Red Bayberry – a new and exciting crop for Australia?

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Summary

The red bayberry is a unique Chinese fruit crop, mainly cultivated in the subtropical region of southeast China. It has berry-like fruit with a palatable sugar-acid balanced flesh. It is extremely popular in China. The rapid expansion of red bayberry industry in the last two decades in China suggests its potential for worldwide production. Opposite climatic conditions offer Australia an opportunity for counter-seasonal production. The recent study tour was to gain insight into red bayberry production, processing and marketing in China and to examine the possibility of developing an industry in Australia. This report summarises the history, distribution and climatic requirements of red bayberry production in China, and recent research and development of the industry, particularly for germplasm and cultivars, cultivation techniques, disease and pest management, and harvest and handling. The potential development of the red bayberry industry within Australia is discussed in relation to Australian climatic and environmental conditions.

Introduction

The red bayberry (*Myrica rubra* Sieb. & Zucc.) is a unique Chinese fruit crop and has been utilised in China for a long time. It is called Yangmei in China, and grown mainly in the subtropical region of southeast China. As one of the very important fruit crops, the red bayberry industry constitutes a valuable part of rural economics and has contributed greatly to rural development (Miao & Wang, 1987).

With the release of elite cultivars and improved orchard cultivation since 1980, cultivation of red bayberry has become more profitable and the industry has expanded considerably. For example, the average return was reported to be $12,000 per ha on a 32-hectare orchard. In Zhejiang province, the cultivated area increased from 17,500 ha in 1985 and 43,400 ha in 2001, and the annual production rose from 46,200 t to 181,000 t accordingly. This rise in production is expected to continue into the future.

Red bayberry has a berry-like appearance with a palatable sugar-acid balanced flesh. The fruit is actually a stone fruit. It is mainly consumed as fresh fruit and is also processed into juice, canned and dried fruit and wine. The fruit is very popular in China. It is highly agreeable to the 'European' palate. Within improved post harvest technology, it is expected to have potential in the global fruit market.

As red bayberry is a summer fruit crop and fruit is harvested and marketed in a narrow window (May and July) within China, opposite climatic conditions offer Australia an opportunity for counter-seasonal production. It can be marketed domestically or exported to China and other Southeast Asian countries. This would extend red bayberry availability in a global sense, and also provide the Australian industry a great opportunity for diversifying the local industry and strengthening its competitiveness in the world fruit market.

This report mainly describes pre-harvest production techniques of red bayberry in China, based on the information gathered during the visit. It includes notes of discussions with experts, industrial officers, orchard managers and growers and various sources of published information. Post harvest information was excluded from this report. Post harvest handling has been included in the review by Joyce *et al.* (2004) as published in the proceedings of the 2nd Australian New Crops Conference. Botanical details of red bayberry have also been published in English language reviews (Li *et al.*, 1992; Chen *et al.*, 2004).

Past and Current Status of Red Bayberry Production

Red bayberry is a subtropical fruit crop and has a very long cultivation history in China. Both archaeological and written evidence suggests that cultivation of red bayberry took place in China at least in the Han Dynasty (about 2000 years ago) (Chen, 1996). In Chinese ancient literature, there are numerous records on red bayberry's cultivation, cultivars, fruit processing methods and the medical use of red bayberry's fruit, bark and root. Unlike stone fruit crops such as peaches and apricots indigenous to China, red bayberry was principally cultivated more like a forestry tree than as a fruit crop (Miao & Wang, 1987). The only exceptions were in Zhejiang province and part of Jiangsu province, where it has long been cultivated as a fruit crop. Red bayberry production has expanded dramatically in China since 1980 (Li *et al.*, 1992). This is driven by the following key factors:

1. Economical return is higher for cultivation of red bayberry with the use of elite red cultivars and with adoption of improved cultivation practices. Elite cultivars were released after nation-wide collaborative research on red bayberry germplasm during the 1980s. Being derived from traditional and local cultivars, they have excellent productivity and fruit quality (Li *et al.*, 1992). In terms of production and management, good quality trees can be produced with the use of reliable propagation methods. Quality nursery trees, tree training and other management practices have shortened the time from orchard plantation to cropping. Only 3-4 years is required nowadays for new planting orchards rather than 7-8 years in the past. Increased input on canopy management, fertigation and the regulation of tree bearing habit, and the control of diseases and pests, also contribute to high and consistent yield.

2. Red bayberry can grow well in poor (i.e. low fertility) soil as its roots associate with the nitrogen-fixing bacterium *Actinomyces frankia* (Photo 1). Adult trees can fix 0.85 kg N per year (Qi, *personal communication*). Red bayberry possesses its own biological mechanism to improve soil fertility.

3. Red bayberry trees have an even, green round canopy, and a well-developed lateral and fibrous root system but a weak tap root. In high rainfall southeast China, it is the one of the best tree species to reduce soil erosion (Lin, 1996; Xue, 1998).

4. Red bayberry trees show good ability to resist fire (Xue, 1998). In forest plantations, they are cultivated as a belt or strip to isolate or stop fire expansion in areas subject to forest fire.

5. Red bayberry is affected only by a few pests and diseases and is suited to being managed as a form of organic food production. The China Organic Food Development Centre (OFDC) has recently granted a 32-hectare red bayberry orchard in LanXi district organic orchard certification. In CiXi district, there are now about 1,800 ha organic red bayberry orchards.

The total cultivated area for red bayberry is about 210,000 ha in China. In Zhejiang province, the largest producing region, the cultivated area and production were, respectively, 4,400 ha and 26,500 tonnes (t) in 1959, 17,500 ha and 46,200 t in 1985 and 43,400 ha and 181,000 t in 2001. Red bayberry has become second only to citrus among the fruit crops in the province. Yield of red bayberry ranges between 7.5 and 15.0 t per ha. Single trees can

yield between 100 and 150 kg with the highest record of 900 kg in Zhejiang province (Qi, *personal communication*). In LanXi district, a return value of A$ 12,000 per ha was achieved for an average yield of 7.5 t per ha of high-grade fruit. The yield is expected to increase continuously. Most produce is consumed locally, but an increasing proportion is being exported to other regions within China and other countries, such as Japan, Singapore, France and Russia (Chen *et al.*, 2004; Qi, *personal communication*).

Photo 1. A red bayberry orchard planted on poor soil on a hillside in LanXi district.

Distribution and Climatic Requirements

Red bayberry is now distributed south of the Yangtze River and north of Hainan Island, approximately 97° to 122° E longitude, and 18° to 33° N latitude (Fig. 1). It overlaps with the area for citrus, loquat, teas and bamboo. In comparison, red bayberry is more tolerant to low temperature (Maio & Wang, 1987; Li *et al*., 1992; Chen *et al*., 2004). The major production region for red bayberry extends along the southeast coast of China and includes eight Provinces: Zhejiang, Jiangsu, Fujian, Jiangxi, Guangdong, Guizhou, Anhui and Hunan. There is also some production in Yunnan, Guangxi, Hainan, Sichuan and Taiwan.

The entire production area is divided into three large regions according to climatic conditions and the importance of the industry (Miao *et al.*, 1995) (Fig. 1 and table 1).

Region I includes south Jiangsu, Zhejiang, Fujian, Guangdong and southwest Guangxi, mid-west Guangzhou and mid-south Yunnan. Red bayberry orchards are located on rain-fed hillsides or upland in the provinces along the southeast coast, but at high attitude in Guizhou and Yunnan Provinces(Yungui plateau). The temperature ranges from –3.9 °C (± 4.4) to 38 °C (± 2.6) with a yearly average above 15 °C. The annual rainfall is over 1,000 mm in the region with almost one third of that rainfall received between May and June. High rainfall in May and June creates humid conditions (RH≈80%), which is conducive to rapid fruit growth prior to fruit maturation and good fruit quality. Slightly acid red and yellow soils are predominant in the region.

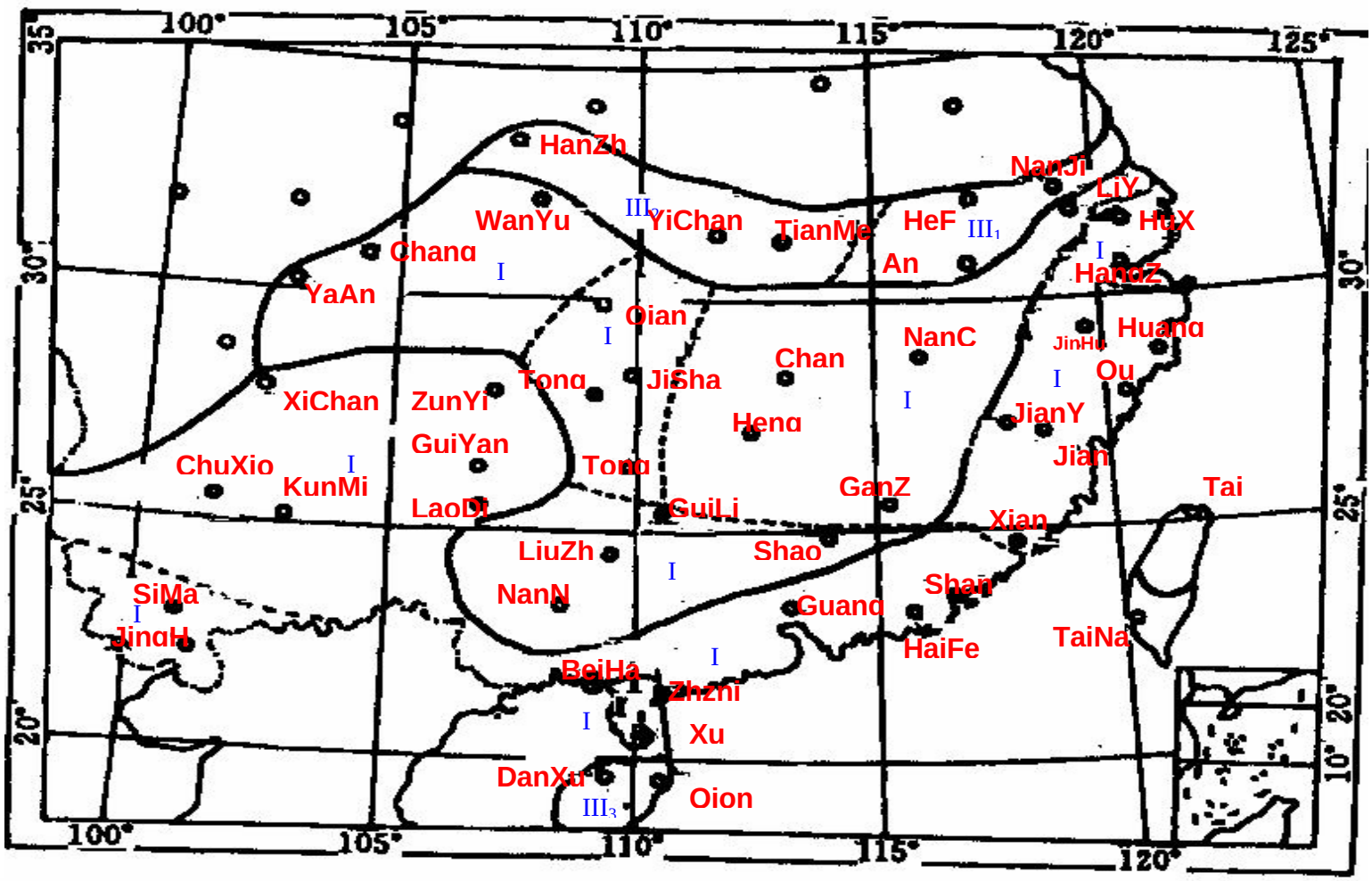

Fig. 1. Ecological distribution of *Myrica* in China (from Miao *et al*, 1995)

Different regions are indicated by Roman numerals I, II and III, and Arabic numerals in the subscript with Roman numerals indicate the subregions.

Table 1. Climatic parameters of *Myrica* production regions in China (data from Miao *et al*, 1995)

	Region I	***Region II***	Region III
Temperature (°C)			
Min.	-3.9 ± 4.4	-6.3 ± 4.8	-7.7 ± 9.5
Max.	38.1 ± 2.6	39.6 ± 1.5	40.0 ± 1.4
Average	18.4 ± 2.6	18.1 ± 2.7	18.4 ± 4.0
Accumulated degree (≥ 10°C)	6174.0 ± 1270.0	5899.0 ± 1186.0	6277.0 ± 1878.0
Rainfall (mm)			
May	183.3 ± 77.6	205.2 ± 70.1	146.0 ± 48.8
June	230.7 ± 67.3	209.8 ± 48.7	183.9 ± 58.3
Annual	1359.0 ± 306.0	1415.0 ± 222.0	1322.0 ± 447.0
Relative humidity (%)			
May	79.0 ± 7.9	80.4 ± 3.3	77.9 ± 4.9
June	82.9 ± 4.3	80.7 ± 3.3	79.2 ± 4.0

Red bayberry has a long cultivation history in this region, and the region is also rich in germplasm and elite cultivars (Table 3). Orchards are managed with improved cultivation practice (Miao & Wang, 1987; Li *et al.*, 1992).

Region II is located from south of the Yangtze River to the northern edge of region I (Fig.1). Climatic conditions and soil types are similar to those in region I with the exception of lower temperature in winter (about 3^{o}C)(Table 1). Fruit quality is poor due to the lack of elite cultivars and the slow adoption of better cultivation practices.

Region III is located north and south of region II (Fig.1). It is the climatic edge for red bayberry cultivation. Yearly average temperature is still above 15 °C, but it is much colder in winter and hotter in summer (Table 1). Relative humidity is relatively lower in May and June due to low rainfall. It is the region where red bayberry grows as wholly wild trees, along with the species *M. edenophora*. Fruit of *M. edenophora* is not edible, and only suitable for making medicine.

Under warm and humid climatic conditions, red bayberry trees exhibit vigorous and healthy growth and have a long bearing life. The trees also exhibit higher productivity and produce large and better quality fruit. Higher relative humidity prior to fruit maturation is particularly important to production of soft and juicy fruit with rounded tips on their papillae, which is preferred by consumers. Conversely, fruit under low humid conditions have more pointed papillae and are comparatively firmer (Qi, *personal communication*). Although pointed papillae and firm fruit are not ideal from a consumer point of view, these fruit can keep longer after harvest (Xi, *personal communication*). The papillae type, either rounded or pointed, is also a significant aspect of a cultivar's character (Miao & Wang, 1987; Xi, *personal communication*). Red bayberry does not have a special light requirement for its growth and development (Miao & Wang, 1987; Li *et al.*, 1992). However, sunny weather during the end of summer to early of autumn favours fruit colouration and the formation of flower buds (Li *et al.*, 1992). A breeze at flowering time can help red bayberry pollination. In Zhejiang province, red bayberry exhibits more tolerance to cold, and also blooms later than other stone fruits (Miao & Wang, 1987), thus there is no record of crop loss due to frost, in contrast to other stone fruits such as peaches, apricots and plums. Red bayberry is prone

to limb breakage and has a shallow root system. Strong wind or cyclone can break branches or even pull trees out of the ground, resulting in excessive crop loss (Miao & Wang, 1987).

Germplasm and cultivars

There are six species of the genus *Myrica Linn* in China, namely *Myrica rubra* Sieb. & Zucc., *M. esculenta* Bunch. –Ham., *M. nana* Cheval., *M. integrifolia* Roxb., *M. arborescens* S.R. Kiet X. L. Hu. sp. nor., and *M. adenophora* Hance. *M. rubra* is a widely distributed species, and can be found across the entire red bayberry growing area; *M. esculenta, M. nana, M. integrifolia* and *M. arborescens* are mainly distributed in southwest China, Yungui Plateau and some parts of Sichuan province; *M. adenophora* only exists in Hainan province (Li et al., 1992; Miao & Wang, 1987; Chen *et al.*, 2004). Botanic information on different red bayberry species can be found in a recent review published by Chen *et al.* (2004).

Red bayberry cultivars all come from the species *M. rubra*. A nation-wide survey conducted in the mid-1980s revealed the existence of about 400 different accessions (Zhuang & Pan, 2001). Of these, 268 were registered as cultivars after the evaluation of their horticultural and fruit characters. Genotypic variation was large for ripening date, fruit colour, size and quality (Table 2). Most of these cultivars are from Zhejiang, Jiangsu, Fujian and Guangdong provinces and a few are from Guizhou, Yunnan and Hunan provinces (Table 3).

Zeng (1935) suggested eight different variants within *M. rubra*: namely, *M. rubra* var. *sylvestris* Tsen, *M. rubra* var. *typical* Tsen, *M. rubra* var. *rosea* Tsen, *M. rubra* var. *alba* Tsen, *M. rubra* var. *nana* Tsen, *M. rubra* var. *astropurea* Tsen, *M. rubra* var. *praemafurus* Li, and *M rubra* var. *conservatus* Li in China. In Miao & Wang (1987)'s opinion, however, it is more proper to regard them as types of cultivars. Nowadays, ripened fruit colour is commonly used as a criterion for cultivar classification, and cultivars can be differentiated into four groups: 'wild', red, black and white (Li *et al.* 1992; Chen *et al.* 2004). Wild type is traditionally used as rootstocks. A few commercial cultivars are available in the other groups (Table 3).

In *M. rubra*, the majority of cultivars are derived from chance seedlings and have been cultivated locally. A few are elite clones or mutants selected in recent decades from elite cultivars (Miao & Zhang *et al.*, 1995; Zheng *et al.*, 2001). In *nana* species, new selections suitable for fresh fruit, processing and ornamental use have been evaluated, but no commercial cultivars have yet been released. No extensive work was conducted on *M. esculenta*, although it produces more sweet fruit and grows as widely as *M. rubra* in Guizhou province (Zou, 2001). Overall, there is no active improvement program for red bayberry in China.

Table 2. Genotypic variation of fruit attributes of 268 red bayberry cultivars in China (data from Zhang and Miao, 1999).

Maturity date		Fruit				Eating quality	
Month	Number (%)	Color	Number (%)	Weight (g)	Number (%)	Rating	Number (%)
April	4 (1.1)	White	25 (9.3)	<6	17 (6.3)	Poor	17 (6.3)
May	17 (6.3)	Pink	15 (5.6)	6-9	69 (25.8)	Below average	48 (17.9)
Early June	36 (13.7)	Red	46 (17.2)	9.1-13	125 (46.6)	Average	102 (38.1)
Mid June	50 (18.7)	Deep red	21 (7.8)	13.1-15	40 (14.9)	Above average	44 (16.4)
Late June	128 (47.8)	Purple	100 (37.3)	>15	17 (6.3)	Good	44 (16.4)
Early July	33 (12.4)	Deep purple	9 (3.4)			Very good	13 (4.9%)
		Purple black	37 (13.8)				
		Jet black	15 (5.6)				

Orchard Cultivation Techniques

Nursery propagation

Red bayberry can be propagated from seeds and by grafting, cutting and layering (Miao & Wang, 1987). Seed-propagated seedlings currently provide rootstocks. There is no general consensus on seed source for rootstock. Seeds of wild trees or cultivars are both suitable, but seed germination is higher for seeds of the wild trees (Xue, 1998). In practice, seeds have to be cleaned well after extraction. Seeds are then mixed with wet sand (3 part of sand to 1 part of seed) and kept moist until densely sown in pre-prepared beds between October and November. The seed rely on winter cold for stratification. Under cover cultivation, seedlings emerge next February. In early spring, seedlings are transplanted in the nursery at a density of 8–10 cm between seedlings and 30-35 cm between rows. Seed germination rate is about 50-60% with the above method (Miao & Wang, 1987). One year growth is needed in the nursery to produce the minimum size of seedling required for grafting (6 mm in diameter).

Best scions are from 1 to 2-year-old matured shoots on 7 to 15-year-old trees. They should be 5 to 8 mm in thickness. The ideal position for collecting scions is on the south and top canopy of the tree, which are exposed to more sunlight. The leaves on the scions should be removed immediately after being taken (Miao & Wang, 1987). The scions should be kept in plastic bags to avoid drying off before being grafted.

The length of scion and grafting time affect the survival of propagated seedlings. Scions about 100 mm in length with more than 10 axillary buds generally have a higher survival rate. The time for scion grafting is between late March and early April in Zhejiang Province (Miao & Wang, 1987; Ye *et al.*, 1995).

Table 3. Name, origin and fruit quality of red bayberry key commercial cultivars in China (data from Miao & Wang, 1987; Miao *et al.*, 1994; Zhang & Miao, 1999).

Name	Origin	Harvest time	*Fruit*			
			Colour	Weight (g)	Brix (%)	Quality rating
Dongkui	Zhejiang	Early July	Deep purple	25.1	13.4	Very good
Biqi	Zhejiang	Late June	Jet Black	10.0	13.0	Very good
Wandaoyangmei	Zhejiang	Early July	Jet Black	11.7	12.6	Excellent
Ding'aomei	Zhejiang	Mid to late June	Purple	11.3	11.1	Excellent
Zaose	Zhejiang	Mid-June	Purple	12.6	12.5	Very good
Chise	Zhejiang	Late June	Red	15.0	12.5	Excellent
Zaoqimianmei	Zhejiang	Eealy or mid-June	Deep purple	9.0	12.4	Very good
Wanqimianmei	Zhejiang	Early July	Purple black	13.0	13.9	Excellent
Zaodaimei	Zhejiang	Mid-June	Purple	15.7	11.0	Good
Dongfengmingzu	Zhejiang	Late June/early July	Purple	25.5	13.4	Good
Shuijingyangmei	Zhejiang	Late June/early July	White	11.4	-	Good
Dayexidi	Jiangsu	Late June/early July	Deep purple	14.7	12.3	Good
Wusuhe	Guangdong	Early June	Purple black	11.5	13.4	Good
Shangchongyangmei	Hunan	Mid-June	Purple black	9.2	12.0	Excellent
Xiechongmei	Hunan	Mid-June	Purple black	9.2	10.0	Very good
Daiyemei	Hunan	Mid-June	Purple	14.6	14.6	Excellent
Niuyemei	Hunan	Late-June	Deep red	8.7	11.0	Excellent
Beimei	Hunan	Mid-or late June	White	11.2	10.5	Good

Table 4. Effect of grafting methods on tree survival and growth (data from Ye *et al.*, 1995)

Grafting Method	Root stock	No grafted trees	Survival Rate[1)]	Growth		
				Shoot length (cm)	Stem thickness (mm)	No branches
Eco-Experimental Station, Changnan						
Nursery cleft	leafed	100	88.0 a	71.3	13.1	4.9
Nursery side	leafed	100	80.0 a	47.3	10.6	3.9
Bench cleft	leafed	100	63.0 b	45.3	10.3	3.3
Zhengao nursery , Lucheng						
Nursery cleft	leafed	100	85.0 a	75.0	12.0	2.6
Nursery side	leafed	100	82.0 a	78.0	11.6	2.5
Nursery cleft	barren	100	10.0 c	44.0	10.0	1.0
Shanlin village, Yangyi town						
Nursery cleft	leafed	228	79.4 a	62.0	7	27.0
Bench cleft	leafed	300	48.3 b	35.0	4.1	13.

[1)]Values followed by different letter indicate significant difference at 5% level.

Survival of propagated trees also depends on grafting methods (Ye *et al.*, 1995). Nursery cleft and side grafts on leafed rootstocks resulted in better survival (≥80%) and also exhibited more vigorous growth (Table 4). In contrast, bench grafted trees exhibited lower survival and weak growth.

Cutting and layering are also used for red bayberry propagation, but are inefficient for propagation of large numbers of trees. Top-working is used to replace low yielding and poor fruit quality trees with productive and good quality cultivars (Miao & Wang, 1987; Gong, 1996; Chen, 1998).

Orchard establishment

Plant density ranges from 225 to 600 trees/ha, and is expected to increase with increased tree training, canopy management and potential use of dwarf rootstocks (Miao & Wang, 1987; Qi, *personal communication*). The optimum time for planting depends on climatic conditions in different regions. In Zhejiang, Jiangsu, Hunan, and Jiangxi, planting takes place during late February to mid-March (Chen et al., 2004).

Red bayberry prefers to grow in slightly acid sandy soils (pH 5.5-6.5). Fertile clay soil is unsuitable for red bayberry as trees tend to produce excessively vegetative growth, which results in poor fruit set and increased tree susceptibility to diseases (Miao & Wang, 1987; Li *et al.*, 1992). A planting hole about 1 m in diameter and 0.8 m in depth is prepared in the winter. At planting time, the hole is firstly filled with sub-surface soil and then with a mixture of soil and livestock manure or canola seed cake up to 80% of its depth. One or 2-year-old trees are then placed in the hole. The hole is finally filled with top surface soil and the tree is watered after planting. Stakes are used to support young trees in windy areas. When plantations are on rain-fed hillsides or upland, watering and mulching are generally required after planting, particularly in areas with dry, hot summers.

Due to the dioecious nature of red bayberry, male trees are interplanted at a proportion of about 1 to 2% (Wang, 1995; Chen *et al.*, 2004). Occasionally, bisexual inflorescences occur in female trees (Miao & Wang, 1987). Due to 'unconscious' elimination of unproductive trees by growers, the diversity of male trees is scarce. Only 11 different male sources exist in red bayberry germplasm. Their breeding values are still unknown (Qi, *personal communication*).

Growth and orchard management

Red bayberry trees show three peaks of flush growth each growing season (Miao & Wang, 1987). The growth takes place in spring, summer and autumn, respectively. In general, terminal bud and four to five axillary buds close to the apex are active and grow and develop into new shoots (Miao & Wang, 1987). Shoot growth is more vigorous in young trees than old ones. Cultivars, crop loading and climatic conditions also influence growth. Observation made by Zhejiang Academy of Agricultural Science demonstrated that the shoot growth peak in 'Biqi' cultivar occurred in April (spring), July (summer) and September (autumn). Summer growth took place just post fruit harvest and autumn growth was coincident with increased rainfall in the season. Spring growth accounted for about 60% of the yearly growth, and summer and autumn growth accounted for about 20%, respectively. Spring shoots were the longest, followed by summer shoots and the shortest were autumn shoots. With growth of new shoots, old leaves commence dropping and new leaves are formed. Subsequently the tree canopy is renewed (Miao & Wang, 1987).

Red bayberry sets fruit on 1-year-old wood. Flower buds are simply formed from axillary buds and never from terminal buds. In 'Xiyeqing' and 'White' cultivars, flower buds initiate in July from 1-year-old shoots, and complete their differentiation in November in Zhejiang Province (Miao & Wang, 1987). In this regard, axillary buds on spring and summer shoots are more likely to develop into flower buds and to bear fruit in the following season. Male flowers are initiated about 2 weeks earlier than female ones. Thick and relatively short shoots are found to have more potential to form flower buds and bear fruit, than thin or excessively long shoots (Miao & Wang, 1987). This is one of the key characters on which bearing regulation is based in cultivation practice.

In traditional orchards, red bayberry trees are seldom trained. The trees gradually grow into a round shape canopy and branches shade each other extensively. This is the type of tree which we have seen during the visit (Photo 2). These trees have a strong biennial bearing habit. The bearing surface of the trees starts to decline and orchard productivity decreases with the accumulation of vegetative growth (Miao & Wang, 1987). In order to overcome this problem, training systems such as open centre, central leader or modified central leader, are being evaluated and utilised in the industry. The choice of the system relies on soil conditions and the growth habit of individual cultivars. The modified central leader is the most popular training system (Miao & Wang, 1987). Tree training is also being used to redesign tree canopy and to improve orchard productivity in old orchards (Miao & Wang, 1987; Chen, 1998).

For canopy management, heading back and thin-out pruning are commonly used with a combination of tipping off and root pruning. Pruning is mainly conducted in the winter and also in the summer for non-fruited trees. Girdling and scoring are applied to inhibit shoot growth and promote flower buds in summer. The methods are useful to reduce biennial bearing of red bayberry in combination with the use of fruiting regulation agents (Miao & Wang, 1987).

Photo 2. Untrained red bayberry trees in Xiaoshan district, Zhejiang Province.

Nutrient requirements were found to be different between red bayberry and other stone fruit species (Zhang, 1999). Red bayberry requires high amounts of nitrogen and low amounts of phosphorus, whereas their potassium requirement is similar to peaches. Adult trees require more potassium than young ones. Red bayberry grows best in sandy soils, but requires nitrogen and potassium to maintain orchard productivity. The recommended ratio for nitrogen, phosphorus and potassium in Zhejiang region is 100:25:85 ($N:P_2O_5:K_2O$) for 5-year-old trees and 100:21-25:116 for adult trees (12-year-old).

Fertigation is normally conducted three times per year (Miao *et al.*, 1996). In March, fast-release fertiliser, including large amounts of nitrogen and small amounts of potassium and boron is applied to meet new growth requirements, blooming and fruit set. In late May, fertiliser including nitrogen and a large proportion of potassium is applied to meet growth requirements for fruit development and flower bud differentiation. After harvest, organic fertilisers, such as organic compost, livestock manure and canola seed cake are applied. Organic fertilisers will degrade slowly and supply nutrients to meet the requirement for tree growth in the following season. In organic red bayberry orchards, nitrogen is provided by applying livestock manure and canola seed cake, and potassium is supplied by applying cereal straw ash (Feng, *personal communication*). Boron deficiency has become a common problem in Zhejiang region and reduces orchard yield, as boron deficient trees exhibit low fruit set (Meng & Hu, 1995). Low-level soil boron and the application of high dosages of phosphorus were identified to be the cause of boron deficiency. In either case, trees respond very well to foliage applications of boron.

Biennial bearing is common in red bayberry trees, but can be managed by pruning, girdling and scoring, and by optimising the use of fertilisers. Another alternative is to apply fruiting regulation agents developed by the Zhejiang Academy of Agricultural Science. They can be used to thin, inhibit, stimulate and retain flowers. Thinning and retaining agents work similar to agents used in other fruit crops. Stimulating and inhibiting agents are used to regulate the number of flower bud formation. For example, foliage spray of flower stimulating agent in late June and early July in heavy bearing seasons can increase flower formation and then increase fruit set in the following season. In contrast, foliage spray of inhibiting agents before flower bud formation in light seasons can reduce the number of flower buds formed, and avoid heavy bearing in the coming season (Liang & Chen, 2000).

Diseases and pests

A number of diseases and pests affect the red bayberry industry (Table 5). *Pseudomonas syringae* pv. m*yricae* is one of the key and most widely distributed pathogens (Li, 2002; Chen et al., 2004). The disease is mainly transmitted by scions. Infection develops in late April to May and reaches the peak in July. Two- and 3-year-old shoots are particularly susceptible to the disease, and infection results in a tumour-like growth known as red bayberry ulcer or sore (Li, 2002). However, young trees exhibited less susceptible to the disease than old ones and there is also variation for susceptibility among different cultivars (Chen, 1996). Orchard hygience combining with the spray of a 0.5% Bordeaux is used to control the infection (Chen et al., 2004). The other measure to reduce the disease spread is to use scions from healthy trees for propagation and to plant healthy trees at orchard establishment.

Brown leaf spot is a key foliage disease in red bayberry. It overwinters in diseased leaves and the spores are spread by wind and rain between May and June. Infected leaves show symptoms 3 to 4 months post infection. Leaf wilting and dropping often occurs in September and October if the infection is severe. Fungicides, such as 0.5% Bordeaux, 70% thiophanate methyl and 50% carbendazol wettable powders, are used to control this disease (Chen et al., 2004). In general, application is done at 1 month and a fortnight prior to harvest and post harvest (Miao & Wang, 1987).

Shoot rot, stem blight and red mould attack branches or trunks of old red bayberry trees. Root rot is an important disease only in Zhoushan Island of Zhejiang Province (Chen et al., 2004). Root-knot nematode and rust are important in Fujian Province.

A few pests have been reported to infest red bayberry, but are only important locally (Table 5). For example, leaf wilt moth is a common pest in Zhejiang and part of Jiangsu. Scale insects only cause damage in Zhejiang Province. They are easily controlled by integrated pest management practices, such as trapping and removal or destruction of infested leaves and other plant parts, and pesticide spray when necessary.

Table 5. Diseases and pests of red bayberry in China (Cai, 1999; Chen, 1994; Chen *et al.*, 1994; Chen, 1996; Luo & Pan, 1998; Chen *et al.*, 2004)

Common name	***Latin name***	Tissue affected	Region affected
Disease			
Brown leaf spot	Mycosphaerella myricae	leaves	Zhejiang
Rust	*Caeoma makinoi* Kusano	leaves	Fujian
Tumors	*Pseudomonas syringae* pv. *myricae*	shoots, trunk	All regions
Red mould	*Corticium saimonicolor*	branches	Zhejiang
Stem blight	*Myxosporium corticola*	trunk	All regions
Shoot rot	*Valsa coronata*	cortex of shoot	Zhejiang
Root rot	*Botryosphaeria dothidea*	roots	Zhoushan,Zhejiang
Root-knot nematode	*Meloidogyna* spp.	roots	Fujian
Pest			
Leaf wilt moth	*Lebeda nobilis*	leaves	Jiangsu, Zhejiang
Leaf roller moth (1)	*Homona* spp.,	leaves	Zhejiang
Leaf roller moth (2)	*Eudemis gyrotis Myrica*	leaves	Guizhou
Scale	*Lepidosaphes cupressi*	leaves	Zhejiang
White ant	*Odontotermes formosanus*, *Macrotermes barneyl*	trunk, root	Zhejiang
Leaf miner moth	*Phyllonorycter* sp.	leaves	Zhejiang
Whitefly	*Bemisia myricae* Kuwana, *Aleurotrachelus camelliae* Kuwana, *Dialeurodes citri* (Ashmead), *Aleurocanthus spiniferus* (Quaintance)	leaves	Zhejiang

Harvest and handling

Red bayberry harvest takes place as early as April (Guizhou Province) and finishes by mid-July (Zhejiang, Jiangsu *etc*) in China (Chen et al., 2004). In Zhejiang and Jiangsu, red bayberry is harvested earlier than other stone fruits (Li *et al.*, 1992). As it is typically non-climacteric and will not continue to ripen once removed from the tree (Joyce & Li, 2002; Joyce & Li, 2003), fruit must be harvested when they become mature. Optimal harvest time varies with cultivars and is mainly judged by fruit colour and eating quality (Miao & Wang, 1987). A large variation exists for fruit maturity within each tree. Consequently, fruit harvest is conducted daily or every second day. As untrained adult trees can grow as high as 3 to 4 metres, ladders or climbing on tree limbs are needed to conduct the harvest.

As matured fruit is very easily damaged, fruit is carefully hand-harvested. At harvest, fruit pickers use small bamboo or plastic baskets, which can hold about 5 kg fruit, to carry harvested fruit. The bottom and inside of the basket is covered with a layer of fresh fern before loading fruit. The fern provides a soft bed for the fruit and minimises fruit damage at harvest. Harvest is often conducted early in the morning and late in the day when ambient temperature is not high. Harvest after rain is not recommended, as wet fruit is prone to rapid deterioration after harvest.

Photo 3. Grading and packing red bayberry at a packing shed in CiXi district.

Photo 4. Trading of red bayberry on a roadside in LanXi District.

After harvest, fruit may be left in the baskets and then directly transported to the market for sale. Alternatively, fruit are loaded into large containers, and transported to packing sheds for grading and repacking, and then sold in the market (Photos 3 & 4). There is still a lack of controlled packing facilities. Harvested fruit has to be sold within 2 or 3 days in the market, otherwise it rapidly deteriorates and becomes unsaleable.

Discussion and implications

Recent development of red bayberry production in China demonstrates that it has potential for further expansion both within and beyond China. Fruit cropping is less affected by adverse spring weather such as spring frost, as red bayberry exhibits more cold tolerant and blooms later than other stone fruits. In Zhejiang region of China, red bayberry is also harvested earlier than other stone fruits, the price is higher in the market and the economic return to growers is good. As only a few diseases and pests affect red bayberry and their risk is low, it is suited to organic food production. In addition, cultivation of red bayberry can improve soil fertility, and reduce soil erosion. Thus development of a red bayberry industry within Australia would not only diversify local fruit industry, but economic and environmental benefits would also be derived from this crop.

Red bayberry prefers to grow under warm and humid climatic conditions. High humidity is vital to ensure healthy and vigorous growth of trees, and also to produce good fruit quality. In terms of regional climatic conditions, it should be possible to grow red bayberry along the eastern seaboard and further inland areas of Australia. Acid to slightly acid soils (pH 5-6) are present in many of these parts, and are optimal for red bayberry production. Heat units are sufficient, and mild winter (≥ -3°C) and frequent clear days in spring and early summer favour this crop. The area within the ≥ 600 mm rainfall per year boundary merits consideration (Fig. 2). In some regions, large fluctuations in humidity during the day might be problematic (Fig. 3 & 4). However, it should be possible to increase humidity through irrigation and protected cultivation when necessary. Alternatively, it may prove possible to identify cultivars that are less sensitive to low humidity. Specific regions suitable for red bayberry production are recommended in the weather mapping study presented in the report to RIRDC (RIRDC project DAV 212A final report: *Red bay berry; an exciting new crop for Australia?*).

China is a nation with a vast knowledge and experience in managing and producing red bayberry. It is also where germplasm and commercial elite cultivars have originated from and a potential export market for red bayberry. Thus, it will be crucial to closely work with the Chinese industry and conduct collaborative research with Chinese scientists to facilitate development of a red bayberry industry in Australia.

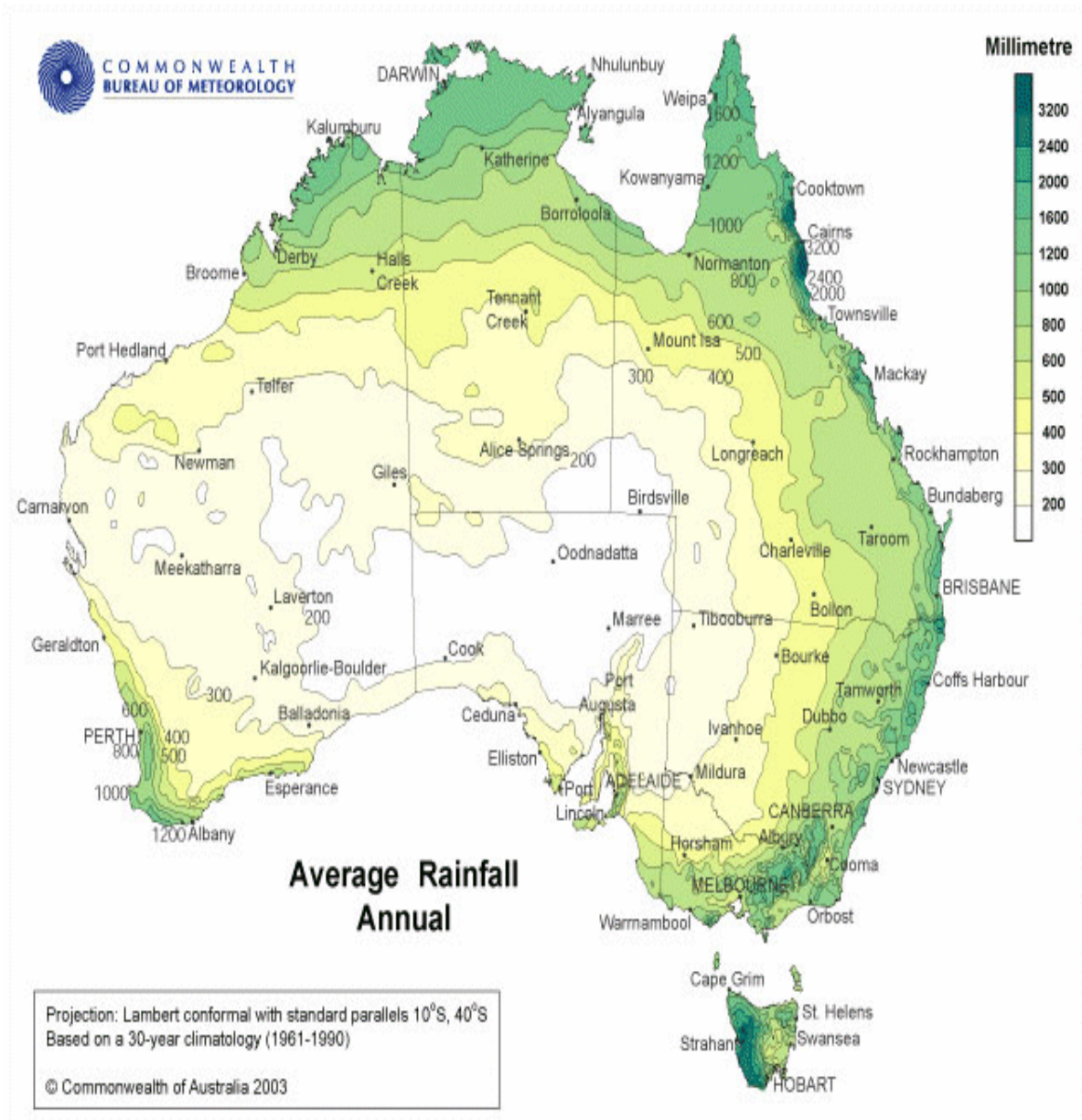

Figure 2. Average annual rainfall map in Australia.

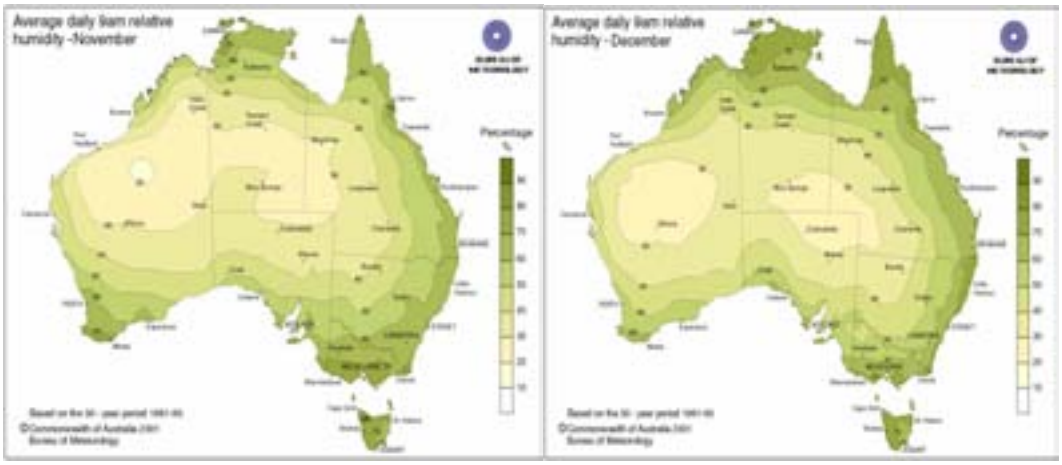

Figure 3. Relative humidity maps at 9 am in November and December in Australia.

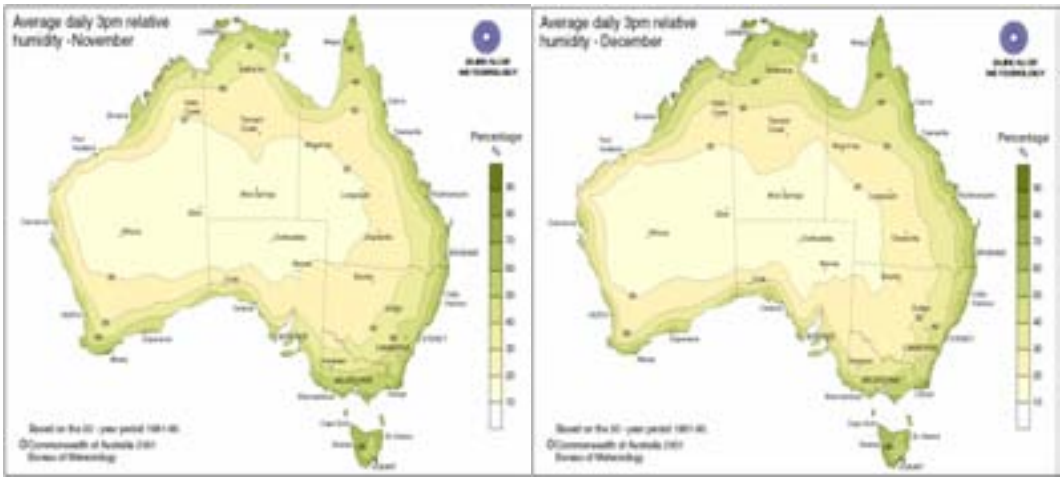

Figure 4. Relative humidity maps at 3 pm in November and December in Australia.

Dissemination of information

This report will be forwarded to the Rural Industries Research and Development Corporation (RIRDC), and the project collaborators.

Acknowledgements

The author acknowledges the RIRDC for funding this project, and is very grateful to Prof. Jianrong Li of Hangzhou University of Commerce and Technology, and Prof. Yueming Jiang of South China Institute of Botany for their hosting the visit and making travel arrangements.

The author also thanks the following organizations and people (Table 6) for their kind assistance and hospitality. Sue Richards is acknowledged with thanks for critical reading of this report during its preparation.

Table 6. List of organizations and people associated with red bayberry industry and visited during the travel in Zhejiang Province.

Name		Contact detail
Organisation		
College of Agriculture & Biotechnology (CAB), Zhejiang University		Hangzhou, Zhejiang,310029
Zhejiang Academy of Agricultural Science (ZAAS)		Hangzhou, Zhejiang, 310021
Bureau of Science and Technology, LanXi		LanXi, Zhejiang, 32100
Jiang's Fruit Tree Nursery, LanXi		LanXi, Zhejiang, 32100
Bureau of Agriculture, CiXi		CiXi, Zhejiang, 315300
Haitong Food Group Co. Ltd		CiXi, Zhejiang, 315300
Red Bayberry Research Institute, CiXi		CiXi, Zhejiang, 315300
People		
Guochang Sun	Professor, Research Coordinator	ZAAS
Ming Xie	Professor, Director	Horticulture Research Institute, ZAAS
Xingjiang Qi	Associate Professor, Deputy director	Horticulture Research Institute, ZAAS
Feibo Wu	Associate Professor	CAB, Zhejiang University
Kunsong Chen	Professor	CAB, Zhejiang University
Yufeng Xi	Professor	CAB, Zhejiang University
Jianguo Jiang	Deputy director	Bureau of Science and Technology, LanXi
Yongsheng Xu	Agronomist	Bureau of Science and Technology, LanXi
Lining Jiang,	Manager	Jiang's Fruit Tree Nursery, LanXi
Zhida Feng	Extension office	Baicha Town, LanXi
Yonghu Tang	Manager	Red Bayberry Grower's Association, Baicha, LanXi
Jincai Sun	Senior engineer	Haitong Food Group Co. Ltd
Lizhong Wu	General manager	Haitong Food Group Co. Ltd
Yongjiang Xu	Director	Red Bayberry Research Institute, CiXi
Kangcheng Huang	Manager	Daoshan orchard, CiXi

Itinerary

Date	Activity
11/06/04	Depart from Melbourne
11/06/04	Arrive Hong Kong
12/06/04	Arrive HangZhou
13/06/04	Travel to LanXi
14/06/04	Back to HangZhou
16/06/04	Travel to XiaoShan & then to the Zhejiang Academy of Agricultural Science: Prof. Guochang Sun, Ming Xie and A/Prof. Xingjiang Qi.
17/06/04	Visit HuaJia Campus, Zhejiang University: Literature search & Prof. Yufeng Xi.
18/06/04	Travel to CiXi
21/06/04	Back to HangZhou
22/06/04	Visit A/Prof. Feibo Wu, Zhejiang University and then depart from Hangzhou.
23/06/04	Arrive Melbourne

Literature Cited

Cai, H. 1999. Rust epidemology and control in red bayberry (in Chinese). *Newsletter of Agricultural Sci-Tech*. 6: 31.

Chen, K. S., C. J. Xu, and B. Zhang. 2004. Red bayberry: Botany and Horticulture. *Horticultural Reviews* 20: 83-114.

Chen, M. L. 1998. Methods for modifying red bayberry canopy (in Chinese). *South China Frui*t 27: 34.

Chen, Y. B. 1994. Red bayberry diseases and pests and their control (in Chinese). *Subtropical Plant Research Communication* 23: 64-68.

Chen, Y. B. 1995. Cropping red bayberry in soil erosion areas (in Chinese). *China Soil Protection* 3: 34-36.

Chen, Y. B., S. S. Zhang, and Z. H. Li. 1994. Study on red bayberry root-knot nematodes (in Chinese). *Journal of Fruit Science* 11: 161-65.

Chen, Z. L. 1994. Biology and control of red bayberry leaf miner moths (in Chinese). *Entomological Knowledge* 31: 351-52.

Chen, Z. L. 1996. History of red bayberry (in Chinese). *Journal of Fruit Science* 13: 59-61.

Chen, Z. L. 1996. Key diseases and pests of red bayberry in CiXi and their control (in Chinese). *Plant Protection* 22: 26-28.

Gong, J. J. 1996. Topworking technique for red bayberry (in Chinese). *South China Fruit* 25: 43.

Joyce, D., Y.M. Jiang, J.R. Li, G. McGregor, and S.M. Liu. 2004. Production and Post-Harvest Characteristics of Red Bayberry (*Myrica Rubra* Sieb.and Zucc.): An Overview. Brisbane: University of Queensland (in press).

Joyce, D. and J. R. Li. 2002. Introduction to the proceeding of the yangmei (red bayberry) postharvest workshop. *Postharvest News and Information* 13: 23.

Joyce, D. and J. R. Li. 2003. Postharvest characteristics of red bayberry. pp.125-226. Proceedings of the Australiasian Postharvest Horticultue Conference, 1st -3rd October. Brisbane, Australia.

Li, S.Y. 2002. Encyclopedia of Zhejiang Agriculture-Red bayberry (in Chinese). China Agri. Sci-Technol. press, Beijing.

Li, X. J., J. L. Lu, and S. Y. Li. 1999. Advances of red bayberry research in China (in Chinese). *Journal of Sichuan Agricultural University* 17: 224-29.

Li, Z. L., S. L. Zhang, and D. M. Chen. 1992. Red bayberry (*Myrica rubra* Sieb. & Zucc.): A valuable evergreen tree fruit for tropical and subtropical areas. *Acta Horticulturae* 321: 112-21.

Liang, S. M. and X. L. Chen. 2000. Study on regulation methods of biannual bearing in red bayberry (in Chinese). *South China Fruit* 29: 27-28.

Lin, N. S. 1996. Preliminary study on effects of red bayberry cultivation on soil erosion (in Chinese). *Fujian Water and Soil Protection* 3: 35-36.

Luo, L. Y., D. R. Pan, and G. P. Pan. 1998. Preliminary report of *Eudemis gyrotis* of red bayberry in Guizhou (in Chinese). *Guizhou Agricultural Sciences* 26: 41.

Meng, S. F. and Y. W. Hu. 1995. Key issues of red bayberry fertigation in Zhejiang (in Chinese). *Zhejiang Agricultural Science* 5: 266-67.

Miao, S. L., S.B. Huang, S.M. Liang and Y.J., Zhang. 1995. Study on ecological distribution of red bayberry (*Myrica)* in China (in Chinese). *Journal of Zhejiang Agricultural University* 21: 366-72.

Miao, S. L. and D. X. Wang. Red Bayberry (in Chinese). Hangzhou, Zhejiang: Zhejiang Science and Technology Press, 1987.

Miao, S. L., Y. J. Zhang, and S. M. Liang. 1996. Effects of fertigation time on biannual bearing in red bayberry (in Chinese). *Journal of Fruit Science* 13: 15-18.
Miao, S. L., Y.J. Zhang, S.M. Liang, X.G. Huang, and S.F. Wang. 1995. A new elite red bayberry cultivar 'Zaose' (in Chinese). *China Fruits* 4: 3-4.
Miao, S. L.,Y.J. Zhang, S.M. Liang and S.Y. Li. 1994. Geographical distribution of red bayberry germplasm in Zhejiang (in Chinese). *China Fruits* 4: 38-39.
Wang, H. Y., Y. Q. Chen, and W. D. Li. 1999. The occurrence of whitefly moths in red bayberry and their control (in Chinese). *Plant Protection Technology & Extension* 19: 27-28.
Wang, J. B. 1995. Pomology of Individual Fruits (for Southern China) (in Chinese). 2nd edition. Beijing: China Agricultural Press.
Xue, Z. Y. 1998. Study on the effect seed source on propagation of red bayberry trees in forest plantation to prevent forest fire (in Chinese). *Fujiang Science and Technology of Tropical Crops* 23: 41-42.
Ye, Y. G., S. D. Chen, and C. Chen. 1995. Investigation on improved survival of grafted red bayberry trees (in Chinese). *China Fruit* 2: 26-28.
Zeng, M. Z. 1935. Red bayberry in coastal counties in Zhejiang (in Chinese). *Horticulture* 1.
Zhang, Y. J. 1999. Annual uptake of key nutrients in red bayberry cultivar 'Dongkui' (in Chinese). *Acta Agriculturae Zhejiangensis* 11: 208-11.
Zhang, Y. J. and S. L. Miao. 1999. Red bayberry germplasm and their utilisation in China (in Chinese). *South China Fruit* 28: 24-25.
Zheng, Y. P., Z. F. Zhang, J. C. Li, X. H. Xia and J. C. Wang. 2001. Red bayberry cultivar 'Dongfengmingzu' (in Chinese). *China Fruits* 6: 4-6.
Zhuang, W. D. and Y. S. Pan. 2001. Advances of red bayberry germplasm research in China (in Chinese). *Journal of Fujian Forestry Science and Technology* 28: 54-57.
Zou, T. C. 2001. Geographical distribution and utilisation of Myricaceae in Guizhou. *Journal of Guizhou University* (Natural Science) 18: 103-23.

Itinerary Notes: Prof D. Joyce

Friday 11.06.04
Air travel to Hong Kong – depart Brisbane, arrive Hong Kong.

Saturday 12.06.04
Air travel to China – depart Hong Kong, arrive Hangzhou:
* meet Professor Li Jianrong from Hangzhou University of Commerce and Professor Yueming Jiang from Chinese Academy of Sciences (South China Institute of Botany).

Sunday 13.06.04
Travel to Lan Xi, a red bayberry (yang mei) production area:
* visit an organic green tea factory en-route – work to a European organic standard called Oko Garantie; take product from ca. 500 ha of organic green tea; have membership of the Zhejiang Institute of Food Science and Technology (Professor Li is the Chairperson); operate four processing factories in the district; export as well as domestic markets; have two fine grade products and two standard grade products; some product goes to Australia ('International Trade Company NSW'); have applied for own export licence; have a range of value-added products (e.g. tea bags in addition to cut and whole leaf, plus fragrant tea and flavoured tea [e.g. strawberry, jasmine]).
* visit a yang mei fruit production village 'co-operative' – visit with representatives of the local government science and technology (agriculture) department; the village visited produces organic yang mei; certification for quality and quality assurance is provided by a government agency in another province; export to Singapore, Taiwan, etc.; use a chemical thinning agent for fruit size control; don't seem to prune the plants; new shoots form readily on the trunk near lopping wounds; lopping evidently due of overbearing; the local variety tastes offensive (viz. pine-resin) and so grow varieties introduced from other regions; have tested a plastic house cover for trees which can advance maturity by 7 to 10 days; to reduce fruit damage and make it easier to find, straw mulch can be spread under the trees; 4-year-old grafted fruit were bearing; bigger trees in the orchard of ca. 33 ha were around 15-years-old; use organic fertilizer (i.e. animal faeces); use a low number of pollinator trees per ha; flowers form on 2-year-old wood, the buds being visible at fruiting the preceding season; the plants grow on very poor soils (i.e. dig hole, use explosive, add fertilizer, plant grafted tree).
* visit a yang mei plant nursery – side graft onto 1 or 2 y.o. seedling stock; produce two commercial fruiting varieties (including Dongfu [the larger fruited variety]) plus the local variety (tastes like pine resin and has smallish fruit) and also a small-leafed variety; they are all used for home garden (i.e. decorative purposes) as well; the nursery uses raised beds with, presumably, flood irrigation; trees fruit within 2 or 3 years of grafting onto 1 or 2 y.o. seedling rootstock.
* stay overnight in Lan Xi.

Monday 14.06.04
Return to Hangzhou University of Commerce:
* visit an orchid co-operative en-route – have a collection of >400 accessions in their 2 y.o. repository and aim to have >800 in the next 5 years; have Chinese orchids, but also accessions from overseas; only grow and sell regionally indigenous native orchids (cymbidium like appearance, but finer leaves); the orchids come from a nearby mountain and river, both named after the regional orchids; comprise ground, tree and rock orchids and a range of species; sell them as pot plants; a ca. 6"-pot can sell at between A$20 (single tiller) to $A200 (multiple tillers); propagation is by tiller divisions (ca. A$20 per tiller); the primary stock plants sell to producers and/or investors for high prices (e.g. RMB>0.1 million per plant [=A$20,000]; e.g. picture of one such plant valued at A$60,000); the village was established with government incentive of discounted land and houses; each family has to have at least 2000 orchid plants; there village has approximately 132 families; it is certified by the Tourism Bureau at the national level (e.g. agritourism); the village has the roles of production, marketing, tourism and a garden for nearby Lan Xi city.

* tour the new campus of Hangzhou University and meet with undergraduate and postgraduate students of the College of Food Science, Biotechnology and Environmental Engineering at the old campus; the research students are working on:

Aloe - gel stability (acemannan); extraction and purification by HPLC; joint research with a company; funded by Zhejiang government; three students working on composition and two on processing (e.g. sedimentation, colour).

molecular biology of a lactase subunit gene; one student.

soft drink factory design - computer-aided design, working with the Nonfu Spring company which produces 300,000 tonnes of water and soft drink p.a.; one student.

heavy metals and pesticides in tea – measuring 15 kinds of organophosphates, etc.; measuring lead, copper and cadmium; non-linear relationships between soil and plant levels; data for HACCP; two students.

microwave of green tea to kill enzymes; one student.

molecular biology of a silk peptide from silkworm – peptides (MW 3 to 10K) from silk protein can lower blood sugar levels and enhance immunological reactions; i.e. functional foods; one student.

ultrahigh pressure processing – extraction of natural ingredients from herbs; soybean processing technology; working with a company; one student.

* have dinner with staff and students of the College FS, B & EE.
* have coffee with Professor Kunsong Chen, Head, Fruit Science Institute of Zhejiang University –
* working on yang mei postharvest physiology and, in time, molecular biology (e.g. EST markers; macro-array); has established a germplasm collection near CiXi (e.g. including white fruited cvs.); believes the fruit to be climacteric (viz. 'early climacteric'); has published a review on yang mei with Ian Ferguson (HortResearch, NZ) in Horticultural Reviews.

Tuesday 15.06.04

Prepare seminar for staff and students of the College FS, B & EE (a.m.).
Have lunch with Professor Kunsong Chen and visit the new campus of Zhejiang University (130,000 students; 200 ha of the 600 ha site has been developed to date.).
Deliver seminar entitled 'Natural Disease Resistance and Other Interests' at the College FS, B & EE (p.m.).
Seminars also delivered by Dr Shiming Liu (breeding seedless grapes; in Chinese) and Professor Yueming Jiang (scientific writing; in Chinese)…
'Strategies for Breeding New Seedless Table Grapes' by Shiming Liu, Steve Sykes and Peter Clingeleffer –
* importance of stensopermic seedlessness in grapes: complex inheritance of stenospermic seedlessness; the proportion of seedless progenies depends on the amount of seedlessness in the parents; general confusion as to genetic reasons/inheritance.
* strategies for breeding seedlessness:
without *in ovulo* embryo rescue – sd x sdls1 plus sd x sdls2 → seeded progenies with desired characteristics → intercrossing → seedless progenies with combined sdls1 and sdls2 traits; +ve = easy to establish a population of optimum size; requires fewer skills; -ve = low proportion of seedless progenies (10-15%); resource and time consuming, less predictable transmission of desired traits.
with *in ovulo* embryo rescue; sdls1 x sdls2 → seedless progenies with combined sdls1 and 2 traits; +ve = high proportion of seedless progeny (40-80%); easy to monitor transmission of other traits; resource and time saving; -ve = difficult to establish populations with optimal size; skills and facilities required.
* better embryo rescue results with increased calcium chloride, increased organics (viz. amino acids, casein hydrolates); significant paternal effects on ovule germination and embryo rescue efficiency; significant season and genotype x season effects for embryo recovery.
Have dinner with Mr Miao Dehua, General Manager, Hangzhou Hangmai Flavours Co. Ltd; and colleagues.
Have coffee with Mr Ying Yaping, Director, International Office, Hangzhou University of Commerce.

Wednesday 16.06.04
Visit Xiaosang Yang Mei festival.
Note – thin yang mei tree shoots to reduce biennial bearing.
Visit Zhejiang Agricultural Research Institute – Professor Sun Guochang (Deputy Director Project Planning and Management), Xie Ming (Director of Horticulture) and Qi Xing Tiang (Deputy Director of Horticulture; yang mei researcher)
* about 210,000 ha of yang mei in China; around half of this is landrace yang mai (i.e. not selected cvs.); the main production provinces are Zhejiang (no. 1 at 35,000 ha of cultivated plantation), Jiangsu and Fujai; all cultivated cvs. come from Zhejiang; in Zhejiang about 17,000 ha of bearing plantation produces around 230,000 tonnes p.a.; value of industry is hard to know, the retail price ranges from A$1 to A$12 (RMB60) per kg, if say A$1 per kg we can calculate a value of A$230 million (i.e. 230,000 tonnes x 1000 kg/t x A$1) for Zhejiang Province, only half of the planted area is at fruiting maturity; some climatic and edaphic conditions (generalized) are – 20-33 degrees N latitude is the growing 'zone', the annual temperature range is 14 to 20 degrees C, yang mei tolerates high (e.g. 40 deg C) and low (e.g. -10 deg C) temperatures, the annual rainfall range is 800 – 1000 mm, need high RH (e.g. 80%?) for fruit development, water stress causes the papillae to 'toughen', the altitude is 50 to 500 m, one bred cv. is OK at 2000 m, like slightly acid soil (pH 5 – 6) and prefer sandy loam over clay, tolerate poor soil fertility and low organic carbon, have a nitrogen fixing associate in *Frankia* (e.g. 23 kg nitrogen per ha per yr for 300 trees per ha), good crop for land remediation (e.g. holds and regenerates soil susceptible to erosion, also fire tolerant), started R&D on yang mei at the institute in 1983, fertilizer was not used before then, now provide nitrogen and phosphorus, need K>>P, N/P/K in good fruit is 20:1:17, can get P toxicity via B deficiency, but P is required for good bud development, fertilise 2 to 3 times p.a. (Autumn = manure, 15 kg per tree plus some K; spring flush [March] = nitrogen at 0.5 to 1 kg per tree plus K and B; fruit growth and development = potassium at 1 to 1.5 kg per tree), there are > 300 yang mei accessions in China (e.g. purple [good flavour], red, pink, white [poor storage life] fruit), range in fruit size from 3 to 50 g and TSS from 10 to 14 % and TA from 0.8 to 1.2 g per L, there are big taste differences among varieties, been doing germplasm surveys for the last 20 years, the institute co-ordinates the national yang mei project doing selection and breeding, of seven of eleven superior lines are in cultivation, a aim is to reduce the juvenile phase, it is now 3 yrs but was 7 yrs, have used rootstocks (superior selections enhance the precocity of the scion) and fertilizer and pruning and chemicals (e.g. PP333 [paclobutrazole]) to achieve this, seed germination can be difficult, seed of one cultivar never germinates, farmers sow and wait till next year, stratification is required in research work, growers use seedling rootstocks from commercial cultivars, institute uses landrace seedlings as rootstock, they are doing experiments on rootstock effects on plant size, other species of *Myrica* (note: there are six in China) are used as vigour/size control rootstocks, control biennial bearing with shoot (note: in heavy years) and flower (note: use institute's chemical formulation applied about 20 days after shoot thinning) thinning, thin flowers at peak bloom to reduce flowers by 30 to 70 percent which increases fruit size and advances maturity by about 10 days, biennial bearing degree varies with genotype, also adjust nitrogen in spring with more in a heavy year and less in a light year, determine fruiting potential in July / August and then try to improve bud differentiation with PP333 if appropriate, there are about 11 different male tree genotypes used, don't know which ones are the 'best' male parents as yet, there are many books and the like on yang mei (one by Wang Ping Xiang, who now works as an IT expert for a bank in Adelaide), planting density was 300 trees per ha and is now 450 trees per ha and will probably become 900 trees per ha on dwarfing rootstock, there are no major insect pests, disease is also of little concern, *Mycosphaerella myrica* Saw. causes a leaf spot after harvest in mid May during the wet season and is controlled by copper and other fungicides and with biological control materials, export is mainly in processed form (e.g. canned) and some fresh fruit.
Have dinner with staff of Zhejiang Agricultural Research Institute and Professor Xu Jianguo (Zhejiang Citrus Research Institute).

Thursday 17.06.04
Visit Zhejiang University and meet people in the Education department (a.m.) –
* Dr Liu Hua and student (researchers in developmental psychology), Professor Zhou Gu Ping (Vice-Dean Education), Professor Chen (Head of Education), Dr Wu ([or Fu?]; English educator), Associate Professor Xianhua Chu (Curriculum and Instruction).
Have lunch with Dr Liu Hua and student.

Visit Westlake area with students of the College FS, B & EE (p.m.).
Have dinner with H U of C staff (Lou) and student (Wang).

Friday 18.06.04
Visit Haitong food company (a.m.), a subsidiary of which Kaiz is a subsidiary. Hosted by Sun Jin Cai (Snr. Engineer) –
Presentation by CiXi district agriculture people = yang mei is the main forest (hill) industry in CiXi in terms of farm level income (the other major industries are tea and bamboo shoots), use 17 different cultivars of yang mei (one group of cvs. is used for 90% of the area), 3,000 ha is grown yielding 18,000 tonnes worth RMB63 million (>A$12 million), most of the industry is to the south of the city in five towns (one of which produces 40% of the total CiXi production), harvest is from June 10th to early July, was sold as a fresh food, health benefits and low chemical input make is very popular, now produce many processed products (about 1/3rd for juice and frozen and wine from the CiXi area), this was to be an 'off' year but production was actually up by 50% and fruit quality was excellent due to a favourable growing season and good weather at harvest which will now be 2 to 3 days longer in duration (i.e. more moderate year), three brands of yang mei product are produced and named after the district (two brands are sold as fresh fruit, they win awards at national and provincial level agricultural shows and they have organic certification, the other brand is a frozen product), much effort goes into production as an organic food and about 2,000 ha is organically managed (of which 600 ha is registered organic by a provincial level authority), organic and quality certification is managed by the OFDC (organic food development centre) in Nanking, four processing companies are involved in yang mei products (two are key players and important employers in the area), some fresh fruit is exported to France, Singapore, etc., it is ca. 20hr from farm to overseas airports, process is pack fresh → cool → plane, sometimes use polystyrene boxes and ice-packs, since 1989 the CiXi district has developed a yang mei festival (i.e. agritourism) to promote the 'yang mei culture' in four growing areas outside the city, some issues that need resolving are a) post-harvest life extension and storage life extension, b) food processing characteristics (e.g. pigment sedimentation problem, flavour trapping), and c) tree size (viz. need to reduce), the CIQ is the equivalent of AQIS, no special QC is in place, harvest fresh fruit daily → size grade, there are local quality standards (but no HACCP, ISO, etc), most orchard belong to the village co-operative (i.e. not individual farmers) and operate the land as a company, a small part of the orchard is for each individual (e.g. 0.2 ha) for use as they see fit, several families own >100 trees and there are company farms that rent land (trees) and also market produce from small farmers, the Haitong food company is registered on the stock exchange, it occasionally sends processed vegetables to Australia via a few importers, it has a new 11 ha factory site with modern facilities (including research laboratory [GC, HPLC; pilot scale processing; QA; R&D], administration building, workers living quarters, 60,000 sq. m. of processing areas, coldrooms, glasshouses, etc.), it is ISO and HACCP certified, it does prepared foods (e.g. export to Japan), it uses a sophisticated production line (i.e. FMC, etc equipment) for yang mei, it has a FMC concentrator that is used for orange juice and may later be used for yang mei juice, it processes juice by VHT and UHT methods, for yang mei fruit harvest is in the morning and processing in the afternoon and evening (receive → dump → (convey) → cull → wash → crush (separate seed out) → temporary juice storage → separation of solids (high speed) → further filtering → cold storage in plastic drums → … packaging, etc.), have fluidized bed freezer (5 tonne per hr capacity) and freeze drying and vacuum pack lines, yang mei is only 1% of turnover for Haitong but is expected to grow.
Lunch with CiXi city and Haitong and Hen He and H U of C staff.
Visit to a 40 ha Hen He Agriculture company organic farm in Da Shan village in the hills and then their packing shed on the flat towards CiXi (p.m.) –
in order to rejuvenate poorly managed orchards they apply organic animal manure plus potassium in the form of burnt rice straw and remove herbaceous and woody weeds and add organic fertilizer (viz. canola seed cake left after extrusion of the oil) and do some land leveling (terracing) under the trees to make picking more efficient and plant some ground cover species, one worker can pick about 60 kg per day and is paid RMB 40 ($A8) per day, can grow soybeans under yang mei trees, the orchard owner/manager runs >200 ha of his own and other's land, half of this area is already converted to organic and the rest will be in 2 years, it takes 3 years to convert from conventional to organic (i.e. no synthetic chemicals), H U of C staff and students are doing experiments with the fungicide Nataxin (viz. normally in bread to retard fungi and very good against blue mould) to control penicillium at the

packing shed and they have found that yang mei can store at 0 to 2 deg C for 1 to 2 weeks if not fungicide treated but for over 3 weeks if fungicide treated, there can be an oversupply in Zhejiang Province and so need to develop storage and transport systems to expand into markets further away in China and OS, production has increased markedly in past years and is still increasing rapidly.
Stay overnight in CiXi.

Saturday 19.06.04
Visit a Dasang company yang mei farm (a.m.) –
Dasang company has over 700 acres, general fruit fall / drop problem, brand is Qi Jia Shan, factory is on-site and DaSang is a village, products are fresh and frozen (eg. wine) and go to Hangzhou and Shanghai and Beijing in China and to Hong Kong and Singapore and Taiwan overseas.
(Note: judging from the berry-like taste of the frozen yang mei product, it could be a *very interesting* ice-cream flavour, it is not used in this way as yet).
Travel with visitors[#] to Shaoxin city ([#]for yang mei harvesting) accompanied by Professor Yueming Jiang (Professor Li Jianrong returns to Hangzhou).
Have dinner with food company hosts[#].

Sunday 20.06.04
Visit Shaoxin city (e.g. poets garden) hosted by food company executives (C/- Ms Liming Yan)[#].
Lunch with Ms Liming and colleagues.
Return to Hangzhou.
Dinner with Professor Kunsong Chen (Zhejiang University's School of Agriculture and Biotechnology) followed by a post-dinner discussion meeting with his staff and student –
a powerpoint presentation on Zhejiang University was given by Professor Kunsong Chen, Zhejiang University is a comprehensive university that is number one (on the basis of postgraduate enrolment and external R&D earnings) in China for agriculture and horticulture teaching and research and in the top three universities in China overall, Zhejiang University is the most important R&D base for pre- and post-harvest yang mei work, other key post-harvest interest fruit crops include Chinese pear and loquat and kiwifruit, however the School of Agriculture and Biotechnology works on a wide range of fruit and vegetable and horticulture crops as well as on all manner of agriculture crops, the university is involved in the rice genome project, the university also has social agriculture and natural resources programs (it is highly complementary with the NRAVS Faculty of UQ), Dr Ian Ferguson (Chief Scientist of HortResearch [NZ]) is an official visiting fellow to the School of Agriculture and Biotechnology, the notion was discussed that a research and education-based relationship might be established between Zhejiang University and Queensland University, both are in the top group in China and Australia respectively, a relationship could start informally and be formalized in time with a MOU, a reciprocal visiting delegate mission might be helpful in allowing each organization to understand each others interests and strengths and so on, opportunities for joint funding (such as for workshops) could be sought, student (e.g. higher degree) exchanges are also of interest on an equitable cost sharing basis (e.g. meeting all 'in-country' costs at each end), joint supervision of higher degree students is also a possibility as is advising on R&D programs.

Monday 21.06.04
Have discussions at H U of C –
* Student Xiu Li Li working with Mr Wang and Professor Jiang on yang mei post-harvest: preliminary investigations on atmospheres (2, 4 and 6 h exposure to pure nitrogen versus pure oxygen) and dips (control, 40% EtOH [10 sec], 0.1 % NaOCL [1 min], NaOCL + dry [1 hr] + 2% NaCl [1 min], NaOCL + dry + NaCl with 1 % $CaCl_2$, NaOCl + dry + 0.01% oxalic acid with 0.5% ascorbic acid), three replications, 10 to 15 fruit sub-samples every 3 days.
* Professor Li Jianrong and Professor Yueming Jiang re arrangements for their reciprocal visit to Australia in November – Australia will pay for airfares and in-country expenses (i.e. accommodation, food, incidentals, regional travel, etc.), LJ to leave from Hangzhou via Shanghai then Melbourne then Sydney then Brisbane then Shanghai back to Hangzhou, YJ travels from/to Guangzhou and prefers to skip the Sydney stop, Shiming and Graeme to organise individual official letters of invitation from DPI-Vic. and to arrange air tickets via travel agent and to arrange funds to UQ for the Queensland leg, tickets will be sent by UPS or EMS or the like, the activities in Australia will include presentation of a seminar on the respective organizations plus on yang mei to staff and students and

discussions with staff and students and visits to research and industry organizations, the Victorian visit will involve time at Knoxfield and Tatura and the Queensland visit time at Gatton with visits to Maroochy and/or Alstonville, an invitation will be extended by DJ to Max Bourke of RIRDC to meet Professors Li and Jiang.
Note: SL to reconcile the budget on return from China and discuss ˜ (see above) with Graeme.
* Professor Li and Professor Jiang re arrangements for future yang mei work –
potential collaborative project with China focusing on post-harvest and processing problems and Australia focusing on germplasm and agronomic issues. Possible collaborators include **UQ** (Daryl Joyce) and **DPI-Vic** (Shiming Liu and Graeme McGregor (and perhaps DPI-Q and NSW Agric) and **H U of C** (Li Jianrong) and **ZARI** along with **SCIB** (Yueming Jiang).
Note: DJ to approach RIRDC, ACIAR and other organizations to resource the project from the Australian end.
* Write (this) summary report.

Tuesday 22.06.04
* Complete summary travel report.
Air travel to Australia – depart Hangzhou, arrive Hong Kong; depart Hong Kong.

Wednesday 23.06.04
Air travel to Australia – arrive Brisbane.

Appendix

Itinerary
Prof. Jianrong Li & Dr Yueming Jiang
UQ Gatton, Queensland

Monday 15th November 2004			
Time	**Activity**	**People**	**Place**
All day	**Visit QDPI Applethorpe Research Station** – *temperate crops R&D site***:** tour laboratories, present seminars, tour station.	**Host: Christine Horlock (Plant Pathologist)**	**Stanthorpe, Qld.**
		Peter Nimmo, Station Director	
		Dougal Wallace , Plant Breeder	
		Other DPIQ horticulturalists and specialists	
Tuesday 16th November 2004			
Morning and early afternoon	**Visit QDPI Maroochy Research Station:** – *sub-tropical and tropical crops R&D site*: tour station, present seminars.	**Host: Barbara Stubbings (Postharvest Horticulturist)**	**Nambour, Qld.**
		Simon Newett (Extension Officer)	
		Bruce Top and Mark Herrington (Plant Breeders)	
		Other DPIQ horticulturists and specialists	
Late afternoon	**Visit Birdwood Nursery:** – *sub-tropical and tropical crops nursery***:** tour propagation and growing facilities.	**Peter Young (Managing Director)**	**Nambour, Qld.**
Wednesday 17th November 2004			
All day	**Visit UQ Gatton:** – *School of Agronomy & Horticulture***:** tour laboratories, present seminars, tour campus.	**Host: Daryl Joyce (Postharvest Horticulturist)**	**Gatton, Qld.**
		Ian Gordon (UQG Plant Nursery Director)	
		Other UQG horticulturists and specialists	
		Postdocs., postgraduate students and technical staff of the School.	

Itinerary

Prof. Jianrong Li & Dr Yueming Jiang

DPI Knoxfield 10th and 11th November 2004

Wednesday 10th November 2004			
Time	**Activity**	**People**	
11:00-11:30	**Welcome. Overview of Physiology and Food Safety Team**	**Bruce Tomkins**	
11:30-12:00	**Overview of food safety and nutrition research**	**Robert Premier**	
12:00-12:30	**Discuss red bay berry project.**	**Graeme McGregor**	
12:30-1:30	**LUNCH**	**GMcG and P&FS Section**	
1:30-2:15	**Phytochemical research**	**Rod Jones**	
2:15-3:00	**Postharvest pathology and disinfestation research**	**Robert Holmes**	
3:00-3:30	**Afternoon tea**		
3:00-3:30			
3:30-4:15	**Storage and packaging of Asian vegetables, Instrumented sphere technology**	**Graeme Thomson**	
4:15-5:00	**Food safety training bush foods, cut flower research**	**John Faragher**	
11th November 2004			
9:00-10:00	**Seminar on Postharvest research**	**Prof. Jianrong Li & Dr Yueming Jiang**	
10:00-10:30	**Morning tea**		
10:30-11:15	**Tour of postharvest facility**	**Bruce Tomkins**	
11:15-12:30	**Market access Discussions with Bin Lu**	**Bin Lu**	
12:30-1:00	**Lunch**		
1:00	**DEPART**		

The original itinerary planned for Prof Jianrong Li and Dr Yeuming Jiang focused on potential regions for bayberry production. This focus was altered after Dr Tahir Khurshid joined the project team and supplied the climatic analysis presented herein. It was deemed more useful to facilitate interactions with QDPI and DPI-V scientists who could potentially contribute to future bayberry research and development, and to raise local awareness of the potential for this crop and for collaborative research.

REFERENCES

Anon, Reconnaissance of the Neolithic site at Ho-Mu-Tu in Yuyao County, Chekiang (Zhejiang) Province. *Wen Wu (Cultural Relic.)* **8**, 6-12,1976. (In Chinese)

Anon, *Myrica rubra* cultivation notes. Plants for a Future. http://www.scs.leeds.ac.uk/cgi-bin/pfaf/arr_html?Myrica+rubra (18/02/02), 2002.

Anon, Typhoons, rains damage bayberries in east China province. People's Daily Online. http://english.peopledaily.com.cn/200107/16eng20010716_75084.html (27.08.03), 2003a.

Anon, *Myrica rubra*. Flora of China. Flora Online. http://flora.huh.harvard.edu:8080/flora/browse.do?flora_id=2&taxon_id=121458 (http://flora.huh.harvard.edu/china/PDF/PDF04/myrica.pdf) (27.08.03), 2003b.

Anon, List of the plants which are prohibited to be imported. (updated April, 2003). http://pps.go.jp/english/law/list2.html (27/08/03), 2003c.

Anon, Information for visitors from the Republic of Indonesia. http://pps.go.jp/english/trip/overseas/list/122.html (27/08/03), 2003d.

Anmin, L. and Bornstein, A.J., Myricaceae. http://hua.huh.harvard.edu/china/mss/volume04/MYRICACEAE.published.pdf (27.08.03), 2003.

Araki, S., Street trees of Tokyo. (updated 2002) http://home.interlink.or.jp/~s-araki/HP-E.html (27.08.03), (2003).

Chen, C.R., Ying, T.J., and Qiang, D.M., Research on mechanical properties of red bayberry fruit and their change regularity in storage. *Food Science* **15**(10), 56-60, 1994. (In Chinese with English abstract)

Chen C.R., Ying T.J., Qiang D.M., and Li S.P., Research on mechanical properties of red bayberry fruit and their change regularity in storage. *Bulletin of Science and Technology* **11**, 54-58, 1995. (In Chinese with English abstract)

Chen, D., Wang, Y.G., Luo, ZS, Xi ,Y.F., and Xu, C., Effects of chitosan coating on quality of Chinese bayberry fruit. *Plant Physiology Communications* **37**, 506-507, 2001. (In Chinese with English abstract)

Chen, K., Xu, C., Zhang, B., and Ferguson, I.B. Red bayberry: Botany and horticulture. Horticultural Reviews 30, 83-114, 2004.

Cheng, Y-P., Chien, C-T., and Lin, T-P., Population genetics of geographically restricted and widespread species of *Myrica* (Myricaceae). *Journal of Heredity* **91**, 61-66, 2000.

Du, Y.K., CA and postharvest technology of fruit, vegetables and ornamentals. Chinese Agricultural University Press, Beijing, China, 2000. (In Chinese)

Hamon, A.B., Nguyen, R., and Browning, H., Bayberry whitefly. Featured Creatures. http://creatures.ifas.ufl.edu/citrus/bayberry_whitefly.htm (27.06.01), 2001.

He, X,H,, Chen, L.G., Hu, X.Q., and Zhang, J.Y., Study on genetic diversity of *Frankia* strains from symbiotic of *Myrica rubra*. *Journal of Zhejiang University (Agriculture & Life Science)* **28**, 659-663, 2002. (In Chinese with English abstract)

Hu, X.Q., Yu, X., and Chen, L.G., Studies of Chinese bayberry fruits on some physiological characters during the storage. *Journal of Zhejiang University (Agriculture & Life Science)* **27**, 179-182, 2001. (In Chinese with English abstract)

Joyce, D.C., and Li, J.R., Introduction to the proceedings of the yang mei (red bayberry) postharvest workshop. *Postharvest News and Information* **13**(4), 23, 2002a.

Joyce, D,C,, and Li, J.R., Current trends in postharvest technology. *Postharvest News and Information* **13**(4), 24-27, 2002b.

Joyce, D.C., and Li, J.R., Postharvest characteristics of red bayberry. pp. 125-226. Proceedings of the Australasian Postharvest Horticulture Conference, 2003. 1st-3rd October, 2003, Carlton Crest Hotel, Brisbane, Australia. (IBSN 0-646-43074-2), 2003.

Li, J.R., Study on the key technologies of postharvest and deep processing of red bayberry. PhD Thesis, Zhejiang University, P. R. of China, 2001. (In Chinese with English abstract)

Li, J.R., Processing technologies for red bayberry and the main vegetables in CiXi city. *Postharvest News and Information* **13**(4), 39, 2002.

Li, J.R., and Chen, Y.P., Production and trade of red bayberry in CiXi city. *Postharvest News and Information* **13**(4), 40, 2002.

Li, S.Y., and Dai S.Z., Preliminary observations on flower bud differentiation of *Myrica rubra* S et Z. *Acta Horticulturae Sinica* **7**, 9-16, 1980. (In Chinese with English abstract)

Li, J.R., Chen, P.L., and Joyce, D.C., Study on thermal degradation kinetics of anthocyanin in *Myrica rubra* juice. *Bulletin of Science and Technology* **18**, 1-5, 2002a. (In Chinese with English abstract)

Li, X., Li, S., Lin, J., Effect of GA_3 spraying on lignin and auxin contents and the correlated enzyme activities in bayberry (*Myrica rubra* Bieb.). *Plant Science* **164**, 549-556, 2003.

Li, J.R., Wang, X.Y., and Joyce, D.C., Red bayberry physiology during fruit development and harvest. *Postharvest News and Information* **13**(4), 41-44, 2002b.

Li, J.R., Liang, X.L., Deng, G., and Joyce, D.C., Isolation and identification of spoilage fungi from red bayberry. *Postharvest News and Information* **13**(4), 49-52, 2002c.

Li XJ, Lu JL, Li SY., (1999) Advances in bayberry of China. *Journal of Sichuan Agricultural University* **17**, 224-229. (In Chinese with English abstract)

Li, Z.L., Zhang, S.L., and Chen, D.M., Red bayberry (*Myrica rubra* Sieb & Zucc.): A valuable evergreen tree fruit for tropical and subtropical areas. *Acta Horticulturae* **321**, 112-121, 1992.

Miao, S.L., and Wang, D.X., Red bayberry. Zhejiang Science and Technology Press, Hangzhou, China, 1987. (In Chinese)

Miao, S.L., Zhang, Y.J., and Liang, S.M., Overcoming the alternate bearing of the *Arbutus* by changing the timing of fertiliser application. *Journal of Fruit Science* **13**, 15-18, 1996. (In Chinese with English abstract)

Miao, S.L., Huang, S.B., Liang, S.M., and Zhang, Y.J., Study on the ecological distribution of Chinese red bayberry. *Journal of Zhejiang Agriculture University* **21**, 366-372, 1995. (In Chinese with English abstract)

Qi, X.J., Wang, L.P., Liang, S.M., Zhu, L.Q., and Chai, X.Q., Study on the mycoflora in bayberry (*Myrica rubra*) fruits treated by controlled atmosphere storage. *Acta Agriculturae Zhejiangensis* **15**, 28-30, 2003. (In Chinese with English abstract)

Ruan, Y.L., and Wu, L.M., A study of photosynthetic characteristics of wintering loquat and bayberry. *Acta Horticulturae Sinica* **18**, 309-312, 1991. (In Chinese with English abstract)

Sawamura, M., Yu, X.L., Miyazaki, T., and Osajima Y., Changes in the quality and components of *Myrica rubra* fruits stored in plastic bags. *Journal of the Japanese Society for Horticultural Science* **58**, 705-711, 1989. (In Japanese with English abstract)

Wang, H.Y., and Huang, W.N., Observation on the structure and ultrastructure of root nodule and nitrogenase activity in *Myrica rubra*. *Acta Phytophylogica Sinica* **16**, 153-157, 1990. (In Chinese with English abstract)

Wang, X.Y., and Shen, L.Q., Study of MAP of fruit. *Food Science* **20**, 62-65, 1999. (In Chinese with English abstract)

Wang, X.Y., Li, J.R., Yang, X.H., and Joyce, D.C. Fresh preservation of red bayberry. *Postharvest News and Information* **13**(4), 53-56, 2002a.

Wang, G.Y., Sheng, Q., Xi, J.R., Zhang, S.H., and Jiang, G.Q., Occurrence and control of major pests in the primary producing area of bayberry in Zhejiang province. *South China Fruits* 1998 (2), 29-31, 1998. (In Chinese)

Wang, X.Y., Li, J.R., Yang, X.H., and Joyce, D.C., Injury of red bayberry during storage and transport. *Postharvest News and Information* **13**(4), 45-48, 2002b.

Xi, Y.F., Luo, Z.S., Xu, C., Chen, D., and Wang, Y.G., Effects of CA storage on quality in fruit of Chinese bayberry (*Myrica rubra*). *Zhejiang Agricultural Sciences* 2001 (6), 291-293, 2001a. (In Chinese with English abstract).

Xi, Y.F., Luo, Z.S., Xu, C., Chen, D., and Wang, Y.G., Effects of CA storage on active oxygen metabolism in Chinese bayberry fruit (*Myrica rubra*). *Journal of Zhejiang University (Agriculture & Life Science)* **27**, 311-313, 2001b. (In Chinese with English abstract)

Xi, Y.F., Zhang, Y.H., Ying, T.J., Ying, J.F., and Chen, Z.L., Senescence physiology of Chinese bayberry fruits during storage. *Acta Horticulturae Sinica* **21**, 213-216, 1994. (In Chinese with English abstract)

Xiao, Y., Huang, J.C., and Li, H.B., The study of calcium and NAA treatment on the storage of red bayberry. *Journal of Southwest Agricultural University* **21**, 305-310, 1999. (In Chinese with English abstract)

Ye, X.Q., Chen, J.C., and Shu, P., Identification of the constituent of anthocyanin in Yang-Mei (*Myrica rubra* cv. Boqi). *Journal of Zhejiang Agricultural University* **20**, 188-190, 1994. (In Chinese with English abstract)

Yin, T.J., and Xi, Y.F., Study on the far transportation of red bayberry in highway. *Food Science* **18**(8), 52-55, 1997. (In Chinese with English abstract)

Yu, D.J., Taxonomy of fruits in China. pp. 305-309. Agricultural Publication House, Beijing, P. R. of China, 1979. (In Chinese)

Zheng, Y.H., Ying, T.J., Xi, Y.F., Mao, L.C., and Chen, Z.L., Effects of vibrational stress on postharvest senescence physiology of Chinese bayberry fruit. *Acta Horticulturae Sinica* **23**, 231-234, 1996. (In Chinese with English abstract)

Zou, T.C., Geographical distribution and evaluation of resource utilisation of Myricaceae in Guizhou. *Journal of Guizhou University (Natural Science)* **18**(2), 103-113, 2001. (In Chinese with English abstract)