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Evaluation of Lychee (*Litchi chinensis* Sonn.) Cultivars on the Atherton Tableland of North Queensland

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Abstract.

Thirty-eight lychee (*Litchi chinensis* Sonn.) cultivars were evaluated between 1970-1991 on the Atherton Tableland of North Queensland for regularity of cropping, yield, and fruit characteristics.

Fruit were harvested between early November and late January. Mean annual yields ranged from < 0.1 to 58 kg/tree. 'Bengal' (58 kg/tree), 'Haak Yip' group (23), 'Souey Tung' (19) and 'Tai So' group (27) were the heaviest croppers. Neither minimum monthly temperatures, deviation from normal minimum, number of days within minimum < 12°C, or heat units during June, July or August (winter) appeared related to yield, although all cultivars failed to crop in a year of no winter cold period when daily minimum temperatures were 1.1, 2.3 and 1.2°C above normal in June, July And August respectively.

Mean fruit weights ranged from 11.3 g ('Groff') to 34.2 g ('Chacapat'), with 9 lines i.e. 'Bengal,' 'Brewster,' 'Chacapat,' 'Fay Zee Siu,' 'Kiamana,','Peerless,' 'Sampao Kaow,' 'Sang' and the 'Tai So' group averaging > 20 g. Three cultivars, 'Kiamana,' 'Kwa Lok' and 'Salathiel' gave > 75% flesh recovery. 'Salathiel' consistently displayed > 90% "chicken tongue" (aborted seed).

Recommended early cultivars are: 'Souey Tung,' 'Fay Zee Siu' (Synonym-'Yook Ho Pow') and 'Tai So,' mid-season: 'Haak Yip,' 'Kwai Mai Pink'; and late season: 'Wai Chee,' 'Luk Lai' and possibly 'Salathiel.'

Introduction

The lychee (*Litchi chinensis* Sonn.), a member of the Sapindaceae or soapberry family (14), is a native of southern China, where it has been cultivated over 2000 years. Towards the end of last and early this century a number of trees were introduced into North Queensland (1, 9, 12).

The origins and identities of many of these early imported trees and the plantings derived from them have been lost or confused. Seeds of Chinese cultivars were probbly also brought into North Queensland by Chinese miners, consequently a number of different local selections have developed along with the true types introduced from China. Considerable misnaming has resulted. Confusion has also been imported from other countries where Chinese varieties have been misidentified (1).

In 1935, Stephens (12) reported that the North Queensland lychee indutry had not expanded due to problems in obtaining plants. coupled with the long period needed for seedling trees to reach maturity and uncertainty of these being good varieties. In 1955, Stephens (13) commented that propagation difficulties were the main reason few trees were grown. Further, he stated that 'Tai So' (misnamed as 'Kwai Mi') and 'Wai Chee' were the best cultivars in the state, 'Haak Yip' was satisfactory and that 'Salathiel' (misnamed as 'No Mai Chee') was an extremely shy bearer.

The most commonly planted cultivars in North Queensland in the 1970s were 'Tai So' (misnamed as 'Kwai Mi'), 'Bengal' (misnamed as 'Brewster' and 'Bedana') and 'Wai Chi,' with 'Haak Yip' and 'Salathiel' minor cultivars (2, 5). Hams (5) stated that 'Tai So' ('Kwai Mi') was the only cultivar that could be recommended in coastal regions, but plantings of 'Gee Kee' should be tried.

The lychee growing area of North Queensland is divided into two distinct zones, i.e. coastal and tableland. The coastal area has a hot, wet monsoonal climate, but the elevated (200-700 m) tableland area has cooler night tem-

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peratures especially during winter and is generally drier than the coast, although the coast has both very wet and drier areas. Approximately 55,000 trees are planted in North Queensland (N. Sing pers. comm.) and 300,000 in Australia as a whole (C. Menzel pers. comm.)

Erratic flowering and production was indicated by Cull and Hams (2) as one of the major problems with lychee in North Queensland, but responses varied among cultivars. Similar findings have been reported elsewhere. For example, 'Tai So' was reported as the most consistent cropper of the common cultivars in Florida, whereas 'Bengal' was an alternate cropper (15). In southern Queensland, Menzel and Simpson (7) considered 'Kwai May Pink' regular in several different climatic zones, 'Wai Chee,' 'Salathiel,' 'Haak Yip' and 'Souey Tung' regular in certain areas, but 'Brewster,' 'Tai So,' 'Bengal,' 'Kwai May Red' and 'Gee Kee' were irregular in most areas. 'Bengal' is the most consistent cultivar in New South Wales, Australia, although it tends to a biennial bearing pattern (D. Batten pers. comm.)

A major problem for North Queensland growers has been deciding which cultivar to plant. Fruit quality and consistency of flowering/cropping of the numerous and frequently misnamed lines available has not been well documented. In the 1970s the Queensland Department of Primary Industries initiated a program to import and evaluate local and imported lychee selections. The main introductions were made by B. J. Watson via Kamerunga Horticultural Research Station (Cairns, Queensland) and D. Batten via the Tropical Research Centre (New South Wales Department of Agriculture, Alstonville, New South Wales). This paper reports on performances of lychee cultivars at Walkamin Research Station on the Atherton Tableland during the 1970s-1980s.

Methods and Materials

Evaluation of lychee cultivars was conducted at Walkamin Research Station (17°7'S; 145°26'E; 570 m elevation) on the Atherton Tableland of tropical North Queensland. The soil is described as a Euchrozem (Great Soil Group) or UF 631 (Northcote) or HAPLVDOX (USDA System) (I. Heiner pers. comm.). Average rainfall is 1,059 mm, 65% of which falls during the summer months of January-March. Maximum monthly daily temperatures range from 23.3°C in July to 30.5°C in November while minimums vary from 12.9°C in July to 20.3°C in February. The Station is frost free. The climate is best described as dry tropical highland. Weather data are shown in Table 1.

Thirty-eight cultivars, a mixture of local and imported, marcotted (air layered) or grafted were planted between 1970 and 1990 (Table 2). The trees were randomized in an observation block containing mixed planting of lychee, avocado, longan and mango. All species were planted at 9m by 9m.

The trees were fertilized according to Hams (6). Bearing trees were fertilized annually after harvest with rates varying according to tree age and previous crop. Irrigation initially was by flooding but was changed to undertree sprinklers in the mid 1980s. Trees were not irrigated in autumn/winter (May-August) or until inflorescences were fully emerged. From 1986, trees were skirted after harvest (lower limbs removed) and topped at 4 m.

From 1980 onwards detailed data were taken on time of panicle emergence, flowering, fruit set, and harvest as well as fruit characteristics (weight, total soluble solids, % aril [flesh recovery], and % aborted seed ["chicken tongue"]). Average fruit weight, % aril and chicken tongue were measured on samples of up to 50 fruit taken at random. Total soluble solids was determined with a Shibuya Number 11 hand-held refractometer from 10-12 fruit measured individually.

Table 1. Long term weather at Walkamin Research Station.

Measurement	J	F	M	A	M	J	J	A	S	O	N	D	Mean/ total
Mean monthly maximum °C	29.9	28.9	28.0	26.5	25.0	23.4	23.3	24.9	26.8	29.2	30.5	30.4	27.2
Mean monthly minimum °C	20.2	20.3	19.4	18.0	16.2	13.6	12.9	13.2	14.6	16.6	18.5	19.5	16.9
Total rainfall (mm)	236	220	241	56	31	22	9	9	8	22	85	120	1059
Total evaporation (mm)	179	139	143	136	116	105	113	136	167	203	198	194	1829

Nine cultivars were represented by 2-3 trees, the remainder by single trees. Tree numbers were limited by the number imported and released by Plant Quarantine. Data for multi-tree cultivars were taken separately but averaged in this report. Data are presented as means. Weeks are presented on a 1-52 basis.

Results and Discussion

Panicle emergence occurred in June, while 50% flowering (anthesis) and fruit set occurred in August-September. Fruit were harvested between November-January (Table 2).

Many cultivars, both local and introduced, were either 'Tai So' or 'Haak Yip' types (Table 2), while the import of 'Sum Yee Hong' did not match Chinese descriptions (3). One line imported as 'No Mai Chee' was 'Kwai Mai Red.'

Yield

Regular bearing cultivars were (in order of maturity), 'Fay Zee Siu' ('Yook Ho Pow') 'Tai So' group, 'Kom,' 'Haak Yip' group, 'A. Neung Hai' (seedling), 'Groff,' 'Kwai Mai Pink,' and 'Wai Chee.'

The cultivars 'Erewhon,' 'Millar 'A,' and 'South Mission Beach' were extremely irregular with only 1 or 2 light crops in 10 years, whereas 'Tai So' cropped most seasons. Results reported here of variation in cultivar cropping consistency are in agreement with reports of varying cultivar responses (2, 7, 15).

In 1986 the crop was poor because only limited flowering occurred. Twenty-eight trees (18 cultivars) flowered, but due to sparce flowering only 16 produced fruit, and then mostly less than 1 kg/tree. Daily minimum temperatures in June, July and August were 1.1, 2.3 and 1.2°C above normal respectively with only 10 days with minimum temperatures below 12°C and no prolonged period with minimum temperatures < 12°C (Fig. 1). Crop failures also occurred with mango (16) and longan.

In 1989 cool conditions did not occur until late-winter (August) and early cultivars such as 'Sampao Kaow,' 'Souey Tung' and 'Tai So' group flushed vegetatively in winter and cropped poorly (1.2. 7.7 and 6.6 kg/tree versus mean yields of 7.7, 19.0 and 33.0 kg/tree respectively). Late season cultivars 'Salathiel' and 'Wai Chee' generally had near or above mean yields (30.1 and 55.9 kg/tree versus long term means of 13.8 and 21.3 kg/tree respectively).

Prolonged cool winter temperatures are reportedly important for flowering (e.g. 2, 4, 5, 10, 17). Groff (4) stated that periodic cold between 0 and 5°C in winter causes changes necessary for fruiting and that in China litchi does not fruit successfully in areas where winter temperatures never go below 10°C. Nakata and Watanabe (10) stated that duration of temperature < 18°C is important for flowering. Young (17) in Florida stated that low soil moisture

Table 2. Observations of mean time of 50% flowering and maturity, yield and fruit quality characteristics of lychee cultivars at Walkamin Research Station.

Cultivar	Number of trees	Years of data collection (tree age)	Date 50% flowers open (week)	Harvest date (week)	Average yield kg/tree/year	Tree vigour[A]	Fruit Weight (g)	Total Soluble Solids	% Aril	% aborted seed	Fruit quality	Comments
Amboina	1	1986-87 (5-6)	28	41	0.04	VL	18.2	17.6	67	50	Fair	Poor tree structure. Fruit lost in 2nd year due to birds.
A. Neung Hai seedling	1	1988-91 (4-8)	38	50.3	13.7	M	14.7	19.6	67.3	40	Good sweet/acid	Variable seed size, aromatic, attractive
Baidum	2	1983-87 (8-11)	38.3	52.8	9.3	M	16.6	17.3	63	11	Fair	Very susceptible erinose mite and parasitic algae.
Bengal	1	1983-89 (12-18)	37.8	52	58.4	H	20.3	17.8	56	8	Fair sweet, juicy	Attractive, large seed, soft flesh.
Brewster	1	1987-91 (4-8)	38.2	50	8.2	H	22.9	18.3	68	4	Fair	Attractive, large big seed.
Chacapat	1	1986-91 (3-8)	40.4	3.8	12.3	M	34.2	16.3	68	10	Poor, sour	Very late, large, attractive, large seed. Parrots avoided.
Erewhon	1	1985-91 (4-10)	37.3	52.5	1.1	VL	12.9	19.7	65	88	Poor fair, sweet	Two harvests only, small fruit, poor light cropper, small seed.
Fay Zee Siu (Yook Ho Pow)	3	1988-91 (3-6)	37.2	48.6	6.8	H	25.8	19.0	72	57	Good juicy, sweet	Uneven skin colour gives appearance of immaturity. Good colour when full ripe.
Groff	1	1986-89 (3-6)	37.2	50.5	6.7	M	11.2	17.2	69	90	Poor, juicy	Unattractive, small.
Haak Yip Group												
-Charlie Tong	1	1985-90 (4-9)	37.6	48.8	22.4	M	17.4	17.9	67	1	Good, sweet	In Hawaii and another site, Charlie Tong is Tai So.
-Chung Tie	1	1987-91 (3-7)	39.5	50	3.9	M	21.8	15.6	70	0	Good, sweet	Only one crop.
-Jim Jee	1	1984-90 (4-10)	37.6	49.8	17.6	M	19.1	17.1	68	0	Good, Sweet	
-Rochdale	1	1984-90 (4-10)	38.0	49.7	24.4	M	18.6	16.6	67	0	Good, sweet	

Table 2. (Continued).

Cultivar	Number of trees	Years of data collection (tree age)	Date 50% flowers open (week)	Harvest date (week)	Average yield kg/tree/year	Tree vigour[A]	Fruit Weight (g)	Total Soluble Solids	% Aril	% aborted seed	Fruit quality	Comments
-Souey Tung	1	1983-90 (5-12)	37.8	49.8	45.5	M	18.1	18.0	70	4	Good, sweet	Not Souey Tung
-Haak Yip	1	1983-90 (3-10)	37.3	49.8	24.1	M	17.1	17.4	70	2	Good sweet, juicy	
Kiamana (7795)	1	1990-91 (4-5)	35	48.5	1.0	?	26.9	17.9	80	66.5	Good sweet, juicy	Young tree, looks promising.
Kaloke Bai Yaow	1	1985-88 (3-6)	32.0	46.3	7.7	M	15.0	16.2	56	1	Poor	Rough skin, very red, poor flavour.
Kom	1	1984-89 (3-8)	35.7	49.1	9.8	M	17.7	17.9	63	41	Poor, tart	Mixed size and maturity on panicle. rough skin.
Kom Hom Liam Chiak	1	1986-90 (3-6)	36.0	47.3	5.3	M	17.3	16.3	54	4	Very poor, tart	Even parrots avoided eating it.
Kwa Lok	1	1988-91 (3-6)	38.7	52.3	0.6	L	19.3	17.8	76	68	Fair, good, sweet, slt aromatic	Lacks colour but good flavour.
Kwai Mai Pink	1	1983-90 (5-13)	37.0	51.6	27.5	M	16.9	19.8	71	24	Good, sweet, aromatic	Can eat when less than full colour, can hold on tree. Very susceptible to mites.
Kwai Mai Red	1	1988-91 (4-7)	39.3	1.0	5.8	M	13.6	17.9	60	33	Good, sweet, aromatic	Not as good as KWP, poor cropper.
Luk Lai	1	1987-91 (3-6)	38.3	52.3	12.5	L	18.9	17.8	69	31	Good, sweet	Attractive, promising, strong resemblance to Wai Chee.
Millar A	1	1978-84 (2-9)			0.06							No fruit to assess. One crop in eight years.
Peerless	1	1986-91 (3-8)	36.7	49.5	24.8	H	20.0	18.0	61	22	Fair, sweet, juicy	Big seed, similar to Brewster. Very attractive.
Salathiel	2	1983-91 (7-15)	38.2	52.4	13.8	L	14.7	18.4	78	99	Excellent, sweet, aromatic	Very susceptible to mites. Can eat when less than full colour.

Table 2. (Continued).

Cultivar	Number of trees	Years of data collection (tree age)	Date 50% flowers open (week)	Harvest date (week)	Average yield kg/tree/year	Tree vigour[A]	Fruit Weight (g)	Total Soluble Solids	% Aril	% aborted seed	Fruit quality	Comments
Sampao Kaow	1	1985-91 (4-10)	34.3	48.0	7.7	H	24.5	18.2	61	3	Poor-fair, not sweet	Large seed, spiny, bad splitting.
Sang	2	1988-91 (3-6)	38.1	53.3	2.9	M	20.1	18.3	68	75	Fair, sweet	Doesn't set well, Tai So flavour, nothing special.
Souey Tung	1	1988-91 (3-7)	33.3	45.5	19.0	M	19.1	15.8	64	23	Good, sweet/acid	Early, worth trying. Testa sticks to aril.
South Mission Beach	1	1978-85	—	52.0	0.9	M	11.4	21.8	65	24	Poor	Two poor crops in eight years.
Sum Yee Hong	1	1988-91 (4-7)	35	51	0.2	L	11.3	21.2	67	26	Poor, sweet	Only one light crop in four years. May not be SYH.
Tai So Group												
-Cheng	2	1990-91 (3-4)	34	1.6	8.1	H	22.3	19.0	69	22	Fair, good, juicy	Young tree, typical TS
-HLH Mauritius	1	1985-91 (4-11)	35.3	48.5	32.6	H	21.6	18.4	68	11	Fair-good, juicy, sweet/acid	Typical TS.
-Hong Huey	2	1990-92 (4-5)	31.5	47.5	6.4	H	24.1	18.8	71	38	Good, juicy, sweet/acid	Typical TS.
-Kwai Mi	1	1977-88 (7-17)	33.8	48.7	36.5	H	20.5	18.6	66	17	Fair, good, juicy, sweet/acid	The standard TS.
-Mauritius	2	1983-90 (5-12)	34.0	49.0	48.0	H	20.7	18.6	6.8	11	Fair, good, juicy, sweet/acid	
-Maw Mong	2	1983-90 (5-12)	34.0	48.6	44.1	H	22.5	18.9	67	9	Good, juicy, sweet/acid	May not be as coloured.
-Muzaffarpur	1	1988-90 (4-6)	—	48.3	15.3	H	18.5	17.5	70	7	Fair, juicy, sweet/acid	Slightly smaller than other TS.
Wai Chee	2	1978-89 (7-18)	38.5	1.8	21.3	L	16.4	18.8	69	17	Good, sweet	Attractive.

[A] — Key to tree vigor: VL = Very low; L = Low; M = Moderate; H = High.

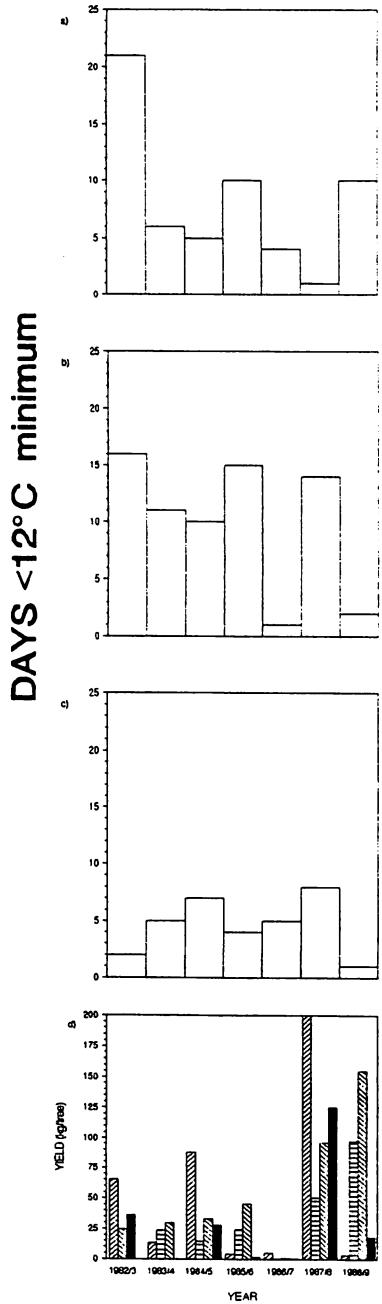

Figure 1. Number of days < 12°C minimum temperature during a) June, b) July and c) August at Walkamin Research Station and d) the yields of Bengal, Haak Yip, Tai So and Wai Chee lychee cultivars.

and temperature between 0-7°C for an extended spell promotes flowering, but low temperature was more important than moisture. Menzel and Simpson (8) found in studies with 7 cultivars at 3 temperature regimes that at 25/20°C or higher no cultivars flowered whereas all flowered to some degree at 20/15°C, and every shoot terminal of all cultivars produced an infloresence at 15/10°C.

The results highlight the difficulty of trying to define relationships between plant performance (yield) and climatic variability. The minimum and maximum temperatures, and heat units (daily maximum temperature - daily minimum temperature - 12)/2 in June, July and August (data not presented), and days < 12°C were unable to consistently predict yield. Conditions required for good flowering in lychee have yet to be fully elucidated.

Mean tree yields ranged from 0 (several cultivars) to 58.4 kg on 'Bengal' (Table 2). Differences in tree age and removal of trees for which ample data had been secured make direct cultivar comparisons difficult; however, of the older trees, 'Bengal,' 'Haak Yip Souey Tung,' and 'Tai So' ('Mauritius' and 'Maw Mong') averaged over 40 kg/tree. Eight other lines of varying tree ages (3 'Haak Yip' types, 2 'Tai So' types, 'Kwai Mai Pink,' 'Peerless' and 'Wai Chee') averaged over 20 kg/tree. All cultivars had high standard deviation values in relation to the mean yield, indicating high annual variation. The high standard deviation was in part due to many of the best yielding cultivars having one year with yields far exceeding any other year. For example 'Bengal' yielded 200 kg in 1987/8 compared with the next best yield of 87.6 kg in 1984/5. Likewise 'Tai So' ('Kwai Mi') yielded 250 kg in 1987/8 versus 43 kg in 1977/8.

Lychees at Walkamin matured from early November (week 41) to late January (week 3.8) (Table 2). Most lines matured at similar times each

season (±) 1-2 weeks. 'Amboina' and 'Souey Tung' were the earliest and 'Wai Chee' and 'Chacapat' the last to mature. This was reflected in their flowering data. Most early types were vigorous and more regular bearers.

Fruit Quality

Mean fruit fresh weight ranged from 11.3 g ('Groff') to 34.2 g ('Chacapat'). 'Chacapat' had a small proportion of fruit weighing 45-50 g. 'Chacapat' was very attractive but sour in flavour even when left to hang on the tree for a prolonged period. Quality of the very early cultivar 'Amboina' was poor. 'Fay Zee Siu' and 'Kiamana,' two promising lines, had mean fruit weight of 25-26 g (Table 2).

Total soluble solid levels generally ranged from 16-19° with limited yearly variations. Flesh recovery (% aril) varied from < 60% ('Bengal,' 'Kaloke Bai Yaow,' 'Kom Hom Liam Chiak') to > 75% ('Kiamana,' 'Kwa Lok,' 'Salathiel'). Percent aborted seed (chicken tongue) varied yearly, but were consistent with cultivar. 'Salathiel' had 100% chicken tongue every year except for one year when one tree had 92%. 'Groff' and 'Erewhon' averaged > 80%, while 'Bengal,' 'Brewster,' 'Haak Yip' group and 'Sampao Kaow' had few chicken tongues.

Subjective fruit quality ratings based on appearance, seed size, and flavour ranged from very poor ('Kom Hom Liam Chiak') to excellent ('Salathiel'). Most lines imported from Thailand, except for 'Tai So' and 'Haak Yip' types, did not rate highly. In addition to 'Salathiel,' 'A. Neung Hai' (seedling), 'Fay Zee Siu,' 'Haak Yip,' 'Kaimana,' 'Kwai May Pink,' 'Kwai May Red,' 'Luk Lai,' and 'Wai Chee' rated highly.

Recommendations

'Souey Tung' is very early but lacks slightly in quality as the seed testa sticks to the flesh. 'Fay Zee Siu' matures the same time as the commercial cultivar 'Tai So,' but is slightly larger, better flavoured (sweeter), with a higher percent of small and/or chicken tongue seed. As with 'Tai So' it is a vigorous tree but more upright and open. Top prices have been received for early, well coloured fruit of this selection. 'Tai So' is recommended because of its productivity and earliness but develops a mature appearance before it is sweet enough to harvest which results in growers marketing sour fruit.

'Haak Yip' bears heavy crops of good quality fruit, but it is not as consistent as 'Tai So' for yield and harvest time. 'Kwai May Pink' bears consistently with good quality fruit and a flexible harvest date.

'Wai Chee' and 'Luk Lai' are compact and produce good quality fruit. 'Salathiel' has nearly 100% chicken tongue, excellent flavour, and good flesh recovery, but is irregular and generally light yielding with small panicles of only 3-4 fruit. 'Salathiel' trees also lack vigour and are slow to establish.

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Apricot Production and Cultivar Situation in California

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Abstract

The cultivated acreage of apricot in California has decreased from 1981 to 1990. Furthermore, the U.S per capita consumption of apricots has also declined from 1970 to 1988. The major apricot cultivars presently grown in California are 'Blenheim,' 'Tilton,' 'Patterson,' 'Castlebrite,' 'Modesto' and 'Katy.' Some new cultivars being introduced are 'Earlicot,' 400-AR-1, 'Mesa #1' and 'Mesa #2.' In addition, some promising advanced selections from the USDA, ARS breeding program at Fresno will soon be available. These improved cultivars will contribute higher apricot quality and lengthen the season of production in California.

Introduction

The United States produced about 115,000 tons of apricot in 1990 (7) and is sixth in apricot production in the world after USSR, Turkey, Spain, China and Italy (3). California is the major producer of apricots in the United States and accounted for approximately 98% of the utilized production in 1989 (6). However, the total acreage of apricot trees has decreased in California the last ten years. The main reason for this is the increasing imports form other apricot producing countries and decreased consumption. Turkey and Spain have increased shipments the last six years, reaching one-third of total tonnage available in the United States in 1988. Also, per capita apricot consumption declined from 1.3 lb/person to 0.85 lb. in the 18-year period from 1970 to 1988 (5).

This paper outlines the acreage and average production from 1981 to 1990 in California. The major cultivars, newly released cultivars, and promising selections will be discussed.

Production and Acreage

California apricot production from 1981 to 1990 was fairly consistant with an average production of approximately 103,000 tons, of which 54.6%