

## Evaluation of Flower Thinning Applied to Yardlong Bean Production

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### Abstract

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Due to fungal infection, using fungicide on yardlong bean during the harvest period is unavoidable. Application of fungicide caused fungicide residue on mature pods, as a result, the pods could not meet the recommended standards for edible period. In this study, we used flower thinning technique by spraying fungicide at juvenile pod stage instead of mature pod stage. The influence of flower thinning on yield of yardlong bean was evaluated. The results demonstrated that accumulative yield of 7-d interval of flower thinning treatment was significantly higher than 10-d interval. Hand thinning stimulated flower formation. The weekly yield of flower thinning treatment showed no significant difference compared to no thinning treatment. The trial attempted to improve hand flower thinning practice for saving labor cost. In consideration of food safety, organic materials were used as flower thinning agent in this study. The flowers dropped or delayed growth without leaves burning after treating organic material B. Phosphorus acid and potassium hydroxide mixture could effectively substitute hand flower thinning in yardlong bean production. However, the efficacy of flower thinning was affected by climatic interference in the field such as rain. The results indicated that the better ratio of phosphorus acid to potassium hydroxide was 1 : 0.7 and the mixture had a potential to use as flower thinning agent.

**Key words:** Yardlong bean, Flower thinning, Yield, Phosphorus acid, Potassium hydroxide.

### INTRODUCTION

Yardlong bean (*Vigna unguiculata* ssp. *sesquipedalis*) is a climbing crop and harvest daily in the field. In recent years, the public concern about food safety and chemical residue in yardlong beans. Continuous harvest encounters a great difficulty in control of fungicide residue on mature pods during harvest

period. Because of a continuous harvest, application of fungicide damages food safety when yardlong bean approaching to maturity. Based on the current guideline, the shortest harvest period for a safe product is 3 d after fungicide spraying. However, yardlong bean forms flower and pods daily, obeying this guideline means no harvest and no income for farmers during the 3-d period. Moreover, previous

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literature indicated that yield varied in different productive seasons and disease pressure (Coker *et al.* 2007). The aim of this technique is to create a spraying time in the juvenile pod stage. By this technique, farmer could avoid these unsafe periods until pods reach maturity. Therefore, we interrupted pod generation daily by flower thinning technique and evaluated the impact on the yield of yardlong bean.

Flower thinning techniques have been applied to several fruit crops such as loquat, blueberry and apples (Razeto *et al.* 2003; Williamson & NeSmit 2007; Hehnen *et al.* 2012). Previous reports demonstrated that flower thinning increased the quality and yield in kiwifruit (Pescie & Strik 2004) and peach (Sauerteig & Cline 2013). Most flower thinning techniques were used on fruit crops. For continuous harvest crop, hand thinning was not economical for farmer's practice. However, hand thinning of flowers provided useful information on yield evaluation of yardlong bean in this study. Several chemical thinning agents have been identified to decrease fruit number such as ammonium thiosulfate, potassium thiosulfate, hydrogen cyanamide, and naphthalene acetic acid (Razeto *et al.* 2003; Milić *et al.* 2011; Kacal & Koyuncu 2012). The appropriate application time and concentration of chemical thinning agents are important factors. These skills determined fruit growth and quality (Razeto *et al.* 2003; Pescie & Strik 2004; Fukuda *et al.* 2015). However, yardlong bean growth characteristic was significant different with fruit crops. The proper interval of flower thinning treatment needs to be modified during continuous harvest periods. On the other hand, the chemical thinning residue was unfavorable and inedible. Therefore, this trial sought for safe flower thinning material as an alternate strategy.

The flower drop phenomenon occurred after rain in the Meinong district of Kaohsiung City in Taiwan. This possibility of flower drop caused by acid rain in Kaohsiung area inspired us to have the idea of thinning flowers with

acid agent. Phosphorus acid was chosen in this trial in consideration of organic cultivation. Neutralized phosphorus acid has been used in organic cultivation and protects plants from pathogens by inducing plant systemic resistance (Guest 1984; Panicker & Gangadharan 1999; McDonald *et al.* 2001; Choudhary *et al.* 2007; Keinath & DuBose 2012). Related reports demonstrated the efficiency of phosphate salts by foliar sprays on foliar diseases (Reuveni *et al.* 1996; Walker 1998). However, there is no literature on using phosphorus acid as flower thinning agent in yardlong bean production. This innovative study attempted to evaluate the feasibility of flower thinning by hand and phosphorus acid. The objectives of this study are (1) to assess a better interval of hand flower thinning time, (2) to investigate the effect of row spacing on the yield of hand flower thinning treatment, and (3) to evaluate the efficacy and yield by using organic flower thinning agent.

## MATERIALS AND METHODS

Three trials were conducted in the field at Fengshan Tropical Horticultural Experiment Branch, Taiwan Agricultural Research Institute, Kaohsiung, during the fall of 2012 to 2014, respectively. Seeds of yardlong bean cv. 'San-Tse-Chin-Pi' used in this study were obtained from farmer of Ligang Township. Seeds were immersed with 42°C water for 2 h to improve germination rate before sowing in 50-well pots (4.5 cm in diameter and filled with peatmoss). Seedlings were transplanted to field 14 d after sowing. The effect of flower thinning spraying interval on yield was assessed in trial 1. The targets of flower thinning were blooming flowers and thinned by hand on the same day. Application of two flower thinning intervals (7- and 10-d intervals) were compared with a non-treated control. Yardlong beans planted along rows with 40 cm between plants and the density was 8 plants per 10 m<sup>2</sup>. Three treatments were compared in this trial, including (1) no flower thinning

(control check), (2) flower thinning at 7-d interval, and (3) flower thinning at 10-d interval. Trial was randomized completely block design (RCBD) with eight plants in each replicate and three replicates for each treatment.

To evaluate the influence of flower thinning under different planting densities, yield of two rows with spacing 40 cm and 80 cm were investigated in trial 2. Yardlong bean planted in a single row for each of densities, 8 plants per 10 m<sup>2</sup> and 4 plants per 10 m<sup>2</sup>, respectively. Four treatments were compared in this trial, including (1) no flower thinning with 40 cm between plants, (2) no flower thinning with 80 cm between plants, (3) flower thinning with 40 cm between plants, and (4) flower thinning with 80 cm between plants. The trial was randomized completely block design (RCBD) with 10 m<sup>2</sup> area of each replicate and three replicates in each treatment. This trial concerned about the production loss caused by the elimination of flower. Flower thinning treatments were carried out by hands and calculated the number of eliminated flowers weekly.

Development of labor-saving strategies for improving flower thinning was the main objective for trial 3. We used phosphorus acid and potassium hydroxide in different ratios to evaluate the efficiency of flower thinning on yield. Two ratios of phosphorus acid and potassium hydroxide were used as organic material A and organic material B. The ratios of organic material A to B were 1 : 0.6 and 1 : 0.7, and pH were 2.3 and 4.3, respectively. Four treatments were compared in this trial, including (1) no flower thinning as a control, (2) flower thinning by hand, (3) organic material A, and (4) organic material B. A period of three days after spraying fungicide was recommended for conventional harvest period in yardlong bean. Therefore, this trial simulated safe yardlong bean production and assessed harvest pods weekly. Seeds of yardlong beans were planted in double rows with 40 cm between plants and the density was 16 plants per 10 m<sup>2</sup>. The trial was randomized completely block design

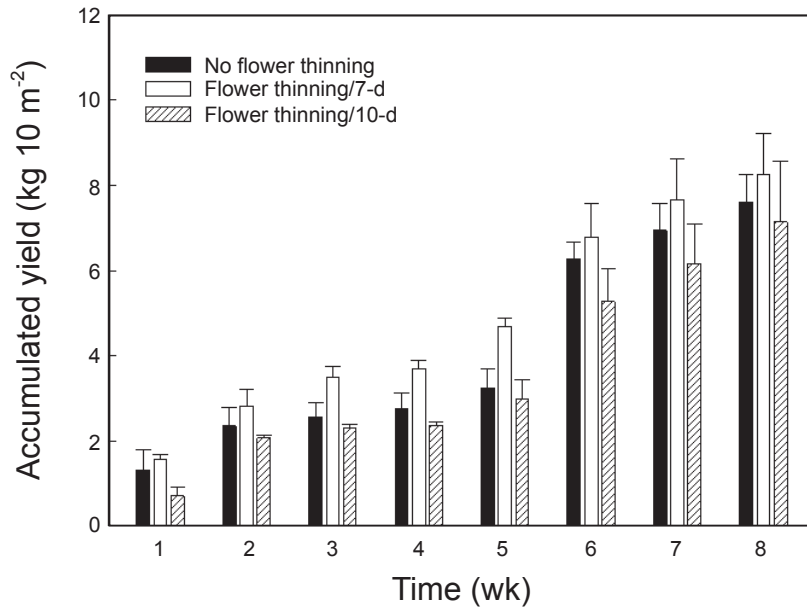
(RCBD) with 10 m<sup>2</sup> area of each replicate and three replicates for each treatment.

## RESULTS AND DISCUSSION

Continuous harvest crops like yardlong bean are harvested almost daily. It means that fungicide will remain on the mature yardlong bean. In this study, we attempted to create a fungicide spraying opportunity in juvenile pod stage after flower thinning. Several days after spraying, these juvenile pods become mature and could avoid from fungicide residue. However, the method is highly questioned and concerned about yield loss. We focus on the influence of yield by flower thinning.

Days required from flowering to pod maturity of yardlong bean cv. 'San-Tse-Chin-Pi' are between 7 to 10 d during spring to summer in Kaohsiung area. According to pods forming period, we evaluated the influence of flower thinning interval on accumulated yield in trial 1. The result showed a better accumulated yield at 7-d interval compared to 10-d interval in the previous five weeks (Fig. 1). The accumulated yield of flower thinning at 7-d interval treatment was also better than no thinning control during the third to fifth week. According to this result, 7-d interval of flower thinning was performed in subsequent trials.

Farmers concerned about the yield drop after eliminating the flowers by flower thinning. Previous report indicated that mechanical and hand blossom thinning decreased fruit set (Sauerteig & Cline 2013), but increased marketable yield (Pescie & Strik 2004). Another literature demonstrated that one or two flower thinnings performed well in fruit trees (Hehnen *et al.* 2012). Different from fruit trees, yardlong bean belongs to continuous harvest crop having successive flowering and pod formation almost daily. This study investigated the influence of several times of flower thinning on yield. In trial 2, flower thinning was conducted in two row spacings, 40 cm and 80 cm. Flower number, elimination amount and yield were calculated and compared weekly.

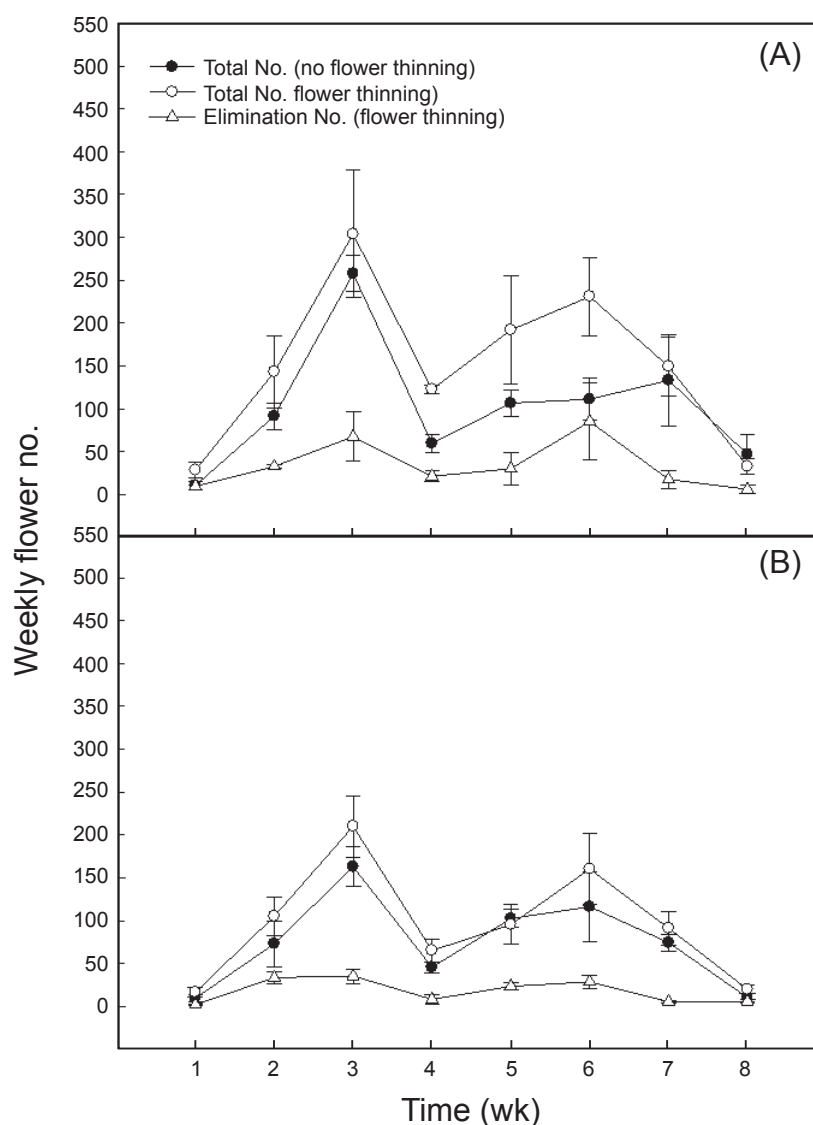


**Fig. 1.** Influence of different flower thinning intervals on the accumulated yield of yardlong bean. Error bars show the standard error of the mean (SE).

The flower thinning treatments showed a better flower formation weekly (Figs. 2A–2B). The total number of flowers of thinning treatment was significantly higher compared to no flower thinning treatment during the fourth to sixth week in 40 cm spacing. On the other hand, the weekly yield of flower thinning treatments showed no significant difference except the fourth to fifth week in 40 cm spacing compared with no thinning treatment (Fig. 3A). Moreover, compared to the accumulated yield in 40 cm spacing, flower thinning treatment was significantly higher than no flower thinning during the fourth to eighth week (Fig. 3B). Fukuda *et al.* (2015) indicated that flower thinning increased fruit number and quality in peaches. This study showed the relationship between flower number and yield. In general, the accumulated yield of flower thinning in plant spacing of 40 cm treatment was significantly higher than that of 80 cm treatment. We speculate that such a result was caused by the double plant density and the competition of growing space. Results of this trial suggest that flower thinning technique could be per-

formed in row spacing of 40 cm. Flower thinning at 7-d interval obviously increased flower amounts and total yield.

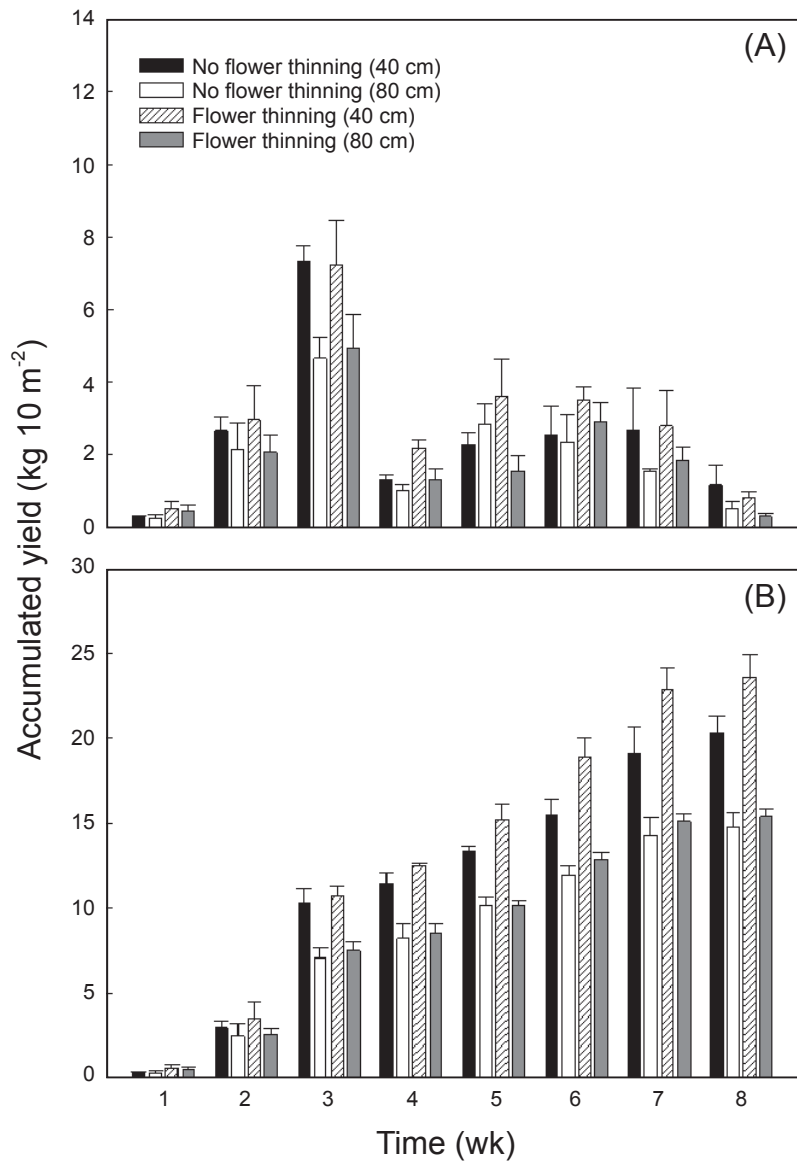
Flower thinning technique was performed by hands in the previous trails. However, this technique required more labor and could not meet farmers' demand. Use of flower thinning agents may be a better choice to reduce the labor cost. Previous report indicated that application of gibberellic acid with a suitable concentration increased fruit weight and yield (González-Rossia *et al.* 2006), and reduced the number of flowering buds (Giovanaz *et al.* 2016). In consideration of continuous harvest and food safety, we were looking forward to seeking a flower thinning method with similar production, but without thinning, to reduce labor cost. In trial 3, we sought a convenient method to eliminate flowers and save the labor cost. The mixture of phosphorus acid and potassium hydroxide with different ratios were evaluated to eliminate flowers in this study. The accumulated yield showed significant difference after treated for four weeks. Flower thinning treatments either by hand or organic



**Fig. 2.** Number of weekly flower formation in row spacing of 40 cm (A) and 80 cm (B). Error bars show the standard error of the mean (SE).

materials showed a better accumulated yield than no flower thinning treatment (Fig. 4A). The definition of safe and edible pods are pods harvested 3 d after spraying fungicide. In such a way, pods can be harvested four times a week. Simulation of weekly safe yield can be deducted from unsafe harvest period (Fig. 4B). The efficacy of organic materials on flower thinning was similar to hand flower thinning. Compared to weekly safe yield, although there

were significantly different in most weeks except the fourth week, organic material treatments showed a better trend than no flower thinning treatment, implying more income for farmers. According to this trial, two organic materials A and B showed slightly different in eliminating flower patterns. After spraying organic material A, flowers dropped and leaves burned. The results were similar to ammonium thiosulfate or potassium thiosulfate. Both

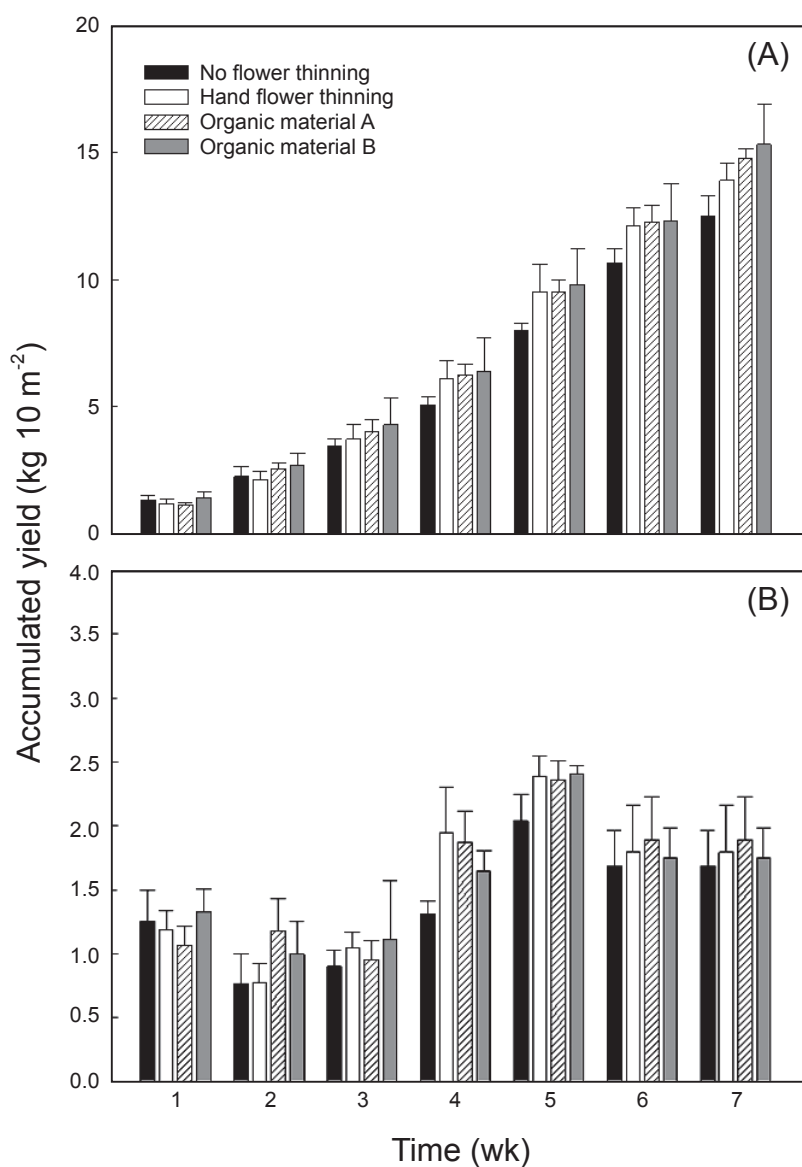


**Fig. 3.** Effect of hand flower thinning on weekly yield (A) and accumulated yield (B) in different row spacings. Error bars show the standard error of the mean (SE).

have been used as commercial flower thinning agents (Milić *et al.* 2011). On the other hand, the organic material B treatment showed flower drop and delay of partial flower development. This phenomenon was similar to the delay of flower bud differentiation by gibberellin sprays (García-Pallas *et al.* 2001). Results of this trial suggest that organic materials B was a better labor saving choice although the

mechanism of flower thinning was indefinite. We surmise that acid materials induce flowers drop or inhibit flower development after spraying on plant. Moreover, the efficacy may be related to climatic factor such as rain and the suitable concentration of flower thinning agent needs an adjustment.

Overall, the results revealed that flower thinning in yardlong bean would maintain ac-



**Fig. 4.** Effect of different flower thinning methods on accumulated yield (A) and weekly safe yield (B). Error bars show the standard error of the mean (SE).

cumulated yield and stimulate the formation of flowers. These trials solved the farmer's doubt about yield reduction. This study demonstrated that 7-d was the best flower thinning interval under row spacing of 40 cm. Hand flower thinning showed a better flower formation. The mixture of phosphorus acid and potassium hydroxide saved the labor cost of flower thinning and may be a potential technique in future.

## REFERENCES

- Choudhary, D. K., A. Prakash, and B. N. Johri. 2007. Induced systemic resistance (ISR) in plants: mechanism of action. *Indian J. Microbiol.* 47:289–297.
- Coker, C., M. Ely, and T. Freeman. 2007. Evaluation of yardlong bean as a potential new crop for growers in the southeastern United States. *HortTechnology* 17:592–594.
- Fukuda, F., K. Hirano, K. Morinaga, and N. Kubota. 2015.

- Flower and fruit thinning in relation to some fruit traits as affected by bloom time and within-tree position in peach. *Acta Hort.* 1084:495–502.
- García-Pallas, I., J. Val, and A. Blanco. 2001. The inhibition of flower bud differentiation in ‘Crimson Gold’ nectarine with GA<sub>3</sub> as an alternative to hand thinning. *Sci. Hortic. Amst.* 90:265–278.
- Giovanaz, M. A., J. C. Fachinello, D. Spagnol, D. Weber, and B. Carra. 2016. Gibberellic acid reduces flowering and time of manual thinning in ‘Maciel’ peach trees. *Rev. Bras. Frutic.* 38:e-692.
- González-Rossia, D., M. Juan, C. Reig, and M. Agustí. 2006. The inhibition of flowering by means of gibberellic acid application reduces the cost of hand thinning in Japanese plums (*Prunus salicina* Lindl.). *Sci. Hortic. Amst.* 110:319–323.
- Guest, D. I. 1984. Modification of defense responses in tobacco and capsicum following treatment with Fosetyl-Al [Aluminium tris (o-ethyl phosphonate)]. *Physiol. Plant Pathol.* 25:125–134.
- Hehnen, D., I. Hanrahan, K. Lewis, J. McFerson, and M. Blanke. 2012. Mechanical flower thinning improves fruit quality of apples and promotes consistent bearing. *Sci. Hortic. Amst.* 134:241–244.
- Kacal, E. and F. Koyuncu. 2012. Use of chemical blossom thinners in ‘Jerseymac’ and ‘Jonagold’ apples. *Bulg. J. Agric. Sci.* 18:898–904.
- Keinath, A. P. and V. B. DuBose. 2012. Controlling powdery mildew on cucurbit rootstock seedlings in the greenhouse with fungicides and biofungicides. *Crop Prot.* 42:338–344.
- McDonald, A. E., B. R. Grant, and W. C. Plaxton. 2001. Phosphite (phosphorous acid): Its relevance in the environment and agriculture and influence on plant phosphate starvation response. *J. Plant Nutr.* 24:1505–1519.
- Milić, B., N. Magazin, Z. Keserović, and M. Dorić. 2011. Flower thinning of apple cultivar Braeburn using ammonium and potassium thiosulfate- Short communication. *Hort. Sci. (Prague).* 38:120–124.
- Panicker, S. and K. Gangadharan. 1999. Controlling downy mildew of maize caused by *Peronosclerospora sorghi* by foliar sprays of phosphonic acid compounds. *Crop Prot.* 18:115–118.
- Pescie, M. A. and B. C. Strike. 2004. Thinning before bloom affects fruit size and yield of hardy kiwifruit. *HortScience* 39:1243–1245.
- Razeto, B., G. Reginato, and S. Rojas. 2003. Chemical thinning of loquat with naphthalene acetic acid. *HortTechnology* 13:128–132.
- Reuveni, M., V. Agapov, and R. Reuveni. 1996. Controlling powdery mildew caused by *Sphaerotheca fuliginea* in cucumber by foliar sprays of phosphate and potassium salts. *Crop Prot.* 15:49–53.
- Sauerteig, K. A. and J. A. Cline. 2013. Mechanical blossom thinning of ‘Allstar’ peaches influences yield and quality. *Sci. Hortic. Amst.* 160:243–250.
- Walker, G. E. 1988. Phytophthora root-rot of container-grown citrus as affected by foliar sprays and soil drenches of phosphorous and acetyl salicylic acids. *Plant Soil* 107:107–122.

## 疏花在長豇豆生產應用之評估

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### 摘要

林楨祐、黃雅穗、李香誼、羅惠齡、王三太。2017。疏花在長豇豆生產應用之評估。台灣農業研究 66(4):267–275。

長豇豆在收穫期間無可避免因罹病而需要噴施殺菌劑，當此成熟豆莢尚未達到農藥推薦使用之安全期標準而予以採收，極易有藥劑殘留於豆莢的情形。本研究中藉由疏花操作來創造幼莢階段，以提供噴施殺菌劑的機會，並評估疏花對長豇豆產量的影響。結果顯示，間隔 7 d 疏花一次，其產量顯著較間隔 10 d 疏花一次為高；在花朵量與產量方面，每週產量在相同種植株距中，人工疏花處理與不處理者幾乎無顯著的差異，但經由人工疏花可刺激更多花量的生成，且其總累積產量則有較佳的趨勢。此試驗中亦試圖改善因人工疏花導致勞力成本耗費的情形，在考量食品安全的前提下利用有機資材作為疏花劑，經處理有機資材 B 後，花朵呈現掉落或延遲生長，且無葉部燒傷現象，此亞磷酸和氫氧化鉀的混合物可有效地替代人工疏花。然而，疏花的有效性易受下雨等天候的干擾，該混合物在混合比率 1：0.7 的情形下具有當作長豇豆疏花劑的潛力。

**關鍵詞：**長豇豆、疏花、產量、亞磷酸、氫氧化鉀。

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