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## Growing jujubes in Western Australia

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# Growing jujubes in Western Australia



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Department of  
**Agriculture and Food**



# Growing jujubes in Western Australia

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Development officer  
June 2014



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## Executive summary

The Chinese jujube (*Ziziphus jujuba* Mill.) is one of the most important fruit crops in China and has been commonly used as a traditional Chinese medicine and food for thousands of years. The jujube is widely grown in China with cultivation records going back more than 3000 years and can also be found in neighbouring countries.

The jujube is a medium-sized tree, growing 7–10 metres high. The tree has shiny deciduous foliage and produces a fruit that is known as a drupe.

The fruit varies in size depending on the cultivar, and it has a thin, dark red skin surrounding sweet, white flesh. The fruit is very nutritious with potassium, phosphorus, calcium and manganese being the major mineral components, as well as iron, sodium, zinc and copper.

The jujube is a rich source of vitamin C and B-complex. The vitamin C content is higher than other fruits which are well known for high content such as oranges. The antioxidant capacity of fresh jujube is also relatively high compared with other vegetables and fruits.

Jujube fruits are eaten fresh, dried or processed as ‘Chinese dates’ which have been used in confectionery such as breads, cake, candy, compote and jam.

In Western Australia, jujubes are grown in the Perth Hills, the northern Rangelands, the South West and Great Southern regions. In eastern Australia, jujubes can be found in a few properties in Victoria and South Australia.

Small quantities of jujube are sold at local markets and some Asian supermarkets in Perth. Fresh jujubes sell in Perth at wholesale prices of \$10–19 per kilogram (2014). Dried product imported from China is sold in some health food stores at \$5–7/kg. Local dried, candied jujubes sell for \$20 per kilogram.

Western Australia’s proximity to South East Asia and its counter-seasonal production to the northern hemisphere provide an opportunity to market product in these places to cater for the increasing demand, especially during festivals. Target markets include China, Singapore, Malaysia, Hong Kong and Taiwan.

The jujube industry in Australia has potential to be a new profitable agricultural business to meet the requirements of domestic and overseas markets.





# Establishing a jujube orchard

## Climate and soils

The jujube has a lower water requirement and higher salt tolerance than most fruit crops. The tree adapts to drought conditions and not only survives but also produces reasonable yields under severe drought.

Under natural conditions the tree forms a deep and substantial taproot, making it drought tolerant. The jujube grows best in climates with a long, hot, dry summer after adequate rain early in the season and cool temperatures during its dormancy.

In Western Australia, jujubes are grown in areas with around 200–1000mm annual rainfall.

The chilling requirement depends on the cultivar and can range from 775 to 1737 hours at less than 7.2°C. Low to medium chill varieties would be best suited to WA and require 775–1015 hours.

Fruit set requires average daily temperatures above 20°C. Fruit development requires average daily temperatures over 24–25°C.

Jujubes grow well on a variety of soils. The tree prefers sandy loams or lighter soils but will grow on heavier clays. The tree can tolerate saline, alkaline or slightly acidic soils but grows best in soil with pH 4.5–8.4 (see Table 1).

**Table 1** Natural growing conditions of jujube in China (Liu 2003)

Item	Value
Annual average temperature (°C)	5.5–22
Average temperature of flower season (°C)	≥22–24
Minimum temperature (°C)	38.2
Frost-free period (days)	≥100
Annual rainfall (mm)	87–2000
Annual sunshine (hours)	≥1100
Soil depth (cm)	≥30
Soil pH	4.5–8.4
Soil NaCl (%)	≤0.15
Soil Na <sub>2</sub> CO <sub>3</sub> (%)	≤0.3
Soil Na <sub>2</sub> SO <sub>4</sub> (%)	≤0.5

## Salt tolerance

Chinese jujube is known for its salt tolerance but varies between cultivars. In Western Australia trees have grown successfully using irrigation water with an electrical conductivity of 320 millisiemens per metre (mS/m).

## Varieties

There are close to 1000 cultivars of jujube recorded in China and the number will increase continuously as new cultivars are developed and local traditional cultivars identified.



**Figure 1** Chinese jujube orchard at York, WA under net

There is enormous variation among cultivars which can be classified into five groups based on the use of the fruit: fresh; dried; candied; multipurpose and ornamental.

In Western Australia around 15 recognised varieties are grown including Li, Chico, Don Polenski, GA866, Suimen, Thornless, Lang, Silverhill, Sherwood, Shanxi-Li, Redlands, Admiral Wilkes and Si-Hong.

The main rootstock used is Jin-Si-Lin, grown from sucker beds, with the chosen scion variety grafted on using a cleft graft. The varieties Chico and Li are most favoured fruit in the current local market.

## Orchard set up

Conventional jujube orchards are planted at 4–5m x 5–6m. In China, intensive orchards are planted at 2–3m x 3–4m, 1m x 2m in planned intensive planting, 0.5–0.7m x 1m in super-intensive plantings and protected plantings in greenhouses. In WA the number of trees planted per hectare ranges from around 550 to 1000.

Prior to planting, pits of 0.6–1m cubed are dug at appropriate distances depending on orchard density. The pits are filled with original soil mixed with manure, superphosphate and urea. Transplanting trees in the field is most successful at bud burst.

Jujube trees can be damaged by winds so windbreaks are advised if the site is susceptible to strong prevailing winds. Netting is recommended to protect jujube orchards from birds, rabbits and kangaroos (Figure 1).

It is estimated that establishment costs for a one hectare netted jujube orchard with drip irrigation (including pump, main and submains and installation) is over \$90 000. In the current market it is estimated that it would take seven years until cash flow becomes positive.





# Managing a jujube orchard

## Soil management

Chinese jujubes grow well on a variety of soils. The tree prefers sandy loam or lighter soil but will grow on well drained clays. It can tolerate saline, alkaline or slightly acidic soils. While they can grow in a range of soils, improvement of acidic, alkaline, salty and sandy soils will improve growth and production.

## Nutrient management

The key times for nutrition are:

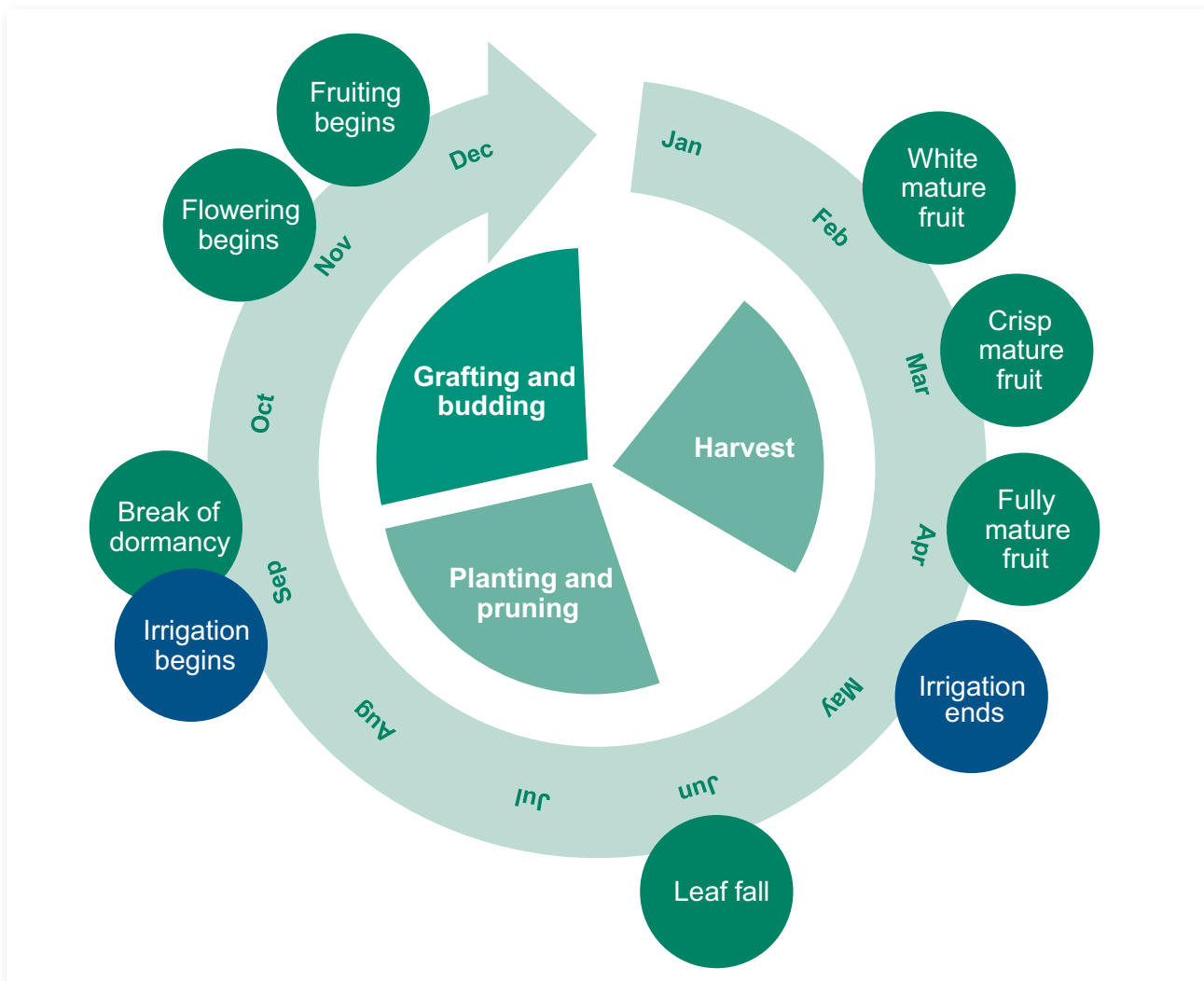
- before bud burst (September)
- early flowering (October/November)
- rapid growth stage of young fruit (December)
- immediately after fruit harvest (April/May). See Figure 2.

Jujube orchards in Western Australia will need a balanced nutrient program supplying nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg) and trace elements at rates depending on soil fertility, tree age and cropping levels. With deciduous orchards the best time to apply the main annual dressing of NPK is in early spring.

Recommended fertiliser programs for jujubes in Western Australia have not been developed and new growers can be guided by fertiliser programs for other deciduous orchard species grown in WA. It has been estimated that 100kg of high quality fresh fruit removes 0.75kg of nitrogen, 0.44kg of phosphorus and 1.1kg of potassium.

Composted or conditioned (treated) poultry manure can be used as a general nutrient source. Raw manure should not be used because of the risk of fly breeding and nutrient leaching. If used, treated manure is best applied in early spring.





**Figure 2** Jujube production cycle in Western Australia

## Irrigation

Jujube trees can survive with very little water, however, strategic irrigation can improve fruit set, reduce fruit drop and improve fruit size, yield and quality.

The key times of irrigation are:

- before bud burst (September)
- early flowering (October/November)
- rapid growth stage of young fruit (December)
- immediately after fruit harvest (April/May).

Soil characteristics will influence the type and timing of your irrigation program. Moisture will drain towards the root zone and plant utilisation and water use efficiency will depend on how long it is held there.

Micro-sprinklers are a good option for tree crops such as jujubes. Compared to larger sprinklers they are efficient, saving water by only watering the ground under the trees and not the inter-rows. They work on lower pressure and are cheap to run. Trickle and drip irrigation are efficient, economical systems that are well suited to jujubes.

The trees require approximately 3–8 megalitres per hectare (ML/ha) over the summer months.

## Scheduling irrigation

Scheduling depends on either measuring soil moisture in the root zone with a moisture meter, or measuring daily evaporation rates. The measurement is combined with a 'crop factor', which is a measure of the crop's water harvesting characteristics. It is affected by the root structure and the soil volume from which the roots can extract water. Current water use varies between growers and regions from 3 to 8ML/ha. Table 2 shows water consumption and crop coefficient of jujubes grown in China.

**Table 2** Water-consumption regulation and crop coefficient of jujube in the Loess Plateau of China where  $ET_0$  is reference evapotranspiration,  $ET_c$  is crop evapotranspiration

Phenological period	Growth days	$ET_0$ (mm)	$ET_c$ (mm)	Water consumption rate (mm/d)	Crop coefficient ( $K_c$ )
Sprout-leaf development	31	137	68	2.20	0.496
Flowering and fruit set	41	178	117	2.86	0.681
Fruit development	49	178	224	4.58	1.262
Fruit maturity	33	70	66	2.01	0.944
Whole growth	154	563	476	3.09	0.846

## Training and pruning

Training is carried out during the first three to five years of growth (see Figure 5). The common forms for conventional orchards are central leader, open centre or modified leader systems, and for intensive planting systems, Y type, dwarf pyramid, pillar, espalier, and spindle have been tested with success in China.

Pruning methods are determined by patterns of fruiting. Pruning can be done in both the dormant and growing seasons. Dormant pruning is done mainly to remove shoots that are incapable of producing fruit of suitable size and quality such as weak, diseased, pest-damaged and crowded shoots. Summer pruning includes removing useless or crowded sprouted buds and new shoots and damaged and diseased shoots. Summer pruning has been shown to be very effective on young and adult trees.

The tree can be trained to a certain shape with or without a central leader by training permanent branches. In general, about six to eight primary branches are kept within a height of 3 to 5 metres and well spaced in all directions. Jujubes need to be pruned annually to enable the tree to bear a full crop.

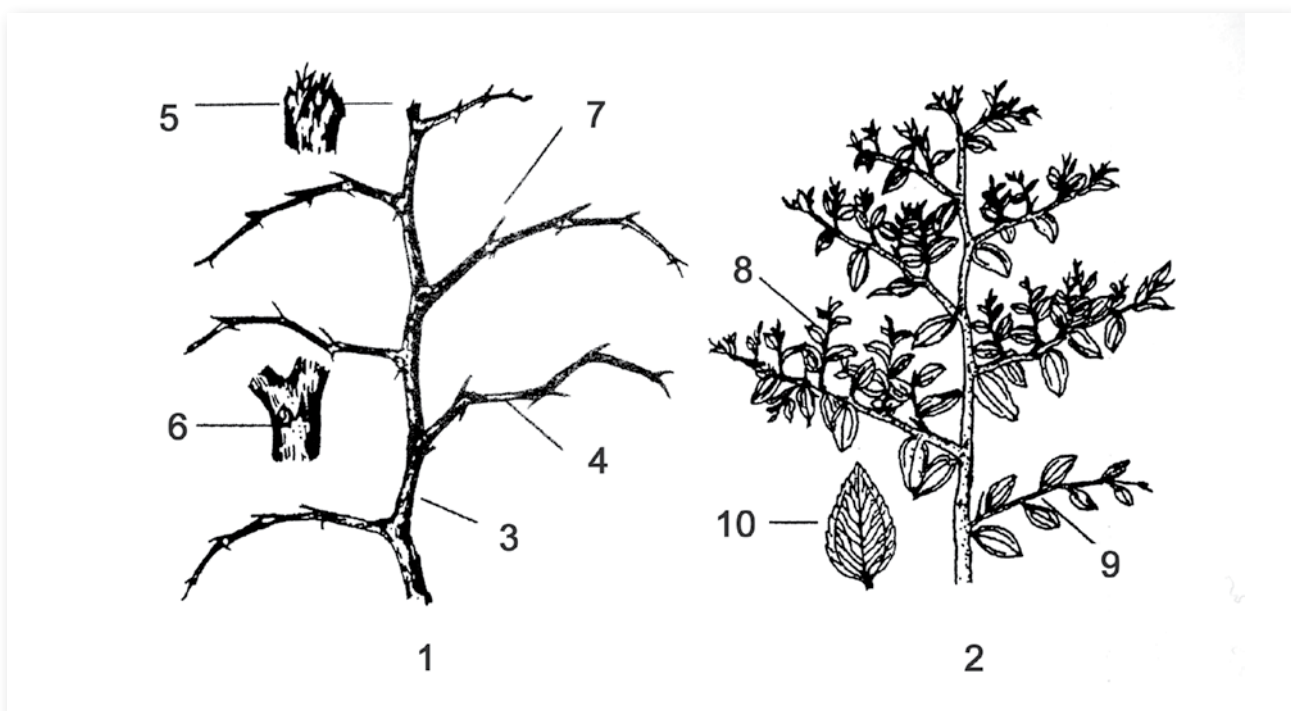
In the first season after planting a grafted tree carry out first training pruning during the dormant season:

1. Cut the dominant central leader shoot at about 50cm.
2. Cut the next three top side shoots back to one to two buds long.
3. Bend down horizontally any side shoots that are too upright.
4. Cut other side shoots back to five or six buds. Only cut to length, never trim any of the lateral shoots coming off the side shoot.



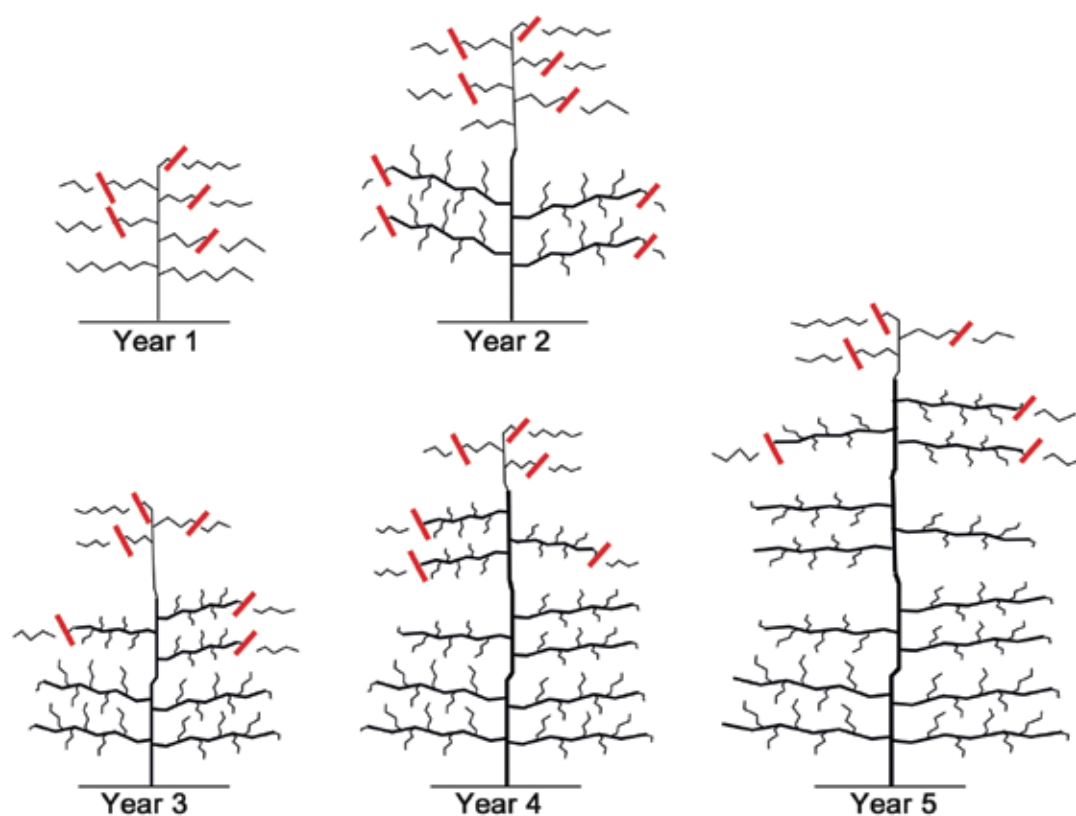
Repeat this pruning strategy each year until the tree is about 3m high. Side shoots need to be monitored during the growing season and pulled down to horizontal if growing too upright. Side shoots that get too long need to be trimmed back as soon as possible to the preferred length. To slow upward growth, the top central leader should be cut at the preferred height during the growing season while the shoot is thin.

If the central leader stem gets too thick before cutting, it will likely reshoot with a new vigorous shoot. When side shoots (fruiting arms) get too thick and old, they will start to develop new strong shoots near to the main central leader. When this occurs it is a sign that the fruiting arm needs replacing. Cut the old fruiting arm back close to the main central leader, but at a point where a suitable new horizontal shoot has grown. This new shoot will become the replacement fruiting arm (see Figures 3 and 4).



**Figure 3** Structure of one-year-old shoot of Chinese jujube (Liu 2006)

1. Shoot system in dormant season
2. Shoot system in growing season
3. Extension shoot
4. Secondary shoot
5. Top main bud
6. Lateral main bud
7. Stipulary spine
8. Bearing shoot
9. Deciduous secondary shoot
10. Leaf



**Figure 4** Recommended pruning methods to train jujube trees from the first year of planting

**Figure 5** Jujube scion bud grafted onto rootstock



## Propagation

Until recently Chinese jujube was propagated primarily by root suckers in China. More farmers in China now graft or bud onto seedling rootstocks. More than 95% of grafts take successfully if scion wood is coated with a thin layer of wax. Tissue culture has successfully been used for propagation but commercial production by this technique is still under development due to the requirements on high skill and expensive facilities.

In Western Australia trees are mainly propagated by budding or grafting. (Figure 5) Budding is performed in November and December with a success rate of around 50%. Grafting is carried out from September to the end of November with success rate of 60–100%. Suckers from established trees are used as rootstock. To encourage suckers, the roots can be cut with a rotary hoe in winter.

## Grafting

Rootstocks used in northern China are Chinese jujube and its direct ancestor sour jujube (*Z. acidujuba*). In Western Australia, jin-si-lin is used as a rootstock.

Fully matured jujube stones and kernels can be used to grow rootstock seedlings. The stones need to be stratified in moist sand for three to five months at 2–5°C before sowing. Kernels are then removed from the stone and soaked in water for 24–48 hours. In early spring treated seeds are sown at a distance of 10–15cm in rows and 40–50cm apart. Seedbeds are covered with plastic film to promote germination.

Seedlings are used for grafting after one year with wedge or cleft grafting the preferred method. The five to six weeks around bud sprouting is the best grafting time. Scions from one to two-year-old extension shoots have been very successful. To prevent water loss the scions should be dipped briefly in paraffin at 100–110°C. The scion, if successful, will burst into growth and should produce some fruit in the first year.

## Pests and diseases

Jujube fruit shrink disease has recently been found in Chinese jujubes in Western Australia. No other major diseases have been found.

Pests include rabbits, kangaroos and birds but these can be controlled by fencing or netting the orchard. The jujube is susceptible to Mediterranean fruit fly (Medfly) so a baiting program may be required. Three main control strategies are recommended:

- cover spraying
- bait or spot spraying
- lure and kill devices.



The effectiveness of these control techniques should be monitored with traps. Medfly not only affects crop production, but limits access to interstate and overseas markets.

Some 86 kinds of pest and 10 kinds of diseases have been reported to be harmful to jujube overseas.

Among diseases, witches broom, fruit splitting and rust are the most serious. Table 3 shows a list of major pests and diseases of jujubes in China.

Fruit splitting is an issue in Western Australia. It is a water-related physiological disorder and can ruin a large percentage of the crop in some years. The severity of the problem depends on water management throughout the growing season, rain around fruit maturation, and cultivar resistance. Maintaining soil moisture during the growing season will help reduce splitting but resistant varieties are the best option.

### Bird control

Parrots are the most damaging pest to small and/or relatively isolated orchards. The rainbow lorikeet has also become a serious pest in some fruit growing areas where it can pose an even greater threat to crops than twenty-eight and red cap parrots.

Bird control methods include:

- **Exclusion netting:** Although expensive (approximately \$30 000/ha) this method will also alleviate the effects of extreme weather events such as hail storms and hot temperatures (sunburn). When assessing the advantage of netting as a means of bird control, the percentage of crop loss as well as the time spent controlling birds by other methods must be taken into account.
- **Bird scaring devices:** Birds generally become accustomed to scaring devices and noise generators in the orchard and their effectiveness is quickly lost. Varying degrees of control can be obtained by swapping from one device to another and altering their location in the orchard.
- **Culling:** Unless many hours are spent each week keeping pressure on birds by shooting, they will continuously invade the orchard and ruin a large percentage of your crop.

Contact your local Department of Environment Regulation office prior to scaring, or culling birds on your property as permits may be required for some species. Without netting, bird control is time consuming and requires constant commitment to prevent crop damage.

**Table 3** Major pests and diseases of jujube in China

	Scientific name	Common name	Major symptoms
Diseases	<i>Phytoplasma</i> (MLO)	Witches broom	Witches broom effect, tree death
	<i>Phakopsora zizyphi-vulgaris</i>	Rust	Leaf rust and early drop
	<i>Colletotrichum gloeosporides</i>	Bitter rot	Fruit rot and early drop
	<i>Alternaria alternata</i>	Black spot	Dark round or elliptical lesion
	<i>Phoma glomerata</i>	Jujube fruit shrink disease	Bitter pulp, early drop
Pests	<i>Carpasina niponensis</i>	Peach fruit moth	Eating pulp, early fruit drop
	<i>Chihuo zao</i>	Jujube looper	Eat open bud and young leaves
	<i>Ancylis sativa</i>	Armyworm	Eating leaves and fruit
	<i>Cnidocampa flavescens</i>	Oriental moth	Eating leaves
	<i>Zeuzera</i> sp.	Leopard moth	Eating pith of stems or shoots
	<i>Ceroplastes japonicus</i>	Japanese wax scale	Sucking sap from shoots and leaves
	<i>Lygus pratensis</i>	Tarnished plant bug	Holes in leaves and flower bud fall
	<i>Scythropus yasumatsui</i>	Beetle	Eat open bud and young leaves
	<i>Contarinia</i> sp.	Midge	Sap sucking causing withering of young leaves

## Flowering

Chinese jujube blooms in early summer and fruit ripens in late summer/autumn but flowering time can vary at different locations and depends on cultivar and climate. Flowering of jujubes generally occurs over an eight week period in summer. The trees flower from November to December in Western Australia, with fruit starting to ripen at the end of February.

Flowers occur in the axils of the leaves on the current bearing shoots. They are short stemmed, light green to yellow and 3–10mm in diameter (see Figure 5). Flower buds complete differentiation and development to mature fruit within a single growing season.

While most cultivars are self-fertile, pollination can be enhanced through the introduction of bees. Pollen is sticky and therefore wind pollination is ineffective. Pollen viability is low in most cultivars. Jujube trees typically have abundant flowering but low fruit set.

Heavy fruit drop occurs after fruit set, caused by lack of fertilisation or degeneration of the ovule. Soil moisture stress, low relative humidity, lack of sunlight and strong winds during fruit maturity can also lead to fruit drop.

Measures to improve fruit set include:

- trunk girdling during flower season
- heading back current year shoots
- keeping bees in orchard during flower season
- two to three sprays of 10–20ppm gibberellic acid (GA<sub>3</sub>) or 0.2% borate during flowering season.

The pre-harvest fruit drop can be prevented via a spray of 10–20ppm naphthaleneacetic acid (NAA) four weeks before harvest.



**Figure 6** Jujube flowering in December in York, WA

## Fruit development

The time for fruit maturation varies among cultivars from 60 to 145 days. Fruit development is slightly longer in warmer climates and shorter in cooler climates. In York, fruits start to form in early December, a month after flowering. In Gidgegannup, Chico and Suimen varieties start to develop fruit in late November, a month after flowering.

The varieties GA866, Li, Thornless, Tarjan, Shanxi-li, Redlands, Sherwood and Si-hong begin to fruit in early December while for Lang, Don Polenski, Silverhill and Admiral Wilkes fruiting begins in late December.



# Handling jujubes

## Harvesting

Jujube fruit matures from February to April in Western Australia. Immature fruits have green skin and will not ripen if picked. Fruit picked later will continue to ripen after harvest. The fruit can be left on the tree to be picked when dried. In full yield, a tree can produce 30–40kg fresh fruit per tree with an estimated yield of 20–30 tonnes per hectare.



**Figure 7** Chico variety of jujube displaying different levels of fruit maturity

Fruit maturation of Chinese jujube can be divided into three phases:

- **White mature:** The fruit is near full size and shape; the skin of the fruit is thin and changes from green to greenish white colour.
- **Crisp mature:** The fruit is half to fully red; the skin becomes thicker, harder and easily separated from the flesh which becomes crisp, juicy and sweet and contains more sugar and acid.
- **Fully mature:** Sugar content of the flesh increases rapidly and water content begins to decrease. The flesh near the stone and fruit stalk becomes yellow and soft. The skin changes to a dark red and fruit becomes wrinkled.

The proper harvesting time depends on the end use of the fruit (fresh consumption, dried or processed). For fresh consumption jujube should be picked at the crisp mature stage to prolong storage life. Fruits to be dried should be picked when fully mature and fruits for candying should be picked at the white mature stage.

In China, fruit harvested for fresh consumption is usually hand-picked. Fruit that is dried can be left on the tree until it drops or harvested by shaking the tree or branches.

Chemical harvest is recommended for dried fruit in China. Spraying ethephon five to seven days before harvest may increase harvest efficiency by 10 times and is beneficial to increase the yield and quality of dried fruit.

## Postharvest treatment

After harvesting, fruits should be graded according to the degree of ripening and fruit size, then stored under low temperature, dried, or processed. Dehydrated Chinese jujube fruits can be obtained by drying under the sun for about three weeks or in a cabinet drier at 60°C for 36–48 hours until the moisture content reduced to less than 25%. The dried fruit can be consumed as such or further processed into juice, wine, powder and other products.

## Fruit quality testing

Two internal maturity parameters should be tested: total soluble solids and citric acid content (used to calculate sugar-acid ratio). Sugar levels are commonly used in a wide range of crops. The percentage sugar, measured in degrees Brix (°Brix), indicates the sweetness of the fruit by measuring the number of soluble solids in the juice.

A hand-held refractometer can be used to measure total soluble solids (percentage sugar/°Brix). Acid content of juice from jujube fruits can be measured using a pH meter. The sugar-acid ratio contributes to the unique flavour of the fruit and can be calculated by dividing the degrees Brix by the citric acid concentration.

Tests on fruit grown in Western Australia showed that Li had the highest level of total soluble solids (31°Brix) of the three varieties tested and Chico had the lowest (25°Brix). Chico had around double the amount of acid as Li and Suimen and therefore the lowest sugar-acid ratio of the three varieties.

## Storage practices

### Pests and diseases

Jujube fruit is very perishable and highly susceptible to postharvest decay. Blue mould caused by *Penicillium expansum* is one of the most serious postharvest diseases in China.

### Storage and processing

Fresh jujube fruit cannot be stored for a long period under ambient conditions due to its perishable nature. Its shelf life is usually only two to three days without any treatment. Semi-red fresh fruits can be kept crispy for over 100 days if packed in 0.04–0.07mm vented polyethylene bags and stored at -1 to 1°C, with relative humidity and carbon dioxide (CO<sub>2</sub>) concentration kept within 90–95% and 5% respectively. Dried fruit can be stored for up to 12 months in a dry, cool and sheltered environment.

Storage is not an issue in Western Australia yet as demand is greater than supply so the fruit does not get stored for long. However, as the industry grows and fruit is marketed either interstate or overseas then the development of storage techniques and transportation will be a priority.

## Markets

Small quantities of Chinese jujube are grown in Western Australia and sold at local markets and some Asian supermarkets in Perth. There is an opportunity to market the fruit both internationally and into the local market as a fresh or dried product.

Fresh Chinese jujubes are currently sold in Perth at wholesale prices from \$10–19 per kilogram. Dried product imported from China is currently (2014) sold in some health food stores from \$5–7 per kilogram.

Western Australia's proximity to South East Asia and its counter-seasonal production to the northern hemisphere provide an opportunity to market product for the increasing demand, especially during festivals. Target markets include China, Singapore, Malaysia, Hong Kong and Taiwan.

The jujube industry in Australia has the potential to be a new profitable agricultural business to meet the requirements of domestic and overseas markets. The development of a jujube industry will be beneficial in fighting salinity and water shortages which are challenges facing sustainable agriculture in Australia. The formation of the jujube grower group in Western Australia will result in a more cohesive and cooperative industry with common goals which should drive the industry forward.

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