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# INCREASED EXPOSURE TO TEMPERATURES BELOW 55 OR 60 °F ARE CORRELATED WITH INCREASED YIELD OF 'MAURITIUS' LYCHEE (*LITCHI CHINENSIS* SONN.) IN HOMESTEAD, FLORIDA

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*Abstract.* **Unreliable flowering is the major constraint to sustained high crop yields in lychee (*Litchi chensis* Sonn.) trees. Insufficient exposure to cool ambient temperatures is the main environmental factor limiting flowering in mature quiescent trees. In south Florida, the warm subtropical climate is considered marginal to induce lychee flowering. Nonlinear regression analysis was used to test the yield responses of trees in 8 to 12 'Mauritius' lychee orchards to the total number of hours per year that orchards were exposed to ambient temperatures below 70, 65, 60, 55, 50, 45, or 40 °F from 1999-2003 in Homestead, Florida. In addition, annual mean ambient temperatures in Homestead in November, December, and January 1999-2003 and the 30-year average temperature were related to annual fruit yields. As the number of hours below 55 or 60 °F increased, the average crop yield increased. In years when the annual mean November through January temperatures were at or below the 30 year average, crop yields were greater than in years with above average November through January temperatures.**

Lychee (*Litchi chensis* Sonn.) production in Florida has been erratic in large part do to a lack of reliably cool winter temperatures necessary for pronounced flowering (Davenport and Menzel, 2004; Menzel, 1988; Stern and Gazit, 2003). Other contributing factors causing erratic flowering include the genetic predisposition of the cultivars grown in Florida (i.e., 'Brewster') to grow vegetatively, improper timing and rates of irrigation and/or nitrogen fertilization, and regrowth following pruning. Recently, lychee cropping has become more reliable due to the Florida lychee industry growing predominately 'Mauritius' lychee (>85%) that appears to have a lower requirement for exposure to cool temperatures (Menzel and Simpson, 1988), and implementation of cultural practices geared to minimizing or eliminating excessive vegetative growth during the fall and winter.

The two main environmental factors which influence the potential for mature lychee trees to flower are ambient temperatures and available soil moisture. Among lychee researchers world-wide, there is agreement that exposure of quiescent lychee trees to cool non-freezing temperatures during the winter is the dominant environmental factor required to induce consistent lychee flowering (Batton and McConchie, 1995; Menzel and Simpson, 1988, 1995; Menzel et al., 1983, 1989; Stern and Gazit, 2003; Young, 1957; Young and Harkness, 1961).

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Lychee is a subtropical tree adapted to climates where winter temperatures average below 68 °F (20 °C) and above 32 °F (0 °C) and it is relatively dry during the winter, spring temperatures are warm (low to high 70 °F; 20 °C), summers are hot (mid 80 °F to low 90 °F; ~27 to 32 °C) with moderate rainfall, and fall temperatures decline to the upper 60 °F to 50 °F (~15 to 10 °C) (Davenport and Stern, 2004; Menzel, 1983; Stern and Gazit, 2003).

Previous research has determined that lychee flowering and fruit production occurs most reliably after exposure to cool non-freezing temperatures (Menzel and Simpson, 1992; Young, 1956; Young, 1970; Young and Harkness, 1961; Zhang et al., 1997). Research on container grown trees in controlled temperature growth chambers has demonstrated that prolonged exposure to temperatures below 68 °F (20 °C) was necessary for flower induction in lychee (Batton and McConchie, 1995; Menzel and Simpson, 1988; Menzel et al., 1989; Menzel and Simpson, 1995). Furthermore, the effect of cool temperatures on the ability of quiescent lychee trees to flower appears to be cumulative i.e., intervening warm temperatures do not reduce the effect of previous cool temperatures, as is the case for temperate fruit crops. However, the precise temperatures and hours of exposure to specific temperatures for flower induction are not known. With this in mind we investigated the effect of hours per year below specific ambient temperatures on 'Mauritius' lychee yields in Homestead, Fla.

## Materials and Methods

Records of continuous temperature data monitored by the Florida Agricultural Weather Network located at the Tropical Research and Education Center (TREC; 25.5°N, 80.5°W) were used to determine the number of hours per year (1998-2003) that November through January temperatures were below specific "thresholds". During the same period, yield data records from 8 to 12 'Mauritius' lychee orchards in the Homestead production area were obtained and correlated with the threshold temperatures of 40, 45, 50, 55, 60, 65, and 70 °F (4, 7, 10, 13, 16, 18, and 21 °C). The lychee orchards ranged in size from 0.3 to 14 acres and trees ranged in age from 4 to 19 years old. Calculating yield on a per acre basis normalized all yield data.

The relationship between hours below 40 to 70 °F (7 to 21 °C) (in 5 °F increments) and average crop yield per acre from the 1999-2000 through the 2002-2003 harvest season was determined by nonlinear regression using TableCurve 2D (Systat Software, Inc., Richmond, Calif.). Also the 30 year mean monthly temperatures (1971-2000; S.E. Regional Climate Center, Columbia, S.C.) for TREC for November through January was plotted on the same graph as the mean monthly temperature for November through January for the 1998-1999 to 2002-2003 seasons and notating the average yield per acre. Factors such as tree age, plant growth stage during cool inductive temperatures, and cultural practices (e.g., fertilizer and water management) varied among the 8 to 12 orchards because they could not be controlled.

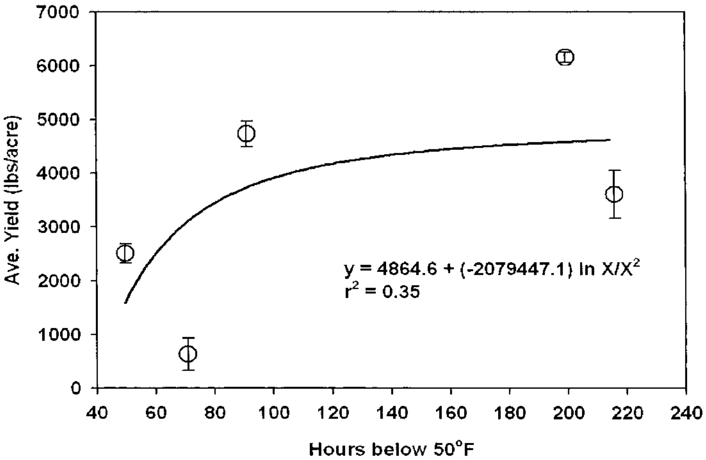


Fig. 1. Hours below 50 °F (10 °C) and average yield of 'Mauritus' lychee in Homestead, Florida from 1998-99 to 2002-03 crop season. Symbols represent mean annual yield at the number of hours below 50 °F (10 °C). Error bars represent ±1 Standard error.

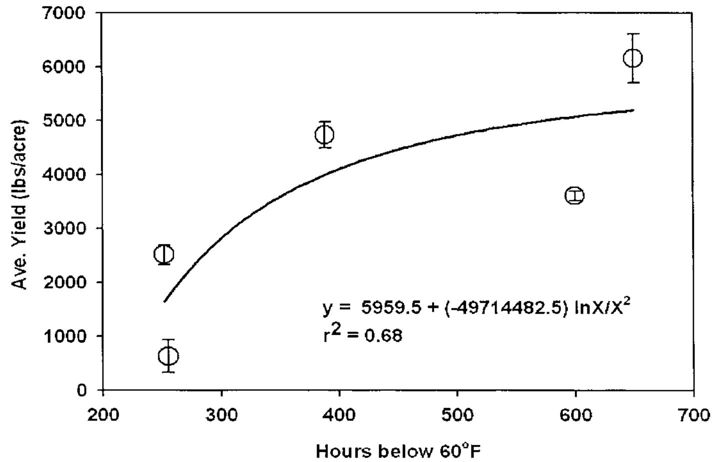


Fig. 3. Hours below 60 °F (16 °C) and average yield of 'Mauritus' lychee in Homestead, Florida from 1998-99 to 2002-03 crop season. Symbols represent mean annual yield at the number of hours below 60 °F (16 °C). Error bars represent ±1 Standard error.

### Results and Discussion

The equation describing the relationship between hours below the threshold temperature was $y = a + b \ln x/x^2$. Of the threshold temperatures tested, the number of hours below 55 °F (13 °C) was most highly correlated with the average yield ($r^2 = 0.72$), followed by 60 °F (16 °C) ($r^2 = 0.68$), 65 °F (18 °C) ($r^2 = 0.35$) and 50 °F (10 °C) ($r^2 = 0.35$) (Figs. 1-4). The coefficients of determination ($r^2$) for the average yield and hours below 70, 45, and 40 °F (21, 7, and 4 °C) were very low [less than 0.30 (data not shown)]. The fact that hours below 55 (13 °C) and 60 °F (16 °C) were best related to subsequent flowering and crop yield agrees with controlled studies and field observations of lychee trees (Davenport and Menzel, 2004; Menzel, 1983, 1988, 1995; Stern and Gazit, 2003). The coefficients of determination of 0.72 and 0.68 are moderately good, however, the fact that the yield data was from the 8 to 12 orchards where we could not control the cultural practices and that the orchard age varied, increases our confidence that the relationship demonstrated by our analysis is valid.

To illustrate the influence of hours below a specific temperature on subsequent crop yields, 4,700 lbs/acre (2.4 tons) will be used as an example. About 180 h below 55 °F (13 °C) (Fig. 2), 390 h below 60 °F (16 °C) (Fig. 3), and 830 h below 65 °F (18 °C) (Fig. 4) would be needed to produce about 4,700 lbs/acre. In contrast, only about 90 hrs at 50 °F (10 °C) would be required to produce 4,700 lbs/acre (Fig. 1). However, in Homestead the number of hours at or below 50 °F (10 °C) historically is very variable and ranges from 30 to 200. Interestingly, Young and Harkness (1961) found a fair correlation between increasing duration of temperatures at or below 40 °F and increased bloom and fruiting of 'Brewster' lychee in Merritt Island (28.3°N; 80.7°W), DeSoto City (27.2°N; 81.3°W), Osprey (27.1°N; 80.1°W), and Davie (26.1°N; 80.1°W) Florida from 1955-1956 through 1960-1961. However, all of these locations are north of Homestead where cooler temperatures are more common.

A decrease in the average temperatures in Homestead from November through January from 1998-1999 to 2002-2003 provides further evidence that an increase in cool tem-

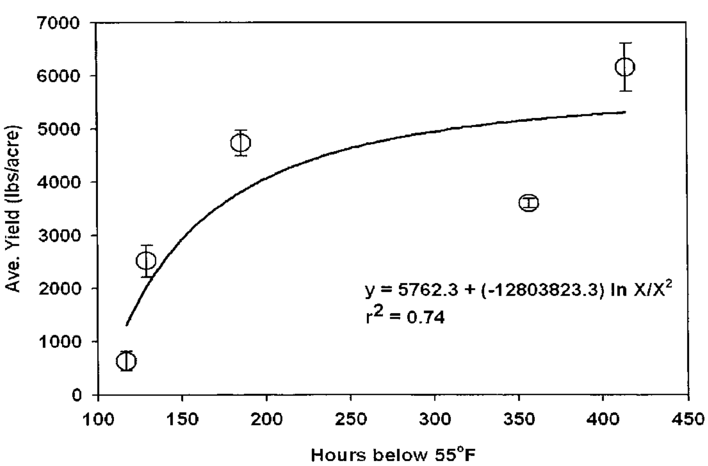


Fig. 2. Hours below 55 °F (13 °C) and average yield of 'Mauritus' lychee in Homestead, Florida from 1998-99 to 2002-03 crop season. Symbols represent mean annual yield at the number of hours below 55 °F (13 °C). Error bars represent ±1 Standard error.

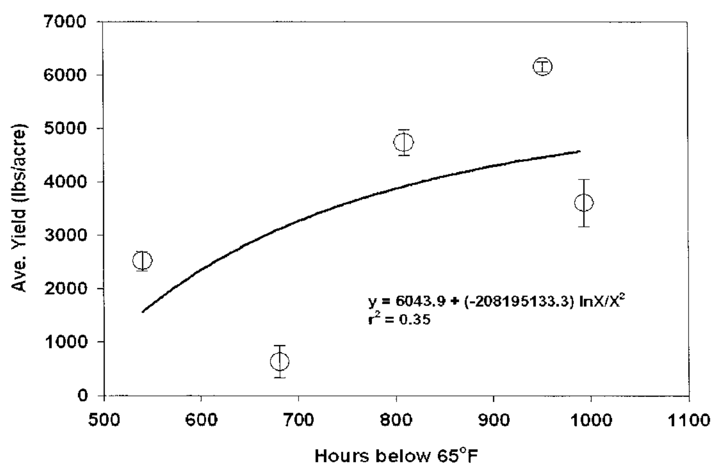


Fig. 4. Hours below 65 °F (18 °C) and average yield of 'Mauritus' lychee in Homestead, Florida from 1998-99 to 2002-03 crop season. Symbols represent mean annual yield at the number of hours below 65 °F (18 °C). Error bars represent ±1 Standard error.

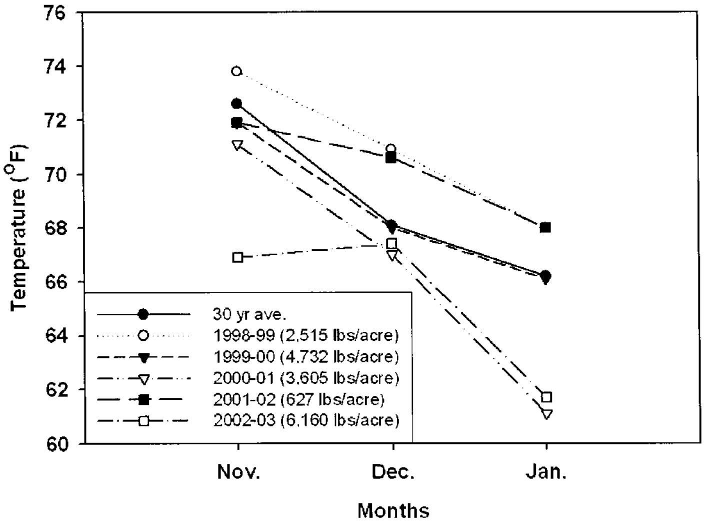


Fig. 5. Thirty year (1971-2000) average of mean monthly temperatures from Nov. through Jan. (●) compared to the mean monthly temperature in 1998-99 (○), 1999-00 (▼), 2000-01 (▽), 2001-02 (■) and 2002-03 (□).

peratures is related to increased crop yield (Fig. 5). Higher than average temperatures from the November through January period during the 1998-1999 and 2001-2002 harvest seasons resulted in less crop yield per acre than in the 1999-2000, 2000-2001, 2002-2003 seasons.

The number of hours below 55 to 60 °F (13 to 16 °C) was correlated with 'Mauritius' crop yields in Homestead (Figs. 2 and 3). However, the number of hours below 70, 45, or 40 °F (21, 7, 4°C) were poorly correlated with crop yield in Homestead, although the relatively small number of hours below 40 or 45 °F (4 to 7 °C) experienced in Homestead, made it difficult to draw definitive conclusions at these temperatures. The fact that the number of hours below 70 °F (21 °C) was not related to crop yield indicates that there was little effect of temperature above 65 °F (18 °C) on flower induction. Similarly, the hours below 50 °F and 65 °F (10 and 18 °C) were only weakly correlated with crop yield. Thus, temperatures between 60 and 65 °F (16 to 18 °C) probably have less physiological effect on stimulating lychee flowering than temperatures below 60 °F (16 °C) (Figs. 3 and 4). These results indicate that the threshold temperatures for lychee production in Homestead are 55 to 60°F from November through January. Our analysis indicates that at least 180 h at 55 °F or 390 h at 60 °F are needed to for moderate yields of 'Mauritius' lychee in Homestead. However, these results need to be corroborative with controlled-temperature studies to definitely determine the hours below specific temperatures required to stimulate flowering of 'Mauritius' lychee trees.

## Literature Cited

Batton, D. J. and C. A. McConchie. 1995. Floral induction in growing buds of lychee (*Litchi chinensis*) and mango (*Mangifera indica*). Aust. J. Plant Physiol. 22:783-791.

Davenport, T. L. 2003. Management of flowering in three tropical and subtropical fruit tree species. HortScience 38:1331-1335.

Davenport, T. L., Y. Li, and Q. Zheng. 1999. Towards Reliable Flowering of Lychee (*Litchi chinensis* Sonn.) in South Florida. Proc. Fla. State Hort. Soc. 112:182-184.

Davenport, T. L. and R. A. Stern. 2004. Flowering. In: C. M. Menzel, ed. The Lychee: Botany, Production and Uses, Chapter 6. CAB International, Wallingford, UK (In press).

Menzel, C. M. 1983. The control of floral initiation in lychee: a review. Scientia Hort. 21:201-215.

Menzel, C. M., T. S. Rasmussen, and D. R. Simpson. 1989. Effects of temperature and leaf water stress on growth and flowering of litchi (*Litchi chinensis* Sonn.). J. Hort. Sci. 64:739-752.

Menzel, C. M. and D. R. Simpson. 1988. Effect of temperature on growth and flowering of litchi (*Litchi chinensis* Sonn.) cultivars. J. Hort. Sci. 63:349-360.

Menzel, C. M. and D. R. Simpson. 1992. Growth, flowering and yield of lychee cultivars. Scientia Hort. 49:243-254.

Menzel, C. M. and D. R. Simpson. 1995. Temperatures above 20°C reduce flowering in lychee (*Litchi chinensis* Sonn.). J. Hort. Sci. 70:981-987.

Stern, R. A. and S. Gazit. 2003. The reproductive biology of the lychee. Hort. Reviews 28:393-453.

Young, T. W. 1956. Two-year performance of 529 'Brewster' lychee trees. Proc. Fla. Lychee Grower's Assoc. 3:42-47.

Young, T. W. 1957. Lychee fruitfulness. Proc. Fla. Lychee Grower's Assoc. 4:9-13.

Young, T. W. and R. W. Harkness. 1961. Flowering and fruiting behavior of 'Brewster' lychee in Florida. Proc. Fla. State Hort. Soc. 74:358-363.

Young, T. W. 1970. Some climatic effects on flowering and fruiting of 'Brewster' lychee in Florida. Proc. Fla. State Hort. Soc. 83:362-367.

Zhang, Z., B. Wang, J. Li, P. Yuan, and Y. Qui. 1997. Litchi, pictorial narration of cultivation. Pomology Res. Institute, Guangdong Academy of Agric. Sci. p. 189.