

combination treatment used for Japan. Physiological damage caused by the cold air treatment includes desiccation, and fruit browning and splitting. Fungal decay is apparently a greater problem in cold-air treated fruit.

Thailand

Only in the past three to five years has fruit export been a serious consideration in Thailand. The country's most important fresh fruit exports are longan, mangosteen, and pomelo. The lychee season in Thailand is May and June while the peak in longan production occurs in mid-July. Government export figures in Thailand reported total 1993 exports of 21,000 tons of longan, and 2,000 tons lychee. Longan is generally shipped by sea to Asia, Europe, and Canada. Lychee and rambutan are shipped via air freight to the same destinations.

Packing companies for lychee are not centralized and commonly are small, private entities that buy directly from growers. No quarantine treatments are currently used for lychee in Thailand. Fruit are harvested by hand and transported to the packinghouse in plastic harvest crates. In the packinghouse, the fruit are separated into small bunches and jumble packed into corrugated cartons. Most companies line the cartons with paper but do not use poly bags to protect the fruit from desiccation. Cartons of various sizes and net weights are shipped in air freight containers or as palletized or bulk-loaded air cargo. The postharvest life of the fruit is understandably short because typically no cooling is used after harvest or during transport. Postharvest browning, desiccation, and fungal decay are sometimes serious problems despite the fact that fruit reach the export country within several days.

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THE ISRAELI LYCHEE INDUSTRY

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Abstract. Israel has about 160 ha of lychees (*Litchi chinensis* Sonn.) planted in the last 10 years for both internal Israeli markets and export markets in Europe. In a recent Fairchild Tropical Garden collecting expedition to Israel, all aspects of this industry were investigated, including the cultivars, production techniques, research, and marketing of the crop. Of particular interest to Florida lychee producers are the directions of the industry in terms of the testing of cultivars such as 'Early Large Red', 'Emperor', 'Late Seedless', 'Kaimana', 'Garnet', and 'No Mai Chee', which need further testing under Florida conditions. Also of great potential interest to Florida producers are the techniques used by Israeli producers to promote consistent flowering and fruiting.

Because of its favorable climate and proximity to European markets, Israel has developed a significant export lychee industry in the last 10 years. The Mediterranean climate with hot, dry summers and prolonged, cold winters is conducive to natural flower induction of lychee. Also, recent scientific advances in floral manipulation have improved consistency in fruit production under most conditions in Israel. With its proximity to Europe, Israel has the advantage of lower transportation costs compared with other production areas (e.g. South Africa) in reaching the European market. In late July of 1994, Israeli lychees also entered the United States, marking a potentially lucrative new market for Israeli lychee producers.

In July of 1994, the Fairchild Tropical Garden sponsored a lychee germplasm collection expedition to Israel. The objective of this expedition was to collect superior lychee culti-

vars for trial in Florida. This expedition also afforded the opportunity to study the Israeli lychee industry in detail. The objectives of this paper are to give an overview of the Israeli lychee industry, with particular focus on the cultivars, production, harvesting and handling techniques employed.

Location and Status of the Lychee Industry

The Israeli lychee industry consists of about 162 ha (400 acres) [S. Gazit, personal communication]. Much of the acreage is less than 5 years old and as yet nonbearing. Production areas are spread throughout the country, with a concentration along the Mediterranean coast (sea level) and in the Jordan Valley near the Sea of Galilee (210 m below sea level). Commercially suitable land for lychee production must have a sufficient supply of low salinity water, as all commercial production must be irrigated to survive. Additionally, suitable locations for commercial production must be warm enough to avoid freeze damage, or provisions must be made for air drainage or cold protection with wind machines, irrigation, etc. Urban encroachment, rising land prices, and water availability have forced the development of new orchards in the less urban regions of Israel such as to the south near Be'er Sheva.

Cultivars

The Israeli lychee industry is almost exclusively dependant on 'Mauritius' and 'Floridian'. 'Floridian' is thought to be a seedling of 'Brewster' selected in Israel, although there is some evidence to suggest that it may be 'Brewster' introduced from another location. 'Mauritius' has exhibited superior natural floral induction in warmer regions when compared to 'Brewster'. Similar results have been found in Florida and other lychee-producing regions. Israeli lychee producers are not satisfied with their dependence on these two cultivars, both of which have relatively inferior flesh to seed ratios when compared with other lychee cultivars now under trial within the country.

In order to find new cultivars to replace 'Mauritius' and 'Floridian', the Israeli Agricultural Research Organization (ARO) supports an active selection and breeding program with lychee. In the selection program located at the Volcani Center in Bet Dagan, superior lychee cultivars have been introduced from around the world for evaluation under Israeli conditions. As in other selection programs, they are searching for cultivars which flower consistently, are productive, have a superior flavor, and a favorable flesh to seed ratio. It will require many more years of evaluation to determine which cultivars have sufficiently superior characteristics to replace 'Mauritius' and 'Floridian'.

'Garnet' has attracted attention in their program. This cultivar was originally selected at the U.S. Dept. of Agr. Subtropical Horticultural Research Unit in Miami by Robert J. Knight, Jr. (R. J. Knight, personal communication). 'Garnet' has flowered and fruited consistently and heavily in Israel, with an excellent deep red color and a good flavor. The seed to flesh ratio is not outstanding, and the protuberances on the skin are large compared with other cultivars. 'Early Large Red' fruits consistently and heavily with a similar color to 'Mauritius'. As in 'Mauritius', the fruit have a somewhat russet appearance as they fully mature. The seed/flesh ratio is not outstanding.

Many other cultivars, including 'Chakrapad' ('Emperor'), 'Fay Zee Siu', 'Hong Huay', 'Late Seedless', 'Kaimana', 'Kwai Mai Pink', 'Kwai Mi', 'Red McLean', 'Sah Keng', 'Souey Tung', and 'Yu Her Pau' are fruiting now or will fruit in the coming season in their test plots and are under evaluation. Many of these cultivars have exceptional fruit quality, but for commercial adoption they must possess horticultural and production characteristics that offer an advantage over 'Mauritius' and 'Floridian'. Their program favors the 'No Mai Chee' type of lychee fruit, with a fine flavor and a small seed. As in Florida, however, they have had trouble with the growth of the trees and are trying grafting to overcome these difficulties. A distinct advantage afforded to the Israeli selection program is the precocious blooming achieved in their environment. It is not uncommon for 2-year-old trees to produce a significant crop, thus aiding in prompt evaluation.

The ARO has invested heavily in a lychee breeding program, planting thousands of lychee seedlings for selection in the last few years at the Volcani Center. These seedling trees are precocious in Israel due to their environment, and many of the seedlings have fruited within 3 to 5 years. Most of the seedlings are not desirable, with wide variation in leaf shape and size, growth and fruiting. They have, however, identified two selections (Bet-Dagan '5-27' and '7-70') that have large fruit, an excellent flavor, and a desirable seed/flesh ratio. These two cultivars will need further evaluation for their fruiting consistency and horticultural characteristics. Both of these cultivars were brought to the Fairchild Tropical Garden Tropical Fruit Program for trial under Florida conditions.

Production Practices

The environmental conditions in Israel present lychee producers with a different array of production problems and opportunities than those faced by Florida producers. The climate of Israel is typified by a prolonged and cool winter, followed by a hot and extremely dry summer. Lychees cannot be grown without irrigation. Low-volume irrigation systems are used (drip or micro-sprinkler), with maximum control of in-

puts to the trees through the injection of nutrients and pesticides. The dependence of the trees on irrigation is a major benefit to producers in terms of bloom induction.

As previously mentioned, due to the considerably cooler winter temperatures experienced in this Mediterranean climate, flowering is more consistent than in Florida. Further, recent research by ARO scientists has shown that drought stress in the autumn can be used to insure consistency in flowering. At this time, Israeli lychee producers feel confident that they can manipulate flowering as needed. The water stress treatments coupled with the cooler temperatures can result in extremely precocious flowering in the second year after planting. Yields in mature orchards have averaged nearly 2.4 ton/ha with 'Mauritius'. In order to get adequate growth in some situations, fruit must be removed from young trees to allow them to grow vigorously.

To insure fruit set, ARO researchers have developed a method of spraying the compound 2,4,5-TP at flowering. This compound keeps the newly set fruit from falling off, resulting in many more fruit per panicle than would naturally set. Observations by the author, however, indicate that this treatment results in the setting of many seedless and small fruit. Following treatment with 2,4,5-TP, many panicles had a mixture of large, fully-mature fruit and small immature fruit. This treatment is not allowed in the United States because of EPA restrictions, and seems unlikely to be registered in the future.

Fruit are harvested by cutting off whole panicles and destemming them in the packing house. The use of elemental sulfur treatments followed by an acid dip to "fix" the red color of the lychee is practiced as a postharvest treatment. This treatment insures that the red color of the fruit remains throughout shipment and storage without oxidative browning due to desiccation, which occurs on untreated fruit (e.g., untreated Florida fruit). The treatment of lychee fruit in this manner allows for the storage of these fruit for 4 weeks or more without significant color loss. Sulfur treatment is currently illegal in the United States.

The trees are generally pruned once after harvest. Pruning is done both by hand in younger orchards and mechanically in older orchards. They prefer to have only one flush per year, if possible, on the trees following harvest. This is easier to control than in Florida, because they can control the water applied to the trees and the cool temperatures of the winter are more reliable. In the older blocks they mechanically prune their trees to maintain a height of about 4.6 m (15 ft). There is interest in maintaining the trees even smaller in the future using tighter spacings of 2.8 m (9 ft) in the row by 4.6 m (15 ft) between rows if possible (S. Gazit, personal communication). This would be possible in Israel due to the slower growth of the trees and the pruning that is practiced.

Of the major pests and diseases of concern to Israeli producers, considerable emphasis is placed on control of the Mediterranean fruit fly (*Ceratitis capitata* Weidemann). The fruit fly lays eggs in the maturing fruit, causing decay and an entry point for secondary pathogens. Mediterranean fruit fly is controlled by a national spray program for all of Israel and the use of bait and spot sprays within individual orchards as the fruit mature. Anthracnose (*Colletotrichum gloeosporioides*), a major problem for the production of lychee in Florida, is of only minor status in Israel due to the low humidity environment. Fruit bats consume significant numbers of fruit before harvest. Left uncontrolled, losses are economically impor-

tant; the bats are controlled by destroying them, and/or by the use of nets to exclude them.

Conclusions

The Israeli lychee industry is fortunate to have a profitable export window of opportunity in Europe and, as of 1994, in the United States. During their season there is little competition from other lychee production areas. As such, producing lychees for export is profitable at the current time in Israel. Israeli growers are also the fortunate recipients of a massive research effort (conducted by the Agricultural Research Organization of Israel) aimed at the development of this industry. The ARO has afforded Israeli lychee producers with consistent production, sound production techniques,

and in the future, the possibility of new cultivars. Challenges lie ahead, however, as continuing immigration into Israel further depletes their already strained water resources. Future immigrants will require water for survival, pressuring agriculture to use alternative water sources, such as reclaimed sewage water. In crops such as mangos, salt tolerant rootstocks have been selected, but with lychee, no salt tolerant germplasm has been identified. Urban encroachment, rising land prices, and the shortage of affordable labor are also increasing production costs. In the face of these challenges, an intensive research effort is necessary to assure survival of this industry. In spite of the challenges on the horizon, Israeli lychee producers and researchers are confident that their industry can and will remain profitable.