pesticides should be avoided.[21]

Photo 15: *Silverleaf whitefly.*

21 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.15 Storage insects

Importance: Widespread and significant. Indian mealmoth (*Plodia interpunctella*) and the tropical warehouse moth (*Ephestia cautella*) are the most common. Larvae of the lucerne seed web moth (*Etiella behrii*) can be delivered to storage depots inside the pod but do not re-infest in storage.

Damage: Storage moth larvae damage kernels, particularly at high moisture levels (Photo 16).

Action level: Control measures should be undertaken at the first sign of damage.

Cultural control: Adopt good hygiene by cleaning threshers, bins, elevators and around sheds. Keep harvested crop <12% moisture content on nut-in-shell basis and keep cool.

Check with peanut shellers before using any stored grain insecticides on peanuts. [22]

Check current registrations on the APVMA website.

Photo 16: *Insect damage to stored kernels.*

22 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.16 Thrips (Thysanoptera)

Importance: Most damage by thrips is minor and infrequent and should not be a problem in irrigated crops (Photo 17). However, the recently introduced western flower thrips (*Frankliniella occidentalis*) is a significant threat to peanuts. Since the arrival of western flower thrips in Australia, there has been a dramatic increase in the incidence of TSWV and *Capsicum chlorosis virus* in many other susceptible crops. TSWV has severely damaged peanut crops in many overseas countries, including the USA.

Damage: Thrips damage is characterised by a general yellowing, silvering and distortion of the leaves that show up in patches of the crop during prolonged dry periods. Thrips may also attack flowers, leading to flower abortion. TSWV symptoms are many and varied, but include stunting, yellowing and distortion of plants, followed by wilting, plant collapse and death. Early leaf symptoms include pale ring spots.

Action level: Sample weekly if it has been dry for a long time. Only spray affected patches, or if there are >4–6 thrips per flower. However, be aware that western flower thrips are resistant to many pesticides, and that pesticides are ineffective in stopping the spread of TSWV. [23]

Photo 17: *Thrips.*

23 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.17 Whitefringed weevil (*Graphognathus leucoloma*)

Importance: Major and sporadic.

Damage: Larvae chewing into the taproot cause the most damage (Photo 18). This results in severely reduced vigour or the death of the plant. Pegs can also be damaged and mature larvae will chew the developing nut. Infestations in a crop are usually patchy. Adults will chew leaves and may cause patchy seedling stands in North Queensland. Root damage from larvae may allow CBR infection.

Action level: Monitor crops after rain from November to January for emerging adults.

Registered chemical: Check current registrations on the APVMA website.

Cultural control: Reduce larvae carryover from the previous season's crop. Remove volunteer peanuts from maize to reduce the carryover of larvae in the soil. Avoid planting on land planted to, or adjacent to, peanuts or lucerne in the previous season. Reduce the frequency of legume and tuber crops in the rotation to help reduce populations; for example, avoid planting potatoes after peanuts. [24]

Photo 18: *Whitefringed weevil. Left: the larvae chew into pods and roots; they do not have an obvious head like a white grub. Right: adults feed on leaves and do little damage*

24 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.18 Cane whitegrubs (*Lepidiota* spp.)

Importance: Significant and sporadic in North Queensland, usually following a grass pasture (Photo 19). Minor and infrequent in southern Queensland.

Damage: Young larvae feed on soil humus and small plant roots. Older larvae attack major roots, killing some plants and reducing the vigour of others. This can provide an entry point for CBR. The developing nuts can also be attacked.

Action level: Not determined.

Cultural control: Cultivation may physically damage many canegrubs, but is not a reliable control method. If grub numbers are high, the first crop following pasture may need to be pulled early. Alternatively, plant a non-legume crop in the first year after a pasture rotation.

Registered chemical: Check current registrations on the APVMA website. [25]

Photo 19: *Canegrubs are a greater problem in North Queensland than in southern districts*

25 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.19 Peanut whitegrubs (*Heteronyx piceus*)

Importance: In the South Burnett, major and frequent. In other areas, infrequent.

Damage: Young larvae feed on soil humus and possibly small plant roots. Older larvae chew into both immature and mature pods, reducing yield and quality (Photo 20). Unlike canegrubs, peanut whitegrub larvae do not cause plant death.

Action level: Not determined.

Registered chemical: Check current registrations on the APVMA website.

Cultural control: Intensive peanut rotations in a region, or on a single farm, lead to peanut whitegrub problems. Avoid planting before November if the area has a whitegrub history. Conventional tillage has very little effect on whitegrubs. [26]

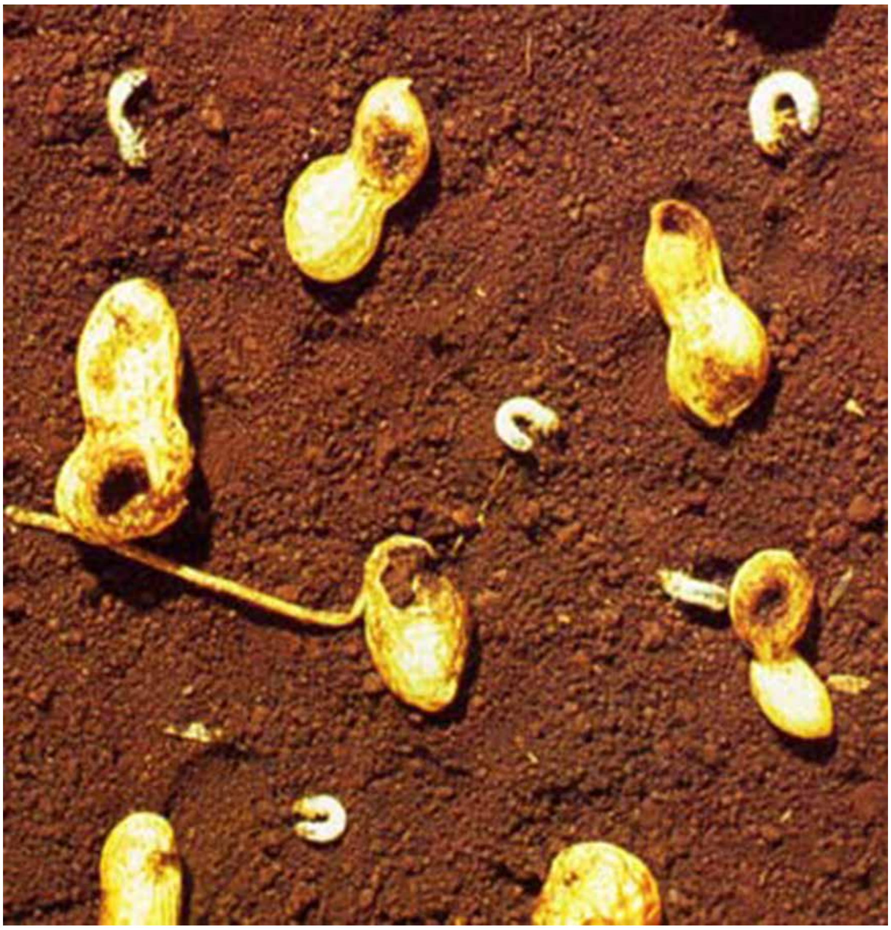


Photo 20: *Damage by whitegrubs is often underestimated, as damaged pods are left behind at harvest.*

26 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

7.5.20 Wireworms (click beetles, Elateridae)

Importance: Not fully documented. Usually not a problem in the South Burnett but significant damage has been reported in Central and North Queensland. On average, infrequent rather than regular.

Damage: Larvae can attack germinating seed and damage seedling roots. Larvae also attack pods, sometimes boring numerous small holes per pod (Photo 21).

Action level: Not determined. Check adult presence with germinating seed baits.

Control: Seed treatment will reduce, but not eliminate damage to seedlings.

Registered chemical: None registered. [27]

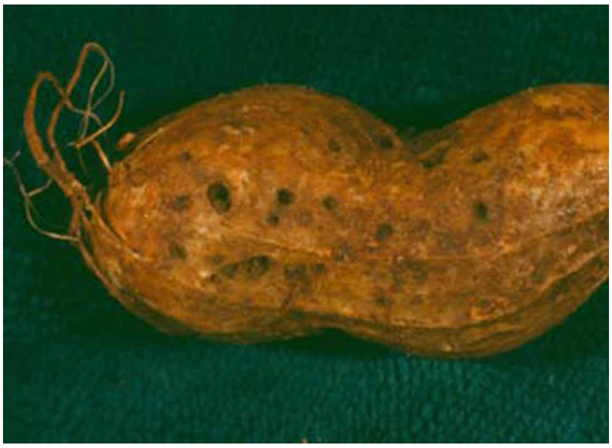


Photo 21: *Wireworm damage to a peanut kernel (top) and to a peanut pod (bottom).*

27 PCA/DPIF (2007) Managing pests. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4b_insect.pdf

Nematode management

Nematodes are microscopic, thread-like organisms that live in soil and plant roots. There are many species of agriculturally significant nematodes, and resistance and susceptibility of crops can differ for each root-lesion nematode (RLN) species. Peanuts tend to be affected most by *Pratylenchus brachyurus*, which can cause significant reductions in yield and quality. Pods are discoloured; therefore, the crop will not achieve nut-in-shell quality. Concerns also exist regarding the root-knot nematode *Meloidogyne hapla*.

In cereals, significant RLN species are *P. thornei* and *P. neglectus*. Peanuts are not hosts of these two species. [1]

Symptoms of *P. brachyurus* include stunted bushes and small lesions on roots, pegs and shells that may not be obvious. Nothing can be done to treat these nematodes in the current crop and no chemicals are registered for use against nematodes in peanuts; however, crop rotation can reduce nematode populations significantly (Table 1). Maize is the most effective rotation crop. [2]

Table 1: *Research showing effects of rotations on the incidence of known peanut pathogens.* [3]

Pathogen	Continuous peanut, winter fallow		Continuous peanut, winter oats		Peanut rotated with soybean, oats and maize	
	Year 7	Year 9	Year 7	Year 9	Year 7	Year 9
Root-knot nematodes (/g DW root)	465a	1,580a	690a	1,775a	32b	29b
Root-lesion nematode (/g DW root)	480	215	668	63	376	201
Verticillium wilt at harvest (% plants)	16.5a	47.8a	4.4b	37.8ab	3.7b	23.1b
Sclerotinia at harvest (% plants)	0	5.8a	0	3.6a	0	15.9b
Plant mortality due to crown rot (% plants)	23.7a	20.7a	24.6a	17.8a	1.6b	6.3b

For each pathogen and year, means followed by the same letter are not significantly different

A survey of peanut plantings in North Queensland showed that the RLN *M. hapla* was confined to red basaltic soils around Tolga and Atherton with a long cropping history. The RLN *P. brachyurus* was widespread throughout the Atherton Tablelands but not found in soils that had recently been brought into cultivation. Infestations of both species were heavier where peanuts had been grown on the same land for two or more successive seasons. Yield responses were obtained only in trials where infestations of *M. hapla* were severe, and not where *P. brachyurus* occurred by itself. [4]

MORE INFORMATION

M Bell *et al.* (2003) The impact of crop rotation on peanut productivity in rainfed cropping systems. Australian Agronomy Conference.

GM Murray, JP Brennan (2009) The current and potential costs from diseases of wheat in Australia. GRDC Report.

K Owen *et al.* Root lesion nematode—Queensland. Fact Sheet. Soil Quality Pty Ltd.

QDAF brochure: Root lesion nematodes

1 GM Murray, JP Brennan (2009) The current and potential costs from diseases of wheat in Australia. Report for Grains Research and Development Corporation, https://grdc.com.au/__data/assets/pdf_file/0026/203957/disease-loss-wheat.pdf.pdf

2 QDAF (2012) Root-lesion nematodes. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/peanuts/managing-peanut-diseases/root-lesion-nematodes

3 M Bell, G Harch, J Tatnell, K Middleton (2003) The impact of crop rotation on peanut productivity in rainfed cropping systems. Australian Agronomy Conference, Australian Society of Agronomy, http://www.regional.org.au/au/asa/2003/c/5/bell.htm

4 RA Broadley (1981) Distribution and control of root-knot and root lesion nematodes on peanuts in north Queensland. *Australian Journal of Experimental Agriculture* 21, 223–226, http://www.publish.csiro.au/paper/EA9810223.htm

8.1 Types of nematodes

8.1.1 Root-lesion nematodes (*Pratylenchus brachyurus*)

Importance: Most widespread nematode affecting peanuts in Australia.

Damage: Can cause significant reductions in yield and quality. Pods are discoloured, meaning that the crop will not achieve nut-in-shell quality.

Symptoms: Stunted bushes. Small lesions on roots, pegs and shells may not be obvious (Photo 1).

Management strategies:

- Chemical: Nothing can be done in the current crop, except to identify nematodes as the cause. No chemicals are registered for use against nematodes in peanuts.
- Cultural: Crop rotation can reduce nematode population significantly. Maize is the most effective rotation crop. [5]

Photo 1: *Root-lesion nematodes: the dark markings on these pods are caused by nematodes burrowing into the shell. The small white lumps are lenticels (or pores) which swell up in wet soil.*

MORE INFORMATION

GRDC Tips and Tactics: Root-lesion nematodes

EL Davis, AE MacGuidwin (2000) Lesion nematode diseases. *The Plant Health Instructor*.

GRDC fact sheet: Plant parasitic nematodes

8.1.2 Root-knot nematodes (*Meloidogyne hapla*)

Importance: Not a major problem in traditional peanut areas, but may become important in new production areas.

Symptoms: Typical root galls are formed and in severe cases, plants are stunted (Photo 2).

Management strategies:

- Chemical: No action is possible in an affected crop, except confirming nematodes as the cause of the damage. No chemicals registered for use against nematodes in peanuts.
- Cultural: Rotation with cotton, sorghum or maize will reduce the population. [6]

5 PCA/DPIF (2007) Managing disease. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4a_disease.pdf

6 PCA/DPIF (2007) Managing disease. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4a_disease.pdf

Photo 2: *Root-knot nematodes: the typical root galls should not be confused with N-fixing nodules.*

8.2 Effects of cropping history on nematode status

Nematode *(Pratylenchus)* numbers build up steadily under susceptible crops and cause decreasing yields over several years. The amount of damage caused will depend on:

- the numbers of nematodes in the soil at sowing
- the tolerance of the variety of the crop being grown
- the environmental conditions.

Growers cropping peanuts in rotation with cotton should consider the effect of RLN species on crops following cotton. Some researchers report that the nematode is quite often found in cotton. [7]

MORE INFORMATION

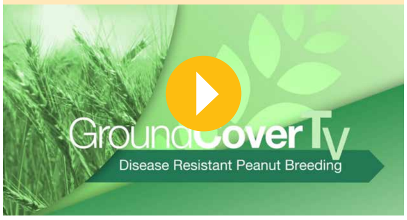
Pratylenchus brachyurus. Atlas of Living Australia.

7 A Machado, L Ferraz, M Inomoto (2012) Pathogenicity of *Pratylenchus brachyurus* on cotton plants. *The Journal of Cotton Science* 16, 268-271, http://www.cotton.org/journal/2012-16/4/upload/JCS16-268.pdf

VIDEOS

Disease management

GCTV14: Peanut Disease Resistance



Diseases

Peanuts are susceptible to several foliar diseases, especially leaf spot, rust and net blotch. Protective fungicides are available to keep most foliar diseases at bay. [1]

It is common to see some peanut plants dying throughout the season from a range of causes. Only when the plant population is significantly reduced should concern be raised. [2]

Peanuts are also susceptible to several soil-borne diseases, especially Sclerotinia blight, white mould and Cylindrocladium black rot (CBR). Good rotational practices, crop management and hygiene are the best defence against these diseases. Effective fungicides are available to control the foliar diseases; however, fungicide options are limited for control of the soil-borne diseases. [3]

Conditions favouring rapid crop growth also favour the development of disease. [4]

The young seedling is normally protected by the seed dressing (a fungicide). A common seedling disease in peanuts is crown rot, caused by *Aspergillus niger*, which is endemic in most soils. Crown rot often kills very weak seedlings and is very prevalent when soil temperatures are high. [5] Note that this is a different disease from that affecting cereal crops (caused by the *Fusarium* pathogen).

9.1 Damage caused by disease

Inherent problems of kernel quality and aflatoxin contamination caused by *Aspergillus flavus* can be aggravated by poor disease control. Peanut producers have access to an excellent range of proven options that work well if recommendations are followed. These include combining important elements of Integrated Disease Management (IDM) that will assist overall disease control. Stick to the rules of:

- control of peanut volunteers, which harbour disease between crop cycles
- prevention not cure—fungicides are much more effective if used preventatively
- thorough and regular disease scouting
- timely routine and strategic fungicide application in line with label recommendations
- rotation of chemistry to avoid resistance
- good spray-application technology
- effective crop rotation—rotations minimise incidence of leaf and soil-borne diseases (less of an issue in cane-farming systems). [6]

9.2 Management of disease

Total prevention is not possible. Peanut volunteers on headlands and in rotation crops can carry diseases, and infected residues from last year's crops can be a source of the leaf pathogens. A three-pronged approach must be taken to manage leaf diseases in all peanut varieties: control of volunteer peanut plants that may harbour the leaf spot and rust pathogens, careful paddock selection, and an appropriate fungicide spray regime. Avoid planting peanuts in the same paddock as the previous

1 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

2 PCA/DPIF (2007) Managing disease. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4a_disease.pdf

3 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

4 GRDC (2010) Managing leaf disease in peanuts. GRDC Fact Sheet, https://grdc.com.au/__data/assets/pdf_file/0030/207687/managing-leaf-disease-in-peanuts.pdf.pdf

5 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

6 GRDC (2010) Managing leaf disease in peanuts. GRDC Fact Sheet, https://grdc.com.au/__data/assets/pdf_file/0030/207687/managing-leaf-disease-in-peanuts.pdf.pdf

MORE INFORMATION

Australian Pesticides and Veterinary Medicines Authority.

VIDEOS

Fungicide use strategies

year and beside paddocks where peanuts were grown the previous year, particularly if late leaf spot was present in the previous crop.

9.2.1 Crop rotation

Crop rotation can have a significant impact on many diseases. For example, where one peanut crop follows another, seedling diseases are generally more common and leaf spot will appear earlier and be more severe.

Peanut diseases spread into new peanut-growing areas in different ways. Rust spores can be blown with the wind for long distances, whereas leaf spot spores travel for shorter distances. Equipment, particularly diggers and threshers, can spread soil-borne diseases.

Some diseases are already present in almost all soils, e.g. *Aspergillus flavus* (the aflatoxin-producing fungus).

In many environments, a fungicide program is needed to control foliar diseases such as leaf spot, rust and net blotch. This may involve 2–10 sprays, depending on district and season. Foliar diseases are a greater problem in more humid areas such as North Queensland and coastal areas than in the inland Burnett and Central Queensland.

Diseases can be divided into categories depending on when and how they attack the peanut plant. Some alternative causes, such as seed damage, are also included.[7]

9.2.2 Fungicide program for high risk areas

To achieve high yields, growers must control leaf diseases. The timing of fungicide sprays will depend on the disease incidence in the region.

In areas where diseases are always present and disease pressure is almost always severe, it is critical that early protectant fungicides are applied as soon as 21 days after emergence (DAE) of the crop. The fungicide program should continue until just before digging.

In the Bundaberg area, application of chlorothalonil products from 21 DAE at 10-day intervals has been shown to effectively control leaf spot and rust in susceptible varieties. Addition of one or two sprays using other products such as Alto® (cyproconazole) or Folicur® (tebuconazole) can also assist. In an average year, 14-day schedules are not frequent enough because the crop grows too quickly in these regions, with new leaves being produced (and therefore unprotected) on the top of the canopy every week. If growing a more tolerant line (i.e. the newly released D281-p40-236A), protective fungicide sprays should still commence from week 4, but the spray interval may be extended up to 21 days later in the crop.

In North Queensland, these schedules are just as important, but more frequent rainfall events require growers to manage fungicide application intervals with a more varied approach. Always seek advice on the latest registrations and recommendations.[8]

9.3 Disease symptoms

Symptoms of disease will be considered as follows:

1. Seedlings dying
2. Leaves with brown spots
3. Leaves with colour variations
4. Branch wilting or plant death
5. Ill-thrift
6. Pods damaged at harvest

7 PCA/DPIF (2007) Managing disease. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4a_disease.pdf

8 PCA/DPIF (2007) Managing disease. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4a_disease.pdf

9.3.1 Causes of seedlings dying (or poor emergence)

Soil-borne fungi including Aspergillus niger *(Aspergillus crown rot) and* Rhizopus arrhizus

Importance: Widespread.

Damage: Can be serious, causing low plant population or creating large gaps in the stand. Remaining plants may not compensate.

Symptoms: Seed does not emerge. Seedlings die. Fungal growth on the seed may or may not be present (Photos 1 and 2).

Spread: Already present in all soils.

Management strategies:

- Chemical: Treat seed with a recommended fungicide.
- Cultural: Plant into warm soil (~18°C). Do not plant if weather conditions are likely to cause soil temperature to fall below 18°C or rise above 50°C. Planting too deep will increase the risk of seedling disease.

Photo 1: *Aspergillus crown rot infection (left). Seedling showing crown rot symptoms (right).*

Photo 2: *Close-up view of crown rot fungus.*

Damaged seed

Importance: Minor.

Damage: Similar effect to soil-borne fungi, except that the losses are unlikely to continue after emergence. Remaining plants may still show poor vigour.

Management strategy:

- **Cultural**: Check planting equipment to minimise damage to seed. Handle seed carefully. Select seed from crops that have not been affected by drought and have been cured slowly. [9]

9.3.2 Causes of leaves with brown spots

Early and late leaf spot (caused by Cercospora arachidicola *and* Cercosporidium personatum*)*

Importance: Major in most peanut areas. Favoured by high rainfall and sprinkler irrigation. The Sutherland variety is resistant to leaf spot.

Damage: Leaves fall off and stems and pegs are weakened if the epidemic starts early and is uncontrolled and weather conditions favour disease spread. Conditions favouring rapid peanut growth also favour the spread of leaf spot. Leaves must be wet from rain, dew or irrigation for long periods (~10 h) to trigger infections. Crop potential is reduced when infected leaves fall off (Photo 3). Harvesting losses increase as infected pegs lose strength and break during pulling and threshing.

9 PCA/DPIF (2007) Managing disease. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4a_disease.pdf

Photo 3: *Leaf drop caused by leaf spot (left) compared with a non-diseased area (right).*

Symptoms: Small, dark spots become brown to black on both sides of the leaf as they enlarge up to 10 mm; there may be a yellow halo around the spots (Photo 4). Spots appear on the lower leaves first, but are not visible for 7–10 days after infection. Symptoms of late leaf spot are similar, but spots do not have a prominent yellow halo, and masses of spores are often seen on the underside of the leaf (Photo 5). Lower leaves are infected first, and infection is only noticed if the dense peanut canopy is parted. Later, stems and pegs may also become infected. Spores are spread mainly when dew dries off in the morning or when rain starts. They do not spread over long distances, so infections will often start from infected crop residues.

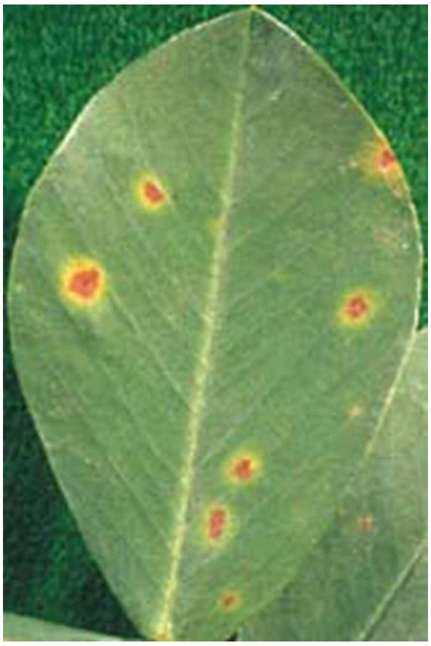


Photo 4: *Early leaf spot: brown spots on upper (left) and lower (right) leaf surfaces, some showing a yellow halo around the spot.*


Photo 5: *Late leaf spot: black spot on the underside of the leaf (left) and coalesced black spots near the base of the leaf (right).*

Spread: The fungal spores are spread by wind and rain. However, the residue of previous peanut crops is the main source of inoculum, so peanuts following peanuts are often the most heavily affected.

Management strategies:

- **Chemical**: Both diseases can be controlled by the same fungicides. In high-rainfall areas and for irrigated crops, a spray schedule of 10–14 days is needed. Leaf spot increases rapidly during warm, wet weather and irrigation. Fungicides also break down more quickly under these conditions and a shorter interval between sprays must be used to protect new foliage. Some fungicides can only provide protection, whereas others can control infections that occurred 3–6 days before application. These eradicant fungicides will not control well-established infections. Spray up to 4 weeks before harvest. When choosing fungicides, consider other diseases in the crop and whether the crop will be baled for hay.
- **Cultural**: Total prevention is not possible. Peanut volunteers on headlands and in rotation crops can carry the diseases between crops and they should be destroyed. Avoid peanut–peanut rotations. Sow the Sutherland variety, because it is resistant to leaf spot.

Rust (caused by Puccinia arachidis*)*

Importance: Widespread in most peanut areas north of Kingaroy. The Sutherland variety is resistant to rust.

Damage: Can cause major crop losses if it starts early and is uncontrolled. Once rust starts in a crop, dews and fogs are sufficient to create a serious epidemic.

Symptoms: Small, yellow spots quickly produce typical 'rusty' spores (Photo 6). Spores are not visible for 7–10 days after infection. They are usually found under the lower leaves and spread very rapidly. Infections are often first found as a 'hot spot' with a few plants covered in rust (Photo 7).

Spread: The spores can blow long distances between crops.

Management strategies:

- **Chemical**: Spray with a fungicide until the crop is within 2 weeks of harvest. A spray program similar to that for leaf spot may be needed. Consider other diseases that may be in the crop.

- **Cultural**: Rust spores cannot survive for very long in the absence of living plants, so destroy volunteer peanut plants between crops, especially on headlands, contour banks and around buildings. There are no known alternative hosts for peanut rust.

Photo 6: *Typical rust spores on upper and lower surfaces.*

Photo 7: *Rust-affected crop.*

The first signs of infection, the small yellow flecks on the leaves, soon develop into small orange pustules. The pustules contain numerous red-brown powdery spores that are spread during dry, windy weather. However, like the leaf spots, prolonged leaf wetness from rain, irrigation or dew is necessary for infection. [10]

10 GRDC (2010) Managing leaf disease in peanuts. GRDC Fact Sheet, https://grdc.com.au/__data/assets/pdf_file/0030/207687/managing-leaf-disease-in-peanuts.pdf.pdf

Puccinia arachidis is a different species of rust from those that typically affect cereal crops.

Net (or web) blotch (caused by Didymosphaeria arachidicola*)*

Importance: It is now the major foliar disease in the South Burnett in wet years.

Damage: Causes rapid defoliation (and subsequent yield loss) during cool, showery weather.

Symptoms: A network of very fine brown lines develops on the top surface of the leaf. These join together to form brownish blotches, which may go through the leaf (Photo 8).

Spread: The fungus survives on peanut residues from the previous season.

Management strategies:

- **Chemical**: Spray as soon as symptoms are seen during cool, showery weather. Not all fungicides control net blotch. Spray programs for leaf spot and rust protect against net blotch provided appropriate fungicides are used. In the dryland crops of the South Burnett, an increase in the number of fungicide applications will be needed to manage net blotch in wet years.
- **Cultural**: Net blotch epidemics are difficult to predict, but irrigation may create ideal conditions for infection. It may be necessary to adjust irrigation practices. Spanish varieties are more susceptible than Virginia types, which are more susceptible than Runner types. For variety characteristics, see GrowNotes Peanuts Section 2. Pre-planting.

Growers should not confuse this disease with the net blotch that affects cereal crops.

Photo 8: *Net blotch may occur with slightly differing appearance on affected leaves.*

Pepper spot and scorch (caused by Leptosphaerulina arachidicola*)*

Importance: Minor but widespread.

Damage: Leaves drop off. Is often one of the earliest foliar diseases to infect crops.

Symptoms: The same fungus causes two different symptoms under different weather conditions. Pepper spot occurs when very small spots, <1 mm, develop on the top of the leaf (Photo 9). Scorch occurs when a V-shaped part of the leaf dies (usually on the margin) and a yellow zone forms next to it.

Spread: The fungus survives on peanut residues and is spread by wind.

Management strategies:

- **Chemical**: The fungicides used for controlling the other foliage diseases usually control this fungus. Use a protectant fungicide if no other disease influences the choice.
- **Cultural**: These diseases are not usually serious in traditional production areas using the current varieties.

Photo 9: *Pepper spot looks sooty.*

Physiological spotting

Importance: Minor.

Damage: Leaf symptoms only.

Symptoms: Dark brown markings on leaves, similar to leaf spot. Some of these appear like 'eyebrows' (Photo 10).

Cause: Unknown.

Management strategies: None needed. [11]

11 PCA/DPIF (2007) Managing disease. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4a_disease.pdf

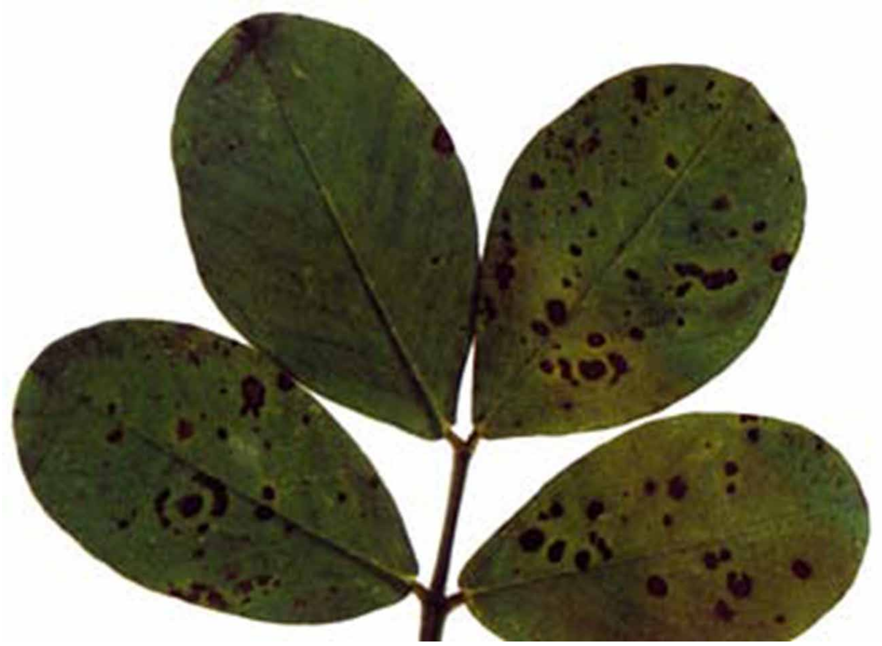


Photo 10: *Physiological spotting; note 'eyebrow' markings.*

9.3.3 Leaves with colour variations

Capsicum chlorosis virus (CaCV)

Importance: Usually minor; sometimes occurs at economically damaging levels in coastal Queensland.

Damage: Affected plants set few kernels and those that do set are small and of poor quality. Severely affected plants are stunted and may die, leaving gaps in rows.

Symptoms: CaCV causes mottling and dark (necrotic) spots on leaves (Photo 11). Internodes are reduced in length and the terminal growing points wilt and die. Affected plants are stunted, particularly when infected early in life, and may eventually die.

Spread: Several thrips species spread the virus, e.g. tomato thrips and melon thrips. CaCV belongs to the same virus group as TSWV and the transmission process for both viruses is almost identical. Thrips acquire the virus from infected plants as immature larvae and transmit to other plants as active adult insects after the virus has circulated and multiplied in the insect. The virus is not spread by other insects such as aphids and jassids. CaCV is not spread by contact, in soil or in seed.

CaCV infects capsicum, tomato and peanut. Billygoat weed (*Ageratum conyzoides*) is a major weed host of the virus throughout coastal Queensland. This weed commonly occurs around cane-fields and along roadsides.

Photo 11: *Capsicum chlorosis virus: mottling and dark (necrotic) spots develop on leaves, internodes are reduced in length, and terminal growing points wilt and die.*

Management strategies:

- **Treatment**: Infected plants cannot be cured. Management aims to reduce disease levels in crops, particularly early infection.
- **Cultural**: Control weeds around and within crops, particularly billygoat weed. Avoid planting new peanut crops adjacent to old crops or near capsicum crops.

Peanut mottle virus (PMV)

Importance: Minor.

Damage: Slight leaf mottling in peanut varieties currently grown.

Symptoms: Leaves show a light mottle through to patches of dark green (Photo 12).

Spread: By aphids.

Management strategies:

- **Cultural**: Use PMV-free seed, if available, in new and isolated areas. Only seed shown to be PMV-free can be grown in the Burdekin Bean Seed Quarantine Area.

Photo 12: *Peanut mottle virus: leaves showing a light mottle through to dark green.*

Tomato spotted wilt virus (TSWV)

Importance: Minor, but potentially serious under certain conditions.

Damage: The incidence of infected plants is usually low. Plants infected early may be stunted and produce few nuts. Plants infected after 40 days are usually not stunted, but some branches may be affected.

Symptoms: This virus produces distinctive patterns on leaves, usually including concentric yellow rings or lines (Photo 13).

Spread: Thrips spread the disease from host plants—capsicum, tomato, lettuce and broadleaf weeds such as stinking roger and cobbler's pegs. Only adult thrips that develop from infected larvae can transmit the virus. These thrips can be blown long distances.

Management strategies:

- **Cultural**: Control weeds in and near the crop. Avoid planting young crops next to old crops where disease is present, because significant movement of thrips occurs over relatively short distances.
- **Chemical**: Control thrips if possible. Often, however, insecticides are not effective against TSWV because thrips feeding times that lead to transmission are short, about 5 minutes, and spread is often from incoming thrips that feed but do not settle and breed in the crop.

Photo 13: *Tomato spotted wilt virus: affected plants are stunted with small, distorted leaves (top) showing green and yellow mosaic patterns, often circular (bottom).*

Verticillium wilt (caused by Verticillium dahliae*)*

Importance: Minor overall, but can be serious on some farms in some seasons. Often occurs on crops grown on the best soils in the South Burnett and in irrigated crops in low-rainfall areas.

Damage: Infection before early podfill may reduce yield, but the impact is small if leaf symptoms appear after this time.

Symptoms: Pale-green blotches appear between the veins and around the leaf margins (Photo 14). The margins then become brown and die. Under dry conditions, these areas dry out, giving the plant a scorched appearance. The vascular tissues in stems and roots are discoloured reddish brown. Wilting and plant death sometimes occur.

Spread: Hosts include the weeds cobbler's pegs, Noogoora burr and Anoda weed, and many crop plants such as cotton.

Management strategies:

- **Treatment**: Once infection occurs, nothing can be done to control Verticillium wilt.
- **Cultural**: Remove weed hosts and infected crop residues. Making hay may be warranted if a large amount of fungal inoculum is present in the leaves and stems throughout the paddock. Dig the crop as early as possible. [12]

Photo 14: *Verticillium wilt: close-up view of yellow leaves with green veins and water-soaked margins (top); plant stunted by Verticillium wilt (bottom).*

12 PCA/DPIF (2007) Managing disease. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4a_disease.pdf

9.3.4 Branch wilting or plant death

Sclerotinia blight (caused by Sclerotinia sclerotiorum *and* S. minor*)*

Importance: Major and expanding. *Sclerotinia minor* is the main problem in the South Burnett, and *S. sclerotiorum* is the main problem on the Atherton Tableland and at Coominya, south-eastern Queensland.

Damage: These diseases can devastate a crop in a few days if it is continuously wet. *Sclerotinia sclerotiorum*, particularly, shows up first in wetter parts of the paddock where the bushes are larger or where there may be shade for longer.

Symptoms: Usually, the first sign of Sclerotinia blight is a wilting branch or bush (Photo 15). The plant will begin to show visible wilting only after it has been infected for many days. Early detection is essential. Both species of *Sclerotinia* produce fluffy, white mould like cotton wool. However, the size of the black resting bodies (sclerotia) formed on and in stems is different; those of *S. sclerotiorum* are larger than a wheat grain, whereas those of *S. minor* are smaller and similar in size to raw sugar crystals (Photo 16). Stems wilt and become dry and bleached where the fungus is present.

The life cycles of the two species differ. *Sclerotinia minor* does not usually produce small mushrooms that release spores into the wind, whereas *S. sclerotiorum* does. Infections of lower stems and pegs develop from germinating sclerotia.

Spread: *Sclerotinia minor* spreads by physical movement of the sclerotia; *S. sclerotiorum* spreads by sclerotia and by wind-blown spores.

Photo 15: *The first sign of Sclerotinia blight is a wilting branch or bush.*

Management strategies:

- **Cultural**: Prevention in future crops is difficult. Avoid damage to plants from inter-row cultivations.
- **Chemical**: Monitor the crop for infection, especially in cool, damp conditions. Spray with a fungicide as soon as the disease is seen. Correct timing is essential to achieve the most effective control. Apply registered fungicide (Rovral®, a.i. iprodione). If the field has a history of Sclerotinia blight, consider spraying as a precaution when the row has half-closed. More than one spray may be needed. Avoid the continued use of chlorothalonil to control leaf diseases in fields where Sclerotinia blight is a problem. Continue to use chlorothalonil if the damage from leaf spot, rust and net blotch is likely to be worse than the Sclerotinia blight.

Photo 16: *The white fluffy mycelium of* Sclerotinia sclerotiorum *is similar to* S. minor. *Note the relatively large black sclerote of* S. sclerotiorum, *which is the main type on the Atherton Tableland and at Coominya (left). Small black sclerotes are produced by* S. minor, *which is the most common in peanuts in the South Burnett (right).*

Cylindrocladium black rot (CBR) (caused by Cylindrocladium crotalaria*)*

Importance: Major in the Burnett and Atherton Tableland.

Damage: The disease is caused by a soil-inhabiting fungus. Although wet conditions allow infection, particularly when plants are young, CBR is more evident when conditions turn dry and bushes start to wilt and die.

Symptoms: The taproot and side roots start to decay from the tip towards the main crown of the plant (Photo 17). There is internal, dark brown discoloration of the roots, and sometimes the stems, but the only symptom seen on foliage is a general yellowing. Eventually, the plant dies from loss of the root system. Red fungal structures (about pinhead size) may form on dead or diseased tissue. These structures do not usually occur on infected tissue in the South Burnett.

Spread: By infected plant parts and soil.

Management strategies:

- **Treatment**: Nothing can be done for the current crop. The future of growing peanuts on that land likely depends on surviving one or two bad crops, after which losses may be acceptable.

- **Cultural**: Some growers on the Atherton Tableland use irrigation and fertiliser to reduce the effects of CBR. The lateral roots feed on the moisture and nutrients after the taproot has died. A rotation of 2 years of maize followed by peanuts seems effective in keeping the inoculum to a low level on the Atherton Tableland.

In the South Burnett, CBR can be quite severe in affected parts of a field for a few successive crops, but generally, the severity decreases in subsequent crops. This does not appear to be the case on the Atherton Tableland, where the severity of the disease varies from season to season depending on weather conditions.

Damage to the root system by soil insects and nematodes can increase CBR infections.

Soybeans, lupins and lucerne are hosts for CBR.

Photo 17: *Cylindrocladium black rot: roots usually become blackened and die back from the tips (top left). The red resting bodies are typical of CBR, but are not always present (top right). Kernels infected with CBR (bottom).*

White mould (caused by Sclerotium rolfsii*)*

Importance: Major. Widespread across all peanut-growing areas. Worse in some years and in some fields.

Damage: Wilting and dead plants. Prefers to live on dead plant matter. Attacks peanut plants mainly when soil organic matter levels are low. Diseased leaves drop and are responsible for the movement of inoculum between plants.

Under dry conditions, the fungus can live under the soil in the moisture around roots and pods.

Symptoms: Produces fluffy white mycelium, thicker than that of *Sclerotinia* spp. In the mycelium are very small, spherical, white and then brown resting bodies, about pinhead size (Photo 18). Plant stems may be destroyed near soil level, and pegs and pods can be attacked. Pods can be affected without any sign of infection on the soil surface.

Spread: Already present in virtually all soils.

Management strategies:

- **Treatment**: Nothing can be done for the current crop.
- **Cultural**: Avoid damaging the plants or throwing too much soil around the crown when inter-row cultivating. Build up soil organic matter status. Decomposed soil organic matter may reduce the incidence of white mould by stimulating antagonistic organisms. Fresh (or under-composed) organic matter can stimulate white mould and make the problem worse. This is particularly the case where decomposed soil organic matter levels are low. The best control is usually to have a good rotation with grass or cereal crops.

The white mould situation in North Queensland may be different from that in the Burnett. White mould is appearing where crops have been well rotated, soil organic matter levels appear high, and, in particular, where stubble is retained on the soil surface.

In North Queensland, avoid planting peanuts into fresh stubble or crop residues maintained on the soil surface. Give organic matter time to break down or decompose. Deep ploughing may be an option, as sclerotia do not survive deep burying for more than a year.

Photo 18: *White mould: the white mycelium is slightly thicker than that of Sclerotinia and tends to form more on the soil surface (top). Note the sclerotia, which are spherical and white, then turn brown (bottom) (those of Sclerotinia are black and an irregular shape).*

Collar rot (caused by Lasiodiplodia theobromae*)*

Importance: Major problem in the Central and South Burnett, but is known in all peanut growing areas.

Damage: Losses can be severe, up to total crop loss across an entire paddock. The disease seems to be worse where the soil is degraded through erosion or scalping during land levelling.

Symptoms: A rapid collapse of plants from complete rotting of the roots and stems at ground level (Photo 19). Plants die throughout the season.

Infection occurs at soil level where stems and crowns suffer from heat stress, soil abrasion or drought.

Management strategies:

- **Treatment**: Nothing can be done for an affected crop.
- **Cultural**: Maintain light irrigations where possible, so the plant can survive on surface roots. Do not delay harvest. Rotation of at least 2 years in other crops should reduce the level of spores in the soil. To minimise risk, plant early and consider planting on beds to obtain groundcover before the middle of summer.

Photo 19: *Collar rot: bushes rapidly wilt and rot at ground level (top). Affected pods go grey inside in the early stages, then the whole pod rots (bottom left). Note the characteristic small black resting bodies on the stem (bottom right).*

Aspergillus crown rot (caused by Aspergillus niger*)*

Importance: Widespread in all peanut-growing areas.

Damage: Causes serious plant losses in some fields in some years. Plants may be killed at any stage up to harvest, although death of young plants is more common.

Symptoms: In seedlings, the soft, below-ground stem is attacked and can be killed rapidly. The affected tissue becomes yellow and depressed and usually develops a sooty, black mass of spores (Photo 20). The rot frequently develops near old pieces of seed attached to the stem.

In plants, a typical crown rot develops and the sooty growth of the fungus is often present on affected tissues. If the damage is near the base of the underground part of the stem, the plant will survive for a while on roots that grow above the affected area. Such plants generally die during dry weather.

Spread: The fungus is present in all peanut-growing areas. It is most serious where peanuts have been grown in the same area for a number of years.

The fungus is often present in seed that becomes infected in the field or during harvesting and handling.

Management strategies:

- **Chemical**: Use good seed treated with recommended fungicides.
- **Cultural**: Avoid damage to the seed before planting. Do not plant deeper than necessary. Take care when cultivating to avoid damaging plants. Rotate with other crops.

Photo 20: *Aspergillus crown rot can kill plants from seedlings to maturity. The infection usually starts at ground level (top). Note the characteristic black spores (bottom).*

Charcoal rot (caused by Macrophomina phaseolina*)*

Importance: Not normally a major problem. May become serious in crops where soil temperature becomes very high during the growing season. It also appears to be drought-induced.

Damage: Plants die progressively during the season.

Symptoms: Root tissues are discoloured beneath the bark layer. Developing pods can rot (Photo 21).

Spread: Already present in most soils.

Management strategies:

- **Cultural**: If possible, keep the soil surface moist to minimise stress due to high soil temperatures or drought. To minimise risk, plant early and consider planting on beds to obtain groundcover before the middle of summer.

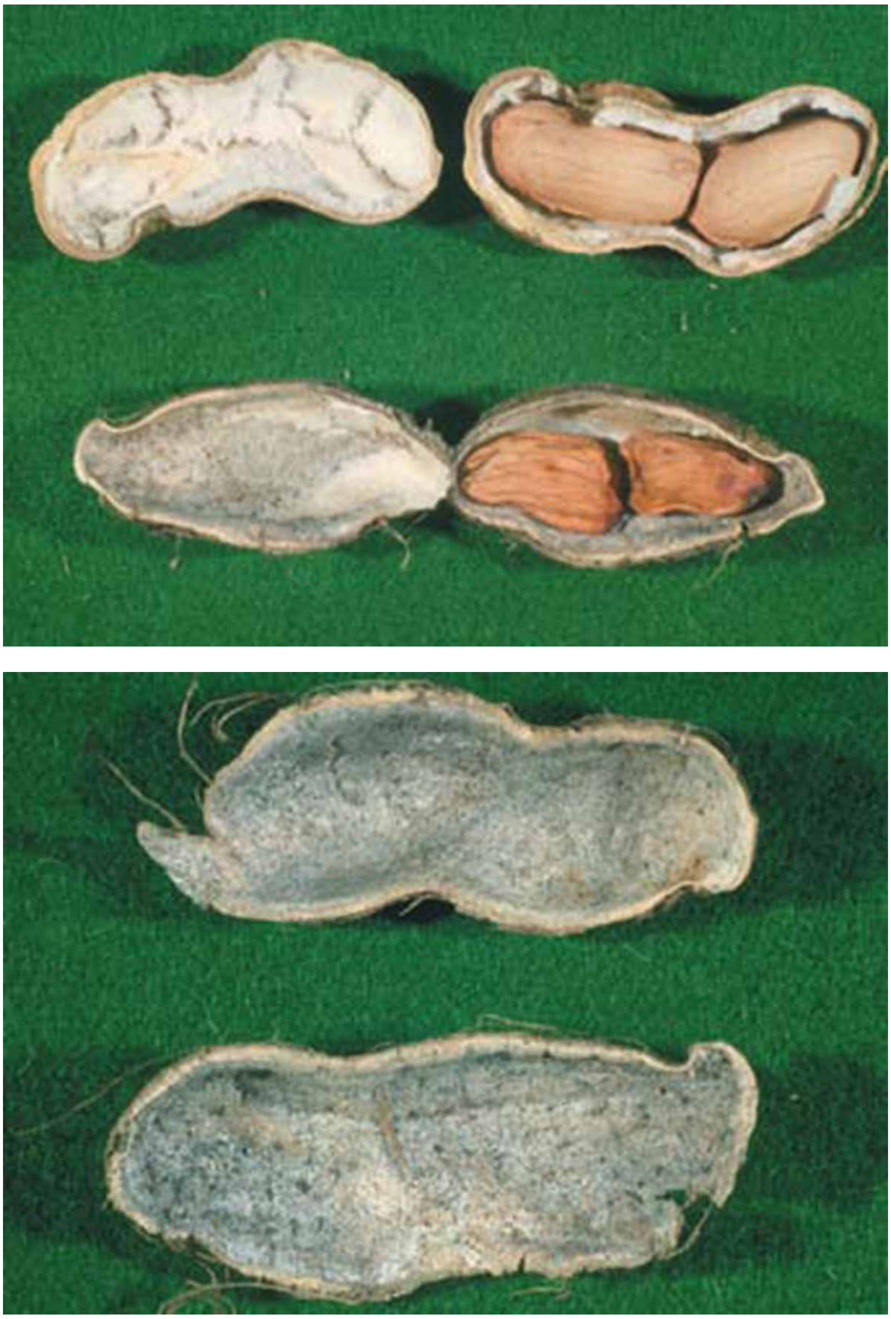


Photo 21: *Charcoal rot.*

Rhizoctonia stem rot (caused by Rhizoctonia solani*)*

Importance: Rarely causes problems under traditional dryland peanut production conditions in Australia. May be a problem under sprinkler irrigation where the soil surface stays cool and moist.

Damage: Plants can be killed from seedling to maturity.

Symptoms: Distinctly zonate brown sunken lesions, which can completely girdle stems, causing part or all of the plant to die (Photo 22). Pegs and pods may also be affected.

Spread: The fungus is already present in many soils and can survive in soil for many years.

Management strategies:

- **Cultural**: Little can be done, except to irrigate so that the plant is wet for the least possible time. Gypsum application may reduce pod rots. Avoid covering the crown and branches of the plant with soil during cultivation. Rotate crops to increase or maintain levels of soil organic matter. [13]

Photo 22: *Rhizoctonia stem rot.*

Photo used with kind permission of Chip Lee, Texas A & M University, College Station, TX, USA

9.3.5 Ill-thrift

*Root-lesion nematodes (*Pratylenchus brachyurus*)*

Importance: Most widespread nematode affecting peanuts in Australia.

Damage: Can cause significant reductions in yield and quality. Pods are discoloured (Photo 23); therefore, the crop will not achieve nut-in-shell quality.

Symptoms: Stunted bushes. Small lesions on roots, pegs and shells may not be obvious.

13 PCA/DPIF (2007) Managing disease. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4a_disease.pdf

Management strategies:

- **Chemical**: Nothing can be done in the current crop, except to identify nematodes as the cause. No chemicals are registered for use against nematodes in peanuts.
- **Cultural**: Crop rotation can reduce nematode population significantly. Maize is the most effective rotation crop.

Photo 23: *Root-lesion nematodes: the dark markings on these pods are caused by nematodes burrowing into the shell. The small white lumps are lenticels (or pores), which swell up in wet soil.*

*Root-knot nematodes (*Meloidogyne hapla*)*

Importance: Not a major problem in traditional peanut areas, but may become important in new production areas.

Symptoms: Typical root galls are formed (Photo 24), and in severe cases, plants are stunted.

Management strategies:

- **Chemical**: No action is possible in an affected crop, except confirming nematodes as the cause of the damage. No chemicals are registered for use against nematodes in peanuts.
- **Cultural**: Rotation with cotton, sorghum or maize will reduce the population. [14]

14 PCA/DPIF (2007) Managing disease. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4a_disease.pdf

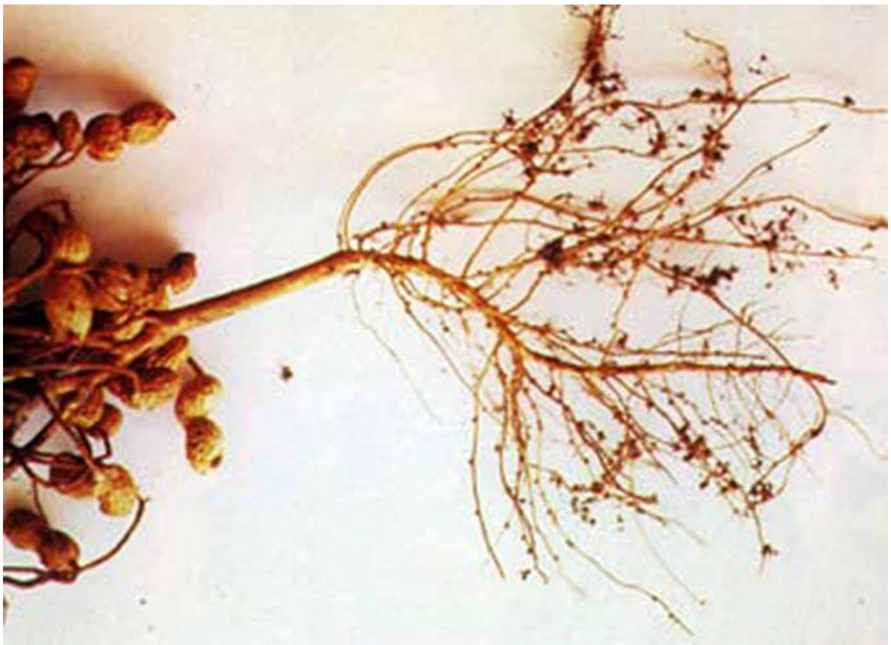


Photo 24: *Root-knot nematodes: the typical root galls should not be confused with N-fixing nodules.*

9.3.6 Pods damaged at harvest

Soil insects

Lucerne seed web moth (*Etiella*), white grub larvae and white-fringed weevil larvae all damage pods (see GrowNotes Peanuts Section 7. Insect control).

Pod-rotting fungi, including Lasiodiplodia theobromae*,* Pythium *spp. and* Rhizoctonia solani

Importance: Major and widespread.

Damage: Many pods (and pegs) are mouldy and/or decayed, causing serious yield and quality losses.

Management strategies:

- **Cultural**: Harvest quickly to reduce losses.

*Aflatoxin-producing fungi (*Aspergillus flavus *and* A. parasiticus*)*

Importance: Major and widespread, particularly in dryland crops.

Damage: Kernels contaminated with aflatoxin bring a reduced price and, in cases of very high levels, may be downgraded to oil quality (Photo 25).

High soil temperatures and drought during flowering and podfill are the major causes of aflatoxin contamination. Pods damaged by insects, disease or rain after a dry period or after harvest allow the fungus access to the kernels.

Aspergillus flavus develops most rapidly at 25°–35°C and when pod moisture is 14–35%.

Symptoms: The greenish yellow fungi are not always visible in harvested kernels. The toxins can only be detected in a laboratory using chemical extraction and analytical instruments.

Cultural management strategies: Irrigation will minimise the risk of pre-harvest aflatoxin. However, if the plant is allowed to stress just prior to maturity, *A. flavus* can still invade the pod.

Dig as soon as the crop is mature.

Leaving peanuts in the windrow to dry to 13% moisture increases the risk of aflatoxin because of the chance of rain re-wetting the crop. The risk is much higher if the plants were moisture-stressed before harvest. Peanuts in well-inverted windrows have a lower risk because they dry quicker.

Harvest irrigated areas separately from dryland areas. This may mean turning in the middle of a row if the irrigator does not cover the paddock. Mixing peanuts from these dry ends of rows commonly results in aflatoxin-positive loads from irrigated crops.

Clean out threshers, bins and elevators between seasons, as one contaminated nut can downgrade a whole load.

Start curing the crop within 3 h of harvest to stop further development of the aflatoxin. Harvested nuts should not be left overnight before curing, even if only part of a bin is threshed.

Low soil calcium may increase the risk of aflatoxin where soil conditions are favourable for *A. flavus* mould development.

Gypsum may reduce the risk of aflatoxin contamination. [15]

15 PCA/DPIF (2007) Managing disease. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/4a_disease.pdf

Photo 25: *Aflatoxin: peanuts contaminated with aflatoxin will be downgraded and may be rejected.*

9.4 Soil-borne diseases

Several soil borne diseases can lead to substantial yield and quality loss. Three diseases of particular consequence are white mould, Sclerotinia blight and CBR.

Although some products are available that can lessen the effects of these diseases, the best policy is to follow a recommended rotational program (involving grass or cereal crops) and practice good cultural management. In particular, excessively aggressive inter-row cultivation should be avoided, especially where soil is pushed against the plant.

Sclerotinia blight can be particularly devastating in some areas. It is recommended that a registered fungicide spray (e.g. Rovral® at 1 L/ha) be applied as a protectant

MORE INFORMATION

New research investment to tackle peanut disease

New research tackles devastating peanut root rot. GRDC Media Centre.

before symptoms appear. This may be as early as when the crop is 6–8 weeks old, or when the first flower petals drop. One or two follow up fungicide applications may be required if symptoms develop. [16] Roval® is more effective at controlling *S. sclerotiorum* than *S. minor*.

9.4.1 Neocosmospora vasinfecta

Neocosmospora vasinfecta is a major soil-borne fungal root-rot pathogen found in all peanut-growing areas of Australia. It has caused yield losses of up to 90%.

There is a lack of information available globally regarding *N. vasinfecta* infection in peanuts, but this is being addressed through new research work being undertaken by GRDC-funded PhD student, Kylie Wenham.

The project is assessing the pathogen's form and structural characteristics, the growth and development of the fungus both *in vitro* and *in situ*, the optimal growth conditions favoured by the fungus, as well as the optimal environment for the fungus to proliferate and infect crops.

9.5 Emerging diseases

9.5.1 Peanut smut (*Thecaphora frezii*)

Peanut smut is currently the most economically important peanut disease in Argentina. During the last 10 years, this disease has caused significant decreases in yield production in Argentina, resulting in 51% losses in some locations. Currently, Argentina is the only country that has reported peanut smut in commercial crops. Both Bolivia and Brazil have reported cases of smut in wild peanuts.

T. frezii produces teliospores, which are thick walled structures that enable the fungus to overwinter in soil and crop residue. Teliospores can survive in a metabolic dormant state in the soil without the presence of live hosts. When peanut pegs penetrate the soil, their exudates disrupt telial dormancy, which promotes spore germination and initiates local infections. [17]

9.5.2 Peanut kernel shrivel

Peanut kernel shrivel (PKS) syndrome is a condition affecting peanut crops primarily in the Bundaberg growing region. Peanut kernels in pods on a plant near maturity stop filling normally and fail to reach their full size. The resulting reduced kernel size and high shell percentage reduces overall crop yield, quality/grading and price/Mt of farmer stock. Affected kernels are small and in many instances develop a shrivelled testa with light tan colour (Photo 26). There are no aboveground symptoms as leaf and stem from PKS-affected plants appear healthy with no obvious signs of nutrient deficiency or disease.

The peanut industry in the Bundaberg region has seen a steady rate of decline in crop grade since 2011, due to the increasing impact of PKS. PKS is currently costing the industry more than $2.5M per annum and growers will consider reducing peanut plantings if a solution to PKS is not initiated soon. [18]

To date, efforts to detect the cause of PKS have been unsuccessful. Initial investigations showed no evidence to indicate abiotic (including water quality and nutritional status) or biotic (including insect, nematodes, viruses and bacteria) factors. Some recent research results have suggested a pathogen (e.g. fungi) might be involved, possibly associated with a toxin or excess hormone production.

16 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

17 AM Rago, LI Cazón, JA Paredes, JPE Molina, EC Conforto, EM Bisonard, C Oddino (2017) Peanut smut: from an emerging disease to an actual threat to Argentine peanut production. Plant Disease 101, 400–408, http://apsjournals.apsnet.org/doi/pdf/10.1094/PDIS-09-16-1248-FE

18 G Wright, 2017, Peanut Company of Australia, personal communication

The University of Southern Queensland (USQ) and PCA have partnered in a GRDC-funded research collaborative project looking into the 'Extent, distribution and cause of PKS syndrome in the Bundaberg and Northern Queensland regions'.

Led by Dr Dante L. Adorada (USQ), work to identify possible biotic factors, focussing on fungi and bacteria and non-culturable microorganisms, is currently underway. The next step will be developing management strategies to minimise the incidence of PKS in commercial peanut crops.

Photo 26: *Symptoms of peanut kernel shrivel (PKS) syndrome.*

Photos: Graeme Wright

Plant growth regulators and canopy management

Not applicable for this crop.

Crop desiccation/spray out

Not applicable for this crop.

VIDEOS

Crop maturity assessment

Harvest

Peanuts are an indeterminate crop, which means that from about 4 weeks onwards, the crop will continue with both flowering and vegetative growth. Commonly, the crop is still flowering at harvest. Because the crop does not mature evenly, it can be difficult to determine the best time to dig.

If the crop is dug too early, significant weight and quality loss may occur because the pods have not properly filled out. If it is dug too late, the peanuts may be over-ripe and often the largest and best pods are left in the soil during digging. [1]

12.1 Hull scrape test

The most common method for determining crop maturity is called the hull scrape test. This involves taking note of colour changes under the outer skin of the shell to indicate kernel maturity.

The outer skin of the pod (exocarp) is removed, which exposes the colouring underneath. The exocarp can be removed by scraping the pod with a pocket knife or 'blasting' the pods with the stream of water from a high-pressure water cleaner. The pods are usually placed in a mesh basket while the exocarp is removed.

It is important to note the colour in the saddle area of the pod (Figure 1). This is where the colour changes first occur on the pod.

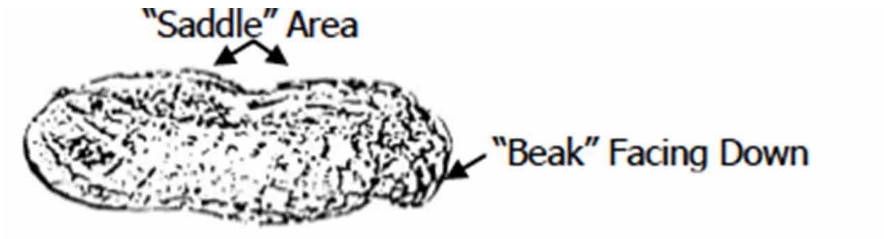


Figure 1: *The saddle area of the pod is where colour changes first appear.*

The colours that occur are:

- black: mature to over-mature
- dark brown: mature
- orange/light brown: close to mature
- yellow: immature
- white: immature to underdeveloped.

Approximately 200 pods should be scraped. This means digging carefully by hand at least six or seven representative bushes from different parts of the paddock. Excess soil should be removed (usually by washing). All pods with a diameter greater than that of a ballpoint pen (i.e. 5–8 mm) should be removed. Growers should take note of the peg strength as each pod is removed.

Pods should be placed in maturity categories as they are scraped. The colours will fade as the pods dry out, and keeping them moist will avoid this. Sometimes it is difficult to tell the difference between orange and brown. Colour charts are available for colour comparisons. Alternatively, growers can shell-out any peanuts they are unsure of and look at the inside of the shell and the kernel.

Peanuts that are mature will be dark brown inside the pod and the seed coat will be thin and tight on the kernel. With experience, growers become more adept at observing the maturity differences.

1 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

Growers must consider the other factors listed below in determining when to dig, but as a general guide, the crop is ready for digging when the following maturity levels are reached:

- Virginia varieties: dig when 60–65% brown and black
- runner and ultra-early varieties: dig when 65–80% brown and black. [2]

12.2 When to dig

The crop's maturity is assessed to determine harvesting time. Harvesting is a two-part operation. First, the taproot is cut and the plant shoots and peanut pods inverted to dry partially in the field for several days before a separate threshing operation is done.

The hull scrape test should be used as a guide only for determining when to dig. Other factors will also influence the decision and must be considered together. These include:

- peg strength
- disease (bush health)
- weather conditions
- soil conditions
- area to be harvested. [3]

12.2.1 Peg strength

The peg extends from the branches of the peanut plant and it is the 'lifeline' connecting the pod, below the soil, to the rest of the bush. If the peg becomes weak and detaches from the pod, then the pod cannot be recovered during harvesting and is lost.

The main factors reducing peg strength include:

- over-maturity
- foliar disease
- soil-borne disease.

To test peg strength, carefully dig several bushes from different parts of the paddock (usually when collecting the maturity sample). Shake the bushes to simulate the mechanical digging action. If a significant number (10–20%) of the pods fall off, then peg strength is declining and urgent digging needs to be considered. The hull scrape test should be done though; this may still determine the final digging date.

12.2.2 Disease

Sometimes it is evident that disease is spreading rapidly through the crop, and there is not sufficient time to wait for the crop to mature properly. In such situations, a decision may have to be made to dig the crop early to salvage the peanuts.

12.2.3 Weather conditions

Growers must take into account the expected weather conditions when determining the time to dig. For example, if prolonged wet weather is forecast, it may be better to dig a little early and have the peanuts properly inverted in a windrow, rather than still in the ground. This may be especially so if the crop is diseased.

Soil trafficability following heavy rain must also be considered.

2 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

3 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

12.2.4 Soil conditions

Growers sometimes dig based on their experience of when their soil is most friable. A soil that sets very hard when dry may make it almost impossible to avoid large losses when digging. It may be necessary to irrigate and dig such paddocks before they become too dry.

Heavy soils usually have only a 'narrow window' available in which to harvest in relation to soil moisture.

12.2.5 Area to be harvested

If a grower has a very large area to be harvested and the crops appear to be maturing all at once, it may be necessary to dig some paddocks earlier than the optimum in order to avoid losses resulting from the last dug peanuts being over-mature. [4]

12.3 Digging and inverting

A specially designed digger or puller is used to remove the peanuts from the soil. These machines are linkage-mounted and may come in 2-, 4- or 6-row configurations. Cutter blades are usually either attached to the digger or mid-mounted on the tractor. It is essential to keep these blades sharp and to check that they are not cutting either too deep or too shallow.

During digging, the taproot of the plant is cut just below the level of the peanuts and the soil around the pods is loosened. The bush, with pods attached, is usually carried to the back of the digger where it is then inverted. This leaves the peanuts lying in a windrow. Two rows of peanuts are normally combined into one windrow.

It is important that the peanuts are properly inverted to allow good air circulation to facilitate drying (Photo 1). If the peanuts are well inverted, they are less likely to be damaged if rain falls. It also keeps the pods up away from the soil surface for easier harvesting and a cleaner sample.

A moisture content of 12–16% is optimal for threshing. Controlled drying brings the peanuts slowly to safe storage moisture content and ensures optimum quality. Extended periods of paddock drying can cause higher losses, more splits, poorer quality and increased risk of rain damage. [5]

A combine or thresher is used to separate the peanuts from the bush. [6]

Factors influencing harvest losses:

- Soil type and soil management. Hard-setting and heavy soils are unsuitable.
- Poor late-season disease control can reduce pod quality and harvestability.
- Harvest management and timely access to harvesting equipment is critical.
- Crop maturity should be carefully assessed to optimise yield and quality.
- Kernel quality losses and aflatoxin can result from delayed threshing and drying. [7]

Several practices, outlined below, have been shown to reduce actinomycete growth post-harvest, and thus reduce the chance of 'off-flavour' contamination.

- When windrows remain wet from rain after cutting, fluffing is essential to improve aeration and ensure rapid dry-down of pods in order to minimise actinomycete growth on and around the pods.

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4 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

5 Peanut Company of Australia, http://www.pca.com.au/

6 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

7 G Mills, R Rachaputi, G Wright, Y Chauhan, J Barnes (2004) Yield potential of peanuts at Mackay. What are the key barriers to obtaining it? GRDC Update Papers February 2004, http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2004/02/Yield-potential-of-peanuts-at-Mackay-What-are-the-key-barriers-to-obtaining-it

- Short digging-to-thrashing intervals (3–5 days) can minimise the time that pod or kernel moisture is in a range suitable for actinomycete growth (i.e. >15% pod moisture). Windrows should not be left in the paddock for >5 days, because actinomycete growth on pods (and thus off-flavour contamination) is likely to occur. This is especially important in areas such as North Queensland, where post-harvest rainfall is likely.
- Thorough pre-cleaning of harvested pods removes extraneous matter including dirt, sticks, corn cobs, gherkins, immature pods and potatoes. If the product is not cleaned, build-up of extraneous materials can cause wet, hot spots and subsequent off-flavour contamination in storage bins. [8]

Photo 1: *A peanut crop with well-inverted and aerated windrows allows rapid drying after wet weather at harvest.*

Photo: PCA

12.4 Windrowing

Peanuts usually contain 40–50% moisture when dug. The peanuts are left inverted in the windrow for several days to bring the moisture content down to the optimum for threshing, which is 12–16%. This may take 3–10 days, depending on prevailing weather conditions.

Growers without access to dryers often have to let the peanuts dry down to 10% moisture in the windrow. This may take 5–14 days. The risk of damage to the crop from inclement weather increases the longer the crop remains in the paddock. Also, as the crop dries down to <12%, the pegs may become weaker and more brittle and crop losses are likely to increase.

In addition, the risk of aflatoxin contamination is much higher if the peanuts are left for more than a few days in the windrow. The best option is always to thresh early and artificially dry.

8 GRDC (2013) Peanut off-flavour. GRDC Fact Sheet, www.grdc.com.au/GRDC-FS-PeanutOffFlavour

12.5 Threshing

Threshers or peanut combines are designed to pick up the windrow from the paddock and separate the pods from the bush. The pods are delivered to a bin on top of the thresher while the bush is carried out of the machine and either spread over the paddock or dropped in a windrow for hay-baling. Threshers come in configurations of 2–8 rows. Most of the modern machines are imported from the USA and are attached to the draw bar and hydraulics of the tractor. AMADAS Industries and John Deere, however, have also developed self-propelled threshers in either 6- or 8-row configurations.

The ideal moisture content for threshing is 12–16%. Below 12%, threshing losses can increase from the pick-up, pods and kernels may be damaged, and the incidence of loose shell kernels (LSKs) increases.

The thresher should be checked and maintained regularly. Excessive drum speed can also result in damaged pods. In addition, fans and blowers may need appropriate adjustments. [9]

12.6 Wet harvest issues and management

Wet conditions at the time of harvest can encourage the growth of actinomycetes, and increase the chance of crop contamination. A long interval from cutting to threshing (>5 days) in combination with poorly aerated windrows, which prevent the plant and pods from drying rapidly down to safe moisture (i.e. <10% pod moisture within 2–4 days) can lead to conditions ideal for microbial growth. [10]

9 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf,

10 GRDC (2013) Peanut off-flavour. GRDC Fact Sheet, www.grdc.com.au/GRDC-FS-PeanutOffFlavour

MORE INFORMATION

Stored Grain Information Hub

Part I Achieving great aeration results and Part II Silo recirculation as an aid to fumigation

Storage

Peanut digging starts in late autumn and extends through the period March–June, when they are left to air-dry in the field for 3–5 days to reduce kernel moisture contents to 12–16%. This is followed by threshing operations to separate the pods from the bush.

Pods are then placed in aeration dryer silos either on-farm or at the shelling plant to further reduce the kernel moisture content down to 8.5%, the delivery standard enabling safe storage (Photo 1). Typically, peanuts are only held on-farm for a brief period (1–2 days) before delivery to a shelling plant, where quality is assessed and kernels are removed from the pods and undergo further processing prior to sale to customers.

Photo 1: *Peanut-drying silos allow pods to dry down to safe moisture content for storage.*

Photo: PCA

13.1 How to dry and store peanuts on-farm

To produce peanuts of optimum quality, most growers artificially dry their loads. Regular checks are required because over-drying can lead to kernel damage (especially higher level of splits), which results in reduced grade-out and lower prices per tonne. Peanuts that are not dried to the proper intake moisture ready for storage will have to be dried after delivery. PCA has facilities in Kingaroy, Gayndah and Tolga for contract drying. Growers should ensure that they book their loads in for drying with the depot's Intake Officer.

To maintain quality, loads must be dried slowly and carefully under controlled conditions. The following guidelines should be followed:

1. Pre-clean loads to remove dirt.
2. Start drying within 3–6 h of threshing to prevent mould and related aflatoxin development.
3. Keep an even depth of peanuts over the dryer floor, generally ≤2 m is preferred.
4. Air temperature in the plenum should not exceed 11°C above ambient temperatures (up to a maximum of 35°C).
5. The moisture removal rate should not exceed 0.5% per h, averaged over the time of drying.
6. The relative humidity of the drying air should be 50–65%.

7. Use a minimum continuous airflow of 200 L/s per m3 of peanuts.
8. Regularly check the temperature and humidity in the air tunnel.
9. The peanuts must have time to equilibrate following drying and before delivery (at least 24 h).
10. Regularly check the moisture content of the peanuts. [1]

Peanuts should only be stored after they have been dried down to a pod moisture content of <~10%.

MORE INFORMATION

QDAF (2012) Aflatoxin in peanuts.

13.1.1 Aflatoxin

In order minimise the risk of aflatoxin contamination, peanuts should be dried evenly and gently, and threshers, bins, trucks, etc., should be free of any old peanuts or organic matter. [2]

13.1.2 Off-flavour contamination

If peanuts are going to be stored on-farm, they need to be in secure and aerated storage bins that prevent leakage and ingress of moisture. Moisture can lead to development of microbial hotspots and off-flavour contamination.

Contamination of peanuts by microorganisms called actinomycetes can occur in the field during the growing season and during post-harvest storage and handling. Actinomycetes produce volatile compounds that contaminate the stored nuts, causing musty and earthy off-flavours. Actinomycete spores are prevalent in the environment and occur on soil adhering to peanut pods, in foreign material accompanying pods (soil, sticks and other plant debris, including immature potatoes) and in storage bins. Post-harvest off-flavour contamination of peanuts is a risk if temperature, humidity and pod moisture conditions are conducive to the germination and growth of actinomycete spores.

Temperatures >25°C and relative humidity >70% are highly conducive to actinomycete growth. Storage above these limits is discouraged. [3]

Generally, on-farm storage after July will result in a high risk of actinomycete growth and potential off-flavour contamination due to increasing ambient temperature and relative humidity. [4]

13.2 Pre-cleaning

MORE INFORMATION

Grain Storage Fact Sheet: Stored grain pests identification

Stored grain pests identification. The back pocket guide

Pre-cleaners are specifically designed to remove soil, sticks, stones and other extraneous matter from a load of peanuts. They usually consist of a set of rollers and screens and sometimes use blowers. Pre-cleaning a load prior to drying makes curing much more efficient and uniform and overcomes problems with wet spots in the load.

Pre-cleaning will often remove many of the loose shell kernels and immature pods that tend to harbour aflatoxin infection. Many growers have found that by pre-cleaning they can dramatically decrease the incidence of aflatoxin in their loads.

For growers who are a long distance from PCA's receival depots, pre-cleaning ensures that they are not paying freight on extraneous matter. Many growers have commented that they have paid for their pre-cleaner through savings made on freight over several years.

13.3 Storage pests

Grain Storage Information Hotline: 1800 WEEVIL (1800 933 845) will put you in contact with your nearest grain storage specialist.

1 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

2 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

3 GRDC (2013) Peanut off-flavour. GRDC Fact Sheet, www.grdc.com.au/GRDC-FS-PeanutOffFlavour

4 GRDC (2013) Peanut off-flavour. GRDC Fact Sheet, www.grdc.com.au/GRDC-FS-PeanutOffFlavour

Environmental issues

14.1 Climate

Based on climate alone, peanuts can be grown from Victoria, through NSW to North Queensland, the Northern Territory and Western Australia. However, commercial peanut production in areas south of Narrabri in NSW and in the north-west of Australia has been limited.

In the USA, peanuts are mostly grown at much higher latitudes.

Growers in different locations need to choose different varieties and management strategies if they are to maximise crop yields.

In some areas, planting times are critical. For instance, in southern regions, crops must be planted to mature before cold weather in autumn. Early-maturing varieties will perform better in these areas. In northern regions, crops should be planted so they will be ready for harvest after the main wet season.

Irrigation is necessary in most areas to produce reliable economic peanut yields. [1]

14.2 Temperature

Warm temperatures of ~25–30°C will prompt vegetative growth, whereas the optimum temperature for reproductive growth is ~22–24°C. Planting should be scheduled so that crops experience warm temperatures early in the season followed by cooler weather for flowering and then mature before there is any risk of frost (Photo 1). Hot soils can also damage peanut plants (Photo 2).

1 PCA/DPIF (2007) Climate and soils. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3a_climate.pdf

Photo 1: *Upper panel: yellowing between the veins of leaves is typical of cool night temperatures <9°C. Lower panel: frost kills the leaf tips but plant growth and pod-filling cease long before it is cold enough to frost.*

Photo 2: *Hot soil can cause leaf distortion and thickening as well as pollen sterility in peanuts during flowering.*

To determine when to sow, measure the soil temperature at planting depth at 9 a.m. each day. When temperatures of 18–20°C are recorded 3 days in a row, it is time to plant provided adequate soil moisture is present. If seeds are sown into cool soil, emergence will be slow because the seeds and seedlings are more susceptible to disease attack. Rain within 2–3 days of planting will lower soil temperature and may affect emergence if the soil temperature falls below 18°C.

Length of the growing season ranges from 110 to 170 days (16–24 weeks), depending on location and variety. For example, Early Bunch, an early-maturing variety, matures in ~170 days in Victoria, 140 days in Kingaroy and 120 days in Bundaberg. This delay in maturity is due to cooler temperatures in elevated and southern regions. Very dry conditions can also delay maturity.

You can predict the crop life cycle quite accurately using the heat-sum approach. Thermal time is calculated as the accumulation of heat units above a base temperature of 9°C up to an optimum of 29°C. Thus, a typical day of 35°C maximum and 23°C minimum will yield a mean daily temperature of (35 + 23)/2 = 29°C, and a thermal time of 29 – 9 = 20°C degree-days. The thermal times for each of the days throughout the season are then added together to give the total heat units for a particular environment.

Virginia and Runner types require thermal time of ~550 degree-days to progress from planting to the beginning of flowering, 950 degree-days to the beginning of podfill and 2150 degree-days to maturity for most locations in Queensland.

Crops can flower in ~35 days in Bundaberg but take up to 45 days in Kingaroy, as the critical 550 degree-days are accumulated much faster under Bundaberg's higher temperatures.

Temperature can also influence growth rates through its effects on photosynthesis. Low night temperatures have a large effect on growth rates. Kingaroy's night temperatures are ~5°C lower than Bundaberg's, and crops take about 30 days longer to mature in Kingaroy. However, Virginia Bunch produces similar dry matter amount and pod yield in both locations. Although growth rates are lower in Kingaroy, the crop has longer to compensate, and so yields are similar.

As minimum temperatures drop to <17°C, peanut growth begins to slow down. Dry matter production drops by about 25% when night temperatures reach 15°C and by 50% at 9°C. The plants virtually cease growing and filling pods long before it is cold enough for frost, so crops must be harvested before frost is likely. In inland southern Queensland, this means that crops should be ready for harvest before the end of April. [2]

14.2.1 Risk management for frost

The variability in the incidence and severity of frost means that growers need to adopt a number of strategies as part of their farm management plan. These include pre-season, in-season, and post-frost strategies. [3]

See GRDC Tips and Tactics Managing frost risk for general principles of establishing a frost management plan.

Growers need to consider carefully whether earlier sowing is justified in seasons where warmer temperatures are predicted. Warmer temperatures may reduce the frequency of frost events but also increase the rate of crop development bringing crops to the susceptible, post heading stages earlier. [4]

14.2.2 The changing nature of frost in Australia

The length of the frost season has increased across much of the Australian grainbelt by between 10 and 55 days between 1960 and 2011. In some parts of eastern Australia, the number of frost events has increased.

CSIRO analysis of climate data over this period suggests the increasing frost incidence is due to the southerly displacement and intensification of high pressure systems (subtropical ridges) and to heightened dry atmospheric conditions associated with more frequent El Niño conditions during this period.

The southern shifting highs bring air masses from further south than in the past. This air is very cold and contributes to frost conditions.

In the eastern Australian grainbelt the window of frost occurrence has broadened, so frosts are occurring both earlier and much later in the season. In the Western Australian grainbelt there are fewer earlier frosts and a shift to frosts later into the season.

The frost window has lengthened by three weeks in the Victorian grainbelt and by two weeks in the NSW grainbelt. The frost window in Western Australia and Queensland has remained the same length, while sites in eastern South Australia are similar to Victoria and sites in western South Australia are more like Western Australia. Northern Victoria seems to be the epicentre of the change in frost occurrence, with some locations experiencing a broadening of the frost season by 53 days. [5]

14.3 Rainfall

Peanuts are moderately drought-tolerant but, like all crops, need readily available moisture throughout the season to produce high yields. Where rainfall is reasonably distributed through the growing season, crops produce about 5–10 kg/ha of pods per mm of rainfall.

For dryland peanuts in Queensland and northern NSW, average rainfall of ≥400 mm from September to March is needed to produce a reasonable crop.

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2 PCA/DPIF (2007) Climate and soils. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3a_climate.pdf

3 GRDC (2016) Managing frost risk. Northern, Southern and Western Regions. GRDC Tips and Tactics, https://grdc.com.au/resources-and-publications/all-publications/factsheets/2016/02/managingfrostrisk

4 J Christopher, B Zheng, S Chapman, A Borrell, T Frederiks, K Chenu (2016) An analysis of frost impact plus guidelines to reduce frost risk and assess frost damage. GRDC Update Papers 20 July 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/07/An-analysis-of-frost-impact-plus-guidelines-to-reduce-frost-risk-and-assess-frost-damage

5 GRDC (2016) Managing frost risk. Northern, Southern and Western Regions. GRDC Tips and Tactics, https://grdc.com.au/resources-and-publications/all-publications/factsheets/2016/02/managingfrostrisk

For optimal yields, ~600 mm of water is required. This means irrigation requirements may be 2.5–6 ML/ha depending on variety, location, rainfall and irrigation method.

Areas with high rainfall (>900 mm annually) or consistently high humidity generally have more problems with leaf diseases. A well-managed fungicide program is needed in these areas to control leaf spot, rust and net blotch.

Dry conditions at harvest are essential. Harvest losses can result from extended rain either just before or just after digging the peanuts. High-rainfall areas have a greater risk of harvest losses due to delayed harvest. [6]

14.4 Daylength

Peanuts are not affected by changes in daylength to the same extent as some other crops (e.g. soybeans). The growth stages of peanuts are mainly controlled by temperature. However, reproductive growth may be reduced when daylength is >14 h if night temperatures are also >20°C. Areas in southern Australia may therefore be affected, but there are no research data to confirm this.

The amount of sunlight can strongly influence peanut growth. In wet tropical areas, such as north Queensland, peanuts often show rank growth where the vegetative growth far outweighs pod growth. This appears to be an effect of moisture and temperature. Short days and cloudy conditions combine to reduce the amount of light each day. [7]

14.5 Soils

Soil type is a most important aspect of growing peanuts.

Peanuts yield best in well-drained, friable (loose) soils (Photo 3). Even though peanuts have traditionally been grown in red soils, texture rather than colour that determines whether a soil is suitable for peanut production. Peanuts will grow and produce a crop in most soils, but the ability to harvest the crop with minimal losses determines the soil's suitability for peanuts.

Soil type is probably one of the two most limiting factors for peanut growth, along with the type of irrigation.

Peanuts tolerate a wide range of soil acidity levels, however ideally the pH should be between 6.0 and 7.0. Soils that are more acidic than this (below pH 6.0) should be limed. Make sure your soil test is properly interpreted by a qualified agronomist.

Heavy clay and poorly drained soils may not be suitable, because waterlogging at harvest makes it difficult to extract the pods gently and cleanly.

Black cracking clay soils used for irrigated cotton and other crops are generally not suited to peanuts. As a rule of thumb, a soil is suitable for peanuts if harvesting equipment can operate effectively 4–5 days after heavy rain or irrigation.

6 PCA/DPIF (2007) Climate and soils. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3a_climate.pdf

7 PCA/DPIF (2007) Climate and soils. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3a_climate.pdf

Photo 3: *Some black soils are suitable for peanut production, but they must be friable and well drained.*

The type of soil can influence the variety grown, because some varieties can be harvested from heavier soils with fewer problems. Spanish varieties, which have strong pegs and pods tightly clustered around the taproot, can be successful in heavier soils. However, wet soil at maturity will cause Spanish types to germinate and split. By contrast, some Virginia types have weaker pegs and their pods are spread over ≥30 cm. These types can have high yield losses in soils that set hard at harvest.

Irrigation management can be used to soften the soil and help harvesting on some heavier or hardsetting soils, provided the soil does not become waterlogged.

Soils must be free of sticks, stumps and large stones that can interfere with harvesting and damage equipment working below and on the soil surface.

Peanuts are relatively tolerant of low-fertility soils compared with other crops. However, for irrigated crops, a moderate fertiliser program is usually needed. A soil test will provide a guide to the nutrient status of the soil.

Iron deficiency is a problem on soils of pH >7.5, usually more so on heavy soils, especially in wet conditions.

Soil calcium is a critical nutrient in peanuts. Lighter sandy soils usually have low calcium levels in the pod-zone and growers must correct any deficiency (Photo 4).

Pesticide residues and heavy metals can contaminate peanuts. Organochlorines (e.g. dieldrin, endrin, BHC, heptachlor and DDT) are the most common problems. A soil test, along with the pesticide history, will indicate likely problems. [8]

8 PCA/DPIF (2007) Climate and soils. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/3a_climate.pdf

Photo 4: *Light-textured soils are often deficient in calcium.*

MORE INFORMATION

[Australian Oilseeds Federation. Quality Standards, Technical Information & Typical Analysis 2017–18]

Marketing

15.1 Consumption

Domestic peanut consumption is ~50,000 tonnes (t) of nut-in-shell, increasing at 2–3% per year. The Australian industry has worked hard to increase production and processing efficiencies to meet this demand.

Australian peanut production usually meets the domestic demand, unless there is a severe drought. The industry is now actively developing and supplying export markets.

Australia is one of the few peanut-producing countries, if not the only country, where imports are permitted with minimal tariffs.

Recently, Australia has imported 5,000–8,000 t of peanuts each year, mainly from Argentina and Nicaragua.

There are about 120 manufacturers in Australia using peanuts for snack-food, confectionery or peanut butter (Photo 1). Seven processors account for ~80% of the market.

Photo 1: *Peanuts are widely used in snack foods.*

Peanuts are sold as:

- nut-in-shell raw, boiled or roasted
- kernels raw, roasted, blanched or salted
- kernels manufactured into peanut butter or used in confectionery
- peanut oil for cooking, food processing and margarine (Photo 2)
- peanut meal, the residue after oil extraction—a high-protein stock feed
- shells for stock feed, potting mix and soil conditioners. [1]

1 PCA/DPIF (2007) Peanut industry. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/2c_indust_hist.pdf

Photo 2: *Worldwide, most peanuts are crushed for oil.*

15.1.1 Food value

Peanuts contain 26% protein, higher than eggs, dairy products and many cuts of meat and fish. This high protein level makes peanuts a nutritional snack-food, even improving the nutritional value of confectionery.

Peanuts have high fibre content and a low glycemic index, one of the lowest of all foods. Peanuts are:

- cholesterol-free
- very low in saturated fat
- rich in vitamin E, thiamine, niacin, folic acid, vitamin K
- a good source of vitamin B6, biotin and pantothenic acid
- a low-sodium food (unsalted peanuts). [2]

15.2 World production

World consumption of peanuts is increasing at a rate of ~3% per annum. Peanuts are called groundnuts in many parts of the world, particularly Asia and Africa. They have also been called goober peas in southern states of the USA.

In 2004–05, world peanut production was 31,582 million t, of which Australia contributed <0.2%. China, India and the USA are the main producers, growing 15, 7.0 and 2.2 million t, respectively (see Table 1).

About 95% of the world's production is consumed within the country of origin, with >50% crushed for oil and used for cooking. Only ~5% is traded on the world market, the majority of which are runner peanuts.

The price of peanuts on the world market has shown little movement over the past 10 years, except in those years when the USA has had a crop shortage. The USA tends

2 PCA/DPIF (2007) Peanut industry. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/2c_indust_hist.pdf

to set world prices as a dominant exporter. Peanuts from China and Argentina usually trade at a price 5–20% less than the US price.

World peanut prices have risen recently because of increased demand for oilseeds worldwide. [3]

Table 1: *2004–05 peanut production, imports and exports ('000 t, nut-in-shell).*

Production		Imports		Exports	
China	15,000	UK	250	China	600
India	7,000	Netherlands	260	Argentina	500
USA	2,200	Germany	230	USA	400
Indonesia	920	Japan	150	South Africa	25
Argentina	800	Indonesia	120	Brazil	2
Senegal	695	Canada	100	India	0
Burma	500	Hong Kong	85	Sudan	0
Sudan	400	France	66		
Other	4,067	Other	544	Other	278
Total	**31,582**	**Total**	**1,805**	**Total**	**1,805**

Source: Peanut Company of Australia

15.3 Contract options

Contract options for marketing are based on a price for each grade of peanuts in the load. For example:

Snackfood	(Jumbo)]	
	(Grade 1)]	
	(Grade 2)]	} Edible kernel portion
Manufactuing	(Grade 5 Splits)]	
	(Grade 7 MFG)	
Oil	Through sieve Hand picked	Oil crushing

This grading system applies to all varieties of peanuts, i.e. Virginia, runner and ultra-early types. Payment is made on the basis of kernel weight and quality as determined from the sample taken at intake (see sample receival advice, Figure 3).

Jumbo, Grade 1 and Grade 2 refer to the size categories in each peanut type. Although this grading system applies to all peanuts, a Jumbo in a Virginia variety (750 kernels/kg) is a different size to a Jumbo in a runner variety (1300 kernels/kg) and does not have an equal payment.

Contracts are on a per-hectare basis and offer flexible payment terms depending on growers' individual requirements. Growers' payments are processed through the PCA Kingaroy Office, and queries regarding the payment system should be directed to the growers' local PCA representative or Grower Payments Officer, Kingaroy. [4]

Growers have a choice of three processors:

PCA
133 Haly Street, Kingaroy, Qld
PO Box 26, Kingaroy, Qld 4610
Ph: (07) 4162 6311
Email: peanuts@pca.com.au

3 PCA/DPIF (2007) Peanut industry. Peanut Company of Australia/Department of Primary Industries and Fisheries Queensland, http://www.pca.com.au/bmp/pdfs/2c_indust_hist.pdf

4 G Wright, L Wieck, P Harden (2015) Peanut production guide, August 2015. Peanut Company of Australia, http://www.pca.com.au/wp-content/uploads/2016/11/PWH-Peanut-Production-Guide-2015.pdf

G Crumpton & Sons Co. Pty Ltd
PO Box 672, Kingaroy, Qld 4610
Ph: (07) 4162 3547
Fax: (07) 4162 4582
Email: qa@crumptons.com.au

Clifton Farming Pty Ltd
118 Willow Springs Rd, Clifton, Qld 4361
(07) 4697 3311

Current research

Project Summaries

As part of a continuous investment cycle each year the Grains Research and Development Corporation (GRDC) invests in several hundred research, development and extension and capacity building projects. To raise awareness of these investments the GRDC has made available summaries of these projects.

These project summaries have been compiled by GRDC's research partners with the aim of raising awareness of the research activities each project investment.

The GRDC's project summaries portfolio is dynamic: presenting information on current projects, projects that have concluded and new projects which have commenced. It is updated on a regular basis.

The search function allows project summaries to be searched by keywords, project title, project number, theme or by GRDC region (i.e. Northern, Southern or Western Region).

Where a project has been completed and a final report has been submitted and approved a link to a summary of the project's final report appears at the top of the page.

The link to Project Summaries is https://grdc.com.au/research/projects

Final Report Summaries

In the interests of raising awareness of GRDC's investments among growers, advisers and other stakeholders, the GRDC has available final reports summaries of projects.

These reports are written by GRDC research partners and are intended to communicate a useful summary as well as present findings of the research activities from each project investment.

The GRDC's project portfolio is dynamic with projects concluding on a regular basis.

In the final report summaries there is a search function that allows the summaries to be searched by keywords, project title, project number, theme or GRDC Regions. The advanced options also enables a report to be searched by recently added, most popular, map or just browse by agro-ecological zones.

The link to the Final Report Summaries is http://finalreports.grdc.com.au/final_reports.php

Online Farm Trials

The Online Farm Trials project brings national grains research data and information directly to the grower, agronomist, researcher and grain industry community through innovative online technology. Online Farm Trials is designed to provide growers with the information they need to improve the productivity and sustainability of their farming enterprises.

Using specifically developed research applications, users are able to search the Online Farm Trials database to find a wide range of individual trial reports, project summary reports and other relevant trial research documents produced and supplied by Online Farm Trials contributors.

The Online Farm Trials website collaborates closely with grower groups, regional farming networks, research organisations and industry to bring a wide range of crop research datasets and literature into a fully accessible and open online digital repository.

Individual trial reports can also be accessed in the trial project information via the Trial Explorer.

The link to the Online Farm Trials is http://www.farmtrials.com.au/

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