Leafless Inflorescence Produces More Female Flowers and Fruit Yield Than Leafy Inflorescence in ‘Yu Her Pau’ Litchi

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Abstract. The purpose of this study was to determine whether the total number and percentage of female flowers and fruit yield were influenced by the type of inflorescence, i.e., leafless or leafy inflorescences in ‘Yu Her Pau’ litchi (*Litchi chinensis* Sonn.). Four 10-year-old field-grown plants in Chunghua, Taiwan, were assessed between March and June 2013. In total, 24 inflorescences comprising 12 each of leafless and leafy inflorescences were investigated. Leaves of the leafy inflorescence, defined as the fourth successive flush, attained maturity before female flower anthesis on 16 Mar. 2013. Shoot diameter and leaf number on the flowering (fruiting) shoot, total number of flowers, and total and percentage of female flowers were recorded. Fruit number, fruit set rate, cluster yield, and fruit quality were also determined at harvest between the two inflorescence types. The two inflorescence types had similar shoot diameters and total leaf number on a flowering shoot. The total number of flowers, female flowers, and the percentage female flowers in leafless inflorescences were 3741, 563, and 16.2%, respectively; these values were 1.3- to 1.7-fold higher ($P \leq 0.05$) than those in leafy inflorescences, which were 2779, 326, and 12.2%, respectively. Leafless inflorescences had significantly higher fruit numbers and fruit yield per cluster at harvest (10.2 and 321.5 g, respectively), although there was no difference ($P > 0.05$) in fruit set rate between the two inflorescence types. No fruit quality trait, such as fruit, pericarp, aril, seed weight, aril proportion, and total soluble solid concentration of aril, was significant ($P > 0.05$) between the two inflorescence types. We concluded that leafless and leafy inflorescences of ‘Yu Her Pau’ had similar carbon assimilation supply potential; however, leafless inflorescence had greater performance in terms of female flower number and thus fruit yield, presumably due to the absence of assimilate competition brought by synchronous development of lateral inflorescence and immature leaves of panicle.

Litchi (*Litchi chinensis* Sonn.) is an important fruit cultivated in the subtropical regions. ‘Yu Her Pau’, the main commercial cultivar of litchi worldwide, is well known for its shriveled seed and high-quality taste, although it has an uneven fruit set from year to year (Chang and Lin, 2003, 2006; Chang et al., 2009; Jiang et al., 2012). Poor pollination and fertilization as well as undesirable photo-assimilate supply–demand between the sink and source organs result in high physiological fruit drop in litchi (Menzel, 1984; Mustard, 1960; Roe et al., 1997; Saúco and Menini, 1989; Yuan and Huang, 1988).

In response to recent climate change, particularly global warming, the increasing

proportion of leafy inflorescences in ‘Yu Her Pau’ has occurred frequently, and the manual removal of leaves from leafy inflorescences has become a standard commercial practice, although it increases the costs of orchard management, while its benefits still need confirmation (Chang et al., 2009). Therefore, management of the leafy inflorescence has become the new issue of the litchi industry (Chang, 2017).

Vegetative and flowering shoots are homologous organs (Li, 2008). The litchi shoot apical meristem initiates inflorescence primordia, comprising leaf and floral primordia as a result of cool-temperature induction (Batten and McConchie, 1995; Li, 2008). The flowering shoot of litchi has a characteristic of flush cycles, and the process of inflorescence initiation and flower development in a flowering shoot is sensitive to temperature (Stern and Gazit, 2003), which may form two types of flowering shoots subsequently in terms of leafless (generative) and leafy inflorescences. The latter, by their leaves and inflorescence relative position, can be sorted into leafy and vegetative/generative transit shoots (Davenport and Stern, 2005). Rudimentary leaves within the

inflorescence primordium shrivel or abscise after sensing adequate cool temperature, resulting in generation of leafless inflorescences. In contrast, rising temperatures during the initiation period of inflorescence primordium development will produce a leafy inflorescence with both rudimentary leaves and lateral inflorescences at the same node along the main inflorescence axis. In some instances, a vegetative/generative transit shoot will be produced if low temperatures followed by warm temperatures occur at the later stages of the inflorescence development (Chang, 1999; Chen, 1994; Chen et al., 2009; Lin, 1987; McConchie and Batten, 1991; Olesen et al., 2002; Zhou et al., 2008). The leafy flowering shoot has been the main leafy inflorescence type in Taiwan (Chang, 2017; Chang et al., 2009).

The leafy inflorescence in citrus has been well recognized to produce better fruit set and quality at harvest than the leafless inflorescence (Goldschmidt, 2013; Hansen, 1969; Hass, 1949; Moss, 1970); however, little is known about the subsequent performance of leafy inflorescence in terms of fruit set in litchi. It is generally assumed that the fruit set on leafless inflorescences is better than on leafy inflorescences (Chang et al., 2009; Davenport and Stern, 2005; Lee, 2008). Leaves and lateral inflorescences synchronize their development within leafy inflorescence (Huang, 2005; Lee, 2014). These young leaves have no net carbon assimilation ability at the initial growth stage of the inflorescence (Wang, 2014). In addition, the red and soft new leaves of the leafy inflorescence inhibit the differentiation of lateral inflorescences (Chen, 1990, 1994; Davenport, 2000), resulting in a decrease in the total number of flowers and female flowers, subsequently reducing fruit yield.

Few studies have been carefully employed on the relationship between fruit set and inflorescence types in litchi. Litchi has three types of flower: male flower (M1), hermaphrodite flower functioning as female (female flower, F), and hermaphrodite flower functioning as male (M2) (Chu et al., 2015; Wu et al., 2017). Kumar (2013) preliminarily indicated that neither female flower percentage nor fruit set rate was influenced by the appearance of leafy inflorescence in ‘Shahi’ litchi; however, in comparison with the leafless inflorescence, the 40% to 60% decrease in the total number of flowers and female flowers resulted in an $\approx 50\%$ decrease in yield of the leafy inflorescence. In contrast, Chen et al. (2014) reported that the percentage of leafy inflorescence and number of fruit set of ‘Yu Her Pau’ litchi increased when 100 mg·L⁻¹ GA₃ was sprayed onto the foliage during quiescence period; however, the percentage of female flowers, cluster yield, fruit set rate, and the residual effects of GA₃ on the leafy inflorescences and fruit were not documented in this study. Whether leafy inflorescences impose a major burden or reduction of the subsequent fruit set and fruit development normally in litchi was inconsistent from their results.

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The purpose of this study was to determine whether the different inflorescence types affect flowering and fruiting performance in terms of flower and fruit number, yield, and quality at harvest in field-grown ‘Yu Her Pau’ litchi plants. The diameter and

number of leaves of flowering shoots of two inflorescence types were measured to demonstrate whether the carbon assimilation supply potential was consistent. Next, the inflorescence quality was assessed in terms of the total number of flowers and female flowers and percentage female flowers within each inflorescence. Finally, to understand the influence of the leafy inflorescences on fruit production, the fruit number, fruit set rate, cluster yield, and fruit quality at harvest were also calculated. The results from our research may prompt changes in the management strategy of litchi orchards with regard to flowering and fruit production and thus provide information on defoliation of leafy inflorescences in the future.

Materials and Methods

Plant materials and inflorescence sampling.

The experiments were conducted at a 10-year-old ‘Yu Her Pau’ litchi orchard (lat. 24°01’N, long. 120°64’E) in Chunghua County, central Taiwan, between March and June 2013. Four plants of similar vigor and size were randomly selected. Three leafless (Fig. 1A) and three leafy inflorescences (Fig. 1B) of similar sizes, emerging from the terminal buds, were equally sampled at eastern, western, northern, and southern orientations from each plant.

Vegetative characteristics of the flowering shoot and its assimilatory potential. A flowering shoot with terminal inflorescences exhibit successive flushes (Chang and Lin, 2007). The sampled inflorescences emerged from three successive flushes of a flowering shoot to ensure sufficient carbon supply for adequate fruit set and growth (Chang and Lin, 2008). Leaves of the leafy inflorescence were defined as the fourth flush and were mature enough (having dark green leaves with net photosynthetic activities) to export assimilates (Hiekie et al., 2002b; Wang, 2014) before the female flower anthesis on 16 Mar. 2013. To determine whether a leafy inflorescence supplies more photo-assimilates to the flowers than a leafless inflorescence, the diameter of the first flush of the shoot of the leafless and leafy inflorescences was measured using Vernier calipers (500-196-20, Mitutoyo Corp., Kanagawa, Japan), which represented the amount of carbohydrate reserves in the inflorescences (Wong, 2003). Further, the number of leaves in each flush was also counted to obtain a measure of the leaf assimilating ability (Chang and Lin, 2007, 2008; Roe et al., 1997; Wong, 2003).

Flower number and type in the inflorescence. M1 has a rudimentary pistil surrounded by stamens with hair-like filaments, and the ovary contains two ovules with no embryo sac. Conversely, M2 has a pistil with a style and ovary surrounded by stamens with filaments. However, the lobes of the stigma do not open for pollination at anthesis. Both M1 and M2 have anthers that open at anthesis. In contrast, F has a fully developed pistil with a functional stigma with fruiting potential at anthesis (Mustard et al., 1953; Robbertse et al., 1995). In addition to the three types of flowers mentioned, flower buds for which the sex could not be confirmed were counted as “others.”

The sequence of flower opening on ‘Yu Her Pau’ litchi inflorescence in this study was in the order of F, M1, and M2 in 2013. To collect all the flowers, the experimental inflorescences were enclosed by meshed silk bags ($35 \times 35 \times 70 \text{ cm}^3$, $20 \times 30 \text{ mesh/inch}^2$) from the beginning of blooming of female flowers on 16 Mar. 2013 (Chang and Lin, 2003; McConchie and Batten, 1991). However, the meshed silk bags were removed between 5:00 AM and 6:00 PM during the blooming period of female flowers to ensure good pollination by honeybees. The number of detached (by abscission) flowers and fruit were counted every 1 to 3 d. Flower sex for each inflorescence was also recorded. The percentages of F, M1, M2, and others were calculated.

Fruit set, cluster yield, and fruit characteristics at harvest. The silk bags were removed on 9 Apr. 2013 to promote fruit growth. Fruit were cooled by ice bath after harvesting on 8 June 2013. Characteristics of the clusters, including number of fruit set (number of fruit per cluster at harvest), fruit set rate [(fruit set number/female flower number on the inflorescence) $\times 100$], cluster yield (total fruit weight per cluster at harvest), and fruit quality were determined in a laboratory at National Chung-Hsing University (lat. 24°07’N, long. 120°40’E). Fruit quality, including the weights of fruit, pericarp, aril, and seed, were measured using an electronic precision balance (XT220A, Precisa Gravimetrics AG, Dietikon, Switzerland). The percentage weight of the aril relative to fruit weight was also calculated [(aril weight/fruit weight) $\times 100$]. In addition, total soluble solid (TSS) concentration of the aril juice was measured using an electronic refractometer (PAL-1, Atago Co. Ltd., Tokyo, Japan).

Statistical analysis. The inflorescence was a basic unit for parameter analysis. Data

Fig. 1. Leafless inflorescences (A) and leafy inflorescences (B) emerging from the flowering shoot of ‘Yu Her Pau’ litchi plants grown in the field.

Table 1. Effect of inflorescence type emerging from the flowering shoot with successive flushes on the vegetative characteristics of ‘Yu Her Pau’ litchi.

Inflorescence type	First flush diam (mm)	Leaf number					Total without fourth flush
		First flush	Second flush	Third flush	Fourth flush ^z	Total	
Leafless inflorescence	11.22 $\pm$ 0.21	7.8 $\pm$ 1.1 b ^y	8.8 $\pm$ 0.9 b	11.0 $\pm$ 0.7 a	—	26.2 $\pm$ 1.2	26.2 $\pm$ 1.2
Leafy inflorescence	10.63 $\pm$ 0.18	5.9 $\pm$ 0.4 c	8.8 $\pm$ 0.3 b	10.9 $\pm$ 0.7 a	5.6 $\pm$ 0.7 c	29.4 $\pm$ 1.1	25.1 $\pm$ 0.7
Significant LSD ($P \leq 0.05$)	NS ^x	NS	NS	NS	—	NS	NS

^zLeafy inflorescences bear leaves and flowers at each node in the inflorescence.

^yMeans followed by the same letter within the same row among four flushes are not significantly different ($P > 0.05$) by Fisher’s least significance difference (LSD) test, $n = 12$.

^xNonsignificant difference ($P > 0.05$) within the same column by Fisher’s least significance difference test, $n = 12$.

Table 2. Effect of inflorescence type on flowering, fruiting, and cluster yield in 'Yu Her Pau' litchi.

Inflorescence type	Total flowers (no.)	Flowers										Cluster / Fruits		
		Sexual flower (No.)					Flower ratio (%)					Cluster yield (g)	Fruit set	
		M1 ^z	F	M2	Others		M1	F	M2	Others	no.		% ^v	
Leafless inflorescence	3741 ± 291	2490 ± 308	563 ± 41	474 ± 98	215 ± 35	64.7 ± 3.8	16.2 ± 1.3	13.9 ± 3.0	5.8 ± 1.0		321.5 ± 73.4	10.2 ± 2.3	1.8 ± 0.3	
Leafy inflorescence ^s	2779 ± 320	2194 ± 298	326 ± 35	184 ± 36	75 ± 13	77.5 ± 3.1	12.2 ± 1.3	5.7 ± 0.9	2.6 ± 0.4		116.7 ± 39.0	3.3 ± 0.8	1.1 ± 0.3	
Significant LSD (<i>P</i> ≤ 0.05)	991.7	NS ^w	113.9	236.0	83.7	10.5	3.8	7.5	2.4		170.5	5.7	NS	

^aM1, F, M2, and others indicate male flower, hermaphrodite flowers functioning as female, hermaphrodite flowers functioning as male, and flower buds without identifiable sexual features, respectively.

^zFruit set ratio was calculated by the number of fruits retained at harvest relative to the number of female flowers.

^xLeafy inflorescences bear leaves and flowers at each node in the inflorescence.

^wNonsignificant difference ($P > 0.05$) within the same column by Fisher's least significance difference (LSD) test, $n = 12$.

were analyzed by one-way analysis of variance using SAS 9.0 (SAS Institute Inc., Cary, NC). PROC GLM procedure was performed to determine multiple pairwise comparisons at a P value ≤ 0.05 by Fisher's least significance difference test.

Results

Vegetative characteristics of the flowering shoot and its assimilatory potential. The stem base diameter of the leafless and leafy inflorescence types at the first flush was not significantly different ($P > 0.05$) at 11.22 and 10.63 mm, respectively (Table 1). The mean leaf number on shoots of the first, second, and third flush and the mean total leaf number on flowering shoots were 7.8, 8.8, 11.0, and 26.2 leaves, respectively, on leafless inflorescences (Table 1), compared with 5.9, 8.8, 10.9, and 25.1 leaves, respectively, on leafy inflorescences, the differences being nonsignificant ($P > 0.05$).

The leaf flush of the leafy inflorescence, defined as the fourth successive flush, had 5.6 leaves on average, which was similar to the average leaf number of the first flush. The total leaf number of the four flushes of the leafy inflorescence (29.4) was not significantly different from the total leaf number of the three successive flushes of the leafless inflorescence ($P > 0.05$). The highest leaf number for both inflorescence types was in the third flush ($P \leq 0.05$) followed by the second flush.

Flower number and numbers of male and female flowers per inflorescence. The total number of flowers and of M1, F, and M2 were 3741, 2490, 563, and 474 in leafless inflorescences, respectively, whereas the percentage of the total flower number represented by each class, namely M1, F, and M2, were 64.7%, 16.2%, and 13.9%, respectively (Table 2). In comparison, in leafy inflorescences, the total number of flowers and of M1, F, and M2 were 2779, 2194, 326, and 184, with the percentage of the total flower number represented by each class, M1, F, and M2, being 77.5%, 12.2%, and 5.7%, respectively. There were significantly higher values of the total flower number, F, and M2 number, and their corresponding percentages in leafless inflorescences. In contrast, the percentage of M1 was significantly higher in leafy inflorescences than in the leafless inflorescences ($P \leq 0.05$).

Fruit set, cluster yield, and characteristics at harvest. Fruit number, yield, and fruit set rate per cluster at harvest were 10.2, 321.5 g, and 1.8%, respectively, in leafless inflorescences at harvest on 8 June 2013 compared with 3.3, 116.7 g, and 1.1%, respectively, in leafy inflorescences (Table 2). Leafless inflorescences had significantly higher fruit number and cluster yield at harvest than leafy inflorescences ($P \leq 0.05$), although fruit set rate was similar in the two inflorescence types ($P > 0.05$) (Table 2).

Conversely, the weight of fruit, pericarp, aril, and seed were 29.03, 4.86, 22.69, and 1.04 g, respectively, and the aril percentage of the fruit weight and TSS concentration of the aril juice in leafless inflorescences was 78.3% and 18.5%, respectively (Table 3). Similarly, the weights of fruit, pericarp, aril, and seed in leafy inflorescences were 29.34, 4.74, 22.97, and 1.20 g, respectively, with 78.2% and 18.1% of the aril proportion and TSS concentration of the aril juice, respectively. None of the fruit quality parameters measured was significantly different between leafless and leafy inflorescences ($P > 0.05$).

Discussion

Litchi is known to exhibit flush cycles emerging from the shoot apical meristem, a phenomenon that also occurs in mango and citrus (Davenport, 2000, 2006; Davenport and Stern, 2005; Subhadrabandhu and Stern, 2005). The stem base diameters of the first flush of 'Yu Her Pau' leafless and leafy inflorescences were similar ($P > 0.05$), suggesting that the two inflorescence types exhibited similar values of carbohydrate reserve potential (Menzel et al., 1995) for export to support fruit development.

The currently mature leaves of litchi exhibited the highest photosynthetic rate (Chang and Lin, 2007; Hieke et al., 2002a), which provided the primary source of photosynthetic assimilates for fruit growth, although, on rare occasions, assimilate reserves from branches and bark were supplied to a flowering shoot that had only a few leaves (Roe et al., 1997). In our study, the flowering shoots had similar leaf assimilatory ability in leafless and leafy inflorescences, with near-identical leaf numbers (Table 1), regardless of the fact that total leaf number consisted of the fourth flush leaves in a leafy inflorescence. As a result, we assumed that the fruit setting ability was unrelated to the inflorescence type in terms of its assimilatory potential.

The total number of flowers, female flowers, and the percentage of female flowers were 1.3-, 1.7-, and 1.3-fold higher, respectively, in the 'Yu Her Pau' leafless inflorescences than in the leafy inflorescences (Table 2). The total flower numbers were markedly higher than those reported previously by Jiang et al. (2012) but were consistent with the data from Chang and Lin (2003), demonstrating that the inflorescences used in this study were representative and grew normally.

Our results were similar to those reported earlier by Kumar (2013), in that the total number of flowers and female flowers per inflorescence were higher in leafless inflorescences than in leafy inflorescences in 'Shahi' litchi. Huang (2005) indicated that a lateral inflorescence development of a leafy inflorescence was influenced by its leaf maturity. Immature leaves, growing synchronously with a lateral inflorescence, inhibited inflorescence development. In our study, the leaves and lateral inflorescences of 'Yu Her Pau' leafy inflorescences showed synchronous development before blooming of the

Table 3. Effect of inflorescence type on fruit quality at harvest in 'Yu Her Pau' litchi.

Inflorescence type	Fruit wt at harvest (g)				Aril (%) ^z	Total soluble solid (%)
	Fruit	Pericarp	Aril	Seed		
Leafless inflorescence	29.03 ± 1.02	4.86 ± 0.24	22.69 ± 0.73	1.04 ± 0.09	78.3 ± 0.4	18.5 ± 0.2
Leafy inflorescence ^y	29.34 ± 1.63	4.74 ± 0.37	22.97 ± 1.31	1.20 ± 0.17	78.2 ± 0.3	18.1 ± 0.4
Significant LSD ($P \leq 0.05$)	NS ^x	NS	NS	NS	NS	NS

^zAril proportion (%) = aril weight/fruit weight × 100.^yLeafy inflorescences bear leaves and flowers at each node in the inflorescence.^xNonsignificant difference ($P > 0.05$) within the same column by Fisher's least significance difference (LSD) test, $n = 12$.

female flower. The soft, red-colored immature leaves, a sink organ receiving carbon assimilates, competed for nutrients with the flowers developing and being differentiated within the inflorescence (Chen, 1994; Hieke et al., 2002a; Jiang et al., 2012; Menzel, 2005), and inhibited inflorescence formation by altering hormone concentration fluctuation in the xylem sap (Chen, 1990; Davenport, 2000), thereby decreasing the total number of flowers in leafy inflorescences.

The percentage of flowers that were female in the leafless inflorescences was significantly higher than that in the leafy inflorescences, at 16.2% and 12.2%, respectively. This result was greater than the observations (10% vs. 14% in 2000, 6% vs. 9% in 2001) by Chang and Lin (2003), but less than that reported from 'Tai So' and 'Bengal' (Menzel and Simpson, 1992), at 21% to 33% and 20% to 43%, respectively.

The results of this study were also different from those reported by Kumar (2013), in which the percentage of female flowers was identical between leafless and leafy inflorescences. The percentage of female litchi flowers varied with respect to genotype (i.e., different cultivars) and the environment (Davenport and Stern, 2005; Menzel, 1984). Increasing the average diurnal temperature from 15 to 23 °C increased female flower percentage of cultivars Tai So and Bengal (Menzel and Simpson, 1991, 1992). However, the growth period of leafless and leafy inflorescences were identical in the present experiment, and thus we suggest that temperature was not a crucial factor affecting the percentage female flowers in 'Yu Her Pau' litchi. Davenport and Stern (2005) reported that the percentage of female flowers in small inflorescences was higher than that in large inflorescences. Inflorescence thinning can limit competition for photo-assimilates, subsequently increasing the percentage of female flowers (Jiang et al., 2012; Wu et al., 2001). Therefore, the primary reason for low percentage female flowers in leafy inflorescences is the assimilate competition brought about by synchronous development of different sinks, the inflorescence and immature leaves, during panicle growth and development.

Leafy inflorescences exhibited greater numbers of fruit set of 'Yu Her Pau' litchi, as demonstrated by Chen et al. (2014). However, their results, in terms of an inflorescence emerged from a shoot apex by spraying with 100 mg·L⁻¹ GA₃, were out of considering the residual effects by GA₃. Moreover, they were unable to investigate

the percentage of female flowers, cluster yield, and fruit set rate. Whether the leafy inflorescences promoted fruit set performance still needed further clarify.

In comparison, the number of fruit set in the harvested leafless inflorescences was 3.1-fold more than that of the leafy inflorescences, resulting in a 2.8-fold greater cluster yield in the leafless inflorescence in present study (Table 2). Both leafless and leafy inflorescences had similar fruit set rates ($P > 0.05$) because of sufficient (or excessive) carbon assimilation supply potential for fruit development. These results were consistent with an observation by Chang and Lin (2003) but lower than the results obtained for cultivars Tai So (Menzel and Simpson, 1992) and Haak Yip (Mustard et al., 1953), at 8% to 21% and 40%, respectively, which suggests that 'Yu Her Pau' has the potential to increase fruit set by increasing the effectiveness of pollination and fertilization especially the leafy inflorescence.

The total number of flowers, percentage female flowers, number of fruit, and cluster yield were significantly higher in leafless inflorescences than in leafy inflorescences in 'Yu Her Pau' litchi ($P \leq 0.05$), although both inflorescence types showed similar fruit set rates, indicating that cluster yield rose by increasing the number of female flowers in an inflorescence and the percentage of flowers that were female. These findings were similar to the data on 'Shahi' litchi from Kumar (2013) and were supported by the observations of Menzel and Simpson (1992) that fruit number at harvest was positively related to the number of female flowers in an inflorescence.

Compared with the greater production produced by the larger number of fruit set in the leafless inflorescences of 'Yu Her Pau' litchi, citrus fruit had proportionally higher production in the leafy inflorescences (Hansen, 1969). Citrus leaves, maturing after the blooming of female flowers in leafy inflorescences, had a net photosynthetic ability (Goldschmidt, 2013; Moss et al., 1972) that promoted the development of the embryo sac in female flowers, subsequently increasing their fruit retention rate by ≈20% (Moss, 1970; Moss et al., 1972).

Moderate to high temperatures, occurring at the period of litchi inflorescence development, produced leafy inflorescences at a high frequency (Batten and McConchie, 1995). However, the temperature has been increasing during the early spring (February to March), as a result of climate change. Subsequently, the proportion of leafy inflorescences in 'Yu Her

Pau' litchi increases annually, especially the leafy inflorescence (Chang, 2017). To increase the total number of flowers and fruit produced and to lower labor costs, the practice of leaf removal in a leafy inflorescence by chemical application would be necessary (Chang, 2017; Chang et al., 2009; Chen, 1994). 'Yu Her Pau', the most widely grown cultivar, with shriveled seeds and poor fruit production, has a low percentage of female flowers in a leafy inflorescence, compared with the leafless inflorescence. Spraying with GA₃ to increase fruit weight (Chang and Lin, 2003) or with the plant growth regulators 2,4,5-TP and 3,6,5-TPA to promote fruit set number and rate (Stern and Gazit, 1999; Stern et al., 2000) may compensate for the low fruit number associated with a leafy inflorescence at harvest.

The fruit quality findings of the leafless and leafy inflorescences of 'Yu Her Pau' litchi were consistent with the earlier observations by Chang and Lin (2003) and Lee and Chang (2014), in that the two inflorescence types did not differ significantly in terms of fruit quality.

Jiang et al. (2012) observed that a small litchi inflorescence consumed fewer assimilate reserves from a flowering shoot, compared with a large inflorescence, resulting in greater fruit growth. Notably, our results showed that a leafy inflorescence did not increase fruit yield, with a smaller number of fruit set in comparison with a leafless inflorescence. The weak sink strength in the leafy inflorescence, caused by the smaller number of fruit set, did not drive the leaf assimilatory capacity of the flowering shoot (Lee, 2014). Any residual photo-assimilates of leafy inflorescence will be stored as carbohydrate reserves in the branches and bark, promoting the vegetative shoot growth after harvest pruning or potentially increasing flower differentiation and fruit set the following year.

Conclusions

We confirmed that litchi fruit production in leafless inflorescences was significantly greater than in leafy inflorescences. Although both inflorescence types had similar total carbon assimilation supply potential in terms of base diameter of a flowering shoot and total leaf number, the leafy inflorescences had low fruit number and fruit yield at harvest as a result of fewer flowers, of which a lower percentage were female, presumably as a result of assimilate competition between the synchronously developing sinks of leaves

and flowers, whereas the fruit set rate and fruit quality were unaffected by inflorescence type because of the adequate source supply.

A labor-saving strategy of defoliation may need to be developed, and the use of plant growth regulators or other orchard managements to increase fruit weight, fruit number, and fruit set rate could increase the yield of the leafy inflorescence.

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