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*Original Research Paper*

# Manipulating female flower intensity in 'Yu Her Pau' Litchi by delayed winter pruning

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## ABSTRACT

'Yu Her Pau' litchi (*Litchi chinensis*) has excellent fruit quality. However, its production on Taiwan is limited by low productivity despite being regarded as a high-quality fruit. It is known that litchi's leaves play a critical role in floral induction under low temperature. Thus, we hypothesized that the flower intensity in spring could be manipulated by altering the leaf quality in winter, thereby increasing crop load. In this pilot study, 'Yu Her Pau' trees were pruned in mid-December [early pruning (EP)], one of the common cultural practices carried out by growers in the region, as control or mid-January [late pruning (LP)]. This resulted in 50% and 100% canopy foliage for EP and LP trees, respectively, between mid-December and mid-January. At the peak blooming time in March, LP trees produced significantly more female flowers than EP trees (95.8 and 56.1/panicle, respectively) with no negative effects on initial fruit set number, fruitlet abscission, or fruit quality at harvest. Our results suggest additional mature leaves present on trees in mid-December onward may benefit litchi flower formation without affecting fruit retention. Thus, preserving leaves with delayed pruning might potentially mitigate the negative impacts of warmer winters due to climate change on litchi flowering.

**Keywords :** Crop load, flowering, fruitlet retention, *Litchi chinensis*, low-temperature induction

## INTRODUCTION

'Yu Her Pau' is an early-maturing litchi (*Litchi chinensis*) cultivar with outstanding fruit quality, but low crop load is a perpetual issue for its production on Taiwan (Chen *et al*., 2013; Chang *et al*., 2022). To obtain better fruit development and retention, some litchi growers would prune lateral branches at the end of vegetative flushing to maximize light interception for enhancing photosynthesis on the remaining fruit-bearing branches. Nevertheless, the benefit of this practice on yields has been anecdotal without empirical evidence. Increasing spring female flowers, which form fruitlets, could be another approach to enhance productivity but has never been explored for 'Yu Her Pau' litchi.

Litchi flower formation is a result of signaling cascades initiated by leaf perceiving winter low temperatures (< 20 °C) (Menzel and Simpson, 1995), which upregulate a litchi *flowering locus t* (*FT*), *LcFT1*, in leaves (Ding *et al*., 2015; Lu *et al*., 2022). Similar responses involving leaf *FT* transcription under floral-inductive low-temperature conditions were reported in citrus (*Citrus* sp.) (Nishikawa *et al*., 2007), mango (*Mangifera indica*) (Nakagawa *et al*., 2012), and avocado (*Persea americana*) (Ziv *et al*., 2014), indicating that the leave's role may be conserved among evergreen woody perennials. Interestingly, in low-temperature-treated citrus, reducing leaf numbers resulted in a progressive decrease in flower buds (Nishikawa *et al*., 2013). This leads to the assumption that litchi's flowering could be manipulated by altering the quantity of leaves to increase productivity. In this pilot study, our objective was to test this hypothesis through evaluating effects of leaf quantity during winter low-temperature exposure on spring female flowering in field-grown 'Yu Her Pau' litchi. Despite the positive correlation between leaf number during fruit development and final crop load in litchi (Chang and Lin, 2008), whether mature leaf appearance as early as floral-inductive period also helps subsequent fruit set and retention is unclear and thus was also investigated in this research as a subsidiary objective.

## MATERIALS AND METHODS

This trial was conducted with ten, 31-year old 'Yu Her Pau' trees at Chiayi Agricultural Experiment Branch, Chiayi City, Taiwan (Lat. 23°29' N, Long. 120°28' E, Alt. 70 m). Except pruning times, all trees were subjected to the same management practices. Experiment was in a randomized complete block design; each of the five blocks contained two treatments, early pruning (EP) as control and late pruning (LP).

For EP, five trees were pruned on 17 Dec 2016 by removing most lateral branches, resulting in about 50% of mature leaves removed from the tree canopy. This treatment, including the extent of branch excision and pruning time, was carried out according to one of growers' common practices in the regions, hence serving as the control in this study. For late pruning (LP), the other five 'Yu Her Pau' trees were thinned on 16 Jan 2017 using the same criteria as for EP. Therefore, from mid-December through mid-January, EP trees had 50% less canopy foliage than LP trees. Spring inflorescence pruning, a conventional practice for litchi production in Taiwan (Chang *et al*., 2022), was done to all trees at the same level on 9 Mar 2017, with the onset of male blooming.

Ten panicles were randomly selected per tree for quantifying flower intensity and fruitlet retention. Newly emerged female flowers were counted every 2 to 3 days from 20 Mar through 7 Apr 2017, followed by the weekly quantification of fruitlets for 11 weeks after full female bloom (AFFB). Weekly fruitlet retention was calculated by dividing the number of fruitlets remaining on the panicles by the number of fruitlets obtained at week 1AFFB. At harvest on 7 June 2017, five randomly selected fruits per tree were evaluated for pericarp, aril, seed and whole fruit weight, and total soluble solids content. The treatment effects of LP in comparison with EP (control) on all parameters measured were determined using one-way analysis of variance with SAS Enterprise Guide (version 7.1; SAS Institute Inc., Cary, NC).

## RESULTS AND DISCUSSION

Both EP and LP 'Yu Her Pau' trees started to produce female flowers from 24 Mar 2017 and had the peak bloom time on 29 Mar (Fig. 1), during which LP trees produced significantly more female flowers than EP trees (Fig. 1). Total female flowers produced in spring were also significantly greater in LP trees than EP trees (208.8 and 153.0/panicle, respectively; $P = 0.022$) (Table 1). These results demonstrated that delayed pruning increased flower intensity without affecting phenology. Notably, from mid-December to mid-January, LP trees had twice as much canopy foliage as that of EP trees, suggesting more mature leaves during this period plays a pivotal role in promoting flowering promotion. Since flowering phenology was unaltered by pruning times, the relationship between the number of mature leaves in winter and spring female flower intensity in litchi is likely quantitative, consistent with the results in citrus (Nishikawa *et al*., 2013). Given the positive

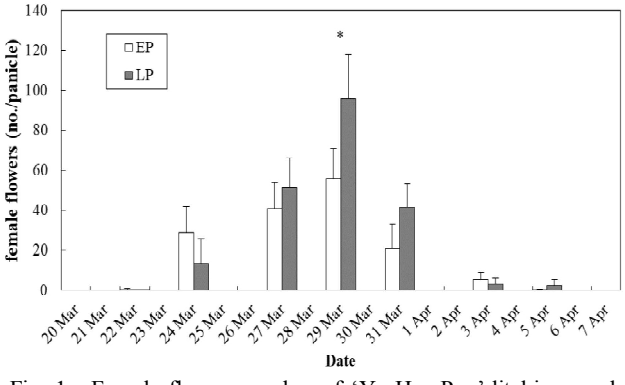


Fig. 1 : Female flower number of 'Yu Her Pau' litchi pruned in mid-December [early pruning (EP)] and mid-January [late pruning (LP)]. *significant differences between two treatments on 29 Mar at P< 0.05.

**Table 1 : Flower and Fruit characteristics in 'Yu Her Pau' litchi pruned in mid-December [early pruning (EP)] and mid-January [late pruning (LP)]**

| Treatment | Female flower no. / panicle | Fruit no. / panicle immediately before harvest | Fw (g) | Pw (g) | Aw (g) | Sw (g) | TSS ($^0$Brix) |
|---|---|---|---|---|---|---|---|
| EP | 153.0 | 2.8 | 29.29 | 5.75 | 22.15 | 1.38 | 19.65 |
| LP | 208.8 | 1.9 | 30.16 | 5.96 | 22.63 | 1.57 | 19.69 |
| ANOVA | * | NS | NS | NS | NS | NS | NS |

FW: fruit weight, PW: pericarp weight, AW: aril weight, SW: seed weight, TSS: total soluble solids (TSS)

correlation between winter leaf carbohydrate levels and spring flower numbers reported in citrus (Garcia-Luis *et al*.,1995), the additional litchi leaves present in December due to LP might constitutes a greater carbohydrate pool to support more flower buds. Alternatively, greater leaf number and area in LP trees may result in a higher *FT* accumulation (Kinmonth-Schultz *et al*., 2019), which corresponded to flower intensity in response to floral-inductive conditions (Nishikawa *et al*., 2007; Tang *et al*., 2021; Lu *et al*., 2022). Relevantly, litchi grown in the North Hemisphere had maximum *LcFT1* expression between mid-December and mid-January (Ding *et al*., 2015), when low temperatures (< 20 ◦C) guaranteed floral induction (Menzel and Simpson, 1995). The mean monthly temperature during this trial was 19.8 ◦C in December 2016, and 18.3 ◦C in January at the orchard that met the low temperature requirement. Together, keeping more leaves under flowering-promoting low temperatures (mid-December through January) may positively affect floral signaling involving *LcFT1*, thereby enhancing flowering.

Litchi inflorescences are heterocladic pleiothyrsoids; each female flower is surrounded by multiple subsequently produced male flowers within a dichasium (Robbertse *et al*., 1995). For 'Yu Her Pau' litchi, the resource competition between new fruitlets (from female flowers) and male flowers is one predominant cause of low fruit set (Chen *et al.,* 2013). Thus, it is possible that, with increased female flowers (Fig. 1), fruit set would be reduced in LP trees due to the concomitant increment in male flowers (Jiang *et al*., 2012; Lee and Chang 2019). In contrast, our results demonstrated that by week 1 AFFB, fruitlet numbers in LP and EP trees (160.3 and 150.0/panicle, respectively) were not different (Fig. 2), suggesting the initial fruit set was not reduced by delayed pruning. As more fruitlets abscised from LP (87.0%) than EP trees (78.7%), fruitlet number remained undistinguishable at week 2 AFFB (Fig. 2). Final fruit number per panicle of both treatments stayed similar through harvest (Table 1), with no difference in pericarp, aril, seed, and total fruit weight or total soluble solids content (Table 1). The results of this study indicate that the increase in floral intensity as a result of delayed pruning did not have a significant negative impact on fruitlet retention or fruit quality in 'Yu Her Pau' litchi.

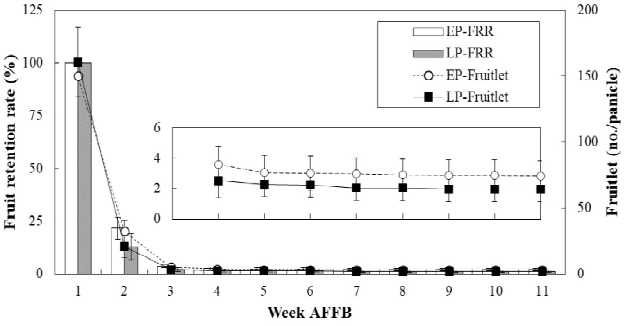


Fig. 2 : Fruitlet number and fruit retention rate (FRR) of 'Yu Her Pau' litchi pruned in mid-December [early pruning (EP)] and mid-January [late pruning (LP)]. (Week AFFB-Week after full female bloom).

Mature leaves during the early to mid-stages of fruit development are the main photo assimilate source for fruitlets nearby (Chang and Lin, 2008). Hence, similar crop load and fruit quality traits of EP and LP trees could be attributed to similar leaf quantity and canopy light interception, achieved by the same extent of pruning (albeit done at different times), past mid-January. This inference further suggests that the presence of mature leaves during the floral-inductive period (mid-December to mid-January), relative to fruit development period, might play an inconsequential part in fruit retention and maturation thereafter.

## CONCLUSION

While literature has provided evidence for the role of leaves, regarding carbohydrate reserves and *FT* transcription, in litchi flower formation, this study was the first to put such knowledge into practice i.e., to effectively manipulate female flowering by increasing leaf exposure to floral-inductive low temperatures with delayed pruning. Our results presented a tool to mitigate low flower intensity in litchi in the event of warmer winters due to climate change. Although our study demonstrated no negative effects of increased flowering on initial fruit set, delayed pruning did not result in an increase in final crop load in 'Yu Her Pau' litchi. This reflects the fact that flower formation is just one component with regard to yields. Therefore, other practices that improve fruitlet retention, like inflorescence pruning and cincturing (Chang *et al.,* 2022), could be used in conjunction with delayed pruning to enhance overall litchi productivity.

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