Cashew information kit

Reprint – information current in 1999

REPRINT INFORMATION – PLEASE READ!

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This publication has been reprinted as a digital book without any changes to the content published in 1999. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research: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- Financial information—costs and returns listed in this publication are out of date.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 1999. 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 cashew 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.

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Queensland Government

Key ISSUES

This section contains more detailed information on some of the important decision-making areas and information needs for cashew. The information supplements our growing and marketing recipe in Section 3 and should be used in conjunction with it. The information provided on each issue is not designed to be a complete coverage of the issue but instead the key points that need to be known and understood. Where additional information may be useful, we refer you to other parts of the kit. Symbols on the left of the page will help you make these links.

Understanding the cashew tree

The aim of cashew growing is to produce a large crop of high quality nuts. To achieve this, it is helpful to have a basic knowledge of what governs fruit and nut production. Here are the important things you need to know.

About the cashew

The cashew (*Anacardium occidentale*) belongs to the family Anacardiaceae which includes other economically important tree crops such as mango and pistachio. The tree is a fast growing, evergreen perennial well suited to the seasonally wet/dry tropics of northern Australia. Depending on variety, tree canopy shape varies from conical to domed. The economic life of the tree may be between 20 and 25 years, though the tree itself is known to survive for much longer.

The cycle of vegetative and reproductive growth of a mature tree (Figures 1a and b) follows a definite pattern where the monthly timing of each phase will depend on local climatic conditions, especially temperature and availability of water. Shoot growth is in distinct flushes.

Tropical conditions of the hot coastal lowlands. In these tropical growing conditions (for example, Darwin), there are generally three flushes throughout the growing season. The first vegetative flush emerges between October and December after nut drop. A second vegetative flush occurs between January and March. The third flush, known as the pre-floral vegetative flush, emerges from May to July before flowering and continues growth to bear the panicle.

Cooler conditions of the inland and highlands. In these cooler growing conditions (for example, the Tablelands in north Queensland), generally only two flushes are produced throughout the growing season. The first vegetative flush occurs between December and April. A second flush occurs in June to September, followed by flowering.

Duration of flowering extends for a few months, from May to September in the coastal lowlands with peak flowering in July/August, and from June to October in the inland and highlands with peak flowering in August/September. Harvesting extends from September to November for the coastal lowlands and from October to December for the inland and highlands.

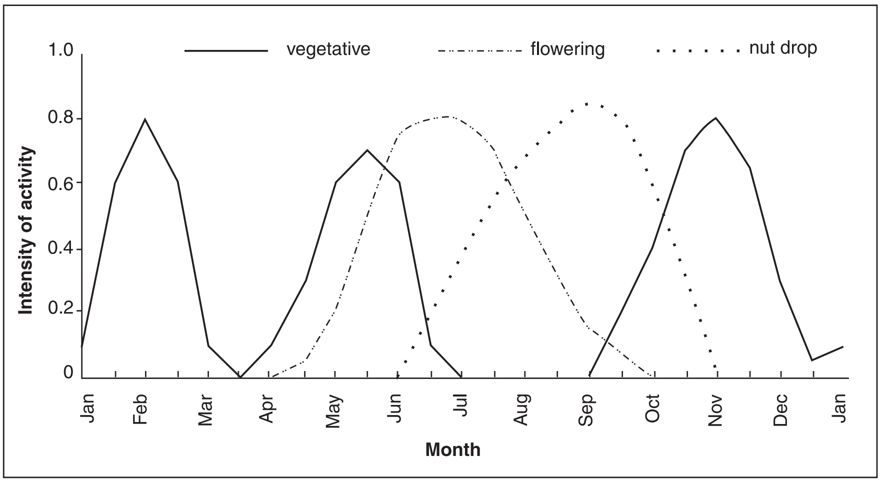


Figure 1a. *Pattern of growth of a mature tree at a coastal lowland location*

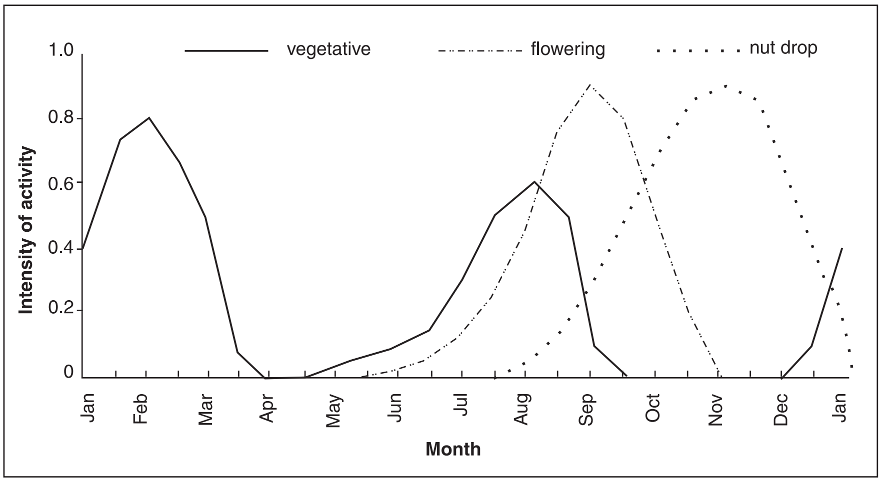
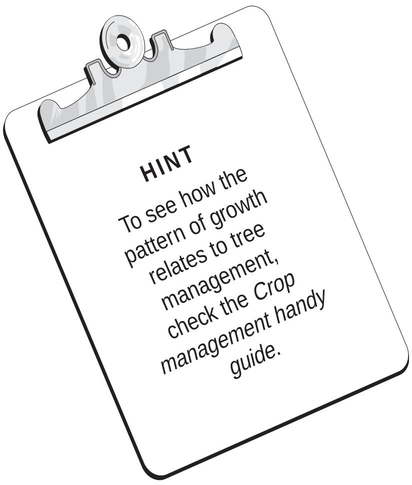


Figure 1b. *Pattern of growth of a mature tree at an inland and highland location*



Floral biology

The cashew tree produces male and hermaphrodite flowers on the same panicle (Figure 2). In a panicle there are many more male flowers produced than hermaphrodite flowers. The ratio is generally around 10 male to 1 hermaphrodite flower, but can vary depending on the variety. Sex ratio can also vary during the flowering period. Moreover, more than 80% of the hermaphrodite flowers drop before they produce a mature nut. Male flowers typically open earlier in the day and hermaphrodite flowers open later, in the early afternoon.

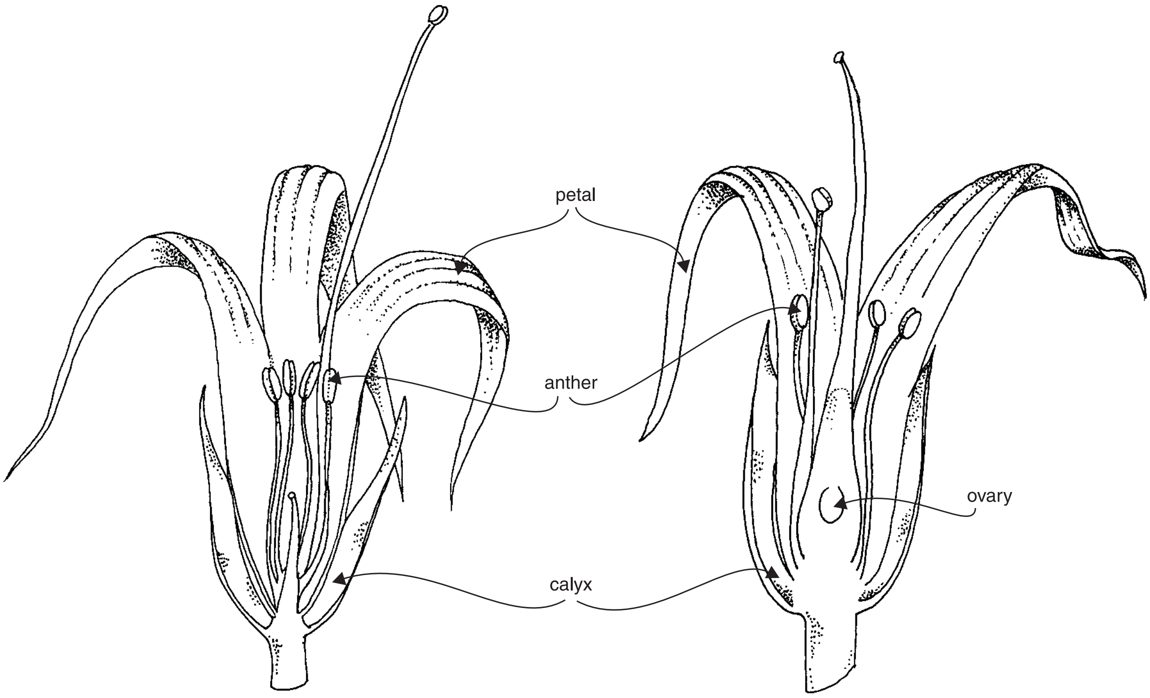


Figure 2. *Male flower (left) and hermaphrodite flower of cashew*

Pollination and nut set

Cashew is mainly pollinated by insects (native bees, honey bees, flies and wasps). Although a large number of flowers are produced in a panicle, nut set is relatively low because of the low sex ratio and poor pollination caused by lack of insect pollinator activity. Inclusion of honey bee hives may be necessary to improve pollinator activity and pollination. The female part of the hermaphrodite flower is receptive to pollen from the male flower for about 6 hours. For better nut set, pollination should occur within this time. Nutrition, water availability, pest incidence and environmental conditions may also influence nut set.

Crop cycle and management

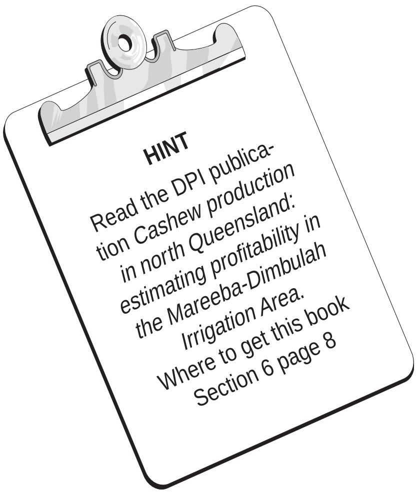
An understanding of the crop cycle is essential for making decisions on scheduling plantation operations such as pest management, fertiliser application, irrigation and forecasting labour requirements.

Methods for describing the crop cycle

Choose 10 trees of each of the varieties grown and assess at monthly intervals whether the tree is flushing, resting, flowering and setting nuts. Estimate the proportion (percentage) of the total area of the canopy that is taking part in each activity. A schedule of management operations can then be planned to coincide with the cycle of crop growth; an example is shown in the *Crop management handy guide*.

Economics

Nut production is characterised by relatively low returns per tree, necessitating a large plantation to generate viable yields. Large capital inputs are needed, though a well managed operation can be profitable. This section provides more information on the profitability of cashew production and includes summaries of gross margin and profitability.



What is a gross margin?

The gross margin represents the difference between gross income and the variable or operating costs for the cashew plantation. The profitability analysis uses a discounted cash flow approach to determine the total annual costs of production and profitability for the farm.

The approach is commonly used to evaluate the profitability of tree crops where there is a significant lag (usually one or more years) between the time when the initial capital cost is incurred and when benefits are received.

Gross margin analysis

Gross margins (Table 1) are a convenient starting point for budgeting enterprises. They can be used as a basis for comparing enterprises or to produce a whole farm budget. The gross margin does not take into account fixed costs such as capital costs, rates, electricity/fuel, insurances, registrations, living allowances and interest. These costs should, however, be taken into account when whole farm budgeting is undertaken.

Table 1. Gross margin per hectare for the 200 ha model cashew farm

Item	$/ha
GROSS INCOME	**4 576.80**
Variable costs	
Preharvest machinery operations (fuel, oil, repairs, maintenance)	87.73
Fertiliser	364.47
Weed control	19.14
Insect and disease control	349.98
Irrigation (water and pumping costs)	107.38
Harvesting, packaging and freight	446.06
TOTAL VARIABLE COSTS	**1 374.77**
GROSS MARGIN PER HECTARE	**3 202.03**

Profitability analysis

A profitability analysis (Table 2) uses a discounted cash flow technique to determine the annual cost of production and profitability. This technique reduces the time stream of costs and benefits to an equivalent amount of today's dollars. That amount is known as the present value of the future stream of costs and benefits. The present values are calculated using compound interest and a specified discount rate (in this case 8%).

The three profitability criteria used were:

- equivalent annual return
- internal rate of return
- discounted pay back period.

Equivalent annual return

The equivalent annual return represents the difference between the present value of cash inflows and the present value of cash outflows expressed on an annual basis.

Internal rate of return

The internal rate of return represents the real value of interest, which equates the present value of benefits and costs. An internal rate of return greater than the borrowing rate implies that a project can be completely financed from borrowed funds.

Pay back period

The pay back period represents the time required for the discounted cumulative cash inflows to become greater than the discounted cumulative cash outflows.

Table 2. *Summary of profitability results for a 200 ha cashew farm at average prices[1] and yields[2]*

Item	$
Establishment costs (including land)	1 606 200
Discounted cash flows on an annual basis	(8%)
Cash inflows	690 401
Less	
Cash outflows (operating)	489 110
Full-time labour (including owner/operator)	96 000
Capital outflows	186 027
Equivalent annual return — net of all operating, labour and capital outflows	144 069
Pay back period	11 years
Internal rate of return	14.3%

1. Farm gate price of $1.63/kg NIS.

2. Full production tree yield of 14 kg NIS from sixth year onwards.

Selecting varieties

Success in cashew production depends to some extent on the correct selection of varieties. Plant the variety that has an upright growth habit and will yield the highest return of good quality nuts. This section outlines the characteristics of a good cashew variety and describes the varieties that are now available.

What makes a good cashew variety?

Cashews do not grow true to type from seed, and seedlings vary in several characteristics including tree growth habit, nut and apple size, shape and colour. Commercial varieties are selected according to several desirable features.

Vegetative growth habit varies from spreading, open trees with few terminal branches to upright, intensive branching trees with a large number of terminal branches. The flower panicles are produced at the end of the branches.

Upright, intensive branching forms have a higher yield potential because of the greater number of panicles per unit area of the canopy. They require less pruning and are easier to manage than spreading forms.

Nut sizes influence kernel size and larger kernels draw premium prices.

Kernel recovery is the weight of kernel expressed as a percentage of the nut-in-shell (NIS) weight. This determines the yield of kernel and the price the processor will pay for nuts sold as NIS. Kernel recovery varies with variety and is commonly 25 to 32%.

Economic assessments indicate that a yield target of 2.8 tonnes of raw NIS/ha is required to achieve satisfactory returns in Australia. At a plantation density of 200 trees/ha, this is equivalent to a yield of 14 kg/tree.

Time of flowering will influence time of nut drop. Crop losses will result if nut drop occurs during the wet season. Flowering must be completed by September to ensure nut drop and harvest is completed before the onset of the wet season.

Breeding program

A joint government and grower research and breeding program is currently developing high yielding varieties adapted to Australian conditions. Varietal performance depends on local climate and the breeding program is assessing hybrids in Queensland and the Northern Territory. Some selections have been made and promising 1988 hybrids are available for test planting from CSIRO's plant industry (horticulture) unit in Darwin. Growers not part of the program are required to enter a testing agreement before propagating and planting this material.

Canopy management

Canopy management is an important crop management operation in cashew. It aims to produce and maintain a tree canopy in a highly productive state, at an optimum size for the particular tree spacing and suitably shaped for machine harvesting.

Young trees

Early canopy management should aim to start branching of the trunk about 100 cm above ground.

This allows for:

- suspension of the 25 mm irrigation poly pipe in the crotch of the branches at about 100 cm above ground level
- access and a 'line of sight' for mechanical harvesting and harvest people
- shaping and training the canopy to a high, conical or inverted 'vase' shape. (Low branches should be removed as they appear.)

Pruning gives several branches, which in turn give a large number of growing points. It maximises branching and increases sites for future nut development.

It is a good idea to stake young trees in areas where high winds can cause them to lean over. You should also stake young trees when vigorous growth results in top-heavy trees because trees are prone to toppling over.

HINT

Pruning achieves a productive canopy in a shorter time compared with not pruning.

Seasonally bearing trees

Pruning should aim to:

- shape trees for effective machinery access for spraying, harvesting
- provide a balanced stable structure
- increase branching for a greater number of growing points
- channel tree energy into production of desirable growth.

Trees should be pruned after the last nuts have been collected and fertiliser applied. This is commonly in November in hot coastal locations and December in cooler inland and highland locations.

Correct pruning will also rectify any problems or potential problems (low branches fouling sweeper or line-of-sight of operators) that were identified during the preceding season.

It will also prevent the canopies of adjacent trees from meeting and becoming intertwined along the row and across the row. Assuming a tree spacing of 8 m between rows and 6 m within the row, this spacing should allow for 4 to 6 years' growth before pruning is needed. During this time active terminals will be produced and farm equipment will be able to move easily along the rows.

Alternatively, pruning along the top and sides of the cashew row (2 to 3 m from the tree line) would produce a hedge effect. Hedging has been used widely in temperate tree crops but has not been tested on cashew in Australia.

Height of pruning should be governed by the reach of equipment, in particular, spraying equipment.

Large numbers of flushing terminals will favour insect attack. Growers should monitor trees continuously to apply timely insect control measures when vegetative and floral flushes are being produced.

Injudicious use of nitrogen (such as applying high rates into and during the peak nut drop period) will cause prolonged flowering, and nut development and nut drop will extend into the wet season. In most cases, this late nut drop will be lost because of harvest difficulties caused by seasonal rains. In addition, the continued flowering and fruiting delays the start of the next vegetative growth phase, resulting in the delay of pruning and other management operations.

High planting densities (6 m x 6 m or 8 m x 3 m) will hasten full light interception (the maximum interception of sunlight per unit ground area) and bring forward the need for canopy management to an earlier age. Less dense plantings (8 m x 8 m or 10 m x 10 m) will delay attainment of full light interception and delay the need for canopy management.

Insect pest management

Insect pest management is a difficult aspect of cashew production. While the selection of a variety, tree management, irrigation and the application of fertilisers are all important for optimal tree growth, your ability to manage insect pests will influence yield and quality.

There are 6 important things you need to consider in a management program for controlling insect pests.

Major pests of cashew

The major pests of cashew identified so far include:

- giant termite (*Mastotermes darwiniensis*)
- mosquito bug (*Helopeltis* spp.)
- mango shoot caterpillar (*Penicillaria jocosatrix*)
- leaf roller (*Anigraea ochrobasis*)
- fruit spotting bug (*Amblypelta lutescens*)
- red-banded thrip (*Selenothrips rubrocinctus*)
- red-shouldered leaf beetle (*Monolepta australis*).

Problems with the chemical approach

The Australian cashew industry is relatively young (less than 20 years old) and the most appropriate pest management practices are continually evolving. As the crop ages and the trees become larger, pest management becomes more complicated. In the past (mainly for research purposes) there has been a tendency to protect the trees at all costs by the overuse and misuse of chemical. There are several problems with this chemical approach.

- The over reliance and misuse of chemical pesticides may result in the development of insecticide resistance, the elimination of natural enemies, environmental contamination, unacceptable chemical residues in the fruit and nuts, as well as concerns regarding workplace health and safety.
- Pesticide applications are a waste of money if the pest is absent or below the economic threshold. An economic threshold is the density at which control measures should be applied to prevent an increasing pest population from reaching the economic injury level. An economic injury level is the lowest population density that will cause economic damage.
- Pesticide applications are costly, particularly when they are poorly timed and applied with inefficient spray equipment. Pesticide treatments need to target the insect's most susceptible stage of life; they must be applied with calibrated spray equipment capable of delivering a lethal dose to all susceptible plant parts.

more info
Monitoring insect pests
This section page 14

Integrated Pest Management

Rather than relying on the exclusive use of chemical pesticides, there is now a tendency to use a range of complementary pest management techniques, some of which are behavioural (pheromone traps), biological (beneficial predators and parasites) and cultural control (mixed cropping) methods. This approach is called Integrated Pest Management (IPM). By using these IPM techniques, growers should be able to reduce the use of pesticides, while still producing quality fruit and nuts.

IPM works by first determining an economic injury level (the lowest pest population density that will cause economic damage) which is considered worthy of attention. The economic injury level can be considered the point at which the damage is roughly equivalent to the cost of control. Pest populations are then accurately monitored and control measures applied only when these populations approach or reach the economic injury level. Monitoring then continues to allow pest populations to be managed at or below the economic injury level. Beneficial insects that naturally attack the pests are also monitored because, in some cases, they alone will be sufficient to keep the pest populations under control.

Tree growth patterns

Successful insect pest management depends on an understanding of tree growth because most of the major insect pests feed exclusively on new vegetative and floral growth. Temperature and rainfall can influence tree growth patterns and by monitoring growth you will be able to identify those periods (during new vegetative and/or floral growth) when insect pests are likely to be a problem.

Although the timing of the various growth phases of trees will vary, all trees will produce essentially similar new growth at roughly the same time of year.

Monitoring tree growth is a relatively straightforward exercise. Choose 10 trees of each of the varieties grown and assess the trees at fortnightly intervals for flushing, flowering, pest activity, etc. Note if the tree is flushing, resting, flowering and setting nuts. Estimate the proportion (percentage) of the total area of the canopy that is taking part in each activity.

Monitoring insect pests

An effective pest management program depends on your ability to check the crop regularly because this will enable you to determine when pests are present. Only when pests are present at damaging levels are chemicals or other control measures applied. This process of checking the crop to determine the need for control is called monitoring. You can do this yourself with some training, but we recommend you use a professional pest monitoring service.

Given that pest monitoring need only occur during periods of flush growth, we recommend that the trees be protected from the moment the buds begin to develop until all new growth is mature. This will ensure a synchronous flush and reduce the period during which insect pest management is required.

If you intend to do your own insect pest monitoring, this is what you should consider.

Training. You will need training and, realistically, it will take the best part of a year to familiarise yourself with all of the pests that are likely to attack each of the flushes. Although there will be some overlap between flushes, you will find each flush has its own insect pest complex. Each pest complex requires its own individual monitoring method.

Apart from visually searching individual terminals, you may also need to use other sampling techniques including sweep nets, pheromone traps, light traps, and coloured sticky cards. Even with training, you may need to use a professional entomologist to help with decision-making and to ensure the most appropriate action is taken.

Major and minor pests. Only a few insects are considered major pests of cashew. A successful monitoring program will depend on your ability to correctly identify the major insect pests and to recognise the minor pests.

Dominant pest or a range of pests. Although one pest may dominate, there is a usually a range of other pests contributing to the overall level of damage. Your decision on whether or not control these pests, or which control tactic is most appropriate, will ultimately depend on which pests are present at that time of the year.

Regular monitoring timetable. You will need to commit to a regular monitoring timetable. During flushing periods you must set aside enough time to monitor each block weekly. The time taken to monitor for insect pests will depend on your experience and the size of the block. As a rough guide, it should take an experienced pest scout about 1 hour to monitor 10 trees. For every 500 trees you should aim to monitor at least 10 evenly distributed trees.

Damage rating system. Many insect pests are difficult to locate. You will need to develop a damage rating system so that pest abundance can be estimated without the need to locate the pest. This means you will have to associate fresh damage with a particular pest.

Making the most of natural enemies

One of the main problems associated with the regular use of chemical pesticides is the elimination of natural enemies. In their absence, both the original targeted pest as well as other secondary pests are able to increase rapidly. If conditions remain suitable, an outbreak is inevitable and the application of another chemical pesticide will be required.

Given a chance, natural enemies such as the green ant (*Oecophylla smaragdina*), meat ant (*Iridomyrmex sanguineus*), mantis, predatory bugs (for example, *Geocoris australis*) and spiders can exert significant control over some major pests such as the mosquito bug, mango shoot caterpillar, fruit spotting bug and leaf roller. Under favourable conditions, for example, the green ant can minimise damage from several major insect pests, thereby eliminating the need for insecticide applications.

Natural enemies occur in the native bushland of northern Australia. If natural bushland is left around the plantation, leaving a 15 m mown area between bushland and trees, it will enhance the diversity of natural enemies in the plantation. Consider using some of the native tree species preferred by natural enemies as windbreak trees within the plantation to enhance and stabilise populations of natural enemies in the cashew trees.

Insecticide applications

Under the Agricultural and Veterinary Chemicals Code, it is an offence to possess or supply an unapproved active constituent or an unregistered chemical product. Under State legislation, which controls the use of chemicals, it is an offence to use an unregistered chemical product or to use a registered chemical product for an unapproved purpose.

Farmoz endosulfan is the only insecticide presently registered for use on cashew. Unfortunately, all endosulfan products containing 500 g/L of active ingredient are phytotoxic (cause plant damage such as burning of leaves and fruit) on Brazilian cashew varieties (including

Brazilian hybrids). Attempts are now under way to apply for an off-label permit to use a range of insecticide products that are registered for use on plantation crops in general. Those currently under consideration include carbaryl, *Bacillus thuringiensis (Bt)*, dimethoate, methadiathon, petroleum oil, pirimicarb and trichlorfon.

A successful insect pest management program depends on well targeted insecticide applications. Irrespective of whether you are using chemical, biological or natural insecticides, effective canopy coverage is essential for maximum control. Adequate coverage may be achieved with either an oscillating boom sprayer or a structurally modified low profile air-blast sprayer with an overhead hydraulic boom. Both sprayers should be calibrated regularly to ensure effective canopy coverage. For effective canopy coverage, growers should maintain all year round a gap of no less than 2 m separating the tree canopies between the rows.

Table 3 indicates rough guidelines for control thresholds for a range of cashew pests.

Table 3. *Rough guidelines for control thresholds for a range of cashew pests*

Species	Control threshold
Mosquito bug	6 – 10% fresh damage symptoms
Fruit spotting bug	6 – 10% fresh damage symptoms
Mango shoot caterpillar	10 – 15% fresh damage symptoms
Leaf roller	10 – 15% fresh damage symptoms
Red-banded thrips	5 – 10% flushing shoots affected
Giant termite	Control immediately when symptoms occur

Nutrition

Good plant nutrition is one of the vital components of achieving high cashew yields. Both deficiencies and excesses of plant nutrients can adversely affect nut yield and quality. Fertiliser use has to be carefully managed to ensure a balanced supply of all nutrients is maintained. Here are the important things you need to know.

How much is enough?

Cashews have developed the reputation of being a 'low input' crop needing little or no fertiliser because they can survive on infertile soils. This is not the case.

To obtain consistently high yields of good quality nuts, cashews need to be supplied with sufficient fertilisers to at least replace the nutrients removed in the harvested nuts. The off-take of nutrients removed from the soil by a cashew tree yielding 10 kg nut-in-shell (NIS) is listed in Table 4.

In addition to the amount of nutrients removed in the apple and nut, cashew trees also remove sufficient nutrients from the soil to grow the vegetative parts, including shoots, branches, leaves and roots produced in each annual crop growth cycle.

The rates of fertilisers recommended previously in Section 3, *Growing the crop* take into account the amounts of nutrients removed to grow vegetative parts and removed in apples and nuts. These amounts can be varied according to the fertility of the soil. Soil and leaf analysis should be used as the basis for calculating fertiliser rates.

Table 4. Estimated off-take of nutrients in 10 kg nut-in-shell

Element	Nutrients removed (g) in:	
	apple (11.5 kg)	nut-in-shell (10 kg)
Nitrogen (N)	98	138
Phosphorus (P)	15	20
Potassium (K)	98	65
Calcium (Ca)	10.5	10
Magnesium (Mg)	10.5	16
Sulphur (S)	9.5	7
Iron (Fe)	2.65	1.9
Manganese (Mn)	0.3	0.3
Zinc (Zn)	0.35	0.35
Copper (Cu)	0.15	0.1

Types of fertilisers

Blended, mixed or straight fertilisers can be used. The final choice will depend on the application method, local availability of different sources, the cost of transport per unit of mineral nutrient, and the number of nutrients that need to be supplied. Some suitable sources for each nutrient are listed in Table 5.

Table 5. Suitable fertilisers for supplying mineral nutrients

Nutrient	Readily available sources	Solubility*
Nitrogen (N)	urea	25
	ammonium nitrate	25
	ammonium sulphate	50
	potassium nitrate	25
	calcium nitrate	30
	mono-ammonium phosphate	25
	di-ammonium phosphate	40
Phosphorus (P)	superphosphate (single and triple)	25
	mono-ammonium phosphate	40
	di-ammonium phosphate	insoluble
Potassium (K)	potassium chloride	25
	potassium sulphate	10
	potassium nitrate	25
Calcium (Ca)	lime	insoluble
	dolomite	insoluble
	gypsum	insoluble
	superphosphate (single and triple)	insoluble
	calcium nitrate	30
Magnesium (Mg)	dolomite	insoluble
	magnesium oxide	insoluble
	magnesium sulphate (Epsom salts)	70
Sulphur (S)	potassium sulphate	10
	ammonium sulphate	50
	magnesium sulphate	70
	gypsum	insoluble
	single superphosphate	insoluble
Iron (Fe)	ferrous sulphate	20
Boron (B)	boric acid or solubor	50

Nutrient	Readily available sources	Solubility*
Zinc (Zn)	zinc sulphate mono-hydrate	insoluble
	zinc sulphate hepta-hydrate	75
	zinc oxide	insoluble
Copper (Cu)	copper sulphate (bluestone)	20
Molybdenum (Mo)	sodium molybdate	50
Manganese (Mn)	manganese sulphate	70

*(kg readily soluble in 100 L of water at 20°C)

When to apply fertilisers

The cashew has a distinct growth cycle of vegetative growth followed by reproductive growth when flowers, nuts and apples are produced. The vegetative growth phase is a period of high demand for nutrients. It is advisable to provide some nutrients at the end of the harvest and before vegetative growth starts.

As the vegetative growth phase coincides with the wet season, leaching can lose soluble nutrients such as nitrogen and sulphur. Any less soluble fertilisers that remain on the soil surface may also be lost by surface flows of runoff water. Solid fertilisers, which are applied as surface dressings before the onset of the wet season, must be irrigated in to minimise potential losses of nutrients by surface flow during the wet season. Losses of soluble nutrients from leaching can not be prevented but applying the minimum rate needed to promote vegetative growth can reduce them.

A major requirement for nutrients occurs during flowering and fruit development. It is important that fertilisers are applied at the onset of flowering for maximum panicle development. Further applications of nutrients can also be made between peak flowering and peak nut development to ensure that nutrient limitations do not cause premature nut drop and reduced yields.

Application methods

Surface or ground application

Insoluble fertilisers (Table 5) are applied to the ground surface by hand or by using a mechanical spreader. With both methods, it is best if the fertiliser can be placed in the 'feeder' root zone, that is within the dripline of the canopy and about 50 cm from the trunk.

Soluble fertilisers

Soluble fertilisers (Table 5) can be applied either as surface dressings or through the irrigation water as fertigation. If they are applied as surface dressings, they should be irrigated into the soil to prevent losses by volatilisation (especially for urea and ammonium-based fertilisers).

HINT
Seek professional advice from an experienced irrigation designer before setting up and operating a fertigation system.

Fertigation

Fertigation is recommended for application of soluble fertilisers because:

- it uses less labour
- fertilisers can be applied closer to the ‘feeder’ root zone
- fertilisers can be applied more conveniently and more regularly.

With fertigation, the irrigation system must be managed more carefully to prevent salt build-up and possible acidification of the root zone. The fertiliser is dissolved in a drum or tank and the concentrated solution is sucked or injected into the watering system. Fertilisers used must be highly soluble to avoid pump damage or pipe blockages. Before you start fertigating, get a water-testing laboratory to analyse your irrigation water. Make sure an iron test is included.

When fertigating, use a three-stage application. Irrigate for a while until the soil is moist and then inject the fertiliser. After injection, continue irrigating for a while to flush any fertiliser residues out of the system. Flush the system regularly with a small amount of chlorine because fertigation can lead to the accumulation of algae in the irrigation system.

Foliar sprays

It is more efficient to apply the micro-nutrients (zinc, copper, molybdenum, boron, iron and manganese) as foliar sprays than as soil dressings or through the irrigation system. As foliar sprays, they can be applied on an as-needed basis and can be incorporated into insecticide/fungicide sprays being applied at the same time. An additional advantage is that the nutrient can be applied directly to the target tissue. This overcomes problems associated with soil applications of zinc and copper where these nutrients become unavailable to the plant because of low soil moisture in the top 5 cm of the soil.

Table 6. *Optimum concentrations of products for foliar spray applications*

Nutrient	Product	%	Concentration (g of product/L)	Notes
Zinc (Zn)	zinc sulphate heptahydrate	0.5	5	Add 3g/L of calcium hydroxide to prevent foliage burn
Copper (Cu)	copper sulphate (bluestone)or copper oxychloride	0.5	5	Add 3g/L of calcium hydroxide to prevent foliage burn
Boron (B)	boric acid or solubor	0.1	1	
Molybdenum (Mo)	sodium molybdate	0.05	0.5	
Manganese (Mn)	manganese sulphate	0.5	5	
Iron (Fe)	ferrous sulphate	0.5	5	

Care should be taken when applying zinc sulphate heptahydrate and copper sulphate to avoid damage to the leaves, flowers and fruit caused by the acidic nature of straight solutions of these products. The addition of calcium hydroxide will neutralise this acidity. There are optimum concentrations at which the different products should be applied (Table 6).

Dried tissue analysis

Analysis of leaf samples should be part of a nutrient management program. Buy a tissue sampling kit from your local farm supply store (or use a consultant). Follow the instructions and send the sample away for analysis. The suggested leaf tissue to be sampled is the largest mature leaf of the pre-floral vegetative flush. Collect 4 leaves per tree from at least 16 trees/ha. Adequate ranges to aim for are shown in Table 7.

Table 7. *Suggested deficient and adequate ranges for nutrient concentrations in the youngest mature cashew leaf on non-flowering branches sampled during the pre-floral flush*

Nutrient	Range	
	Deficient	Adequate
Nitrogen (%)	<1.4	1.4 – 1.8
Phosphorus (%)	<0.1	0.12 – 0.14
Potassium (%)	<0.68	0.72 – 1.1
Calcium (%)	<0.11	0.24 – 0.75
Manganese (%)	<0.11	0.22 – 0.31
Sulphur (%)	<0.08	0.11 – 0.14
Copper (mg/kg)	<7	>7
Zinc (mg/kg)	<12	>20
Manganese (mg/kg)	<26	91 – 204
Iron (mg/kg)	<92	148 – 165
Boron (mg/kg)	<39	56 – 67

Postharvest soil analysis

Samples should be analysed at least once a year to monitor soil fertility. Buy a soil sampling kit from your local farm supply store (or use a consultant). Follow the instructions and send the sample away for analysis. The optimum nutrient levels to aim for are shown in Table 8. Discuss your results with your farm supply agent or consultant and work out how much fertiliser is needed to adjust all nutrients to the desired levels.

Table 8. *Suggested levels of nutrients in soil for interpretation of soil test data*

Parameter	Level	Notes
pH (1:5 water)	6.0 – 6.5	satisfactory
Electrical conductivity (ds/m)	<0.15	low (good)
	>0.30	medium (undesirable)
Phosphorus (bicarbonate) (mg/kg)	<30	low
	30 – 50	adequate
	>50	high
Potassium (cmol$^+$/kg)	<0.1	low
	0.2 – 0.4	adequate
Calcium (cmol$^+$/kg)	1.6 – 1.8	adequate
Magnesium (cmol$^+$/kg)	0.2 – 0.3	adequate
Zinc (mg/kg)	<0.5	low
	0.5 – 1.0	marginal
	>1	adequate
Copper (mg/kg)	<0.3	low

Irrigation

Although the cashew trees may not show it, water stress at critical times in the development of the crop can dramatically affect nut yield and quality. Careful management of irrigation is a key factor in achieving good plantation performance. Here are the main things you need to know.

HINT

For irrigation assistance contact your local DPI, state agriculture department, CSIRO or a competent horticultural consultant. See Contacts, Section 6.

Water usage

Quantity required

Assuming a maximum of 3.5 ML/ha is required annually, then a 200 ha cashew plantation will require 700 ML at mature production levels each year.

Quality

No specific quality standards apply to cashew irrigation, however, the general water quality standards can be used. Electrical conductivity of irrigation water should not exceed 0.8 dS/m and total dissolved ions should be less than 600 mg/kg (ppm).

HINT

For more information on irrigation allocations, licensing and legislation, contact the water resources section of your state government water resource authority.

Water source

The source of the irrigation water, its volume capacity and its distance from the trees determines the design of the irrigation system. Water source also influences the degree and type of filtration required and whether settling ponds or tanks will be need. Pumping from a bore with clean water will give the cheapest filtration costs, whereas water from a dam may need multiple media filters, disc filters, etc.

Water cost

If you are in an irrigation area you will have to pay for each unit of water delivered. If you are licensed to pump from a river or bore, or have your own dam, you will pay a licensing fee only.

Scheduling irrigation

Evaporation methods

If you measure or know the evaporation rate in your area, you can use this to schedule irrigation; that is to decide when and how much water to apply. By multiplying the daily evaporation rate times a 'crop factor' (K_c), you can calculate the maximum daily water use per plant. For cashews, K_c varies from about 0.8 at peak flowering to 1.1 at peak nut set. By knowing your calculated daily water requirement and the precipitation rate of sprinklers or drippers, you can calculate how many hours of irrigation are required.

It is highly unlikely that rain will fall from May to October in northern Australia. Evaporation-based methods require a considerable level of experience to be predictive, and suffer from not actually relating plant water demand to soil supply capacity.

Soil-based methods

There are a multitude of soil-based methods, varying enormously in accuracy, cost and expertise required. Generally, the higher the cost, the more accurate and the more demanding the system. Table 9 shows some of the more common soil-based methods and their advantages and disadvantages.

Table 9. *A comparison of soil-based irrigation scheduling methods*

System	Approximate cost ($)	Advantages	Disadvantages
Tensiometers	100 – 1000	Cheap, easy to make	High maintenance, small sensor
Capacitance probes (i.e. Enviroscan)	15 000	Constant logger, reliable, accurate, real time	High costs, limits on sensor numbers, installation errors, training
Neutron probe	10 000	Accurate, reliable, no limit on sensors	Radiation hazard, high cost, labour intensive, requires calibration, not real time measurement, training
Starlogger	5000	Relatively cheap	Requires calibration, reduced accuracy, records moisture tension only
Gopher	1650	Cheap, accurate, portable	Installation errors, labour for reading

To schedule irrigation you not only need an effective soil moisture sensor, you also need an awareness of plant available water capacity, that is how much water your soil can store between the full and re-fill points. If you are using tensiometers or Starloggers, you need to know the soil moisture 'tensions' at irrigation on (refill point) and irrigation off (full point).

Irrigation rates and timing

Cashews need irrigation from the onset of flowering through to late nut set. Supplementary irrigation for younger plants may be required during drier parts of the year and to assist with fertiliser applications.

Trees irrigated with sprinklers will need about 500 L/tree/week; from drip irrigation about half this amount. Tree water use will increase from early flowering through to peak nut set; thereafter it will decline. You should stop irrigating just before starting harvest, to avoid nut germination on the ground.

Application systems

Fertigation

Fertigation is effective for cashews. You may use direct injection, venturi injection or pressurised dilution tanks. Fertigation should start at the onset of flowering through to peak nut set.

Certain soil types (sandy soils) have high percolation rates when water is applied through drip irrigation. It is very important to know when water is moving out of the root zone (drainage) as it will carry fertilisers with it. Excessively high concentrations and frequencies of fertigation in soils may lead to high soil electrolytic conductivity levels (more than 0.3 dS/m), and possible growth retardation.

Automation

The location of solenoid control valves to split irrigation into stations should be determined during the irrigation design phase, taking into account emitter types chosen, pumping capacity, pump duty and variations in soil types. A suitable irrigation controller can be linked to irrigation solenoid valves and your irrigation designer can install the pump.

Application systems

Growers may choose from drippers, drip tape and micro-sprinklers. The requirements, advantages and disadvantages are shown in Table 10.

Table 10. *A comparison of application systems for irrigation*

System	Volume required (L/tree/week)	ML/year	Installation costs	Approximate irrigation hours /week	Problems
Micro-sprinklers	500+	3.5	high	10 – 15	Low precipitation rates
Drip tape	250+	1.75	low	14 – 28	Very high precipitation rates, reduced wetted areas
Drippers	250+	1.75	medium	10 – 30	Reduced wetted areas, medium precipitation rates