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 We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research: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- Financial information—costs and returns listed in this publication are out of date.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

Chapter 3

Growing the CROP

This section is our recipe for growing and marketing a commercial crop of brassicas. To keep the section as brief as possible and easy to follow, we give little explanation with the recommendations. Where more information may help, we refer you to other chapters. Symbols on the left of the page will help you make these links.

Getting the crop started

To give yourself the best chance of success with brassica crops, you need to start planning your production and marketing program several months before the crop is planted. This involves twelve key steps.

- Decide when to plant
- Choose an irrigation system
- Plan a weed management strategy
- Plan a pest and disease management strategy
- Decide whether to transplant or direct seed
- Select varieties
- Calculate the number of plants needed and order transplants
- Prepare the land
- Lay out the field
- Apply establishment fertiliser
- Apply pre-emergent herbicides
- Plant

Decide when to plant

Your market and climatic constraints, for example hot summers, wet season rains and frosts will influence the time of planting.

Understanding brassica plants Chapter 4 page 119

Match the crop's climatic requirements with the highest possible market returns to determine your production season. Brassica crops grow best under cool temperatures. While the highest prices are often obtained during summer, most Queensland brassica crops are grown in autumn, winter and early spring because the crop is not suited to summer production in most districts. The cooler highland areas are the exception.

Apart from quality problems, pests and diseases can be more difficult to manage under warm growing conditions. Diamondback moth, heliothis and other caterpillar pests are usually more troublesome from late spring to early autumn. During extended rainy weather, plants are more likely to become infected with fungal and bacterial diseases. These diseases are difficult to manage once they are established in the field.

Temperature

Cool, sunny days with temperatures between 15° and 25°C and night temperatures between 10° and 15°C are considered ideal although some Brassica varieties are tolerant of temperatures outside of these optimums. In Queensland, only the elevated areas around Toowoomba and Stanthorpe

have the cool conditions necessary to produce quality summer brassica crops. Warm to hot conditions, especially at night, can cause problems such as bolting in cabbage and poor head quality in cauliflower and broccoli. Heavy winter frosts (-4°C and below) will damage heads of established plants and kill young seedlings. Table 8 shows the main planting and harvesting times for the major brassica production districts of Queensland.

Table 8. Main planting and harvesting times in the major production districts

District	Crop	Plant	Harvest
Lockyer and Fassifern Valleys and Eastern Darling Downs	Cabbage	Mid February to August	Late April to early November
	Cauliflower	Mid February to July	Late April to September
	Broccoli	Mid February to August	Mid April to mid October
Highland regions	Cabbage	Mid August to February	Mid November to May
	Cauliflower	September to February	December to May
	Broccoli	Mid August to early March	November to May
Southern coastal areas	Cabbage	February to mid August	Mid April to September
	Cauliflower	Mid March to June	May to mid September
	Broccoli	February to mid August	April to early October

Choose an irrigation system

Effective irrigation management is critical in producing high quality brassica crops. It includes operating an efficient watering system, scheduling irrigation and managing interactions with nutrition and pest management.

If you are new to small crop production, consult a qualified irrigation equipment supplier or designer and have them develop an irrigation plan.

Brassicas are shallow rooted crops that have a limited capacity to exploit deeper water reserves. Most of the roots are in the top 35cm of soil and readily available soil moisture should be kept in that zone. The irrigation system must be capable of uniformly delivering the required amounts of water on demand, when the crop requires it. This can be up to twice per week during establishment. Brassica crops need between 2.5 to 4.0 megalitres (ML) of water per hectare of crop—this is between 250 to 400mm of total rain or irrigation.

Overhead sprinklers are needed to establish the young plants. This system can then be used to water plants throughout the season. Use single knocker, impact sprinklers on short risers to allow spray machinery to pass overhead. The recommended sprinkler jet size is 2 or 2.4mm.

Drip, also known as trickle, irrigation is an alternative method once plants are established. It has some advantages over sprinkler irrigation. Drip irrigation can reduce water use slightly, reduce risk of leaf diseases,

and can be used to apply soluble fertilisers (fertigation) directly into the plant's root zone. Drip systems are expensive to install and require consistent, timely management to work effectively.

Selecting which type of drip system to use is complex so always consult a qualified irrigation supplier or irrigation designer for advice on design, installation and use. On sandy soils, use a trickle tube with outlets no more than 20cm apart. On clay loam soils, emitters can be 40cm apart.

Water quality

Brassicas are moderately tolerant of saline irrigation water. Ideally, brassicas should be irrigated with water that has an electrical conductivity (EC) of less than 1.7dS/m (deciSiemens per metre). Irrigation water with an EC higher than this may reduce yields and cause damage under difficult growing conditions such as hot dry windy weather. The effects of applying saline irrigation water will vary with soil texture, weather, rainfall, stage of crop growth, salt levels in the soil and the irrigation method used.

Irrigation scheduling

Irrigation
Chapter 4 page 168

The decision when to irrigate has often been made by feeling the soil, looking at the plants or watering at a pre-determined time interval. Once the crop is established, it is better to schedule irrigation with much greater precision by using instruments such as tensiometers or soil capacitance systems.

Tensiometers are comparatively cheap and effective instruments for irrigation scheduling. They show changes in soil moisture, and so indicate the actual needs of the crop. Soil capacitance systems are more expensive requiring greater skill during installation and for interpreting information. They are generally used by crop consultants and large-scale growers.

Plan a weed management strategy

While brassicas are relatively competitive against weeds, an effective weed management strategy is still required for reliably achieving high quality produce. Economic and environmental considerations mean that producers should aim for an integrated approach to weed management rather than simply relying on reactionary herbicide solutions.

This involves combining preventative practices that reduce the overall weed seed load in the soil with strategic use of herbicides. This includes:

- cover cropping and strategic crop rotations in paddocks to be planted to brassicas to reduce weed seedbanks,

Managing weeds
Chapter 4 page 237

- irrigation prior to planting to germinate weeds,
- timing of bed formation and mechanical cultivations to eradicate germinated weeds,
- careful selection of chemical herbicides to suit specific situations—herbicide options vary between brassica vegetable crops so refer to herbicide labels and seek expert advice before assuming a product is legal to use.

A combination of a number of these options will be needed for most situations.

Plan a pest and disease management strategy

As with weed management, the best approach to controlling pests and diseases is an integrated approach. This involves combining a range of management tactics with regular crop monitoring and strategic use of chemicals. Planning ahead and putting in place preventative measures is essential for effective disease control and will help minimise the risk of pest problems. Include the following practices:

Club root

Club root is a potentially serious disease. More information can be found in Chapter 3 page 52 and Chapter 4 page 225.

- Good farm hygiene to firstly prevent diseases and pests from coming onto your property and secondly, being spread around the farm from paddock to paddock.
- Cover cropping and strategic crop rotations in paddocks to be planted to brassicas to reduce soil borne disease problems.
- Destruction of old crop residues and weeds. Plough in crop residues as soon as harvesting is completed.
- Good soil preparation to reduce risks from damping off and other soil borne diseases. All crop residues and organic materials should be completely decomposed before planting.
- Adequate drainage systems to reduce water logging problems. Plant on beds to assist with drainage and air circulation.
- Avoid planting into paddocks that have a history of brassica disease or pest problems.
- Consider prevailing wind direction in farm planning and layout. Plant new blocks of crop upwind of older blocks.
- Growing in the production timeslot for your district, avoiding hot weather production and selecting the right variety for the season.
- Transplanting rather than direct seeding crops.
- Learning as much as you can about pests and diseases that are likely to cause problems in the crop and the different options available for managing them.

IPM
Chapter 4 page 183

Decide whether to transplant or direct seed

In Queensland, the majority of brassica crops are established using transplants which are grown on-farm or bought from a seedling nursery. Transplants are normally produced as container grown seedlings.

Brassicas can also be direct seeded. Direct seeded crops cost less to establish but can mature up to two weeks later than seedlings planted out at the same time. The extra risks associated with direct seeding can severely reduce crop stands and should not be underestimated. They include soil crusting, problems with weed control, soil disease and insect problems. Direct seeding can also result in the crop maturing unevenly making harvesting more difficult and expensive.

Direct seed or transplant
Chapter 4 page 145

Unless you are an experienced vegetable grower, we recommend that you use transplants bought from a commercial seedling nursery supplier to establish your crop.

Select varieties

Variety selection is an important decision as there is no one variety that performs well across all planting seasons and districts. Commercial brassicas crops are almost entirely grown from F1 hybrids. These are available through a number of seed companies.

Variety selection should be based on the preference of the target market and the environmental constraints of the site where the crop is to be grown. Table 9 lists the current 'standard' varieties of cabbage, cauliflower and broccoli for main season production in the major production areas. These varieties have been tested over several seasons and in a number of locations and are likely to perform well if grown in the right time slot for your district.

Table 9. Popular brassica varieties grown in the major production districts of Queensland

	Cabbage	Cauliflower	Broccoli
Lockyer and coastal	Warrior, some Kameron and Neptune (winter). Sugarloaf–Endeavour, also Cape Horn, Sunrise.	Charlotte, Thalassa, Fremont and Cauldron for early season. Escale for mid season, some Discovery.	Atomic or Viper for early season. Babylon for mid season, also Mongoose and Ironman. Bravo for late season.
Highland areas	Kameron and Warrior. Sugarloaf–Endeavour	Discovery for spring, some Escale. Cauldron, Fremont and Charlotte for warm season.	Babylon, some Mongoose and Ironman for spring. Atomic or Viper for summer, also Shilo.

Crop scheduling

To ensure a reasonably consistent supply of product for your customers over a long period it is necessary to stagger the planting dates of seeds or transplants. This is known as crop scheduling. Cauliflower and broccoli must be harvested as soon as they reach maturity and careful crop scheduling is therefore very important for these crops. Cabbage varieties have been bred to remain in good condition in the field once they have reached maturity so crop scheduling, though still necessary, is not as critical.

Crops are usually planted on a weekly schedule. To develop a planting schedule you will need to estimate the time it will take for a variety to mature from planting to harvest. General guidelines on maturity times are given in Table 10 but we suggest you discuss planting and maturity times with your seedling supplier or seed company representative. Remember that the prevailing temperatures of your locality will influence maturity times.

Table 10. Guide to number of weeks from transplanting to harvest

Season	Cabbage		Cauliflower		Broccoli	
	Lockyer & coastal	Highland areas	Lockyer & coastal	Highland areas	Lockyer & coastal	Highland areas
Autumn/spring	10 – 12	12 – 14	10 – 12	12 – 14	8 – 10	10 – 12
Winter	13 – 16	*	12 – 14	*	10 – 13	*
Summer	*	9 – 11	*	9 – 11	*	8 – 9

*not commercially viable at these times of the year

Selecting varieties for your farm

Use the standard varieties for your district to develop a draft planting schedule for the season. Finalise your planting schedule by contacting local resellers, seed company representatives and seedling suppliers for advice on varieties best suited to your growing conditions and market, and for specific planting and harvesting dates for these varieties in your district.

Varieties
Chapter 4 page 127

Seed companies are constantly breeding, importing and testing new seed lines and standard brassica varieties change, sometimes from one season to the next. Growers should make small trial plantings of promising new varieties alongside their standard variety to see if they are suitable for their locality before planting larger areas.

Calculate the number of plants needed and order transplants

Row width and plant spacing

Brassicas can be planted in a variety of configurations. Planting can be on the flat if soils are extremely well drained, on hilled single rows or, most commonly, in single, double or triple rows on raised beds. The majority of broccoli is grown in two or three rows per raised bed, cauliflower and cabbage are often grown in double rows on raised beds or, sometimes in single hilled rows. The actual density chosen varies with the equipment available, variety grown, the head size required and the time of the year. Table 11 gives details of a range of common planting configurations that are used in brassicas.

Table 11. Common planting configurations used in brassica crops

	Number of rows per bed	Distance between bed centres	Distance between rows on beds	Distance between plants in row	Plants/hectare
Broccoli	Double	1.5m	500–600cm	300–500cm	26,000–45,000
	Triple	1.5m	350–400cm	350–500cm	40,000–57,000
Cabbage	Single	0.9m	N/A	500–750cm	15,000–22,000
	Double	1.5m	500–600cm	600–750cm	18,000–22,000
Cauliflower	Single	0.9m	N/A	450–750cm	15,000–25,000
	Double	1.5m	500–600cm	450–750cm	18,000–30,000

In higher density plantings, disease and insect management can be more difficult. Plant crowding increases humidity within the crop canopy favouring disease development and good plant coverage with insecticide and fungicide sprays is more difficult to achieve. Planting on raised beds helps improve drainage and air circulation.

Decide how many plants you need

A commonly used planting arrangement for broccoli is shown in Figure 10. In this example, plants are grown in two rows on raised beds 0.9m wide and on 1.5m centres (the spacing from centre to centre of the beds). Rows on the bed are 550mm apart. Plants are spaced at 300mm intervals along the row. Plants can be staggered in the double rows (as illustrated) or planted side by side. This gives a planting density of about 45,000 plants per hectare.

Excluding headlands and roadways, the number of plants required per hectare (10 000 m^2) is determined by:

1. the distance in metres between the centre of each bed (A);
2. the number of rows on each bed (B);
3. the distance in metres between plants in the row (C).

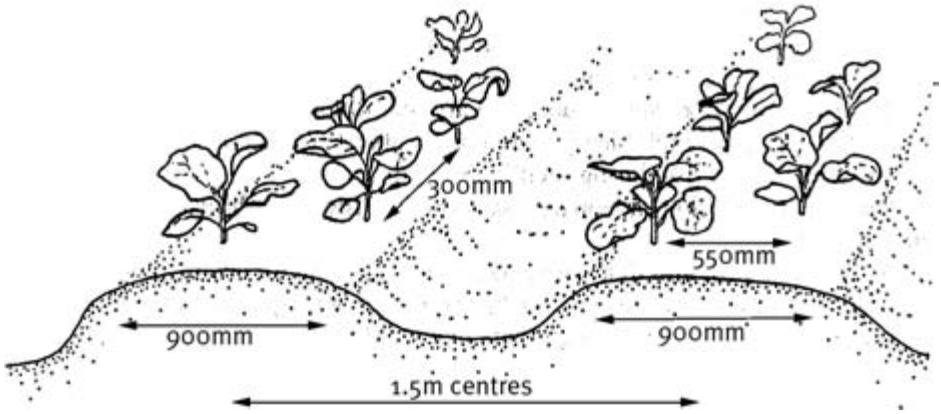

Figure 10. A commonly used planting arrangement for brassicas. Plants can be staggered (as in the drawing) or planted on the square side by side

The numbers for (A) and (C) must be in metres. To calculate the number of plants required per hectare, use the formula:

(10 000 ÷ A) x B ÷ C

For example: How many plants will you need at 1.5m bed centres (A) with 2 rows per bed (B) and 300m (0.3 m) between plants (C)?

Use the formula: (10 000 ÷ A) x B ÷ C

(10 000 ÷ 1.5) = 6666 x 2 = 13332 ÷ 0.3 = 44,440 plants/ha

Order transplants or seed

Contact your transplant or seed suppliers for details on what varieties they have, when they will be available and the price and delivery arrangements. Finalise varieties and planting schedule, then order transplants. Do this at least three months before your proposed planting date, or better still, when plans for your planting schedule are being drawn up before the season starts. Ordering early gives you the best chance of getting the varieties you want when you want them.

Prepare the land

Protect against wind

more info
Where to buy transplants or seed
Chapter 5 pages 277, 278

Brassicas are leafy plants easily damaged by strong winds. Windy conditions also increase moisture loss from the plant and the soil. Permanent tree windbreaks are best and may be practical in some situations. Temporary windbreaks of bana grass or forage sorghum established at 40 to 50 m intervals across the field will provide some protection. Strips of a cereal crop are sometimes planted between lands to give some protection from wind.

Protect against soil erosion

Uncontrolled runoff water removes valuable topsoil while the land is being prepared. Ideally, slopes should be no more than 3 %. On steeper slopes, plan the farm layout to avoid erosion and allow for efficient irrigation and use of equipment.

There are six important steps in avoiding soil erosion through runoff.

1. Build a grassed contour drain across the top of the block. This drain should have a grade of between 2% and 4% and will catch runoff water from above the block and divert it into waterways running down the slope.
2. Space waterways 50m apart. Make them flat-bottomed, at least 2m wide, and lower than the surrounding land. Where possible, use natural depressions in the block.
3. Form raised beds parallel to the top drain so that water can be channelled between the beds into the waterways.
4. Build traffic ways beside the waterways.
5. Plant seed or runners of couch, kikuyu or carpet grass in the base of waterways and traffic ways. Once these structures are established, they can remain as permanent fixtures.
6. Run beds across the slope, parallel to the contour drain. This layout minimises loss of soil between beds and combines good water infiltration and safe removal of run off.

These layouts can be used safely on all slopes with a fall of up to 8%. Brassica crops should not be grown on steeper slopes.

Crop rotation

Practice crop rotation to prevent the build up of pests, diseases and weeds. This means spelling the land between brassica crops for periods of two or more years. Lucerne and pastures are two practical long-term options to use in rotation with brassicas. Most other crops can be used as short-term rotation crops.

Cover cropping or green manuring in rotation with cash crops improves soil structure and productivity and will reduce weed, pest and disease problems. Cover cropping combined with other soil conservation methods, such as contour banks on steeper slopes, will reduce erosion and help maintain your most valuable asset, your soil.

A guide to soil preparation

Soil preparation for brassica crops should aim to produce a friable soil at the time of planting, free of clods and weeds, with all previous crop

Table 12. Suggested land preparation schedule for brassica crops

Operation	Summer crop (Granite Belt and Toowoomba)	Autumn crop (all areas)	Winter crop (Lockyer Valley and coastal)	Spring crop (all areas)
Cultivate soil, rip if necessary, add manures, plant cover crop (take advantage of rainfall)	March	April to May	September	January to February
Slash cover crop	Probably not required	October	November to December	Probably not required
Do soil analysis	June to July	November	December	April
Incorporate cover crop and lime, dolomite or gypsum	August	December	January	May
Final land preparation, apply fertiliser, form beds	September to November	January to February	February to April	June to July

residues completely broken down. Table 12 shows suggested land preparation schedules for the main brassica growing districts of Queensland.

Initial cultivation

If your land is under grass or weeds, plough or disc-cultivate the block. If the previous crop was fibrous and bulky, slash it before incorporation. Cultivate when the soil is moist but not wet. Cultivating very dry soils will damage soil structure, while cultivating wet soils will lead to soil compaction.

A hard pan or compaction layer may be formed by excessive cultivation, overuse of the rotary hoe or movement of equipment over wet fields. This will restrict plant growth and may cause drainage problems. If you suspect that you have a hard pan, dig a hole and check. Deep rip in both directions to break up this hard pan. If the soil is wet it will not shatter; if too dry large clods will be formed.

Ripping is best done immediately after final harvest to allow water to penetrate deeply during fallow and salts to be leached out of the root zone. In the self-mulching clay soils of the Lockyer Valley, the hard pan may be broken by using a summer forage sorghum crop. This crop dries the soil profile, causing shattering of the compacted layers. On these soil types, this practice has been shown to be more effective than deep ripping.

Cover cropping

Green manure crops help to build-up soil organic matter which is reduced by cultivation. Rotations that increase soil organic matter are particularly important in light, sandy soil. Other benefits of cover cropping include:

- improved soil structure and internal soil drainage
- improved water-holding capacity
- reduced leaching of nutrients
- increased activity of micro-organisms
- reduced soil erosion
- reduced pest, disease and weed problems
- recyling of nutrients

Summer. Use either forage sorghum planted at 25 to 40 kg/ha, or maize planted at 45 to 65 kg/ha. Forage sorghum can be ratooned several times by slashing. Do this before seed heads develop and stems become too fibrous.

Winter. Cereals such as oats, triticale and barley can be sown from March to July at 75 kg/ha of seed. Oats are most suitable for early planting, barley for late planting.

If the previous vegetable crop was heavily fertilised, cover crops may not need fertiliser. Otherwise, fertilise with urea (100 kg/ha) after the cover crop has emerged. Apply urea before rain, or irrigate immediately after application. Extra nitrogen may be needed if the cover crop is slashed several times.

Rotations with other vegetable crops can provide similar benefits as cover crops provided they return large volumes of organic matter to the soil after harvest, for example, sweet corn, pumpkin and watermelon.

Organic additives

Animal manure from cattle feedlots and poultry sheds is useful for increasing soil organic matter as well as supplying all or some of the nutrients required by the crop. Apply manures several months before planting to allow decomposition and for any chlorides to leach out. Check chloride levels of organic additives before application. Application rates will depend on the nutrient content of the manure and the amount of other fertilisers to be used.

The ideal time for applying animal manure is before or during the cover cropping phase, however the timing will depend on the season. Allow at least six to eight weeks in warm weather and several months under

cool conditions for proper decomposition of organic additives before planting.

Soil analysis

A soil analysis takes the guesswork out of fertiliser scheduling. Take the sample at least eight weeks before your intended planting date. Follow the sampling instructions supplied by the laboratories.

A soil analysis measures the pH, conductivity, organic matter and the level of nutrients in the soil. Results will be interpreted by the laboratory and should be back in about two weeks, allowing time for the treatments to be incorporated into the soil.

Soil pH

Nutrition
Chapter 4 page 152

The pH level is a measure of the soil's acidity or alkalinity on a scale from 0 to 14, with 7 being neutral. A pH of 5 is 10 times more acid than a pH of 6. Brassicas prefer a slightly acid soil, between 6.0 and 6.5. In this range, most major and trace elements present in the soil are available to plants, without being at toxic levels. Brassicas will tolerate slightly alkaline conditions, up to pH 7.5.

Lime and dolomite are used to raise pH. Dolomite will add calcium and magnesium while lime will only add calcium. A complete soil analysis will show which is most suitable by providing information on calcium and magnesium levels in the soil. Lime or dolomite is best applied two to three months before planting, or when the previous crop or cover crop is incorporated into the soil.

Gypsum. In alkaline soils, an application of gypsum will increase calcium levels but not change soil pH. Use naturally occurring gypsum, as phosphogypsum is derived from the manufacture of phosphatic fertilisers and usually contains the heavy metal cadmium.

Some clay soils used for growing brassicas are alkaline and high in sodium. These sodic soils do not maintain their structure when wet and form a hard surface crust as they dry out. This can prevent seedling emergence in direct seeded crops, may restrict root growth and can cause stem girdling of transplants. Sodic soils are also more likely to develop hard pans.

An application of 5 to 10 t/ha of gypsum can benefit heavy clay loams that have high sodium levels and a pH higher than 8.0. Apply gypsum before the wet season so that accumulated salts are leached beyond the root zone well before planting. It takes about one year for the effects of gypsum to become fully apparent.

Final land preparation

Calculating number of plants required
This chapter page 40

All organic materials from previous crops, weeds, added organic material and cover crops should be incorporated into the soil well before planting to allow it to break down completely. Undecomposed plant material will increase the risk of soil-borne diseases and can tie up soil nitrogen as it breaks down, making it unavailable to the crop. Decomposition takes about four weeks in warm, moist soil and eight weeks or longer in cold or dry weather.

In very dry conditions it may be necessary to apply about 25 kg/ha urea and irrigate to encourage decomposition by soil micro-organisms, otherwise the organic matter decomposes when the crop is first irrigated. This increases the risk of crop damage by soil-borne diseases and soil insects.

Soils are normally worked once or twice with disc or tine cultivators and then brought to a clod-free condition using tine cultivators or harrows before bedding up. Aim to produce a crumbly soil with little sign of fibrous pieces.

Lay out the field

The field layout will vary depending on machinery, irrigation system and harvesting method used. Fields are divided into cropping areas, commonly called lands, which are usually twice the working width of spray equipment. Leave 3 m wide roadways between the lands for easy movement of equipment, tractors and vehicles.

Distance between rows or beds depends on planting configuration. Refer to the earlier section on calculating the number of plants needed. If using trickle irrigation, the length of row used depends on the slope of the land. Under ideal conditions the accuracy of water distribution decreases after about 120 m. Additional ‘lay flat’ tubing can be placed across the rows to increase row lengths.

If possible, divide fields into uniform soil types for easier and more efficient cultivation, irrigation and fertilising. Provide all weather access to the block and allow room for vehicles to turn easily at the end of the rows. Design the layout so that new plantings are made into the wind to reduce pest and disease movement from older plantings.

Form beds

If the soil is in good, friable condition, the final cultivation and bed forming can be done in one operation. Alternatively form beds after the last cultivation using a bed-former attached behind a rotary hoe.

Establishment fertiliser can be applied before planting by banding along the intended row or bed position and incorporating during bedding up. If trace elements are deficient some are best applied to the soil before the final cultivation. Soil applications will often last for a few years, whereas foliar applications only benefit the plants to which they are applied.

Control weeds

It is essential to plant into a weed-free seedbed. A program of crop rotations will help reduce weed build-up and cover crops will smother weeds. Do not allow weeds to set seed. In most situations it is advisable to pre-irrigate beds before planting to germinate weed seeds and kill seedlings using relatively low cost non-selective herbicides or mechanical cultivation. The timing of the pre-irrigation needs to be sufficiently early to allow as many weed seeds as possible to germinate and be eradicated prior to planting.

Managing weeds
Chapter 4 page237

Apply establishment fertiliser

Brassica crops are quick growing so it is important that plants have immediate access to nutrients. Fertiliser requirements will vary with the season, soil type, as well as the block's previous cropping history. Base fertiliser rates on soil analysis results. Varieties can vary in their nutrient requirements, so contact your seed or seedling supplier for specific advice on fertilising their varieties

Plan your complete fertiliser program at this stage but be prepared to modify it as the crop develops. Once the first area planted has been cut, review your fertiliser program for future plantings based on the quality of the harvested crop and adjust fertiliser rates if necessary.

If soil analysis data is not available then use one of the following options depending on the soil type:

- 300kg/ha of 13:15:13 NPK fertiliser on soils that are known to have low phosphorus availability, such as red earth soils and krasnozems.
- 300kg/ha of 15:4:11 NPK fertiliser on soils that have high levels of available phosphorus.

Apply the establishment fertiliser either before planting by banding along the intended row position and incorporating during final cultivation and bedding up, or apply at planting by narrow banding 5cm to the side and below transplants. Drill the fertiliser into the bed in this way in soils where phosphorus may be tied-up in the soil (mainly red earths and krasnozems).

Apply pre-emergent herbicides

After any eradication of weed seedlings but before or just after planting the crop, pre-emergent herbicides are normally applied to kill any seedlings that germinate. Which herbicide to use, the timing of the application and rate all depend on the planting method, the crop type and the species of weeds (weed spectrum) to be controlled.

There are six pre-emergent herbicide options for brassica crops and these are listed in Table 13. None of these herbicides will kill established weeds. Note that not all herbicides are registered for all brassica vegetables, so it is important to refer to product labels to determine legal uses.

Table 13. Pre-emergent herbicides for weed management in brassica crops

Chemical	Direct sown	Type of weeds controlled or transplant
oxyfluorfen	transplant	Wide spectrum of broadleaf weeds that are still emerging or very small seedlings, not very good on young emerged grass seedlings
metolachlor	transplant	Only kills grass and broadleaf weeds that are emerging, not effective on small seedlings already emerged. Not very effective on fat hen, small-flowered mallow, turnip weed or wild radish.
propachlor	transplant	Similar to metolachlor but less effective on thornapples, nightshades and other Solanaceae species, better on fat hen and mallows.
pendimethalin	transplant	Many broadleaf and grass weeds, particularly fat hen and brassica weeds when combined with propachlor. Not effective on Solanaceae or Asteraceae species such as potato weed.
chlorthal-dimethyl	direct sown	A range of broadleaf weeds and grasses that are still emerging, does not control any emerged weeds.
trifluralin	direct sown	Mainly active against grasses but does suppress pigweed, some amaranthus and knotweed.

Plant

Brassicas can be direct seeded or transplanted as nursery-grown seedlings. We strongly recommend that you use transplants purchased from a commercial vegetable seedling nursery if you are new to brassica production. While direct seeding reduces up front planting costs, it increases the risk of losses through pests and diseases, weed competition and soil crusting problems.

Direct seeding

Direct seed or transplant
Chapter 4 page 145

Direct seeded crops should be planted on beds cultivated to a fine tilth after pre-plant fertiliser has been incorporated. Use a precision vacuum seeder set up for planting brassica seed into your soil type. Plant seeds

at the required spacings at a depth of 1 to 2cm. Seeding depth depends on soil type and season for example, in lighter soils and warm weather it will be more difficult to keep the top layer of soil moist and seed should be planted deeper.

Seeds will germinate over a wide range of soil temperatures from 7° to 35°C for cabbage, 7° to 29°C for cauliflower and 5° to 35°C for broccoli but germination is most rapid between 20° to 28°C. Seed size varies from 270 to 350 seeds/gram. Seeding rates will vary with seed size, germination percentage and target plant density.

Figure 11. Broccoli (upper) and cabbage (lower) transplants ready for planting out

Solid-set irrigation minimises soil crusting and surface drying, allowing more uniform germination. Keep the surface soil moist until seedlings have emerged.

The aim of precision planting is to minimise the need to thin seedlings later. If thinning is necessary, thin young seedlings when the plants are 30 to 50mm tall, chipping out weed seedlings at the same time.

Transplanting seedlings

Ensure that container grown seedlings have been hardened off in full sunlight for at least a week before transplanting. Soft plants (plants that have not been hardened off) are the greatest cause of transplant losses. Water well before planting out.

Plant seedlings at the three to four true leaf stage (Figure 11). Grade seedlings for size and discard weak or spindly plants, using only vigorous, healthy plants. This will ensure a uniform crop stand which is critical for maximising crop production. The aim is to produce a crop with heads of a uniform size that mature at the same time.

Take the following precautions when transplanting seedlings:

- Plant in the early morning or late evening and avoid planting on hot or windy days.
- Check that equipment and staff are planting seedlings properly to achieve close contact between the seedling root ball and the soil.
- Irrigate plants with an overhead watering system immediately after planting.

Getting the crop established

Depending on the weather, transplanted crops will take between 10 to 21 days to develop a good root system after planting while direct seeded crops will take up to 5 weeks to become established after sowing. There are four important things to manage during the establishment stage.

a key issue
Understanding the brassica plant
Chapter 4 page 119

- Monitor soil moisture and irrigate
- Apply supplementary fertiliser (side dressings)
- Manage pests and diseases
- Control weeds

Figure 12. *The frame indicates planting to establishment*

Monitor soil moisture and irrigate

a key issue
Irrigation
Chapter 4 page 168

Adequate watering during the first few weeks after planting is critical for crop establishment and any water stress at this stage will affect the yield and quality of the final product. In the first three weeks after transplanting, do not wait for tensiometer readings to reach critical values but apply light irrigations (10 to 15mm) once or twice per week depending on the weather. For direct sown crops, do not rely on the shallow tensiometer readings until about 5 weeks after seedling emergence.

Apply supplementary fertiliser (side dressings)

Supplementary fertiliser should provide adequate nutrients to maintain even and vigorous crop growth. The number of side dressings required, if any, will vary with soil type, the amount of fertiliser applied before planting, the variety grown and the season.

As with the establishment fertiliser, a complete soil analysis before planting provides the best basis on which to calculate supplementary fertiliser needs. Leaf and sap testing of the growing crop is a useful guide for monitoring the effectiveness of the fertiliser program and for fine tuning fertiliser programs for subsequent crops.

Side dressings may be drilled in beside plants at the last working or spun on as broadcast dressings. The total amount to be applied can be split into several applications, with the first generally applied two to four weeks after transplanting. If using trickle irrigation, supplementary fertiliser can be applied more frequently in small amounts with the irrigation water. All fertiliser should be applied before early head or curd formation. In the absence of a soil analysis, Table 14 is a guide to the supplementary nitrogen and potassium requirements in soils of different fertility. Note that total phosphorus requirements for the crop are applied at or before planting.

Table 14. Supplementary fertiliser requirements in soils of different fertility levels

Nutrient	Minimum (fertile)	Average	Maximum (infertile)
Nitrogen (N)	25 kg in 1 application	110 kg in 2 or 3 applications	140 – 160 kg split into 3 or more applications
Potassium (K)	0 – 15 kg in 1 application	50 kg in 1 or 2 applications	75 kg in 1 or 2 applications

Trace elements

Apply trace elements if deficiency symptoms have developed in previous crops, local experience suggests that particular trace elements are likely to be a problem or where soil analysis results suggest low levels of specific trace elements. Some trace elements are best applied to the soil before planting and will often last for several years.

Nutrition
Chapter 4 page 152

Brassica crops are sensitive to boron and molybdenum deficiency. In the absence of soil test results, apply 250 g Solubor/100 L water within two weeks of transplanting and repeat at fortnightly intervals. Two or three applications may be needed.

Molybdenum levels are not measured by a soil test. If previous crops or local experience indicate that molybdenum deficiency is likely to occur, apply two to three sprays of 60 g sodium molybdate/100 L water at fortnightly intervals early in the crop's growth.

Add 500 g urea/100 L of water to the above foliar sprays and spray leaves to the point of run off. Do not exceed application rates as this can cause leaf burn. Apply foliar sprays separately from pesticide sprays.

Manage pests and diseases

Check your crop regularly for signs of pests and diseases or employ a consultant to monitor the crop for you. During the first three to four weeks after planting, be especially vigilant for centre grub and cutworm damage in summer and autumn planted crops. For centre grub, look for signs of webbing and wind blown soil around the growing point of seedlings and check these plants for small larva. For cutworm, look for seedlings that have been chewed off near ground level, have fallen over or have withered and died. If cutworm and centre grub are active, spray with an appropriate insecticide from the *Chemical Handy Guide*.

Aphids can be a problem in seedlings in the milder weather of spring and autumn. If you have avoided use of broad-spectrum insecticides to control other pests, natural enemies (for example lacewings, ladybirds and parasitic wasps), often keep aphid numbers below damaging levels. If you consistently find colonies of aphids on seedlings, spray with an appropriate insecticide from the *Chemical Handy Guide*. Diamondback moth (DBM) and other caterpillar pests may also be active during crop establishment. If these pests are found in damaging numbers, use a narrow spectrum insecticide such as *Bacillus thuringiensis* to control the caterpillars. Check the *Chemical Handy Guide* for specific registrations.

Become familiar with the insect and disease problems you are likely to encounter in the crop. See sections on managing insects and diseases in *Key issues,* Chapter 4.

Also
Photos and what to do about the problem can be found in the companion book available from DPI&F offices—
PICTURE GUIDE: *Brassica problem solver and beneficial identifier*

Diseases are generally not a major problem during crop establishment in transplanted crops provided you practice crop rotation, have put in place sound farm hygiene practices and plant into well-prepared soil. During extended wet weather, look out for diseases such as black rot, leaf scald, damping off, wirestem and downy mildew. Use a protectant fungicide from the *Chemical Handy Guide* as a preventative treatment when weather conditions favour disease development or at the first sign of disease. Correct identification of the problem is critical for selecting the most effective control option.

If you find stunted plants that wilt during the middle of the day, check for signs of root galls, knots and swellings. If you suspect club root infection, be careful not to break any of these roots or allow them to drop onto 'clean' soil. Quarantine the area and contact the nearest DPI office for assistance.

Application of chemicals

Most chemicals are applied as sprays with hydraulic boom sprayers, the most commonly used spray equipment in brassica crops. Other types of sprayers that can be used include air-assisted boom sprayers, controlled droplet applicators (CDA), air-blast sprayers and mist sprayers.

Spray application
Chapter 4 page 244

The results you get from spraying will only be as good as the coverage you achieve with your equipment. Whatever type of spray equipment

you use it is essential that it is set up to provide maximum coverage of the crop.

For detailed information on pesticide application technology refer to the DPI&F publication, *Pesticide application manual.*

The ideal droplet size for insecticides and fungicides ranges from 100 to 250 microns. Spray equipment must be well-maintained and regularly calibrated to achieve this. Nozzles need to be changed when they start to wear which may be every 10 hours when wettable powders like copper are used through brass jets.

Do not apply herbicides with your pest and disease sprayer. This avoids the risk of herbicide residues in the sprayer damaging your crop.

Care with chemicals. Agricultural chemicals should always be handled responsibly and with care. They are most dangerous when undiluted. Protective clothing, including boots, overalls, gloves and a mask, should be worn at all times. ALWAYS READ THE LABEL before opening the container. Use according to directions only. Avoid spraying if spray is likely to drift off the crops. Dispose of waste chemicals and containers thoughtfully to protect the environment.

Use and disposal of pesticides
Chapter 4 page 256

Manage animal pests

Hares, rabbits, wallabies, kangaroos and ducks are only occasional pests of brassica crops but they can cause significant damage. Not all birds seen in the crop will be damaging plants. Most are beneficial predators, eating insects and slugs.

If animals are the problem, build a netting or electric fence around the perimeter of the block to keep them out. An electric fence consisting of three wires, the first 10cm from the ground and the others 15cm apart, can be used to exclude hares and rabbits (Figure 13). Wallabies, kangaroos, ducks, and other native animals including most birds are protected. If you have problems with these animals contact the Environmental Protection Agency/ Queensland Parks and Wildlife Service. The department will issue a Damage Mitigation Permit which allows you to shoot native animals only if you can show evidence of significant damage and can demonstrate that you have tried other control methods. Deterrent methods for birds could include scare guns; suspended hawk kites, other scarecrow type devices; and audio devices. Hares and rabbits are not protected. You can legally shoot them provided you hold a firearms licence.

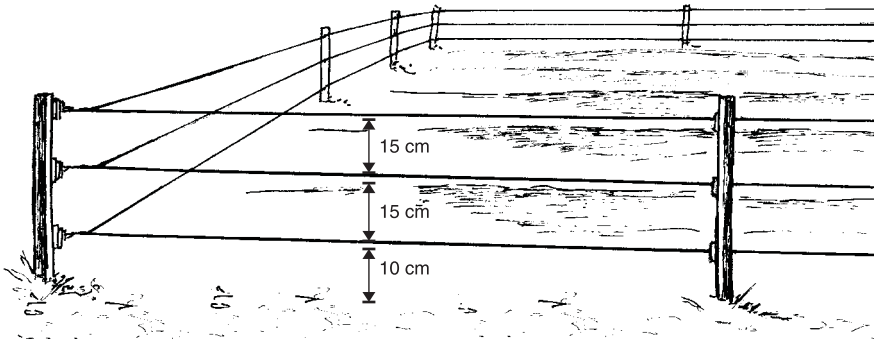

Figure 13. A diagram of an electric fence to exclude hares and rabbits

Control weeds

Broadleaf weeds that appear in the crop during or after establishment can only be killed by cultivation or hand weeding. If pre-emergent herbicides were applied, disturb the soil as little as possible to maintain the chemical barrier in the soil to avoid further weed emergence.

The best time for mechanical weed control varies with environmental conditions, weed species, variety and soil type. To maximise benefits of pre-emergent herbicides, delay mechanical weed control as late as possible, but remember that large weeds are difficult to kill with shallow cultivation. The limited space between rows in advanced brassica crops makes it difficult to cultivate without damaging plants.

Grass weeds are seldom a problem in brassica production. Most grasses will be controlled by pre- and post-planting practices. Table 15 lists the five chemicals that are registered for post-emergent grass control in brassica crops. These chemicals are selective as they kill grasses but will not have any effect on the brassica plants or broadleaf weeds.

The choice of herbicide depends on grass species to be killed, as each chemical controls a slightly different weed spectrum. The registration status of these five chemicals also varies for cabbage, cauliflower and broccoli and long withholding periods of between 7 and 63 days apply, so it is important to check labels carefully before use. The withholding period is the period between the last chemical application and harvest.

Table 15. Post-emergence grass herbicides registered for use in brassica crops

	Registration status and withholding period		
Chemical	**Broccoli**	**Cauliflower**	**Cabbage**
fluazifop-P	42 days	42 days	42 days
sethoxydim	42 days	42 days	42 days
quizalofop-P-ethyl	not registered	14 days	63 days
quizalofop-P-tefuryl	not registered	14 days	63 days
clethodim	not registered	not registered	7 days

Looking after the crop until harvest

After establishment, the crop will take a further seven to thirteen weeks until harvest depending on the type of Brassica grown, temperatures and variety. To get good yields of high quality heads, you must carefully manage four key steps.

- Manage insect pests and diseases
- Monitor soil moisture and irrigate
- Apply supplementary fertiliser (side dressings)
- Late in-crop and postharvest weed management

Understanding the brassica plant
Chapter 4 page 119

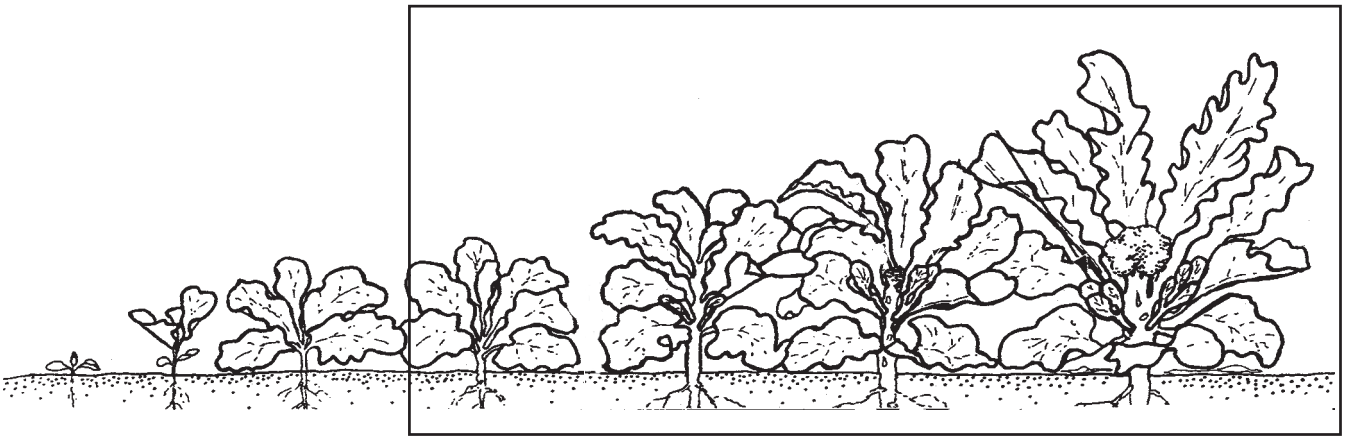

Figure 14. The frame indicates establishment to harvest.

Manage insect pests and diseases

Serious pests and diseases are likely at some stage and these can cause major and even total crop losses. Insect pests such as diamondback moth (DBM) and heliothis, as well as cabbage cluster caterpillar, cluster caterpillar, cabbage white butterfly, thrips, silverleaf whitefly and aphids can all cause damage to maturing brassica crops. Insect pests are most likely to cause problems in warm weather. DBM can be particularly difficult to control during hot weather and we strongly recommend that you do not attempt to grow brassicas during summer in districts with tropical or sub-tropical climates.

Diseases such as black rot, sclerotinia, club root and bacterial head rots can also cause significant losses. Wet and humid weather tends to increase disease problems and makes them more difficult to manage.

Two options are available for managing insects and diseases at this stage of the cropping cycle. They are:

- spraying the crop on a routine basis;
- inspecting the crop regularly for insects and early signs of disease and only spraying when necessary.

Integrated Pest Management (IPM) Chapter 4 page 183

The latter strategy is called crop monitoring and is an important part of Integrated Pest Management (IPM). This is a more sustainable and environmentally friendly way of managing insects and diseases.

It is difficult to provide a recipe for controlling insects and diseases, as problems will vary from season to season. If you spray on a routine basis, you may be wasting money as well as applying a product which may be ineffective against the insect or disease problem you are trying to control. Your ability to manage insects and diseases in brassicas effectively comes only with experience.

We recommend that you follow an Integrated Pest Management program and hire a crop consultant to help you manage insect and disease problems.

Problem identification

Photos and what to do about the problem can be found in the companion book available from DPI&F offices—
PICTURE GUIDE: *Brassica problem solver and beneficial identifier*

Correct identification is the first step to control. Is the problem caused by an insect, for example, caterpillars, aphids, whiteflies or thrips? Is it a disease caused by a fungus, bacteria or virus? Or is it a nutritional or physiological problem? The treatments would be different in each case. To manage these problems, learn as much as possible about insects and diseases and their recommended management. Several useful books for identifying pests, diseases and disorders are listed in Chapter 5, *Contacts and references*.

Insect pests

Check your crop at least weekly for signs of insect activity and damage. Brassica crops can tolerate substantial damage at some stages in their development without significant loss in yields. Once crops are established, broccoli and cauliflower can tolerate low levels of insect pests up until a week or so before heads start to form. Cabbage are less forgiving with the weeks around early head formation being the most critical for controlling insect pests. In general, aphids are not a problem during cooler weather once the crop is established. Diamondback moth, heliothis, western flower thrips and silverleaf whitefly are the most likely insects to cause economic losses. If insect numbers reach damaging levels, spray with an appropriate chemical from the *Chemical Handy Guide*. Be aware of and observe the withholding period (WHP) of the products you use.

Insect management in the field
Chapter 4 page 202

Natural enemies can have a significant impact on pest numbers. To make the most of this natural pest control, minimise the use of chemicals and avoid using broad-spectrum chemicals. These are pesticides which kill a wide range of insects, including natural enemies.

Synthetic pyrethroids, carbamates and most organophosphates are considered broad-spectrum insecticides. Choose 'softer chemicals' such as *Bacillus thuringiensis* to control caterpillars. To get a good result, spray larvae when they are still small.

Natural enemies
Chapter 4 page 218

Check the *Chemical Handy Guide* for insect pests and their registered products and refer to the product label for information on the impact of the chemical on natural enemies.

Diseases

Brassicas are affected by a number of bacterial and fungal diseases. Preventative management practices, in particular good farm hygiene, are essential for achieving effective disease control. Following these guidelines should help.

- Ensure seed has been hot water treated.
- Use transplants to establish crops rather than direct seeding.
- Avoiding double cropping.
- Rotate with other non-brassica crops.
- Incorporate all brassica crop residues into the soil immediately after harvest.
- Plant into a well prepared soil that is free from undecomposed crop residues.
- Control brassica weeds such as shepherd's purse, wild turnip and wild radish.
- Use resistant cultivars when they are available.
- Work from young crops to old crops, not the other way around, to minimise the spread of diseases.
- Restrict movement of visitors onto the farm and control movement of visitors, staff, machinery and vehicles around the farm.

Disease management in the field
Chapter 4 page 223

Once the crop is established, bacterial leaf diseases and bacterial head rots are the most likely to cause problems. During rainy weather, these diseases can be very difficult to control. When checking crops for insect pests also look out for early signs of disease. Apply an appropriate chemical from the *Chemical Handy Guide* when weather conditions are favourable for disease development or at the first sign of the disease.

Mice

Feeding mice damage broccoli and cauliflower heads. Bare fallowing a 10 metre border around plantings will help prevent mice migrating into the crop. Keep the areas around fields clear of debris and undergrowth to eliminate breeding sites.

There are two types of rodenticide available:

- Those that require rodents to have several feeds of the bait but break down quickly in the animal, are not present in the rodent when it dies and so constitute a minimal risk to native animals.
- Those that are relatively fast-acting but are not broken down quickly in the rodent so they are more likely to cause secondary poisoning in animals eating rodents.

Wherever possible it is best to use 'wildlife-safe' types that will not kill animals that feed on the poisoned rodents. To prevent birds, native animals and pets from eating the baits, create bait stations by placing baits in short lengths of PVC pipe. Check with your chemical supplier that the rodenticide is registered for use in the situation where you will be using it. Many products are registered for use only in and around buildings, though some can be used on crop headlands and in pre-plant or fallow situations.

Monitor soil moisture and irrigate

Brassicas are shallow rooted plants and are very susceptible to water stress. Avoid any check to plant growth through lack of water as this can result in reduced yields and quality problems such as tipburn in cabbage and brown bead in broccoli.

Irrigation
Chapter 4 page 168

The amount and timing of irrigation depends on soil type, temperature, wind and crop growth stage. Once plants are established, heavier and less frequent irrigations will encourage root growth and reduce the risk of disease. Brassica crops on sandy soil or under drip irrigation may require less water more frequently.

Irrigation scheduling

The amount and timing of irrigation should be based on a soil moisture monitoring system such as tensiometers. Tensiometers measure the moisture status of the soil, and allow irrigation to be timed to actual crop needs rather than an estimate of weather and soil conditions.

Install tensiometers in pairs. Place the tip of one 15cm deep in the root zone and the other below the main root zone about 60cm deep (Figure 15). The shallow tensiometer indicates when to irrigate while the deep one indicates how much water to apply.

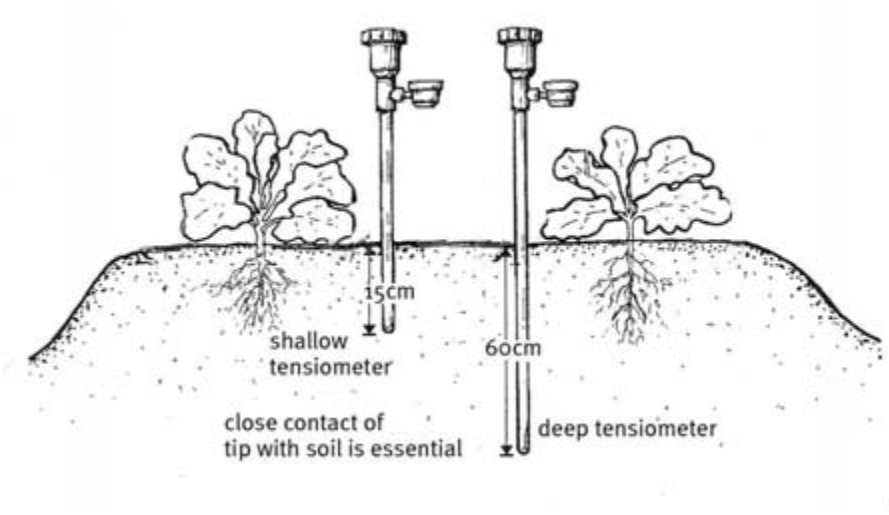

Figure 15. A monitoring site illustrating placement of the shallow and deep tensiometers.

Once tensiometers are installed read the gauge to determine when to start and stop watering. Tensiometer values represent water tension in the soil on a scale of 0 to 100 centibars or KiloPascals (kPa). Read tensiometers between sunrise and 8 a.m., because at that time there is little movement of water in the soil or plants and they are almost in equilibrium.

The specific tensiometer readings used to trigger irrigation depends upon the type of brassica crop being grown, its stage of growth and soil type. Use the following shallow tensiometer values as a guide for irrigating once the crop is established:

- **Broccoli**. Start irrigating when shallow tensiometer values reach 35 to 45 kPa.
- **Cabbage**. Start irrigating when the shallow tensiometer reaches 50 to 60 kPa during the early vegetative growth. Once heads develop, irrigate when shallow tensiometer values reach 40 to 50 kPa to maintain head weight and quality.
- **Cauliflower**. Intermediate between the broccoli and cabbage ranges.

The deep tensiometer should read between 10 and 20kPa for most of the time. If deep tensiometer values continue to rise after irrigation, too little water has been applied. If values fall to less than 5 to 8kPa after irrigation, too much water has been applied.

Apply supplementary fertiliser (side dressings)

more info
Getting the crop established
This chapter page 47

Apply any remaining supplementary fertiliser not previously applied during crop establishment. Use the fertiliser program developed from your soil analysis or the guidelines provided on supplementary fertilisers. All fertiliser should be applied before early head or curd formation.

Leaf and sap tests are useful guides for monitoring the effectiveness of the fertiliser program and are usually available from the same laboratories as the soil analysis. Leaf analysis is a benchmarking tool for checking the effectiveness of the fertiliser program. Its value is in assessing the fertilising schedule used in the current crop and how it may be improved for the next crop. Use the results of soil and leaf testing to refine the fertiliser schedule for subsequent plantings.

Sap analysis is a means of rapidly assessing a plant's current nutrient status. It can be used to highlight deficiencies of essential elements or to monitor the nitrate and potassium levels during the crop cycle. Sap testing can allow growers to adjust the fertiliser regime in the current crop and to correct any nutrient problems before yield or quality is affected. The flow of nutrients in sap is sensitive to factors other than nutrient supply so care should be taken in interpretation of results.

Late in-crop and postharvest weed management

Late emerging weeds will not affect yields but should still be controlled. Fast growing weeds can interfere with harvesting, but it is also important to prevent weeds from setting seed and some hand chipping of weeds up to harvest may be necessary. Destroy weeds once harvesting is finished to prevent them setting seed and adding to future weed problems.

Harvesting and marketing

Brassicas must be harvested, handled and marketed with care. Broccoli in particular must be cooled as quickly as possible after harvest, but cauliflower and cabbage also deteriorate rapidly if not cooled after harvest. Final product quality and therefore price received will largely depend on how well you manage the following five key steps.

- Harvesting
- Cooling and storage
- Grading and packing
- Transport
- Marketing

Harvesting

The variety, the time of transplanting or seeding and subsequent weather conditions determine the length of time it takes from planting to harvest. The aim is to achieve a once over harvest of cabbage and to minimise the number of passes required to harvest a crop of cauliflower or broccoli.

Assessing maturity

Closely monitor your crop in the lead up to the estimated harvest date to ensure that harvesting begins at optimum crop maturity. Check with your seedling supplier or seed company representative on the number of days to harvest for each variety planted. This information will help in estimating the harvest date. If the weather is cooler than expected, the crop will take a several days longer to mature. If it is warmer than expected, the crop may mature several days earlier than your estimated harvest date. Table 16 outlines the general harvest indicators for cabbage, cauliflower and broccoli crops.

Table 16. General harvest indicators for cabbage, cauliflower and broccoli

Crop	Indicators
Cabbage	Harvest when the majority of heads are firm, heads still appear fresh and before any splitting occurs.
Cauliflower	Harvest when the curd is fully expanded but still compact, white and smooth in appearance, and before the curd begins to open and become 'ricey' or 'fuzzy'.
Broccoli	At harvest the head should be compact and dark green in colour. Heads should not show any signs of yellowing, limpness or open buds.

Harvesting techniques

Brassicas are usually harvested into bulk bins, pre-cooled and then packed. Infield packing into cartons is less common. For small plantings, pickers can place heads directly into a bulk bin mounted on a tractor (Figure 16). Harvest aids are often used on larger farms. Pickers place heads onto a conveyor belt which then moves them to a central moving platform and into bulk bins (Figure 17). Do not overfill the bulk bins as heads on the top will be crushed if bins are stacked for transport.

Figure 16. Picking cabbage directly into bins

Figure 17. Harvesting a large planting of broccoli using a harvest aid

Harvest in the morning before the heads get too hot. Do not leave bulk bins standing in the sun at any time of the year. If immediate cooling is not possible, shade bins while waiting for transport to the packing shed, and then quickly place into cool rooms.

Brassica crops can be damaged during harvesting. Take time to train and supervise your pickers and make them aware of the need for careful handling. You will get better results if your pickers have good working conditions.

Cabbage. Use a sharp knife to cut the stalk close to the head. Leave one to three whorls of outside leaves around the head for protection on cabbages to be sold on the domestic market (Figure 18). For export all outside leaves are removed in the field. Once over harvesting is standard practice for green cabbage but red and Savoy varieties need to be cut over several passes due to variation in maturity.

Figure 18. A head of cabbage trimmed for the domestic market

Figure 19. Cauliflower trimmed for the domestic market

Cauliflower. Commence harvesting when about 20% of the heads are ready for cutting. Use a sharp knife to cut the stalk close to the head. For the domestic market any large leaves should be trimmed away until only enough leaf remains to protect the curd, which is normally 1 to 4 layers (Figure 19). If produce is destined for the export market all leaves are removed to save space when packing.

Harvest on a 2 to 3 day cycle to ensure that the heads are cut at the correct maturity. Depending on the variety and weather conditions 3 to 9 passes will be needed over a maximum 21 day period to completely harvest a single planting.

Broccoli. Commence harvesting when at least 20% of the heads are ready for cutting. Use a sharp knife to cut heads and square off the stem. Remove any leaves and small side shoots on the stem (Figure 20).

Harvest on a 2 to 3 day cycle to ensure that the heads are cut at the correct maturity. Depending on the variety and weather conditions 2 to 4 passes will be needed over a 7 to 10 day period to completely harvest a single planting. The aim is to harvest the maximum number of quality heads with the minimum number of passes.

Yields

For broccoli, an average yield range of 900 to 1000 icepacks per hectare would be expected mid season with a plant population of about 40 000 plants per hectare. In warmer weather, average yields can decrease to 700 icepacks or less per hectare.

For drumhead cabbage, an average mid season yield of 16 000 heads per hectare would be expected on a planting density of 20 000 per hectare. Yields would be lower for crop grown in warmer weather or adverse weather conditions.

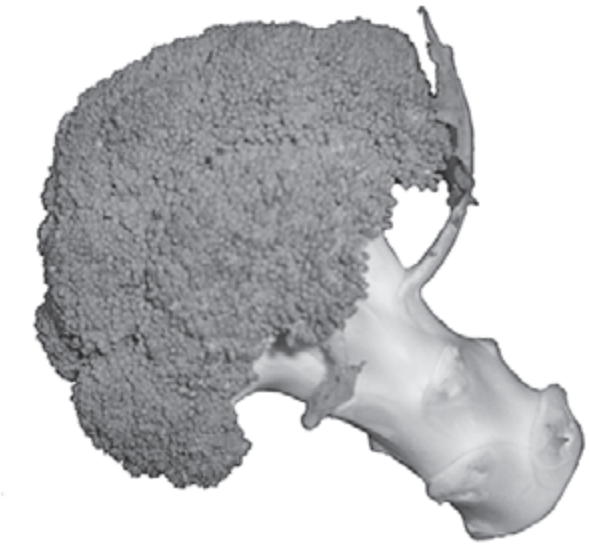

Figure 20. Broccoli head trimmed for the domestic market

For cauliflower, yields range from 1600 to 2000 cartons per hectare depending on the plant population, cut out rates and heads packed per carton. For example, an average yield of 1800 cartons would be expected mid season with a plant population of 24 000 per hectare, a cut out rate of 75% and packing 10 heads per carton.

Bacterial head rots

Bacterial head rot problems can cause major crop losses in brassica crops. Broccoli is particularly prone to the disease during warm, wet weather. Avoid harvesting wet crops and sterilise cutting knifes if the disease is present in the field.

Bacterial head rot problems can almost be eliminated by good field and shed hygiene, cooling the produce before transport and proper low temperature storage.

Cooling and storage

Broccoli. Pre-cooling is essential for this highly perishable product. Harvested heads are immature flower buds on thick, fleshy stalks and they have a high respiration rate, are easily damaged and lose water quickly. To overcome these problems, pre-cool broccoli to 0° to 2°C, starting cooling within one hour of harvest. Forced-air cooling is the most common method of removing field heat quickly, but hydro-cooling bulk bins of produce is also an option.

The DPI&F booklet, *Forced-air cooling* discusses forced-air cooling in more detail.

Hydro-cooling systems use refrigerated or iced water to rapidly cool the broccoli heads. In this cooling system, bulk bins are either plunged into a water bath, or a shower of water flows over and through the bulk bins of produce. Consult a reputable refrigeration specialist for advice. Water used for hydro-cooling and/or to make ice must be from a potable (drinkable) source, or be treated with an approved sanitiser.

Forced-air cooling facilities should be designed to allow high humidity cooling to 0° to 2°C within four to eight hours. Consult a reputable refrigeration specialist for advice.

Initial crop quality and the speed with which field heat is removed from the product will determine shelf life. Broccoli will store for two to three weeks at 0°C and a relative humidity of 95%, however cut stems may show some browning after this length of storage.

Cabbage. Rapid pre-cooling is not needed for cabbage but storage at 0° to 2°C is recommended if the product is to be kept for any length of time. Drumhead cabbage varieties can be stored in a standard cool room and since the leaves of these types of cabbage are waxy and not susceptible to wilting, a high humidity cool room is not necessary.

Cauliflower. This product is less perishable than broccoli but more sensitive to poor handling than cabbage. Cauliflower should be cooled by high humidity forced-air cooling as soon as possible after harvest. Storage should be at 0° to 2°C.

Ethylene damage

Broccoli is very sensitive to ethylene gas, which causes yellowing and opening of buds. Ethylene is given off by a number of fruit and vegetables, for example, apples, pears, stonefruit, passionfruit, papaws, mangoes, rockmelons, tomato and capsicum. To avoid ethylene damage during cooling, storage and transport, do not mix broccoli with these products. Ventilate the cool room regularly to reduce the risk of damage.

Cabbage should not be stored with fruits emitting ethylene as the leaves may abscise or turn yellow if exposed for several weeks to ethylene. Cauliflower are sensitive to ethylene but tend not be affected by ethylene in practice as the crop is usually not stored for any length of time. Extended storage of cauliflower with fruits emitting ethylene could cause floret opening on the curd.

Wilting injury

Wilting affects broccoli and cauliflower and is caused by dehydration after harvest. It is less of a problem in cabbage. To prevent wilting, cool and store produce in a high humidity cool room (95% relative humidity).

Freezing injury

Brassicas will freeze at temperatures below 0°C. Freezing in storage and transit is caused by improperly adjusted or malfunctioning refrigeration units; or incorrect stacking of produce in refrigerated trucks resulting in poor circulation of chilled air causing excessive cooling (possibly freezing) in restricted parts of the chamber. The top of the load near the refrigeration unit is most at risk of freezing.

Grading and packing

Grade standards

Industry wide grade standard regulations for broccoli, cabbage and cauliflower no longer apply. The grading standards you use should be negotiated with your agent, merchant or buyer. The grade standards

which were traditionally used are included below as a guide to the standards expected in the marketplace.

The Quality Descriptor booklets are listed in Chapter 5 *Contacts and references* page 291

- Broccoli heads must be sound, clean, fresh, compact, domed and have small buds. They should be dark green with a bluish hue and no sign of yellowing or limpness. Heads should be of the same variety and the same head size in any one container. The Broccoli Quality Descriptor Language booklet, available from the DPI in Victoria, provides guidelines for discussing quality with customers and staff.
- Cabbages must be sound, clean, reasonably firm, fresh, not wilted and not discoloured. Only cabbages of the same or similar varieties can be packed together. The Cabbage Quality Descriptor Language booklet, available from DPI Victoria, will provide guidelines when discussing quality with customers and staff.
- Cauliflowers must be sound, clean, compact, and fresh. The curds must be free from riciness (loose, open or granular appearance), bracts (leaves growing through the head) and blemishes. A quality descriptor language booklet for cauliflower is available from DPI Victoria.

Packages

Packaging for brassicas varies depending on the product and the market. Check with your wholesaler on preferred packaging for different markets.

For **broccoli** two types of packages are commonly used:

- Waxed fibreboard vegetable cartons. These are packed to hold a minimum 10 kg net of produce. Most growers aim to pack 10.5 kg to allow for shrinkage during marketing. Modified atmosphere bags can be used in fibreboard cartons (along with pre-cooling) to extend shelf life. Bags made from a range of commercial plastic films are available (Lifespan® is one example). Some supermarkets require broccoli to be packaged using these bags. Unwaxed cartons can be used with this type of bag.
- Polystyrene 'coffin' icepack. This package usually holds around 8 to 10 kg of product plus 2kg of ice in a layer placed on top of the produce. A polystyrene lid is taped onto the top of the package. The package does not have drainage holes and melted ice at the bottom of the package can sometimes cause problems when stored or transported for longer than a week at less than ideal temperatures.

Cabbages and cauliflowers can be packed either in waxed vegetable cartons or in bulk bins (Figure 21), depending on customer requirements.

- Ballhead and Savoy cabbages are usually marketed in bins. When cartons are used they are one-piece waxed, ranging from 58L to 78L, but mainly 72L and 78L.

- Red cabbage is usually marketed in one-piece waxed cartons these can vary from 68L to 78L, but mainly 72L or 78L are used.
- Sugarloaf cabbage is usually sold in one-piece 58L or 62L waxed cartons, occasionally 68L are used.
- Cauliflowers when packed in waxed cartons are mainly packed in 72L and 78L sizes, occasionally 68L cartons are used

Carton dimensions are based on a base of 570mm x 380mm. Depth varies depending on size: 290mm (58L), 310mm (62L), 340mm (68L), 360mm (72L), 380mm (78L). The height of bulk bins for cabbages is usually 700 to 800mm. Bins of this size hold about 0.5 tonne of product.

Figure 21. Cabbage packed into a half tonne bulk bin with liner

Packing

Cabbage, cauliflower and broccoli heads should be tightly packed so no movement occurs during transport.

Broccoli is packed either in fibreboard vegetable cartons or polystyrene ice packs. Ice packs can be either wide and shallow, or narrow and deep. Both types of ice pack contain 8kg of heads when packed. The wide ice packs consist of two layers of heads, the narrow icepacks can contain 3 layers depending upon head size.

Current practice is to pack all heads with the stalk down so that the heads do not sit in water from melted ice, which may damage the florets. The heads are staggered in each layer so that they fit together snugly and the stalks do not rub on the heads in the layer below. Aim to pack heads of similar size to improve the overall appearance of the pack. Much depends on the size of the heads and packs. Figures 22 and 23 show how broccoli can be packed in a wide polystyrene icepack.

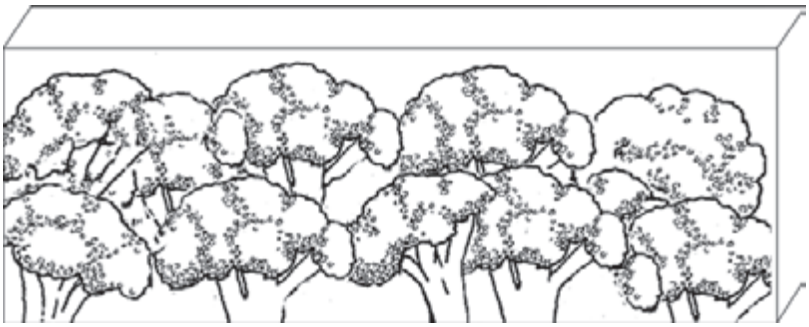

Figure 22. Side view of two-row packing arrangement

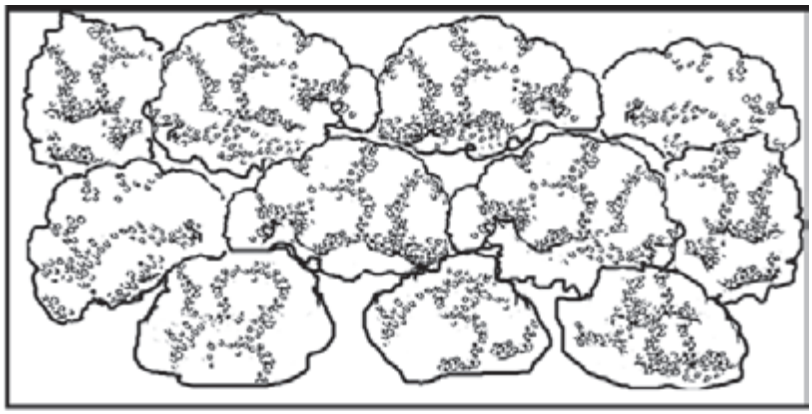

Figure 23. Top view of broccoli packed in a wide, shallow polystyrene ice pack

Cauliflowers should be packed in such away as to avoid the butt of one head rubbing on the softer florets of another head. In any single package the diameter of the heart of the largest cabbage or cauliflower should not be more than 50% larger than the diameter of the smallest.

Labelling cartons

Each carton must be labelled clearly (by stamp, stencil or print) with the name and address of the grower/packer. The name of the product must also be marked on the carton. An example of a carton end panel is shown in Figure 24.

Most customers also require growers to include a product identification and traceability code on each package. This may be a packing date or code, and/or a block number or code. Check with your customer to determine their requirements. The date, block number or code on the package needs to link to farm records so that any package can be traced back to a particular source on your farm. A product identification and traceability system will also enable accurate, recorded information about how the product was handled to be made available to customers in the event of a major quality or food safety problem.

Figure 24. End panel labelling on a cauliflower carton

Palletising

Palletisation of icepacks and cartons has speeded up turn-around time and resulted in much less transport damage to produce. The base dimensions of the Australian Standard Pallet are 1165 x 1165mm. Cartons are normally stacked 48 or 56 to a pallet, icepacks are stacked 36 to a pallet.

The way the product is palletised will depend on the strength of the carton and the shape of the carton your customer has requested, and is best worked out with your packaging supplier. Some customers may also have height restrictions on palletised loads in relation to occupational health and safety requirements for maximum lifting heights.

When putting cartons on pallets it is best to stack similar quality product on individual pallets to make handling in the market chain easier. This is referred to as unitising. Overfull cartons with incorrectly fitted lids put a lot of pressure on the product, especially on the bottom of a pallet. This needs to be considered when choosing or designing the carton, as the carton not the product, should be supporting the weight on the pallet.

When loading the pallet it is most important that all cartons are fitted squarely onto it and that the air vents of each layer of cartons line up to allow the maximum air-flow through the stack for efficient forced-air cooling. Pallet stacking aids assist with this operation. The stack may be held together with corner stays and straps, or taped or wrapped with stretch nylon netting. Some growers use palletising glue to prevent cartons slipping over each other if pallets are not well secured. The pallet can be shifted with fork lifts or pallet jacks. A pallet hire pool operates in most districts.

Transport

Broccoli and cauliflower should be transported to market in refrigerated vehicles or containers set at 0° to 2°C and with high humidity (95%). Load only pre-cooled product as refrigerated vehicles and containers will not lower the temperature of produce, only maintain it. Refrigerated air must be circulated to all parts of the container.

Since cabbages are not as perishable as broccoli and cauliflower, refrigerated transport of cabbage in bulk bins is not essential for shorter distances. For longer distances and for product packed in cartons, use

refrigerated transport, making sure that product is cooled to 0° to 2°C prior to loading.

If using stabilising sheets placed through the load, ensure they are placed so that airflow over, around and under the load is not blocked. Poorly positioned sheets prevent air movement through the load, particularly if the cartons are not palletised.

To avoid ethylene damage in broccoli, do not mix loads with fruit and vegetables that produce ethylene, for example, apples, pears, stonefruit, passionfruit, papaws, mangoes, rockmelons, tomato and capsicum.

Both rail and road transport is available to most centres. Road transport is more expensive, but is quicker to its destination. Trucks can be loaded on the farm and unloaded at the market.

Marketing

There are a number of options for marketing brassica crops. These include selling:

- to a local merchant or packhouse;
- to an agent or merchant at the major markets;
- direct to a retailer; for example the major supermarkets or smaller retailers;
- overseas, either direct to buyers or through an exporter.

Note that agents sell your produce on your behalf, then receive a commission, usually about 12.5%. Merchants buy the produce from you at an agreed price, then sell it for whatever price they can get.

Know your market

To get to know your market talk to people who are in constant contact with it, that is your agent or wholesaler and your retailer. Maintain a good relationship with your wholersalers and keep them informed of the quantities of produce you are consigning and the standard (quality) of the produce. Ask for feedback on the quality of your product in the marketplace.

To provide what your customers want you will need to have a quality management or QA program, or be able to demonstrate good food safety practices.

Quality assurance and food safety

Marketing and quality management is a vital step in brassica production. How well you manage this, and the quality of your product, will have a direct impact on the profitability of your business.

The retail market is now dominated by several major players and the diverse market once enjoyed by the vegetable industry, where growers could sell to a large number of agents or merchants, is slowly shrinking. This concentration of the market to fewer, larger buyers means that, more than ever, brassica growers must make sure they have a customer organised before they plant or they could face an already fully supplied marketplace.

Quality management
Chapter 4 page 104

Lack of quality assurance (QA) or on-farm food safety protocols can restrict your access to markets. It is essential that you know to whom you are going to sell your product before planting. Different customers may have different requirements for QA and food safety, and you will not be able to supply these customers unless you satisfy their requirements.

Domestic markets

Most cabbage, cauliflower and broccoli is marketed as fresh produce on the Brisbane, Sydney and Melbourne wholesale markets or direct to major retailing chains. Smaller markets are Adelaide, Newcastle, Perth, Townsville and direct selling to smaller retail outlets.

It is best to deal only with a specialist brassica or vegetable wholesaler. Seek advice on selecting a wholesaler from your local grower's association or the market authority where you intend to sell your product.

Major retailing chains are important outlets for vegetables. Although some of their requirements are met from the wholesale markets, they commonly also buy direct from growers. This is usually on the basis of an agreed pricing system, ability to supply agreed quantities of product over time and some form of quality assurance system. If possible, visit the major market in which your product is sold at least once a season.

Processing

A proportion of Queensland grown cabbage is processed into coleslaw, or chopped/ sliced for inclusion in pre-prepared salad or vegetable mixes. Broccoli and cauliflower florets are also sold in pre-prepared form. Small quantities are sold for freezing and pickling.

Levies

There is a national levy for vegetable research and development of 0.5% of the value of domestic, export and processing product. The money raised is matched by the federal government via Horticulture Australia which manages the funds on behalf of the Australian vegetable industry.

The Australian Vegetable and Potato Growers Federation (AUSVEG), Australia's grower representative body for vegetables, works closely with Horticulture Australia to ensure funding is used in line with the strategic direction of the Australian vegetable industry.

Interstate quarantine

Interstate requirements are subject to change so contact your local DPI plant health inspector. Plant health coordinators in major DPI centres can assist businesses with inspection services. Growers are advised to confirm the details of requirements and fulfil these in advance, before sending brassica produce interstate.

At date of publication of this book, there were no restrictions on the movement of cabbage, cauliflower and broccoli crops within Queensland.

Interstate movement provisions
Chapter 5 page 285

Marketing overseas

Small but significant export markets exist for Queensland Brassica crops in Japan, Singapore, Hong Kong, Malaysia, Taiwan, Indonesia, the Philippines and Brunei.

Requirements and product specifications for these and other export markets vary. Growers intending to produce for the export market must undertake extensive market research to ensure that their product meets the specific requirements of the markets they intend to supply.

Export Control (Fresh Fruit and Vegetables) Orders, produced by the Commonwealth of Australia, shows the specific requirements for exporting fresh produce. *Schedules 25, 5 and 4* refer to broccoli, cabbage and cauliflower respectively and these should be used as a guide for exporting brassicas to other countries. Cartons must be marked with the grower's or packer's name and address, export number and the words 'Produce of Australia'. The product must meet any description marked on the package.

Where to buy *Export Control (Fresh Fruit and Vegetables) Orders*, Schedules 25,5 and 4 see *Contacts* Chapter 5 page 291

Produce destined for export markets must be of high quality and free from insect pests and disease. Correct postharvest handling and storage during transit are critical to ensure that produce arrives at the destination in good condition. Airfreight, using polystyrene ice boxes, can be used for higher value perishable produce such as broccoli. Bulky lower value produce such as cabbages and cauliflower are normally exported in refrigerated shipping containers.

Produce for export to countries that require a phytosanitary certificate may be grown and packed in an on-farm Registered Export Establishment (REE) or prepared for export in a premises that has current REE status for the commodity being exported. Produce exported to non-phytosanitary certificate countries must, at some stage within the export

process travel through a REE. This may be a packing shed, exporter's premises or a freight forwarder.

AQIS offices in Queensland are found in Chapter 5 *Contacts*, page 284

Protocols have been established with some countries such as New Zealand to access these markets. These protocols are commodity specific and have been established for the product from growing through to export.

A country may require exporters to obtain an import permit before export. This permit specifies the latest requirements for that country.

The Australian Quarantine and Inspection Service (AQIS) supervises registration of establishments. As quarantine requirements vary between countries intending exporters should keep informed through local AQIS offices.

Chapter 1

Before you START

If you have never grown cabbage, cauliflower or broccoli before, then you will find this section very useful. It is a brief checklist of the essential things you need to know before you start. It will help you make the right decisions. The information here is brief and to the point. We provide more detail on important areas in other sections of the book. Symbols on the left of the page will help you make these links.

Contents

A brief overview of the Queensland brassica industry

Official statistics suggest that the Queensland brassica industry is relatively static, although supply tends to fluctuate from year to year. In 2001–02, around 40 000 tonnes of cabbage, cauliflower and broccoli were produced from about 2 800 hectares. Table 1 shows the industry had a farm gate value of about $21 million and a gross value of around $32 million.

Table 1. The Queensland brassica industry

Crop	Area (ha)	Production (tonnes)	Farm gate value ($ millions)	Gross value ($ millions)
Cabbages	366	13,148	2.7	4.7
Cauliflower	693	15,058	4.1	8.2
Broccoli	1758	11,569	14.3	18.8
Totals	**2817**	**39,775**	**21.1**	**31.7**

Source: *Australian Bureau of Statistics* 2001–02 estimates

Most Queensland brassicas are grown in the south-eastern corner of the State in the Lockyer Valley, Eastern Darling Downs and the Granite Belt. Small growing areas exist in coastal areas and other horticultural production districts of the state.

The industry primarily supplies the domestic fresh market, either through the central market system or direct to supermarket chains which account for the majority of sales. There are small markets for semi-prepared or semi-processed product (coleslaw, salad and vegetable mixes).

Brassicas from Queensland are sold throughout Australia. Fresh cabbage, cauliflower or broccoli can be sourced from Queensland at any time of the year but the main supply period is from May to September when the Lockyer Valley and Eastern Darling Downs are in full production. During the warmer months, production is centred in the cooler highland areas of the Granite Belt and around Toowoomba.

Returns can vary greatly. Prices are often low during peak production in winter. Summer prices are often high. In regions with warm or hot summers such as the Lockyer Valley, lows yields, reduced head quality and pest and disease problems are often not offset by these higher summer prices.

Some larger brassica growers have actively pursued export markets for a number of years with some success. The major overseas markets for Queensland brassicas are south-east Asia and Japan, with $5.7 million of broccoli, $1.8 million of cauliflower and smaller quantities of cabbage exported during 2002–03 (Source: *Australian Bureau of Statistics*).

Know what you are getting into

The average price for broccoli, cauliflower and cabbage varies between seasons, making profitability and cash flow inconsistent and hard to estimate. The market is often oversupplied, particularly during winter and early spring, when returns may be below costs of production.

Consistent yields and quality can be difficult to achieve due to insect pests (for example, diamondback moth), disease problems (for example, head rots) and climatic factors. These include frosts, heat wave conditions or wet weather during harvest. Varieties also perform differently in various growing areas and under different growing conditions.

Growing brassicas is labour intensive, particularly at planting and harvest times, and there can be problems getting a good, reliable labour force.

Successful production requires cool to mild growing conditions, a well-drained soil and reliable irrigation. Capital costs can be high depending on arrangements for harvesting and packing of product. Access to rapid pre-cooling and cold storage facilities is essential for broccoli and highly desirable for cauliflower. Cabbage can be cooled and stored in a conventional cold room.

IMPORTANT
Do a marketing and business plan. This will give you a more accurate picture of what you are getting into.

Table 2 lists the some of the strengths, weaknesses, opportunities and threats (SWOT) affecting the brassica industry.

Table 2. Factors affecting the brassica industry of Queensland

Strengths	Weaknesses	Opportunities	Threats
Staple, well known products	Not suited to warm weather production	Value adding and semi-processing	Overproduction
High nutritional value	Cabbage and cauliflower not fashionable	Health aspects of the product	Lack of irrigation water (drought)
Versatile product	Generic promotions	Targeted promotion	Substantial price fluctuations
Value for money	Competition from southern states in domestic markets	New varieties	Club root
Convenient	Strong competition in export markets	Niche markets, organics, eco-labelling	Insecticide resistance problems
Reliable crop to grow in season with good management	Highly perishable product (broccoli, cauliflower)	New export markets	Labour, packaging and freight costs

What can you expect to make?

Yields vary considerably, depending on climatic conditions, pests and diseases, variety, season and planting density. Prices vary greatly, depending on supply and quality.

Cabbages are usually supplied in bulk bins and sold on a per head basis. Sugarloaf cabbages are often sold in waxed fibreboard cartons. Cauliflowers are sold either on a per head basis or, more commonly, in 78L cartons that hold 10 or 12 heads. Broccoli is usually sold in icepacks holding 8 kg of heads or in waxed fibreboard cartons holding 10 kg of product.

Production and marketing costs for cabbages, cauliflower and broccoli vary, depending on yields achieved, the size and efficiency of the operation and the cost structure of the business. Each farm is different. The estimates given in the following sections are intended only to illustrate the level of costs involved for growing, harvesting and marketing the different brassica crops.

IMPORTANT
Estimate costs for your situation. See *Economics of production* in Chapter 4, Key issues.

Of the three crops, cauliflower is by far the riskiest crop to grow as production costs are high and yields can vary substantially. Cauliflowers also require a fair amount of agronomic and management expertise to grow successfully. Cabbage and broccoli are easier to grow. However, since broccoli is the more perishable of the three products, timeliness of harvest and access to adequate cooling facilities complicate crop management.

Cabbage yields and prices

Marketable yields commonly range from 14 000 to 18 000 heads per hectare.

Market prices
Chapter 6 page 282

Price can range from $0.20 to $4.00 or more per cabbage head, but is usually in the $0.60 to $2.00 range. Figures 1 to 3 show average prices for ballhead cabbages on the Brisbane and Sydney markets and throughput of all cabbages at the Brisbane market for 2001 to 2003. The bigger the variation above or below the average price, the greater the opportunity or risk involved.

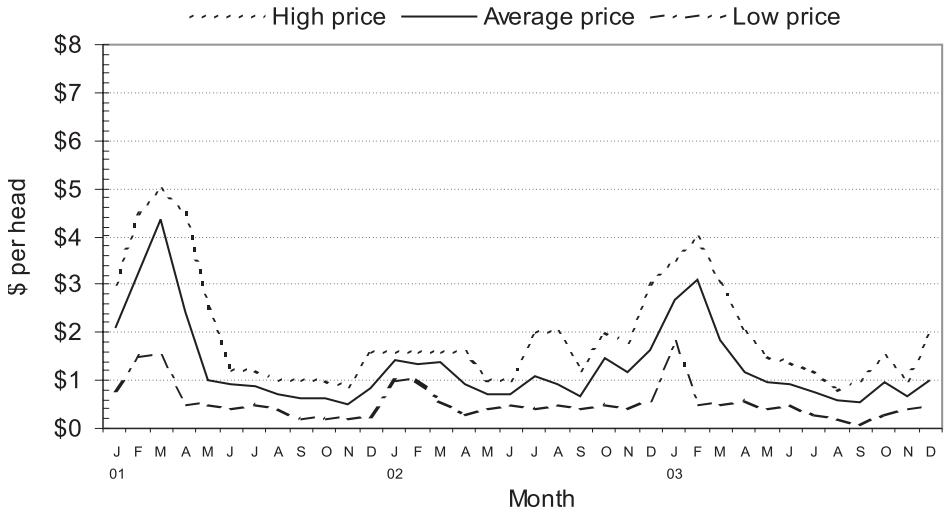

*Figure 1. Average monthly price for ballhead cabbage on the **Brisbane** market 2001 to 2003*

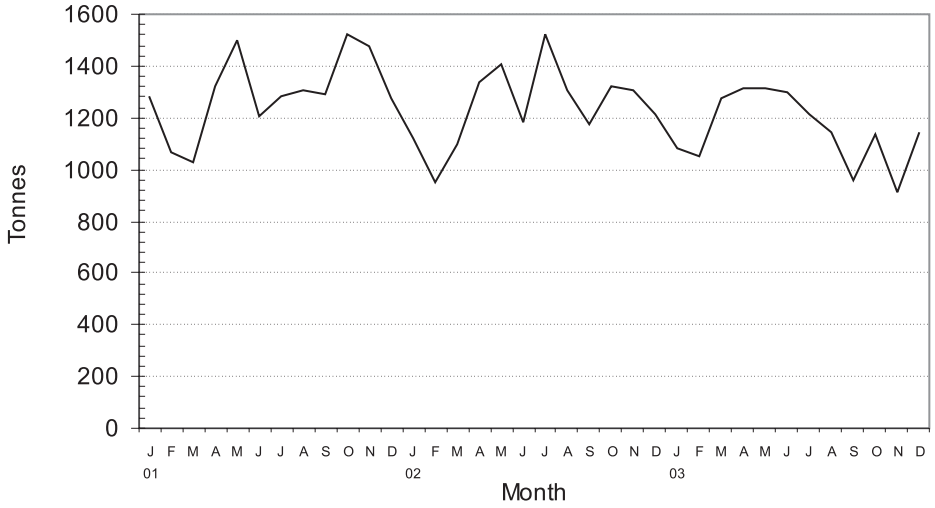

*Figure 2. Throughput of cabbage on the **Brisbane** market 2001 to 2003*

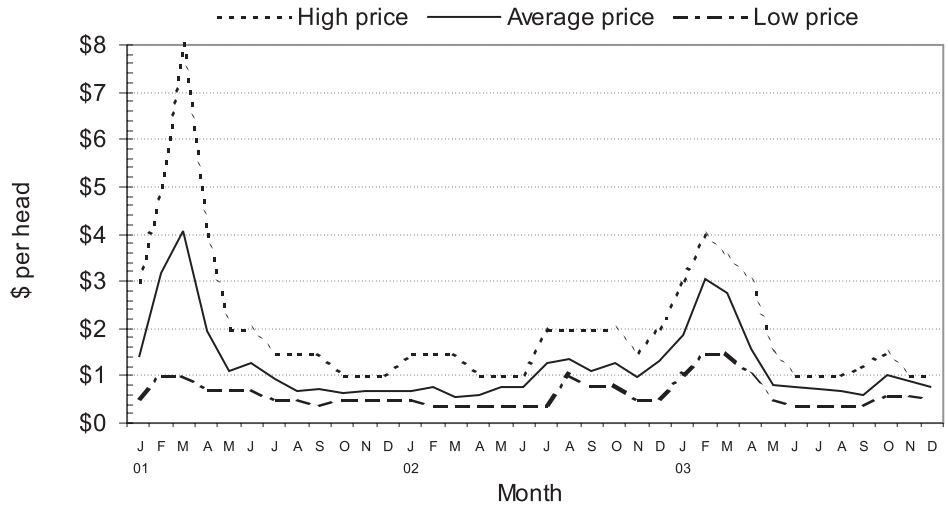

*Figure 3. Average monthly price for ballhead cabbage on the **Sydney** market 2001 to 2003*

Production costs for cabbage

Production and marketing costs in southern Queensland are at least $0.70 per head. Variable growing, harvesting and marketing costs range from $10 000 to $16 000 or more per hectare.

Table 3 shows the estimated average costs of a southern Queensland crop yielding 16 000 heads per hectare sold in fibreboard bulk bins at $1.00 per head on the Brisbane market.

Table 3. Example costs of producing and marketing a cabbage crop grown in southern Queensland

Costs	$ per head	$ per hectare
Growing	0.22	3 520
Harvesting (pick, pack & bin)	0.37	5 920
Marketing (freight and commission)	0.25	4 000
Total variable costs	**0.84**	**13 440**

Gross margin

At an average yield of 16 000 heads per hectare and an average price of $1.00 per head, the gross return would be $16 000/ha. The gross margin (income after deducting growing, harvesting and marketing costs) for the yield, price and cost averages used here would be $2560/ha. To determine your net income, deduct fixed and capital costs such as rates, vehicle registration, insurance, electricity, administration, interest and living expenses.

Cabbage gross margin
Chapter 4 page 87

Cauliflower yields and prices

Marketable yields commonly range from 1 500 to 2 000 cartons per hectare. Yields can be substantially lower during unfavourable growing conditions.

Price can range from $2.00 to $50.00 per carton, but is usually in the $8.00 to $18.00 range. Figures 4 to 6 show average prices and throughput at the Brisbane market and prices at the Sydney market for 2001 to 2003. The bigger the variation above or below the average price, the greater the opportunity or risk involved.

Market prices
Chapter 6 page 282

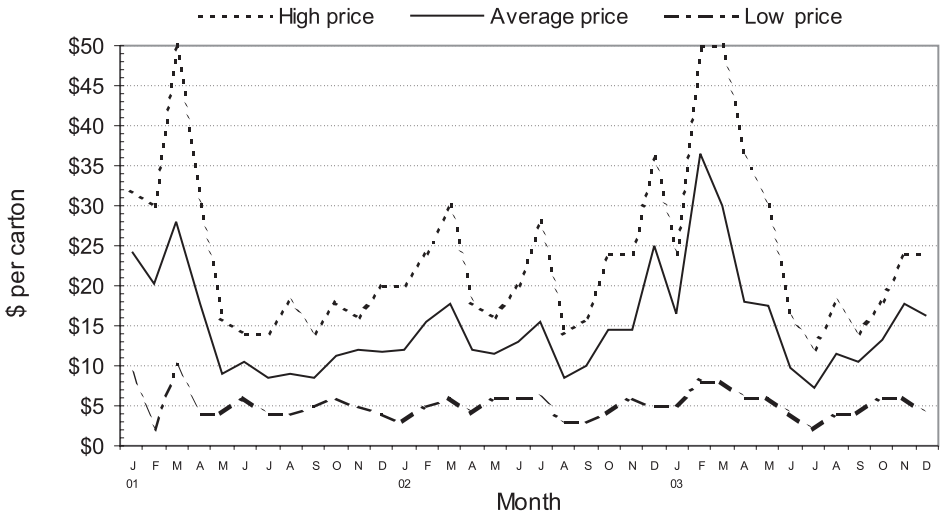

*Figure 4. Average monthly price for cauliflower on the **Brisbane** market 2001 to 2003*

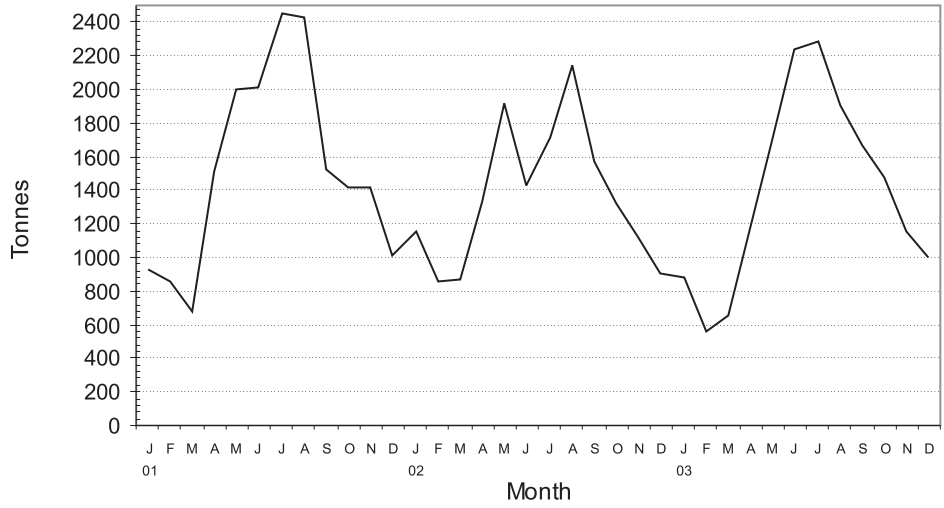

*Figure 5. Throughput of cauliflower on the **Brisbane** market 2001 to 2003*

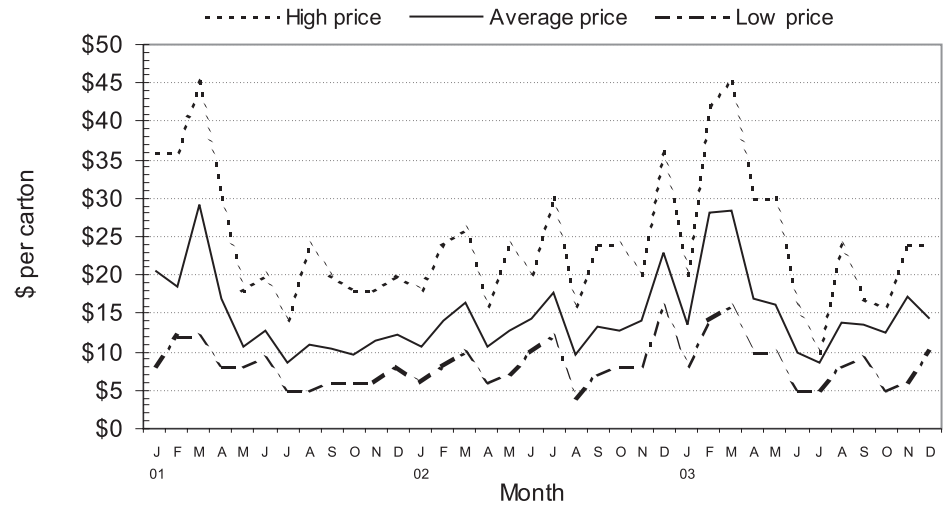

*Figure 6. Average monthly price for cauliflower on the **Sydney** market 2001 to 2003*

Production costs

Production and marketing costs in southern Queensland are at least $9.50 per carton. Variable growing, harvesting and marketing costs are at least $14 000/ha, but can be $20 000 or more per hectare. The evenness of crop maturity will have a significant impact on harvesting costs.

Table 4 shows the estimated average costs of a southern Queensland crop yielding 1 700 cartons per hectare sold at $12 per carton on the Brisbane market.

Table 4. Example costs of producing and marketing a cauliflower crop grown in southern Queensland

Costs	$ per carton	$ per hectare
Growing	2.77	4 709
Harvesting (pick, pack & carton)	5.61	9 537
Marketing (freight and commission)	2.35	3 995
Total	**10.73**	**18 241**

Gross margin

Cauliflower gross margin
Chapter 4 page 90

At an average yield of 1 700 cartons per hectare and an average price of $12 per carton, the gross return would be $20 400/ha. The gross margin (income after deducting growing, harvesting and marketing costs) for the yield, price and cost averages used here would be $2159/ha. To determine your net income, deduct fixed and capital costs such as rates, vehicle registration, insurance, electricity, administration, interest and living expenses.

Broccoli yields and prices

Marketable yields commonly range from 700 to 1000 icepacks per hectare.

Market prices
Chapter 6 page 282

Price can range from $3.00 to $40.00 per icepack, but is usually in the $12.00 to $22.00 range. Figures 7 to 9 show average prices and throughput at the Brisbane market and prices at the Sydney market for 2001 to 2003. The bigger the variation above or below the average price, the greater the opportunity or risk involved.

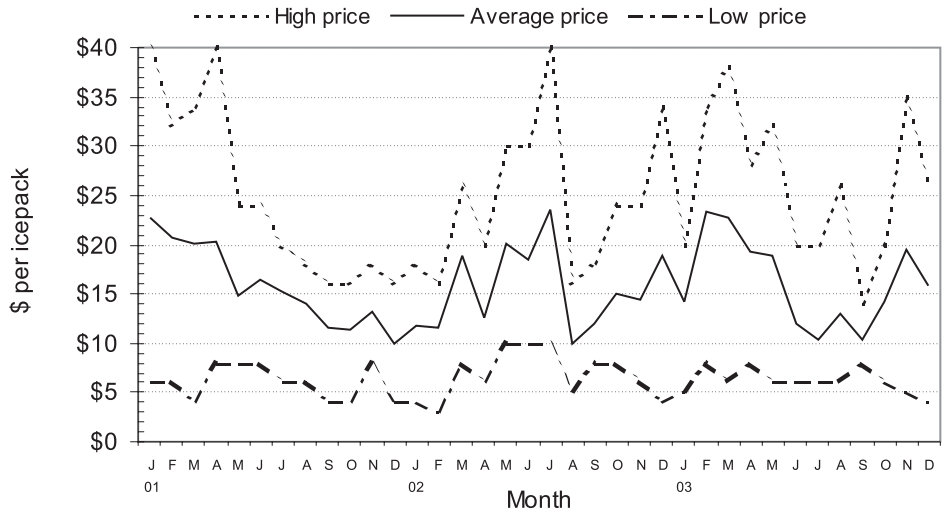

Figure 7. Average monthly price for broccoli on the ***Brisbane*** *market 2001 to 2003*

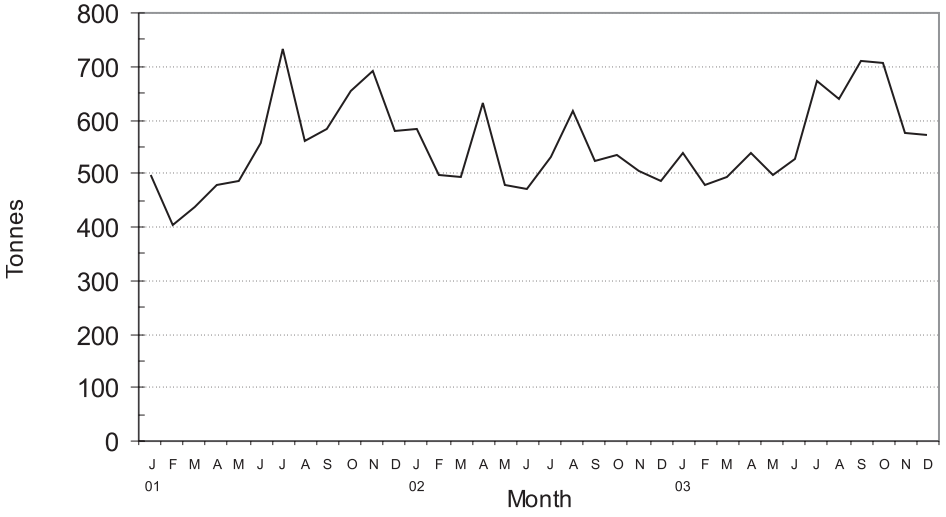

Figure 8. Throughput of broccoli on the ***Brisbane*** *market 2001 to 2003*

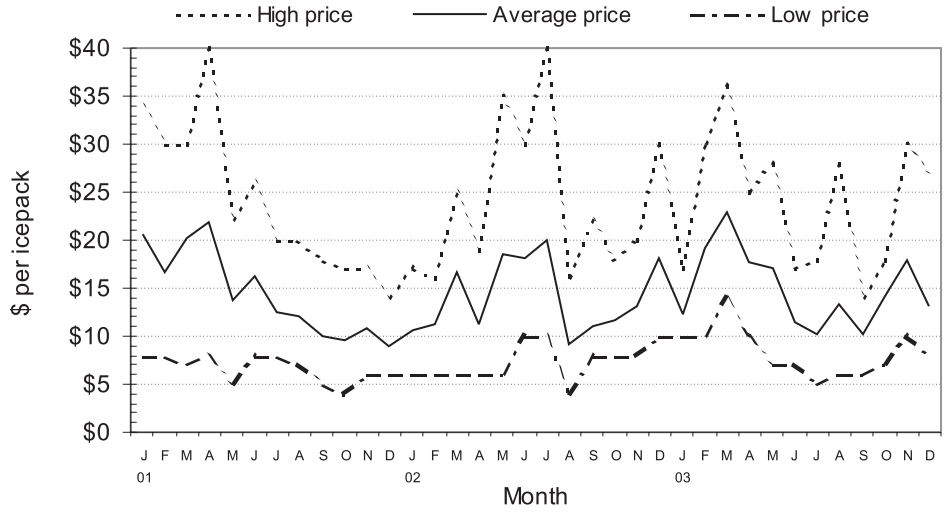

Figure 9. Average monthly price for broccoli on the ***Sydney*** *market 2001 to 2003*

Production costs

Production and marketing costs in southern Queensland are at least $13.00 per icepack. Variable growing, harvesting and marketing costs range from $11 000 to $15 000 or more per hectare.

Table 5 shows the estimated average costs of a southern Queensland crop yielding 900 icepacks per hectare sold at $16.00 per icepack on the Brisbane market.

Table 5. Example costs of producing and marketing a broccoli crop grown in southern Queensland

Costs	$ per icepack	$ per hectare
Growing	4.75	4 275
Harvesting (pick, pack & icepack)	6.66	5 994
Marketing (freight and commission)	2.50	2 250
Total	**13.91**	**12 519**

Gross margin

Broccoli gross margin
Chapter 4 page 93

At an average yield of 900 icepacks per hectare and an average price of $16 per icepack, the gross return would be $14 400/ha. The gross margin (income after deducting growing, harvesting and marketing costs) for the yield, price and cost averages used here would be $1881/ha. To determine your net income, deduct fixed and capital costs such as rates, vehicle registration, insurance, electricity, administration, interest and living expenses.

Capital required

Assuming that you own or have access to suitable land, it would cost around $250 000 to $300 000 to buy the minimum amount of new machinery, plant and equipment needed to set up a 20 to 30 hectare brassica enterprise. This will depend on which crop you grow and what harvesting and packing arrangements you use. Cabbage would generally be less capital intensive than broccoli or cauliflower.

To reduce capital outlays, you could lease or borrow equipment and contract harvesting and packing operations. Second-hand equipment prices are normally about half that of new equipment, depending on condition and age.

You will also need to finance production and marketing of the crop. Brassicas are usually planted on a weekly schedule over a number of months. You may be looking at investing $100 000 to $200 000 in variable growing, harvesting and marketing costs before receiving a gross return from the first harvest.

The farm you need

Soil

Getting the crop started
Chapter 3 page 34

Brassicas will grow on most soil types but the crop needs at least 300mm of friable, well-drained topsoil. Poorly drained soils or heavy clay soils become waterlogged after rain or irrigation, making crop management more difficult. Brassicas prefer a slightly acid soil (pH 6.0 to 6.5) but will tolerate a slightly alkaline soil, up to pH 7.5.

Climate

Brassicas grow best under cooler temperatures. Mild, sunny days with temperatures between 15° and 25°C and cool nights with temperatures between 10° and 15°C are considered ideal. Heavy winter frost (below –4°C) can damage heads and will kill young seedlings. Some varieties will tolerate hot conditions but high temperatures will reduce both head quality and yields. Cauliflower is particularly sensitive to temperature extremes.

During extended rainy weather, plants are more likely to become infected with diseases such as black rot and bacterial head rots. These are difficult to manage once the disease is established in the field. Rainfall will also restrict machinery operations, particularly on heavy soils.

Brassica crops are attacked by a range of butterfly and moth larvae (caterpillars). These can be difficult to control, particularly in the warmer months.

Slope

Ideally slopes should be no more than 3%. A slight slope will provide better drainage while still allowing for efficient irrigation and use of machinery. Steep slopes will be more difficult and expensive to work. Uniform slopes are desirable but not essential. Soil erosion can be a problem on steep slopes while depressions can result in waterlogging.

Prepare the land
Chapter 3 page 41

Slopes above 5% require recognised soil conservation practices. Slopes above 8% make machinery operations hazardous and it can be difficult to maintain uniform irrigation.

Water

An adequate water supply is essential to ensure economic yields of high quality product. Each crop will require 2.5 to 4 megalitres (ML) of water per hectare, depending on season, soil type and crop type. This is equivalent to 250 to 400 mm of total rain and/or irrigation over one hectare of land.

When surface water, for example dams, is your main source of irrigation water, a storage capacity of 6 to 8 ML will be required for each hectare of crop grown. This will ensure that you have adequate water supplies to meet peak irrigation demands even in unseasonably dry conditions.

Brassicas are usually watered with overhead irrigation systems although some growers are switching to drip (trickle) irrigation.

Irrigation management
Chapter 4 page 168

The crop is moderately sensitive to poor quality water. Electrical conductivity is a measure of water salinity. Table 6 shows the water conductivity threshold for different soil types at which yield reductions may occur.

Table 6. Water conductivity threshold for different soil types

	Sandy	Loam	Clay
Cabbage	3.5 dS/m	2.0 dS/m	1.2 dS/m
Cauliflower	3.2 dS/m	1.8 dS/m	1.1 dS/m
Broccoli	4.9 dS/m	2.8 dS/m	1.6 dS/m

Source: *NRM Facts, water series W55*

Until recently water conductivity was reported in microSiemens per centimetre (µS/cm), however it is now reported as deciSiemens per metre (dS/m).

To convert from µS/cm to dS/m use the following formula.

microSiemens per centimetre (µS/cm) divided by 1000 = deciSiemens per metre (dS/m)

Example: 1200 µS/cm divided by 1000 = 1.2 dS/m

To convert from deciSiemens per metre to microSiemens per centimetre multiply by 1000.

Example: 1.2 dS/m x 1000 = 1200 µS/cm

The machinery and equipment you need

The machinery and equipment required will depend on the size of the enterprise and crop grown. Table 7 lists the machinery and equipment considered essential for brassica production on a small scale (20 to 30 hectare). Machinery, plant and equipment listed as desirable would make management easier by increasing flexibility and would be considered essential in a larger enterprise.

The prices listed in the table are estimates only. Rather than buying new machinery you could lease, borrow or buy second-hand equipment to reduce capital outlays. Harvesting, cooling and packing can be contracted out in most major vegetable production districts.

Table 7. Estimated cost of new machinery and equipment

Equipment	New price $
Essential	
Tractor (26 kW) for planting, cultivation, spraying, harvest	30 000
Tractor (45 to 60 kW) for discs, ripper, rotary hoe	60 000
Truck or tractor and trailer	10 000–40 000
Cultivation equipment	20 000–25 000
Bed-former	2 000
Transplanter	4 000
Fertiliser spreader	10 000
Spray equipment for crop	10 000
Irrigation equipment	80 000
Tractor mounted forklift	10 000
Pallet jack	700
Desirable	
Power harrows (1.5m width with bed-former)	17 000
Spray equipment for herbicides	4 000
Harvest aid	26 000
Shed forklift	30 000
Slasher/pulveriser	3 000–6 000
Sorting/packing tables and equipment	10 000
20 pallet coldroom	35 000
Forced air cooling facilities (8 pallet room)	50 000

The labour you need

One person could grow 10 to 15 hectares of crop over a six-month period with additional labour to help with transplanting, harvesting and packing. Cabbage production is less labour-intensive than cauliflower and broccoli growing.

Three people plus a driver are required for planting. This team could plant out around 5000 to 7000 transplants per hour.

A team of four can cut around three half-tonne bins of cabbage per hour. Six to eight people are needed to operate a harvest aid efficiently. Using a harvest aid, a team of eight could pick and pack between 40 to 50 icepacks of broccoli per hour or 60 to 80 cartons of cauliflower per hour. Cutting and packing rates would slow considerably when more than two or three passes are needed to harvest the crop.

Transplanting, harvesting, cooling and packing operations can be contracted out for all three crops; this reduces problems associated with managing a large number of staff.

Other considerations

Growing brassica crops involves hard, physical work. This includes land preparation, planting, spraying for weed, pest and disease control, fertilising, irrigating, harvesting and packing. There is a high labour requirement for transplanting, picking and packing, particularly for product sold in cartons or icepacks.

Management skills or access to consultants with these skills are required for managing finances, administration, staff and the crop. Good communication skills, or staff with these skills, are essential for successfully managing labour and organising markets. Skills in machinery operation and maintenance, the ability to read and understand chemical labels, and skill in observing and fixing problems in their early stages, are essential. Careful attention to detail is necessary to be a successful brassica grower.

Quality of the end product is most important in successful cabbage, cauliflower or broccoli growing. This starts with good land preparation, careful selection of varieties to suit the district and season and continues through the growing of the crop, harvesting, cooling, packing and marketing.

Organic production
Chapter 4 page 260

Brassica crops may be grown organically. However, it can be difficult to achieve adequate weed, pest and disease control.