Brassica information kit

Reprint – information current in 2004

REPRINT INFORMATION – PLEASE READ!

For updated information please call 13 25 23 or visit the website www.deedi.qld.gov.au

This publication has been reprinted as a digital book without any changes to the content published in 2004. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research:

- Chemical recommendations—check with an agronomist or Infopest www.infopest.qld.gov.au
- Financial information—costs and returns listed in this publication are out of date. Please contact an adviser or industry body to assist with identifying more current figures.
- Varieties—new varieties are likely to be available and some older varieties may no longer be recommended. Check with an agronomist, call the Business Information Centre on 13 25 23, visit our website www.deedi.qld.gov.au or contact the industry body.
- Contacts—many of the contact details may have changed and there could be several new contacts available. The industry organisation may be able to assist you to find the information or services you require.
- Organisation names—most government agencies referred to in this publication have had name changes. Contact the Business Information Centre on 13 25 23 or the industry organisation to find out the current name and contact details for these agencies.
- Additional information—many other sources of information are now available for each crop. Contact an agronomist, Business Information Centre on 13 25 23 or the industry organisation for other suggested reading.

Even with these limitations we believe this information kit provides important and valuable information for intending and existing growers.

This publication was last revised in 2004. The information is not current and the accuracy of the information cannot be guaranteed by the State of Queensland.

This information has been made available to assist users to identify issues involved in brassica production. This information is not to be used or relied upon by users for any purpose which may expose the user or any other person to loss or damage. Users should conduct their own inquiries and rely on their own independent professional advice.

While every care has been taken in preparing this publication, the State of Queensland accepts no responsibility for decisions or actions taken as a result of any data, information, statement or advice, expressed or implied, contained in this publication.

Queensland Government

PICTURE GUIDE

Brassica
problem solver
& beneficial identifier

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Brassica grower's problem solver

First published 2004
QI04005

National Library of Australia Cataloguing-in-Publication

PICTURE GUIDE: Brassica grower's problem solver

Includes index.

ISBN 0 7345 0261 3.

1. Brassica–Queensland. 2. Brassica– Diseases and pests–Identification. I. Heisswolf, Sue. II. Queensland Dept. of Primary Industries.

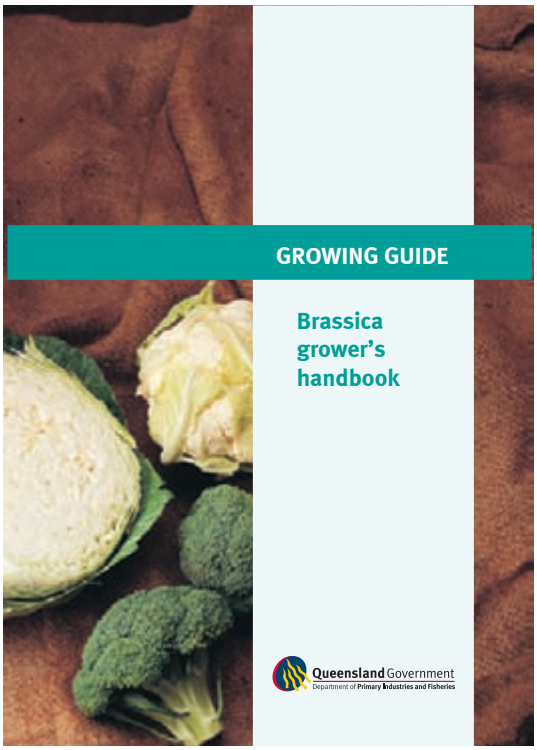
635.309943

IMPORTANT NOTE

The companion book, ***GROWING GUIDE: brassica grower's handbook*** takes you step-by-step from planting to marketing brassicas in Queensland.

References to the *Chemical Handy Guide, Key Issues* and *Growing the Crop* are found in the **GROWING GUIDE**.

Please consult local information before applying information included here to other brassica growing areas.



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Acknowledgements

The authors are grateful for information and advice provided by Noel Vock, John Duff, John Bagshaw, Siva Subramaniam, Peter Rigden and Jerry Lovatt from the Department of Primary Industries and Fisheries, and Mike Furlong from the University of Queensland. We also thank Ethna Brown for digitising many of the images.

Photographs were kindly provided by the book's authors; John Duff, Siva Subramaniam, Jozef Wessels, Alex Banks, Peter Stephens, Dan Galligan and Peter Deuter; and the authors and the editors of the following publications:

Diseases of vegetable crops, Denis Persely (ed), (1994), Department of Primary Industries, Queensland.

Herbicide effects in crop plants, J.F. Gage and H.E. Munroe, 2nd Edition, (1987), Department of Primary Industries, Queensland.

Pests and beneficials in Brassica crops, S. Heisswolf and E. Brown, (1997), Department of Primary Industries, Queensland.

Plant nutrient disorders 3, Vegetable crops, R.G. Weir and G.C. Cresswell, (1993), New South Wales Agriculture, Sydney.

Insect pests of fruit and vegetable crops, G.A. Swaine, D.A. Ironside, R.J. Corcoran (eds.) 2nd Edition, (1991), Department of Primary Industries, Queensland.

About the authors

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Contents

Every crop will inevitably have a problem or two. The key to dealing with problems is prompt identification, and where appropriate, prompt treatment. This picture guide aims to help you with both these decisions. It includes photographs of common problems together with information on the possible causes and solutions. Photographs are grouped according to the main symptom. From the contents, find the symptom that best fits your problem. On that page you will find the possible causes, and the solution, if there is one.

Natural enemies in brassicas

Not all the 'insects' we see in brassicas are causing damage to the crop. Many are in fact beneficial — natural enemies of the real pests doing the damage. It is important to be able to recognise 'friend from foe', and take the necessary action. This section will help you make that distinction.

Seedlings die in the field

Missing plants

Upper: good plant stand. Lower: crop with missing plants.

Cause. Poor soil preparation. Cold weather or frost, excessive rain after planting, over or under watering. Herbicide damage. Soil diseases such as *Rhizoctonia* or *Pythium*. Attack by cutworms, wireworms, crickets or snails, hares or birds.

In transplanted crops: use of poor quality seedlings, poor transplanting technique, planting out in hot conditions.

In direct seeded crops: uneven planting of seed, poor quality seed, slow seed germination due to high or low soil temperatures. Soil crusting.

Management. Use hardened-off seedlings. Check watering and planting techniques. Avoid planting out or seeding under extreme weather conditions. Ensure soil is well prepared before planting. In direct seeded crops, check seed quality. Consider switching to transplants. If disease or insects are causing the problem, consider using an appropriate chemical from the *Chemical Handy Guide*.

Cutworms

Cutworm larvae (up to 40 mm long).

Cause. Larvae of the *Agrotis* moth. Cutworms chew seedling stems causing the plant to fall over and die. Plants are often damaged during the first night after transplanting but damage may continue for up to three weeks. Worse in warm weather and weedy paddocks. Hares, ducks and slugs sometimes cause similar damage.

Management. Prepare soil well before planting. Cultivation exposes larvae and pupae to predators such as birds. Check for cutworms in the top few centimetres of soil near affected plants. Spray with an appropriate chemical from the *Chemical Handy Guide* if cutworms are active.

Wireworms and false wireworms

Upper: wireworm (20 mm). Lower: false wireworm (larva 15 to 20 mm long, adult 10 mm).

Cause. Larvae of the click beetle, family Elateridae, and adults of the beetle *Gonocephalum* spp., the false wireworm or northern wireworm. Larvae feed on roots and stems, while false wireworm adults chew on the stems just below the soil.

Management. Cultivate well before planting to expose larvae and pupae to predators such as birds.

Seedlings die in the field

Crickets

Left: black field cricket (25 mm) Right: mole cricket (30 mm).

Cause. Feeding by adults and nymphs of the black field cricket *Teleogryllus commodus* and the African mole cricket *Gryllotalpa africana*. Field crickets feed on the above ground parts of the plant, while the mole cricket feeds on below ground parts. Worse in summer.

Management. If crickets are causing economic damage, use an appropriate chemical from the *Chemical Handy Guide*.

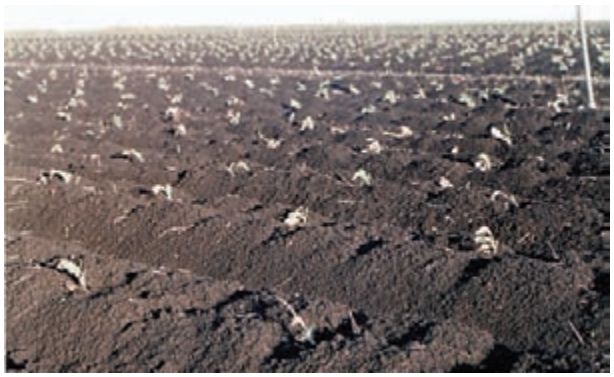
Seedlings are stunted or grow poorly

Poor establishment after transplanting

Upper: well-established transplant. Lower: poor establishment.

Cause. Poor quality transplants: soft plants, plants too old, root bound, leggy or of uneven size. Poor transplanting techniques: planted too deep, too shallow or with poor soil/ root ball contact. Seedlings not watered before and after planting out. Poor soil preparation. Hot conditions, cold weather, frost or excessive rain.

Management. Buy quality transplants and make sure plants are hardened off ready for planting out. Plant into well prepared soil. Check watering and transplanting techniques. Avoid planting out under extreme weather conditions.



Water stress

Cause: Plants not irrigated immediately after transplanting. Not enough water applied to establish plants (volume or frequency). Hot or windy weather conditions. Poor soil/root ball contact. Severe moisture stress will cause burning of leaf margins, stunting or death of the seedling.

Management: Improve irrigation practices. Check irrigation equipment. Avoid planting out in hot or windy conditions. Check transplanting techniques.

Seedlings are stunted or grow poorly

Herbicide damage

Left: stunting caused by herbicide damage. Some seedlings are starting to grow out of the problem. Right: death of lower leaves and puckered, disfigured upper leaves.

Cause. Either a herbicide residue from the previous crop or an incorrectly applied herbicide.

Management. Check registration of herbicides before use and carefully follow label instructions for use and application. Calibrate spray equipment regularly.

Damping off

Upper: damping off in the field. Lower: close-up of plant affected by wirestem.

Cause. Soil-borne fungal diseases. *Pythium* infects the roots and stems of seedlings causing a wet rot. Plants collapse, wither and die. More common in seedling nurseries, direct seeded crops and in cool, wet conditions. *Rhizoctonia solani* causes wirestem, a dry rot of the stem at or near ground level. The disease tends to affect older seedlings and prefers warm, humid weather.

Management. Ensure all organic matter is completely broken down before planting. Use transplants rather than direct seeding. Avoid injuring seedlings when planting. Do not plant too deeply. Improve drainage in heavier soils. Use an appropriate chemical from the *Chemical Handy Guide* if either disease is likely to cause economic losses.

Club root

Field symptoms of club root infected plants (circled).

Cause. The soil borne fungus, *Plasmodiophora brassicae*. Infected plants are stunted and wilt during the warmer part of the day. Club root is a serious disease of brassica crops but distribution within Queensland appears restricted to the Granite Belt district and one positive identification in the Lockyer Valley.

Management. Check suspect plants for signs of root galls, knots and swellings. Contact your nearest DPI&F office if you suspect club root. Quarantine the area. Refer to *Key issues* for details on managing club root.

Damaged growing point

Cabbage centre grub

Left: cabbage centre grub (to 8 mm long) burrowing into seedling. Right: growing point showing damage.

Cause. Cabbage centre grub, *Hellula hydralis*. Webbing and wind-blown soil around the growing point indicates that centre grub is active. Most destructive in summer and autumn. Seedlings are prone to attack for 3 to 4 weeks after transplanting.

Management. Check seedlings for centre grub damage at least weekly for the first 3 weeks after transplanting during the warmer months of the year. If the pest is active use an appropriate chemical from the *Chemical Handy Guide*.

Holes or chewing damage

Snails or slugs

Cause. Feeding damage from snails and slugs. Caterpillars and grasshoppers can cause similar damage.

Management. Snails and slugs prefer a moist environment. They are usually found in crop areas close to the edge of a dam or adjacent to a waterway. Wet areas and associated long, green grass favour these pests. Avoid planting low-lying areas, improve drainage and keep headlands and waterways mowed.

Caterpillars

Severe diamondback moth damage.

Cause. Feeding damage by butterfly or moth larvae. A variety of caterpillars attack brassica crops. They include diamondback moth, heliothis, cluster and cabbage cluster caterpillars and cabbage white butterfly.

Management. Make sure you know which insect is causing the damage by having the pest identified or learning to do this yourself. Consider employing a crop consultant to regularly check crops for you. See *Key Issues* for details on identification and management of caterpillar pests. Refer also to pages 17, 18 of this picture guide.

Hares

Hare damage (leaf on right).

Cause. Hares feeding on the crop. Ducks, other birds and wallabies can cause similar damage.

Management. Electric fencing may be an option. You can shoot hares legally if you have a firearms licence. If native animals are the problem, contact the Environmental Protection Agency/Queensland Parks and Wildlife Service for management advice.

Discoloured or mottled seedlings

Downy mildew

Upper: yellow to pale-green spots on the upper surface of affected leaves. Lower left: white, fluffy fungal growth develops under cool, moist conditions. Lower right: mottling and damage on an older seedling in the field.

Cause. The fungus *Peronospora parasitica*. This fungal disease is often a problem in seedling nurseries. Less of a problem after transplanting.

Management. Avoid overcrowding in nurseries and improve air circulation. Avoid irrigating in the morning. Apply a protectant fungicide at first sign of the disease. Continue a regular spray program when conditions are wet and cool. See *Key Issues* for details on management. Check the *Chemical Handy Guide* for appropriate chemicals.

Phosphorus deficiency

Left: bronze-purplish, dull green colour of stunted seedlings showing phosphorus deficiency. Right: healthy seedlings.

Cause. Low available levels of phosphorous. More likely in acid soils, in cold weather and in soils low in organic matter.

Management. Get a soil analysis done six to eight weeks before planting. Adjust pH to around 6.5. Ensure sufficient phosphorous fertiliser is applied in the seedling mix and as a pre-plant soil dressing.

Lack of fertiliser

Broccoli seedling showing nitrogen, magnesium and other nutrient deficiency symptoms.

Cause. Ineffective fertiliser program. Severe nutrient deficiencies are more likely to occur in light, infertile soils.

Management. Complex nutrient deficiencies are difficult to diagnose. Have a leaf and soil test done to confirm the problem and decide on best management options. For future crops, get a soil test done 6 to 8 weeks before planting to develop a fertiliser program to suit the crop and paddock. See *Key Issues* for more information.

Pale seedling leaves

Frost

Cause. Freezing of plant tissues. Medium to heavy frosts can kill brassica seedlings. Damage will be seen within a few hours or a day or two after a frost.

Management. If damage is not severe, seedlings may grow out of the problem. Avoid planting in low-lying areas where frosts are usually more severe.

Cupped seedling leaves

Boron deficiency

Cause. Inadequate supply of boron. Common in light, heavily limed or alkaline soils, or in cold weather.

Management. Brassicas have a high boron requirement. Apply several foliar sprays of 250g/100L Solubor at fortnightly intervals. Apply the first spray within 2 weeks of transplanting. Use a comprehensive soil analysis to determine boron levels in the soil and develop a fertiliser program for the crop. See *Key Issues* for more detail.

Manganese toxicity

Strongly cupped leaves and leaf spotting.

Cause. High levels of manganese in the soil. Mostly a problem in acidic soils. Made worse by waterlogging or use of acidifying ammonium fertilisers. Symptoms are more severe on older leaves.

Management. Raise soil pH by liming. Improve drainage if waterlogging is a problem. Avoid use of acidifying fertilisers.

Aphids

Left: leaf cupping. Right: colony of cabbage aphids (1 to 2 mm).

Cause. Damage by high numbers of aphids feeding on plant sap. Cupping is usually worst in younger leaves.

Management. Check seedlings for aphids, especially on leaf undersides and the growing point. If you need to spray, use an appropriate chemical from the *Chemical Handy Guide,* preferably one that is not harmful to natural enemies.

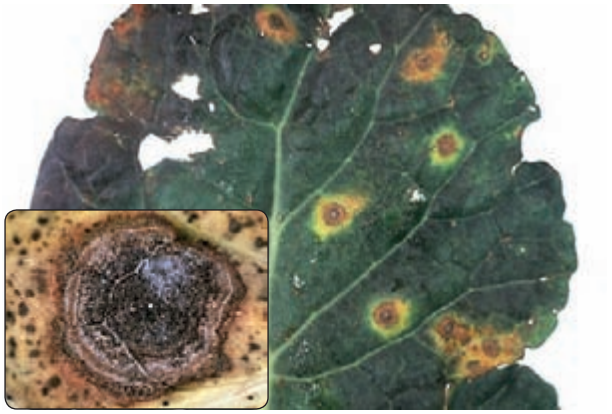
Spots or marks on leaves

Downy mildew

Necrotic spotting on upper leaf surface (left); yellowing and necrotic areas with white fluffy fungal growth on underside of the leaf (right).

Cause. The fungus *Peronospora parasitica*. Downy mildew is more common in seedling nurseries, but can be a problem in the field in cool, rainy weather.

Management. Avoid overcrowding of plants and improve air circulation in the crop. Avoid irrigating in the morning. Apply a protectant fungicide at first sign of the disease and continue with a regular spray program when conditions are wet and cool. See *Key Issues* for details on management. Check the *Chemical Handy Guide* for appropriate chemicals.



Ring spot

Dark, circular spots on leaves surrounded by a yellow halo. Insert: Close-up of ring spot showing small black fruiting bodies (pycnidia) of the fungus.

Cause. The fungus *Mycosphaerella brassicicola*. Ring spot can be a serious problem in cold, wet weather. The fungus survives on undecomposed crop residues but can also be seed borne.

Management. Plant into well-prepared soil. Use an appropriate chemical from the *Chemical Handy Guide*. Plough in diseased crops immediately after harvest.

Peppery leaf spot

Cause. The bacterium *Pseudomonas syringae* pv. *maculicola*. The disease causes small, purple to brown spots. Under cool, wet conditions, spots may coalesce to cover large areas.

Management. Cauliflower is the main host. Severe losses can occur after frost or cold, wet weather. Ensure seed has been hot water treated. Practice crop rotation and plough in old crops as soon as harvesting is completed. Apply an appropriate chemical from the *Chemical Handy Guide* to limit the spread of the disease. See *Key Issues* for details on management.

Zonate leaf spot

Cause. The bacterium *Pseudomonas cichorii*. Light-brown water-soaked spots develop on leaves. These spots darken as they mature. If head leaves are pulled back, spotting and necrotic areas often extend well into the head. Usually a minor disease, but can spread rapidly under wet, windy conditions.

Management. Plant into well-prepared soil and avoid planting highly susceptible varieties.

Spots or marks on leaves

Alternaria spot

Cause. The fungus *Alternaria brassicicola*. In warm, moist weather, large brownish to black spots develop on leaves, stalks and heads or curds. The fungus is seed borne, survives in old crops and crop debris. Spores are spread by wind and water.

Management. Practice crop rotation, plough in crops after harvest and ensure seed has been hot water treated. See *Key Issues* for details on management. If necessary, use an appropriate chemical from the *Chemical Handy Guide*.

Herbicide damage

Left: Dual® herbicide damage in cauliflower. Right: pale necrotic spotting on leaf.

Cause. Herbicide applied incorrectly, spray drift or unregistered use of a herbicide.

Management. Check registration status and instructions for using herbicides before use. Maintain spray equipment and calibrate regularly. Do not apply herbicides in windy conditions.

Thrips damage

Upper: extensive onion thrips damage on leaf surface. Lower: damage on underside of leaf.

Cause. Feeding damage by thrips. These tiny insects are difficult to see with the naked eye.

Management. Control weeds around crops. Natural enemies of thrips tend to keep populations down, but under dry, warm conditions, thrips numbers can increase rapidly to economically damaging levels. If necessary, use an appropriate chemical from the *Chemical Handy Guide*.

Tunnelling in leaves

Diamondback moth (DBM)

Cause. Feeding damage by young larvae of the diamondback moth. After hatching from eggs, larvae burrow into the leaf to feed. After a day or two, they emerge to continue feeding on the outside of leaves.

Management. Check crops for pests on a regular basis, avoid year round production of brassica crops and avoid use of broad-spectrum insecticides. See *Key Issues* for more detail. If necessary, use an appropriate narrow-spectrum chemical from the *Chemical Handy Guide*, timing the spray application to target small caterpillars.

Yellow or brown leaf edges

Black rot

Upper: Typical symptoms of black rot infection. Middle: Black rot in cauliflower. Lower: Black rot in cabbage.

Cause. The bacterium, *Xanthomonas campestris* pv. *campestris*. The bacteria infect plants through water pores along leaf margins causing typical V-shaped yellow areas with dark veins. Black rot is a common disease of brassica crops and can cause serious losses in wet weather. Some strains of the bacteria cause bacterial scald (see page 15).

Management. Ensure seed has been hot water treated. Control weeds and insects, work from new to old crops, and plough in crops as soon as harvesting is completed. Practice crop rotation. Use an appropriate chemical from the *Chemical Handy Guide*. Under extended wet weather, the disease can be very difficult to contain. See *Key Issues* for more detail.

Yellow or brown leaf edges

Tipburn

Cause. Calcium deficiency. Hot weather, rapid plant growth, water stress and poor quality irrigation water contribute to the problem. Calcium deficiency affects the younger parts of the plant causing death of leaf margins of younger leaves, brown buds in broccoli and internal browing in cabbage. Deficiency problems can occur even in soils with adequate levels of calcium.

Management. Check water quality and irrigation techniques. Get a soil test done to check that soil calcium levels are adequate. Foliar sprays of 800 g calcium nitrate per 100 L of water at weekly intervals may help. Foliar applications of calcium are ineffective for internal browning, as the calcium solution must reach the affected plant part. See *Key Issues* for details on fertiliser and irrigation management.

Potassium deficiency

Cause. Lack of potassium often caused by a poor fertiliser program. More likely in soils with a pH below 5.5 or above 7.5. Potassium is easily leached from the soil.

Management. Have a leaf or sap test done and fertilise as recommended. Get a soil test done six to eight weeks before planting. Adjust pH to 6.5 and ensure sufficient potassium is applied at planting and through side-dressings. In light soils, apply potassium fertiliser after heavy rain.

Salt burn

Cause. The electrical conductivity (salt content) of the irrigation water is too high. Water stress or fertiliser burn can cause similar symptoms.

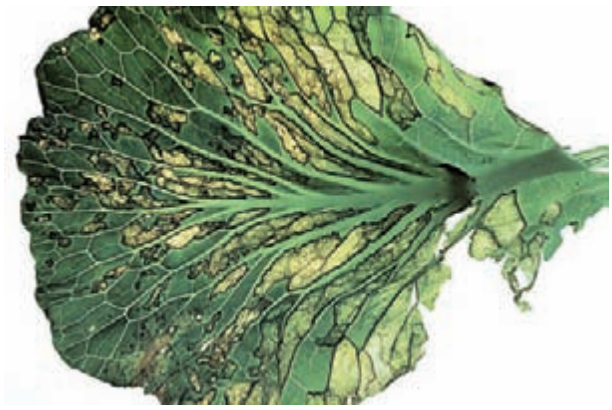
Management. Brassicas are moderately sensitive to saline water. Avoid using water with an electrical conductivity (EC) above 1.7 dS/m (deciSiemens per metre). Sound irrigation practices and good internal soil drainage are important for minimising salt build up in the soil.

Frost damage

Cause. Freezing of exposed parts of the plant. Young plants are most at risk. Once the crop is established, brassicas can usually tolerate light frosts (to -4°C). Frost damage tends to be worst in the lower lying areas of a field.

Management. Avoid planting in frost prone areas in winter. Do not grow brassicas through winter in temperate areas with frequent heavy frosts.

Leaf scald/scorch



Bacterial leaf scald

Cause. The bacterium *Xanthomonas campestris* pv. *campestris*. The bacteria infect plants through leaf stomata (breathing pores) or damaged leaf tissue. Leaf scald can cause serious losses in wet weather. Some strains of the bacteria cause black rot (see page 13).

Management. Ensure seed has been hot water treated. Control insects and weed hosts, work from new to old crops, and plough in crops as soon as harvesting is completed. Practice crop rotation. Use an appropriate chemical from the *Chemical Handy Guide*. Extended wet weather makes the disease difficult to contain. See *Key Issues* for more detail.

Potassium deficiency

Cause. Lack of potassium. More likely in soils with a pH below 5.5 or above 7.5. Easily leached from the soil. Symptoms can vary from grey leaf scorching to yellowing and death of leaf margins (see page 14).

Management. Use leaf and soil tests. Adjust pH to 6.5 and ensure sufficient potassium is applied at planting and through side-dressings. In light soils, apply potassium fertiliser after heavy rains.

Discoloured mottled leaves

Black ringspot

Cause. The turnip mosaic virus spread by aphids. A minor disease in Queensland. During warm weather, a mild leaf mottle is visible but in cold weather, characteristic dark rings and bands form.

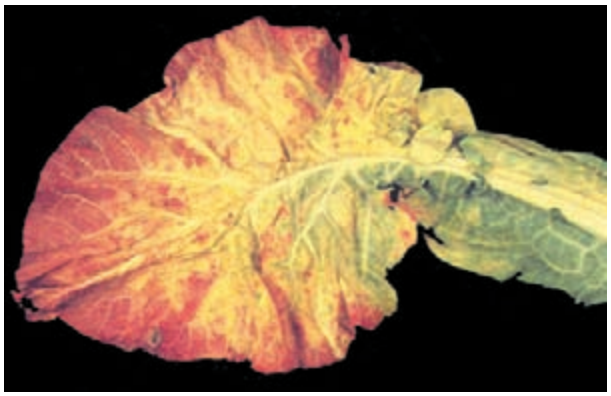
Management. Control weeds and aphids, plough in diseased crops after harvest, use tolerant varieties and avoid growing cabbages in cold weather if the disease is common in your area.

Manganese toxicity

Cause. High levels of soluble manganese in the soil causing yellowing, mottling and necrosis in older leaves. Most common in acid soils where waterlogging and climatic extremes can contribute to the problem.

Management. Increase the soil pH to 6.5 by liming. Check that soil drainage is adequate. Improve if waterlogging is likely to occur.

Older leaves turn yellow



Nitrogen deficiency

Upper: note yellow older leaves in a nitrogen deficient crop of cauliflower. Lower: leaf showing yellowing and reddish-purple margins.

Cause. Insufficient nitrogen available to the plant. Too little nitrogen applied, nitrogen has leached from the soil through excessive rain or irrigation, decomposing organic matter is temporarily locking up nitrogen in the soil. Cold weather and waterlogging can also result in nitrogen deficiency problems.

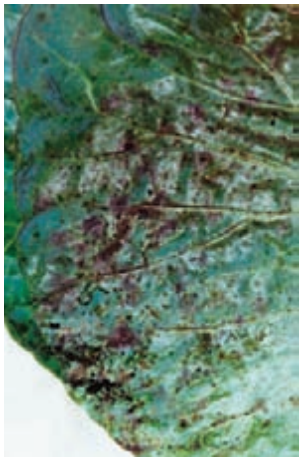
Management. Apply an additional light side-dressing of a nitrogenous fertiliser up until early heading in broccoli and cauliflower, or two or three weeks before harvest in cabbage. For future crops, make sure all crop residues are completely decomposed before planting. Check soil drainage and irrigation practices. Use soil and leaf tests to work out a balanced fertiliser program. See *Key issues* for more details.

Magnesium deficiency

Cause. A shortage of magnesium. More common in acid, light textured soils. Large applications of lime or potassium prior to planting can contribute to the problem.

Management. Confirm diagnosis with a leaf test. In young crops, fortnightly foliar sprays of 2 kg magnesium sulfate per 100L applied as a high volume spray should correct a magnesium deficiency. For future crops, use a comprehensive soil test to work out a balanced fertiliser program. See *Key Issues* for more details.

Black sooty mould



Black sooty mould on leaves or heads

Left: sooty mould on cabbage leaf. Right: yellow whitefly nymphs (0.3 to 0.6 mm) on underside of leaf.

Cause: Mould growing on the sticky secretions (honeydew) of silverleaf whitefly *Bemisia tabaci* nymphs and adults (see page 20).

Management. Maintain good farm hygiene. Keep weeds under control. Allow natural enemies to build up. Regularly check crops for whiteflies. If whitefly numbers appear to be increasing, spray with an appropriate chemical from the *Chemical Handy Guide*, preferably one that is not harmful to natural enemies. Apply a clean up spray before destroying heavily infested, old crops to prevent whitefly adults migrating into younger crops.

Purpling of leaves

Phosphorus deficiency

Cause. Low available levels of phosphorus. Plants are stunted and older leaves show dull purple tints along the outer parts of the leaf. Cold weather can produce similar symptoms.

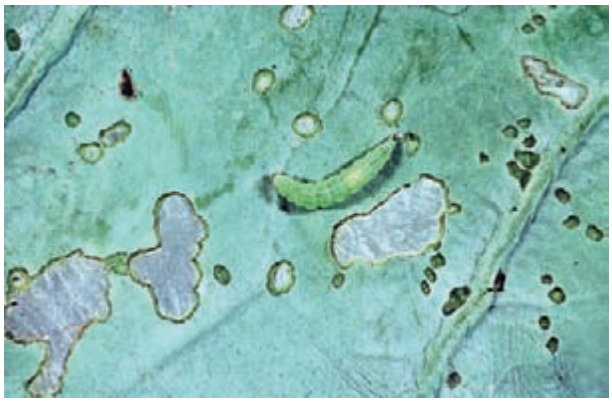
Management. Get a soil analysis done six to eight weeks before planting and ensure sufficient phosphorous is applied pre-plant. Acid soils high in iron and aluminium can tie up large amounts of phosphorus. Narrow band the establishment fertiliser to the side and below transplants in these types of soil. See *Key Issues* for details.

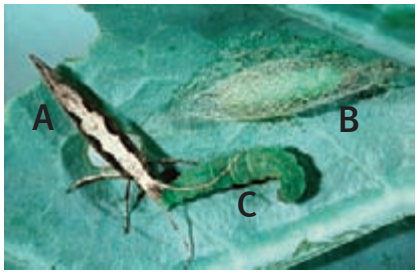
Black leg

Cause. The fungus *Leptosphaeria maculans*. Plants wilt and leaves become a reddish colour around the margins. The stem develops sunken, dark spots and an internal brown dry rot.

Management. Plough in diseased crops immediately after harvest. Plant into well prepared soil and practice crop rotation. Use seed that has been hot water treated.

Holes in leaves





Windowing damage

Upper: typical windowing damage by Diamondback moth larvae (to 10 mm long). Lower: Diamondback moth (A), pupa (B) and mature larva (C).

Cause. Feeding damage by larvae of the Diamondback moth *Plutella xylostella*. The pest is also known as DBM or cabbage moth.

Management. DBM can be very difficult to control as it has developed resistance to a range of insecticides. Successful management of the pest relies on a combination of control strategies including regular crop scouting, a break in production and well-timed applications of narrow spectrum insecticides to control pest outbreaks. Natural enemies of the pest can help keep pest numbers below economically damaging levels. For more detail on managing DBM, see *Key Issues*.

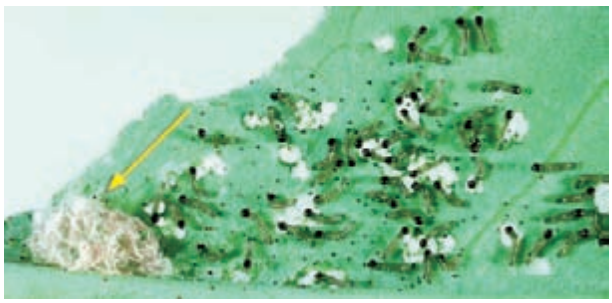
Holes in leaves

Distinct holes or chewing damage

Upper left: damaged cabbage and mature caterpillars of cabbage white butterfly (to 28 mm long). Upper right: cabbage white butterfly *(Pieris rapae)*. Lower right: heliothis moth (*Helicoverpa armigera*). Lower: large heliothis caterpillar (to 25 mm long).

Cause. Feeding damage by caterpillars, snails or slugs.

Management. Make sure you know which pest is causing the damage. See *Key Issues* for help with identification and management advice. If the pest is still active, spray with an appropriate chemical from the *Chemical Handy Guide* making sure you select the right chemical for the species causing the damage. Time the spray to target small caterpillars.



Skeletonised leaves

Upper: skeletonised leaf with feeding cluster caterpillars (arrows). Middle: egg mass (arrow) and newly hatched cluster caterpillars. Lower: mature cabbage cluster caterpillars with webbing. Below: yellow egg mass of cabbage cluster caterpillars (left) and hatching caterpillars (right).

Cause. The cluster caterpillar *Spodoptera litura* or cabbage cluster caterpillar *Crocidolomia pavonana*. Both pests are active in warmer weather. As cluster caterpillars mature they become solitary. Cabbage cluster caterpillars remain gregarious, usually spinning webbing across the skeletonised heart of the plant as they mature.

Management. Check for egg masses, small caterpillars and early signs of damage when crop scouting. See *Key Issues* for details on identification and management. If necessary, use an appropriate chemical from the *Chemical Handy Guide*. Note that registrations and effectiveness of insecticides vary for the two different species of caterpillar.

Distorted leaves

Aphids

Curled leaf edges caused by feeding of grey cabbage aphids (*Brevicoryne brassicae*). Insert: winged adults are about 2 mm long (circled); nymphs have a grey mealy appearance.

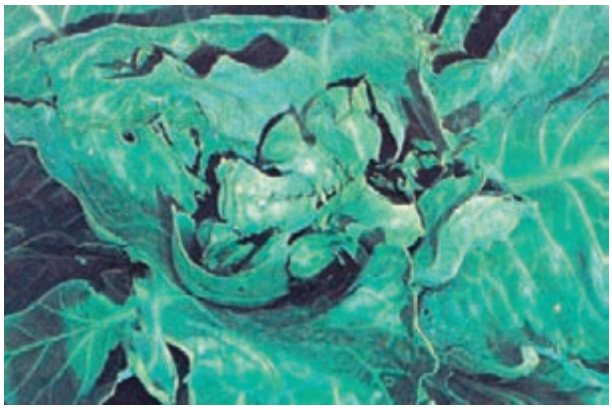
Cause. Feeding damage by colonies of aphids.

Management. Most active in spring and autumn. Natural predators and wasp parasitoids often give effective control of aphids. If the pest is causing economic damage, consider using an appropriate chemical from the *Chemical Handy Guide*.

Wiptail

Cause. Molybdenum deficiency. Cauliflower is particularly susceptible, with some varieties more sensitive than others. The problem occurs widely but is more common in leached soils with pH below 6.0. Margins of inner leaves die, causing them to become progressively narrower and distorted.

Management. Foliar sprays are not effective once the disorder has developed. In acid soils, raise the pH to 6.5 and apply molybdenum before planting if deficiencies have occurred in previous crops. Alternatively, apply two or three foliar sprays of sodium molybdate (60g/100L) early in the crop's growth.



Hormone damage

2,4-D damage causing leaves to thicken and distort and hearts to open up.

Cause. Usually a drift (can be several kilometres) of a hormone spray, for example 2,4-D herbicide. Plants can also be damaged if spray equipment has been contaminated.

Management. Use separate spraying equipment for herbicides. Do not use hormone sprays in windy weather and ensure your neighbours know the location of your crops.

Blistered leaves

Frost damage

Cause. Freezing of exposed parts of the leaves causing the epidermis to blister and crack. Damage is usually worst in low-lying parts of a field.

Management. Avoid planting crops in low-lying areas when frosts are likely. Do not grow brassicas during winter in temperate areas with frequent heavy frosts.

Many white flying insects

Silverleaf whitefly

Left: whiteflies on underside of leaf. Upper right: adult (0.8 to 1.2 mm long). Lower right: nymphs (0.3 to 0.6 mm long).

Cause. Adults and nymphs of the insect *Bemisia tabaci* feeding on the undersides of leaves. They can occur in very high numbers and are resistant to many insecticides.

Management. Maintain good farm hygiene, keep weeds under control and allow natural enemies to build up. Regularly check crops for whitefly. If whitefly numbers appear to be increasing, spray with an appropriate chemical from the *Chemical Handy Guide*, preferably one that is not harmful to natural enemies. Apply a clean-up spray before destroying old crops to prevent whitefly adults migrating into younger crops. See *Key Issues* for more details.

Dark spots on heads

Alternaria spot

Upper: Alternaria spot on cabbage. Lower: black, sunken spots on cauliflower curd.

Cause. The fungus *Alternaria brassicicola*. Brownish to black spots, often large in size, occur on leaves, stems and heads. The fungus prefers warm, moist weather and is most common in cauliflower.

Management. Practice crop rotation and make sure old crop residues are completely broken down before planting. Hot water treatment of seed is effective against the fungus. See *Key Issues* for more details. If necessary, use an appropriate chemical from the *Chemical Handy Guide*.

Bacterial head rot

Cause. The bacteria *Erwinia* and *Pseudomonas*. Infection is through injuries. The slimy, foul smelling soft rot can affect heads in the field and after harvest. Worse in warm, wet conditions. Can cause serious breakdown in transit or storage.

Management. Good farm hygiene in the field and packing shed can help limit the spread of bacterial head rots. Avoid harvesting wet crops, sterilise cutting knives and handle product with care. Cool heads quickly after harvest and store at 0°C. Treat produce with an appropriate chemical from the *Chemical Handy Guide*.

Damaged heads

Mice

Cause. Mice feeding on cauliflower curds or broccoli heads.

Management. Bare fallow a 10 m border around fields to discourage mice from migrating into the crop. Use a wild-life safe rodenticide if mice are causing economic damage. Check with your chemical supplier that the rodenticide is registered for use in the situation where you will be using it. For more detail, see *Growing the Crop* in the Brassica Grower's Handbook.

Insects

Cabbage cluster caterpillars with webbing.

Cause. Feeding damage by caterpillars is the most likely cause.

Management. Make sure you know which insect is causing the damage. See *Key Issues* for more details. Consider using an appropriate chemical from the *Chemical Handy Guide*. However, it may be too late to achieve effective control in crops close to harvest.

Split heads

Cause. Overmature. The crop has either been left too long before cutting or the variety is not suited to the district or time slot in which you are trying to grow it.

Management. Ask your seedling supplier or seed company representative to help you estimate days from planting to harvest. Check that the variety is suited for your district and the production season. Harvest when the majority of heads are firm but still appear fresh.

Discoloured heads

Purpling

Cause. Cold weather damage to broccoli head.

Management. Grow the right variety for the season. Avoid planting brassicas in districts with cold winters.

Discoloured heads

Greenish yellow heads

Cause. Genetic variations in the seed line. Colours can vary from yellowish-green to reddish-purple and may be accompanied by a non-typical head shape for the variety.

Management. Use commercial varieties that have a reputation for consistency and quality.

Greyish-brown florets

Cause. Downy mildew caused by the fungus *Peronospora parasitica.*

Management. The problem cannot be cured once heads are affected. For future crops, practice crop rotation, plant into well prepared ground, control weeds and use disease-free transplants. Apply a protectant fungicide from the *Chemical Handy Guide* at the first sign of the disease. Continue a regular spray program while conditions are wet and cool. Good coverage of leaf undersides is essential for effective control.

Poor head quality

Uneven heads

Cause. Variety grown out of season or not suited to the district's climatic conditions. Poor head quality may have been caused by abnormal seasonal conditions if the variety performed well in previous years.

Management. Check with your seedling or seed supplier to ensure that the variety is recommended for the district and time slot in which you are growing the crop. Plant only small trial areas to new varieties and evaluate their performance before planting larger areas.

Open, loose heads

Cause. Warm temperatures. The variety is not suited to the district or timeslot in which you are trying to grow it. Stress through variable temperatures, lack of water or nutrients can contribute to the problem.

Management. Check with your seedling supplier or seed company representative that the variety is suited for your district and the time slot in which you are trying to grow it. Ensure that the crop is not stressed through poor water or nutrient management.

Poor head quality

Ricey curds

Cause. Cauliflower variety grown out of season or abnormal seasonal conditions. The curds tend to be light in weight.

Management. Check that the variety is recommended for the district and time slot in which you are growing the crop. Plant only small trial areas to new varieties and evaluate their performance before planting larger areas.

Large beads in broccoli

Cause. Some warm weather varieties produce heads with large beads.

Management. Shorten the production season to avoid growing broccoli when there is a risk of night temperatures exceeding 15°C and day temperatures rising above 35°C. Change varieties. Consult your seedling supplier or seed company representative for small beaded varieties worth trying in small trial plots before planting larger areas.

Leaf in head

Cause. Warm temperatures. The problem is often accompanied by poorly shaped heads.

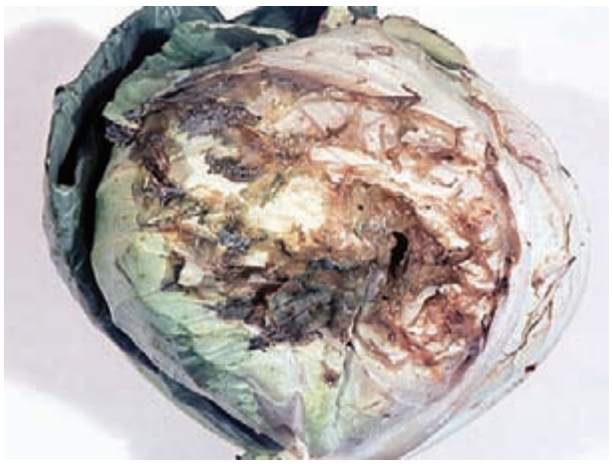
Management. Check that the variety is recommended for the district and time slot in which you are growing the crop. If other varieties have shown similar problems in this time slot, consider shortening the production season.

Poor head shape

Cause. Wrong variety for the district, variety grown out of season or unusually warm temperatures. Broccoli heads may also be flat or concave rather than domed and have ‘leaf in head’ problems.

Management. Check with your seedling or seed supplier to ensure that the variety is recommended for the district and time slot in which you are growing the crop. Plant only small trial areas to new varieties and evaluate their performance before planting larger areas.

Rotting heads



Bacterial head rot

Upper: bacterial head rot in cabbage. Lower: broccoli affected by bacterial head rot after wet weather.

Cause. Several species of bacteria including *Erwinia* and *Pseudomonas*. Infection is through injuries. The slimy, soft rot can affect heads in the field and after harvest and is accompanied by a characteristic foul smell. Worse in warm, wet conditions and can cause serious breakdown in transit or storage.

Management. Good farm hygiene in the field and packing shed can help limit the spread of bacterial head rots. Avoid harvesting wet crops, sterilise cutting knives and handle product with care. Cool heads quickly and store at 0°C. Treat product with an appropriate chemical from the *Chemical Handy Guide*.

Sclerotinia rot

Upper: brown rotting with sclerotia in cabbage. Inset: closeup of sclerotia (2–10 mm). Lower: white cottony, fungal growth on cauliflower.

Cause. The fungus *Sclerotinia sclerotiorum*. Typical symptoms are water-soaked rotting of leaves, stems and heads accompanied by a white, fluffy fungal growth and large, compact resting bodies called sclerotia. These sclerotia are white at first but later turn black and hard. Cool, wet weather favours sclerotinia rot.

Management. Sclerotinia has a wide host range and can survive in the soil for many years. Rotate susceptible crops with grasses or grains. Do not plant into infected areas in the cooler months. Avoid planting into wet, shaded areas and irrigating close to harvest. Deep plough diseased crops immediately after harvest. At first sign on the disease, spray young crops with an appropriate fungicide from the *Chemical Handy Guide*. Good crop penetration and correct timing of sprays are essential for effective control with fungicides.

Cracked or split stems


Frost

Left: split midrib. Right: blistering on stems.

Cause. Frost damage.

Management. Avoid planting crops in low-lying areas when frosts are likely. Do not grow brassicas during winter in temperate areas with frequent heavy frosts.


Boron deficiency

Left: corkiness and splitting of petioles. Right: splitting and transverse cracking on midribs and start of hollow stem in curd.

Cause. Boron deficiency. The problem is common in brassica crops in most districts but worse in light, heavily limed, alkaline or strongly acid soils, particularly in cold weather.

Management. The deficiency cannot be cured in advanced crops. Get a soil analysis done six to eight weeks before planting, adjust the pH to 6.5 and apply boron as recommended. Alternatively, apply several foliar sprays of 250 g/100L Solubor at fortnightly intervals starting within two weeks of planting. See *Key Issues* for more details.


Hormone damage

Left: bent stem. Right: horizontal splitting and callus formation of cauliflower stem damaged by 2,4-D herbicide drift.

Cause. Hormone damage usually caused by spray drift (which can be over several kilometres) of a herbicide, for example 2,4-D used to control weeds. Plants can also be damaged if spray equipment has been contaminated.

Management. Use separate spray equipment for herbicides. Do not use hormone sprays in windy weather and ensure your neighbours know the location of your crops.

Black leg

Dry, brown, sunken rot near the base of the stem.

Cause. The fungus *Leptosphaeria maculans*. The disease can be introduced in infected seed and survives on undecomposed crop residues. Spores are spread by rain or overhead irrigation. More common in cool climates.

Management. Use seed that has been treated with hot water or a fungicide. Ensure that all brassica crop residues have thoroughly decomposed before replanting, or preferably, do not grow brassicas in the same paddock more than once every 3 to 4 years.

Hollow stems

Boron deficiency

Upper: hollow stem in cauliflower at harvest. Lower left: early symptoms of boron deficiency showing a discolouration of internal stem tissue in cauliflower. Lower right: advanced hollow stem in broccoli.

Cause. Boron deficiency. The problem is common in brassica crops in most districts. Worse in light sandy soils, soils that recently had heavy applications of lime or dolomite, alkaline soils or strongly acid soils.

Management. Once symptoms are seen in the crop the deficiency cannot be cured. Take a soil test six to eight weeks before planting and follow recommendations. Alternatively, apply foliar sprays of 250g/100L Solubor within two weeks of planting and repeat fortnightly. Weather conditions and rapid plant growth rates can impact on boron uptake. See *Key Issues*, for more details.

Internal growth cracks

Cause. Fast growth rates during warm weather particularly if combined with excessive nitrogen applications. May be linked to boron deficiency and contribute to hollow stem problems.

Management. Do not apply nitrogen after early head formation. Use leaf or sap tests to check nitrogen status of the crop. Calculate nitrogen requirements using a soil analysis taken 6 to 8 weeks before planting. See *Key Issues* for more details.

Rotting butts

Bacterial soft rot

Field symptoms of bacterial soft rot in cabbage.

Cause. The bacterium *Erwinia carotovora.* Infection occurs through damaged tissue. Rot produces a foul smell. In the field the bacteria are spread by water splash, contaminated cutting knives and insects. Warm, wet weather favours disease development.

Management. Avoid harvesting wet crops. Sterilise cutting knifes if the disease is present in the field. Handle produce with care to minimise injury. Clean and disinfect harvesting equipment and packing sheds. Cool heads quickly after harvest. Store and transport at 0°C. See *Key Issues* for more details.

Swollen, club-shaped roots

Club root

Advanced club root infection showing spindle-shaped, knobby, club-shaped swellings.

Cause. The fungus *Plasmodiophora brassicae*. Club root is a serious disease in most brassica production districts in Australia. Distribution of the disease within Queensland appears to be limited to the Granite Belt district and one positive identification in the Lockyer Valley.

Management. The disease is spread through soil on farm machinery, vehicles, footwear, transplants etc. so good farm hygiene is critical in preventing the disease from infecting your land. The first sign of the disease are wilting plants through the hotter part of the day. Contact the nearest DPI&F office for assistance with identification and management if you suspect club root. Quarantine the area. See *Key Issues* for more details.

Stunted or wilting plants

Poor crop establishment

Stunted plants on the left, mature head on the right.

Cause. Poor quality transplants or poor transplanting techniques.

Management. Buy quality transplants and make sure plants are hardened off before planting out. Grade transplants before planting, discarding spindly or leggy plants. Plant to the right depth into well-prepared soil and ensure good soil/root ball contact. Water plants before and immediately after planting. Avoid planting out under extreme weather conditions.

Wrong variety or poor seed line

Cause. The variety has been grown out of season or seed was of poor quality. Stunting and premature heading is also a response to environmental stress such as dry or waterlogged conditions, compacted soil, poor transplanting techniques, extreme temperatures.

Management. Check with your seedling supplier or seed company representative that the variety is suited to your district and the time slot in which you are growing it. Use only high quality seed or transplants. Ensure good soil drainage, plant into well-prepared soil and maintain adequate moisture. Review transplanting techniques.

Stunted or wilting plants

Water stress

Note stunted plants in foreground.

Cause. Poor irrigation over parts of the paddock particularly during crop establishment.

Management. Check irrigation equipment to ensure that it is capable of delivering an even amount of water over the whole paddock. Avoid watering the crop on windy days. See *Key Issues* for more details.

Cabbage yellows

Note yellowing of the lower leaf, uneven plant development and brown discolouration of the water-conducting tissue.

Cause. The fungus *Fusarium oxysporum* f. sp. *conglutinans*. The fungus survives in the soil for long periods and infects plants through the roots. Warm weather favours disease development.

Management. Plant varieties resistant to the disease. Implement good farm hygiene practices to minimise spread of the disease through soil movement.

Club root

Several adjacent plants, often within the row, wilt through the hottest part of the day. Insert: severely infected root system.

Cause. The fungus *Plasmodiophora brassicae*. Club root is a serious disease of brassica crops nationally. Distribution within Queensland appears limited to the Granite Belt district and a positive identification in the Lockyer Valley.

Management. The disease is spread through soil on farm machinery, vehicles, footwear, transplants etc. so good farm hygiene is critical in preventing the disease from infecting your land. Check wilted plants for signs of typical spindle, knobby or club-shaped roots. Contact the nearest DPI&F office if you suspect club root for help with identification and management. Quarantine the area. See *Key Issues* for more details.

Black leg

Cause. The fungus *Leptosphaeria maculans* causing plants to wilt and collapse. Leaves turn a reddish colour around the margins. The stem develops sunken, dark spots and an internal dry rot (see page 25).

Management. Plough in diseased crops immediately after harvest. Plant into well prepared soil and practice crop rotation. Use seed that has been hot water treated.

Collapsed plants

Sclerotinia rot

Advanced sclerotinia rot in cabbage.

Cause. The fungus *Sclerotinia sclerotiorum* causing a water-soaked rotting. Accompanied by a white, cottony fungal growth and large, dark, hard resting bodies called sclerotia. Cool, wet weather favours the disease.

Management. Sclerotinia has a wide host range and can survive in the soil for many years. Practice crop rotation. Deep plough diseased crops immediately after harvest. Use an appropriate fungicide from the *Chemical Handy Guide* as a preventative treatment or at the first signs of disease. See *Key Issues* for more details.

Damaged plants

Insect damage

Left: Diamondback moth (*Plutella xylostella*) damage. Right: Cabbage cluster caterpillar damage.

Cause. Extensive feeding damage by caterpillars.

Management. Make sure you know which pest is causing the damage by looking for the caterpillars. See *Key Issues* for help with identification and management advice. If the pest is still active, spray with an appropriate chemical from the *Chemical Handy Guide* making sure you select the right chemical for the species causing the damage.

Hail

Cause. Severe hail storm.

Management. Apart from not planting crops when the risk of severe hail storms is high, there is not much that you can do. Hail netting is unlikely to be an economic proposition.

Split heads

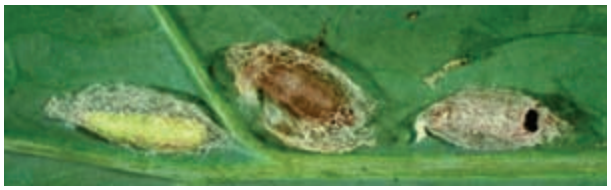
Cause. The plant has started to initiate flowering. The variety may not be suited to your district or the time slot in which you are trying to grow it. Or it has been left too long in the field before cutting.

Management. Ask your seedling nursery or seed company representative about suitability of the variety for your district, recommended planting times and estimated days from planting to harvest. Cut when the majority of heads are firm but still fresh in appearance.

Natural enemies: Parasitoids and predators

Wasp parasitoids

Diadegma wasp searching for caterpillars



Left: Healthy cabbage moth pupa

Centre: Parasitised pupa with gauze-like covering partly removed

Right: Parasitised pupa–with exit hole where wasp has emerged

Diadegma

The wasp *Diadegma semiclausum* plays an important role in suppressing diamondback moth (DBM) populations in mild to cool weather so making it a very useful biological control agent on farms practicing IPM. The wasp is black, about 7 mm long, and if well established in the crop, can be seen flying about searching for prey. The wasp lays its egg into small DBM caterpillars, and its larva then feeds and develops into an adult inside its host. When the mature DBM caterpillar is ready to pupate, the wasp larva spins a white, bullet-shaped cocoon inside the gauze-like DBM pupal covering. This cocoon turns brown as it matures.

To check if DBM caterpillars are parasitised, carefully pull the caterpillar apart to see if it has a wasp larva feeding inside it. To check if DBM pupae have been parasitised, look for the wasp cocoon within the gauze-like pupal covering. An exit hole towards one end of the cocoon shows that the *Diadegma* wasp has already emerged.

A cabbage white butterfly caterpillar with a mass of *Cotesia* larvae

Cotesia

These parasitic wasps lay their eggs into the larvae of such pests as cabbage white butterfly and heliothis. After about two weeks of internal feeding, the wasp larvae emerge by burrowing through the skin of the host caterpillar. Each wasp larva then spins a white cocoon about 3 mm long on the outside of the caterpillar. The dead caterpillar may still be attached to the white bundle of cocoons. The wasps that emerge from the cocoons are black and around 3 mm in size.

Cotesia glomerata is a common parasite of cabbage white butterfly and can provide useful control of the pest on farms practicing IPM. Look for bundles of white cocoons on leaves while crop monitoring.

Cotesia cocoons

Small parasitic wasps (*Pteromalus*) emerged from the exit holes of this cabbage white butterfly pupa

Pteromalus

The parasitic wasp *Pteromalus puparum* lays its eggs into cabbage white butterfly caterpillars. The parasitised caterpillar pupates, then after several days many small adult wasps emerge through the skin of the host pupa. Wasps are about 3 mm long. When crop monitoring, check brown pupa for signs of exit holes of the wasps.

Microplitis demolitor cocoon attached to its dead host

Microplitis

The wasp *Microplitis demolitor,* attacks pests such as heliothis, cluster caterpillars (*Spodoptera*) and loopers. The wasp lays single eggs into young caterpillars. Their larvae feed inside the host, then emerge, killing the caterpillar and forming a brown pupa that is lightly attached to the dead grub. Another wasp emerges from this cocoon about a week later.

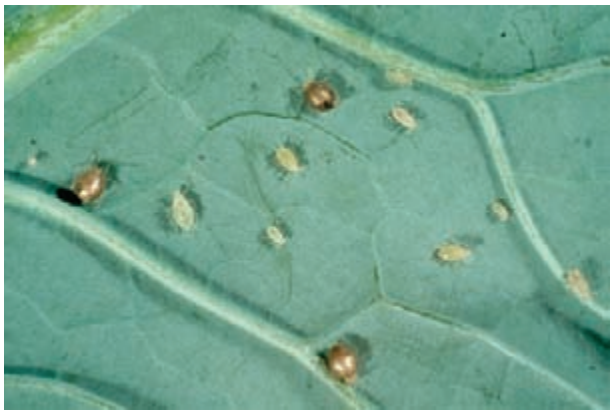
Trichogramma wasp laying her egg into a heliothis egg

Heliothis eggs– newly laid (left); black parasitised (right)

Trichogramma egg parasitoids

There are several species of egg parasitoid, the most common is *Trichogramma pretiosum*, which is commercially reared. Depending on the season, other species such as *Trichogrammatoidea* also occur in brassica crops. The adult wasps are all minute and rarely visible when monitoring crops, however the black parasitised eggs can be easily spotted.

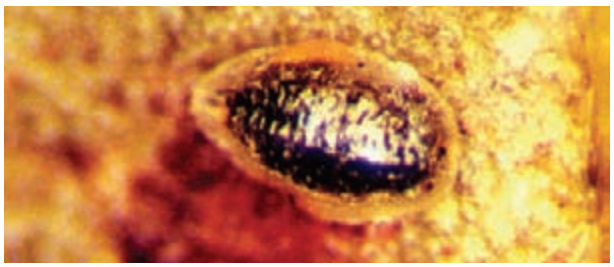
In some vegetable crops, egg parasitoids can have a significant impact on heliothis populations when broad-spectrum insecticides are not used. However in brassicas, *Trichogramma* are of less importance in reducing DBM populations. While DBM egg parasitism rates of up to 75% have been recorded in unsprayed crops, parasitism rates are much less, usually around 10%. Natural populations can be augmented by releases of commercially reared wasps although the effectiveness of this practice for brassicas has not been well tested.



Green peach aphids and three pearl-like mummies

Aphid parasitoids

Cabbage aphids are the main host of the parasitoid *Diaeretiella rapae*, but this wasp also parasitises green peach aphids. The wasp lays an egg into the aphid nymph, which once it has hatched, feeds inside its host causing the aphid to become an empty shell – a shiny, bloated, buff coloured 'mummy'. A brown wasp, about 3 mm in size, emerges through a round hole in the mummy. When crop monitoring look for round, pearl-like mummies amongst aphid colonies.



Silverleaf whitefly nymph parasitised by Encarsia wasp

Eretmocerus and Encarsia

These two species of wasp parasitoid lay their egg into the young nymphs of silverleaf whitefly. The larva of the wasp then feeds inside the nymph as it grows and develops. Once the nymph pupates, a wasp parasitioid emerges from the pupa instead of a whitefly.

Two-toned caterpillar parasite wasp

Some other wasp parasitoids

Several larger parasitic wasps up to 20 mm long are sometimes active in brassicas. The two-toned caterpillar parasite *Heteropelma scaposum,* and the orchid dupe *Lissopimpla excelsa,* attack a range of caterpillars including heliothis and cluster caterpillar. Both species of wasp lay their eggs inside caterpillar hosts. The parasite larva feeds inside its host but does not kill its host until the caterpillar pupates. A wasp emerges from the pupa instead of a moth.

The orange caterpillar parasite *Netelia producta,* attaches its eggs to heliothis caterpillars by a stalk. The parasite larva develops when the heliothis caterpillar has pupated, with a wasp later emerging instead of a heliothis moth.

Orchid dupe wasp

Orange caterpillar parasite with heliothis caterpillar

Parasitic flies


Adult Tachinid fly


Eggs of Tachinid fly on heliothis caterpillar

Tachinid fly

These parasitic flies are grey-black and slightly bigger than a housefly. They lay their eggs either on foliage on which caterpillars feed or directly onto the body of the caterpillar. The fly larva bores into the caterpillar and attaches to the skin, leaving a breathing hole. The maggot then grows inside the caterpillar, eventually killing it and forming a brown, oval pupal case from which the fly emerges. Tachinid flies parasitise heliothis and a range of other caterpillar pests. They are usually not very common.

Spiders


Flower spider

Spiders

Three types of spiders are commonly found in brassica crops – web spinners, foliage dwellers and soil dwellers. Their impact on pests has not been well documented but we suspect that it is quite high. Wolf spiders are common soil predators, whereas flower spiders, lynx spiders, jumping spiders, orb weavers and many others are active predators in plant canopies.

Spiders will prey on most insects including moth and butterfly eggs, small and large caterpillars, aphids, thrips and whiteflies. When crop scouting, make a note of the level of spider activity in the crop. It is not uncommon for a crop grown with minimal or no sprays to have a spider's web on almost every plant.


Lynx spider


Wolf spider


Jumping spider

Predatory bugs


Assassin bug feeding on a large heliothis caterpillar

Assassin bug

Assassin bug (*Reduviidae*) adults and nymphs are predators of a range of insects including large caterpillars, bees and spiders. They have very strong, curved, piercing-sucking mouthparts, which can penetrate the hard, outer skeleton of their prey.

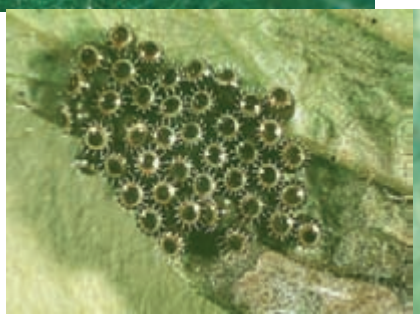
Adult assassin bugs range in size from 10 to 30 mm depending on the species. They are usually drab red-brown in colour and ambush their prey by waiting quietly near flowers and other places frequented by insects and spiders. Nymphs sometimes camouflage themselves with plant debris.

Predatory shield bug

Adults and nymphs of the predatory stink bug *Oechalia schellenbergii,* are predators of large caterpillars such as loopers and heliothis. They use their strong, piercing-sucking mouthparts to impale their prey and suck up the body fluids. Adults are between 8 to 12 mm long. They are a mottled grey to brown colour with a large, lateral spike on each shoulder. Nymphs are wingless and have reddish-brown markings.

Top: Predatory shield bug feeding on a heliothis caterpillar

Right: Eggs



Predatory shield bug nymph

Damsel bug

The damsel bug *Nabis kinbergii,* preys on soft-bodied insects such as aphids, jassids, caterpillars, and moth and butterfly eggs. They are brown, thin and up to 10 mm long.

Big-eyed bug

As its name suggests, the big-eyed bug *Geocoris* spp. is distinguishable by its large protruding black eyes. This 4 mm long black bug preys on aphids, young caterpillars and moth and butterfly eggs.

Pirate bug

Pirate bugs (*Orius*) are black, about 3 mm long and their wings make a black and white cross pattern on their back. They are commonly seen where thrips are active. The wingless nymphs are orange and black. The eggs are white, oblong and are laid embedded on the leaf. Pirate bugs are common predators of thrips but also feed on moth and butterfly eggs, aphids and small caterpillars.

Other predators

Green lacewing nymph (left) and adult (right)

Lacewings

Brown *Micromus* spp. and green *Mallada* spp. lacewing larvae are predators especially of aphids. They are common in unsprayed brassica crops.

The brown lacewing adult has brown wings and larvae are also brown with white markings. Eggs are laid singly on leaves. Green lacewing adults are slightly larger than brown lacewing adults. Eggs are laid on stalks attached to the plant. Green lacewing larvae are squat and pale brown and they camouflage themselves with the carcasses of their prey.

Green lacewing eggs

Brown lacewing adult (top right) and larva with aphids

Transverse ladybird adults and larva atttacking aphids

Minute two-spotted ladybird adults and larva

Predatory beetles

Predatory beetles include ladybirds of which several species can be found in IPM grown brassica crops. Their bodies are dome shaped with a hard wing covering. Ladybird eggs are yellow, oval shaped and laid upright on leaves, usually in a cluster. Larvae are black with coloured markings on the back. They have three prominent pairs of legs.

Ladybirds are very effective predators of aphids, but will also eat moth and butterfly eggs and small caterpillars. Other general predatory beetles such as Carabid beetles have also been found in research studies of brassica crops.

Ladybird eggs

Hover flies (syrphid flies)

Hover fly larvae are important predators of aphids and other small, slow-moving insects. Hover fly larvae are sluggish, legless maggots often green in colour that feed by puncturing their prey and consuming the fluid contents. Adult hover flies are up to 12 mm long and resemble bees and wasps as they have black and yellow banding on their abdomen. Adults feed on nectar and pollen and are often seen hovering around flowering weeds.

Natural enemies: Insect pathogens

Fungal diseases

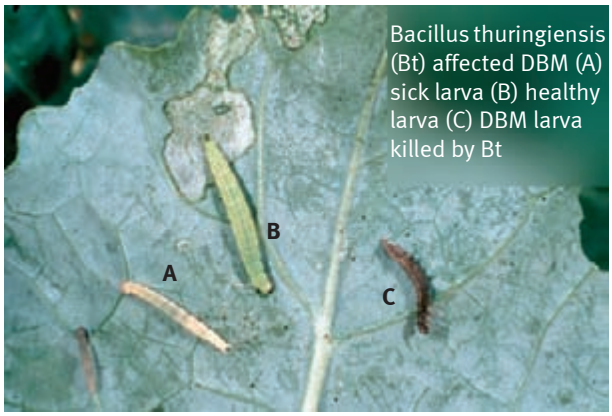
DBM larva killed by the Entomophthora fungus – healthy larva on top

Entomophthora

Fungal diseases affect aphids, the larvae of some caterpillar pests and a range of other insects. The fungal spores invade the body of the host insect, giving it a colour and sheen characteristic of that particular fungus.

In brassicas, the fungus *Entomophthora* can play an important role in containing DBM outbreaks under the right environmental conditions. Infected caterpillars become stiff and are anchored to the plant by fungal threads. Prolonged wet or humid conditions favour the development of fungal disease outbreaks.

Bacterial diseases



Bacillus thuringiensis (Bt) affected DBM (A) sick larva (B) healthy larva (C) DBM larva killed by Bt

Bacillus thuringiensis

Pests may become infected with bacterial diseases and *Bacillus thuringiensis* (Bt), a bacterium that occurs naturally, has been developed as a microbial insecticide to control several different types of pests. Formulations of two varieties of Bt — Bt *kurstaki* and Bt *aizawai,* are used to control caterpillars in brassica crops.

Caterpillars must feed on Bt to become infected, so good coverage of the crop is essential for effective control. Affected caterpillars become inactive, stop feeding and essentially die of starvation and tissue damage.

Viral diseases

Heliothis larva killed by nuclear polyhedrosis virus (NVP)

NPV

Outbreaks of the nuclear polyhedrosis virus (NPV) occur sporadically in crops and affect the larvae of pests such as heliothis and cabbage white butterfly. Infected caterpillars become pale and die, and are often found on plants with the head characteristically hanging downward.

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