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Fruit quality of the low-chill early ripening peach cultivar 'KU-PP2' is affected by the time of fruit thinning

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Abstract

This study aimed to see how the timing of fruit thinning affected the fruit quality of the peach cultivar 'KU-PP2'. In the present study. 'KU-PP2' peach trees (12-year-old) were trained to an open center system at the Kagawa University Research Farm in Japan. Fruits were thinned at intervals of 7, 14, 21, and 28 days after full bloom (DAFB) on four branches per tree, for a total of 16 branches, to determine the best fruit thinning time for high fruit quality and larger fruit size. The branches were hand-thinned at each thinning date, keeping a distance of 10 cm between the fruits. Fruit maturity was accelerated by the fruit thinning treatments. Fruit weight and size increased when the fruits were thinned at 7 and 28 DAFB. Furthermore, the highest total soluble solids were found at 7, 14 and 28 DAFB, followed by 21 DAFB, which was higher than the control. All of the thinning treatments reduced skin and fruit firmness; however, the treatments did not affect flesh firmness. In control, the fruit colour value L* was highest. The fruit colour value a*, on the other hand, was the highest at 7 and 28 DAFB. Furthermore, b* did not differ significantly between treatments, including the control. Based on our findings, we concluded that the 7 DAFB fruit thinning treatment produced the best results compared to other treatments.

Key words: Fruit size, fruit thinning time, low-chill requirement, maturity, *Prunus persica*

Introduction

Peach (*Prunus persica* (L.) Batsch) is one of the most important summer fruits in Yamanashi, Fukushima, Nagano and Okayama prefectures in Japan. Generally, peach produces a large number of flowers and fruitlets; hence fruit thinning is essential to ensure adequate fruit quality (Southwick *et al.*, 2000). After bloom, the fruits undergo cell division, fruit development with lignification of the endocarp, expansion of cells, and fruit maturation and senescence, respectively, until the ripening stage (Lopresti *et al.*, 2014; Masia *et al.*, 1994; Zanchin *et al.*, 1994). Japanese fruit growers remove small, deformed or disoriented shapes and excess fruits to obtain larger fruits with good quality. Another advantage of fruit thinning is that it shortens the ripening period of fruits. The purpose of fruit thinning is to reduce fruit number and energy competition, which results the fruits with the larger size and improved quality (Byers *et al.*, 2003). Fruit thinning could determine the size and quality of peach fruit.

The low-chill peach cultivar, 'KU-PP2' was developed by Kagawa University and registered in 2016. It requires about 400 chilling hours to break bud dormancy (Manabe *et al.*, 2015). Furthermore, 'KU-PP2' cultivar has short fruit development period (approximately 90 days), therefore, they can be carried to the peach market earlier. However, this cultivar bears small fruit with poor fruit quality compared to the standard quality of Japanese high-chill cultivars. Fruit thinning timing could determine the size and quality of this cultivar. However, the best fruit thinning timing is still unknown in 'KU-PP2' peach.

Although the effects of thinning have been studied in peach (Byers *et al.*, 2003), the information on low-chill and early ripening cultivars, such as the cultivar 'KU-PP2' has not been comprehensively determined. Thus, in this study, the effects of timing of fruit thinning on fruit size and quality of 'KU-PP2' peach were investigated.

Materials and methods

Plant materials: The experiment was carried out on 12-year-old peach 'KU-PP2' trees with a spacing of 2.5 × 2.5 m and trained to open centre system at Kagawa University Research Farm, Japan in 2020. The experimental location is situated 34.2758°N latitude and 134.1251°E longitude. During the experiment, the maximum and minimum temperatures were recorded 30.1°C and 5.1°C, respectively. The experiment was conducted using four trees of homogenous shape and vigour. Four treatments were arranged for each tree. All the selected trees were given uniform cultural practices during the study period.

The measurement of fruit growth and quality: The experiment was started after one week of full bloom (19th March, 2020). For fruit spacing, the immature fruit thinning was conducted at about 1 fruit per 10 cm interval. In this experiment, the fruit thinning treatment was conducted at an interval of 7, 14, 21 and 28 days after full bloom (DAFB), when 80% of blossom was observed. The control trees were unthinned. Fruit growth in length and width was measured weekly using a digital calliper (0-150 mm) after 1 month (12th April, 2020) of full bloom until the date of harvesting.

Fruit maturity was recorded on harvesting time. Fruit size and weight were measured using digital calliper (0-150 mm) and high-precision tuning fork balance (Vibra, Shinko densi Co. Ltd). The skin and flesh firmness was measured using fruit hardness tester (KM type, 0-1 kg, Fujiwara scientific Pvt. Ltd) at the same day. For the analysis of total soluble solids (TSS), the juice of each fruit was extracted separately using cotton clothes and measured by Refractometer (PR-101α, Atago, Co. Ltd.). Skin colour, whereas L* varies from 0 (black) to 100 (pure white), +a indicates red and –a indicates green, +b indicates yellow, and–b indicates blue was measured with Chroma meter (CR-40, Konica Minolta).

Titratable acid (TA) was measured using acidity titration (Titrator TA-70, DKK-TOA Corporation). For TA analysis, 1 mL of juice was diluted to 50 mL with distilled water, and subjected to neutralisation titration using 0.05 N of NaOH solution and converted to malic acid by following formula:

TA content (%) = volume of NaOH (mL)×0.05×1.004×0.067/ volume of sample (mL) ×100

Statistical analysis: The data was subjected to analysis of variance (ANOVA) using the statistical software SPSS version 20.0. Comparison between means were established using Tukey`s test and differences were considered statistically significant at P>0.05.

Results and discussion

Change of fruit size: The present study exhibited that the timing of fruit thinning affected the fruit expansion of the 'KU-PP2' peach (Table 3). In terms of an increase in the fruit length, during the early fruit development stage (S1 and S2), the late fruit thinning had a higher fruit length than that in the early fruit thinning (7 DAFB), whereas, during the S3 period, the fruits of 7 DAFB were lengthier than those in the other treatments. Conversely, the fruit width of an early fruit thinning during S1 and S2 was higher than the later fruit thinning, but it was comparable with the control. However, the fruit width of the 28 DAFB treatment was higher than another fruit thinning treatment throughout the last stage of fruit development. Although the timing of fruit thinning influenced fruit expansion in each development stage, the effects of fruit thinning on fruit shape were not observed at the final stage. The final fruit shape of all the treatments was round, and the fruit length and width ratio varied between 0.9 to 1.0. We hypothesized that the difference in the fruit expansion of 'KU-PP2' between fruit thinning treatments could be associated with the cell division and the sink competition between fruitlets during an early fruit development stage (S1).

The fruit quality at harvest: The thinning of the 'KU-PP2' peach increased fruit size, even performing as late as 28 DAFB. In this experiment, early thinning (7 DAFB) resulted greater fruit size. Early thinning may increase the final fruit size (Oliveira *et al.*, 2017 and EI-Boray *et al.*, 2013), which can be explained by a reduction in the initial competition for carbohydrate distribution (Table 1). In this study, we obtained the same result. This increment in fruit size might be due to peach fruit cell division that starts in first month (S1) and immediately turns to cell expansion (S2) later. All thinning treatments resulted in early maturity compared to the control. This might be due to the immediate accumulation of minerals and metabolites that contribute to the early development of thinned fruits which is in line with Chanana *et al.* (1998), who also reported that thinning advanced peach fruit maturity well. The maximum fruit weight was recorded at 7 DAFB treatment (178.7 g), followed by 28 DAFB treatment (176.0 g), while minimum was recorded in the control (147.9 g). The increased fruit size might be the result of initial carbohydrate competition because there will be less competition for nutrition between fruits. The results in this experiment are in line with Oliveira *et al.* (2017) and EI-Boray *et al.* (2013). In this experiment, we found that by earlier thinning (7 DAFB), we can obtain the largest fruit of 'KU-PP2' peach cultivar. Fruit size, which was also determined by appropriate thinning time, is an important external quality that influences consumer acceptance. The fruit lengths were found non-significant between the treatments. The highest fruit length (64.2 mm) and cheek (70.8 mm) were recorded at 7 DAFB treatment. However, the length of both 7 DAFB and 28 DAFB treatments were significantly larger than those of the control treatment. The length of cheek was found the highest in 7 DAFB treatment but was non-significant among the treatments including control. The length of the suture was the highest (69.4 mm) in 28 DAFB. The fruit skin firmness was significantly higher in the control (0.82 kg/cm^2) compared with the other treatments (Table 1). Reasonably, this might be due to the larger cell size, which plays a role in decreasing the strength of the cell wall and reducing the solidarity between the cells. Similar results were reported in other studies (Drogoudi *et al.*, 2009; Njoroge *et al.*, 2008). The flesh firmness was not significantly different in each treatment. The total soluble solids (TSS) was recorded highest (10.3 °Brix) in 7, 14 and 28 DAFB treatments followed by 21 DAFB (10.0 °Brix), while control recorded lowest (7.7 °Brix). All the treatments were not significantly different among each other but were significantly different with control. This experiment resulted that the thinning process increase TSS level of 'KU-PP2' fruit but could not exactly found which DAFB would be suitable for fruit thinning in the side of increase TSS level. TA was not significantly different between the treatments. The

Table 1. Effects of fruit thinning on fruit maturity, size and firmness in the peach cultivar 'KU-PP2'.

Fruit thinning time (DAFB)	Days to maturity (days)	Fruit weight (g)	Fruit diameter (mm)			Firmness (kg/cm^2)	
			Length	Cheek	Suture	Skin	Flesh
7 DAFB^Z	92	178.7 b	64.2 b	70.8	65.3 b	0.70 a	0.33
14 DAFB	92	163.2 ab	61.8 ab	70.1	65.6 b	0.66 a	0.34
21 DAFB	92	166.0 ab	62.5 ab	70.0	64.5 b	0.69 a	0.31
28 DAFB	91	176.0 b	63.5 b	68.9	69.4 c	0.72 a	0.34
Control	100	147.9 a	60.0 a	66.9	60.1a	0.82 b	0.34
Significance		*	*	NS	*	*	NS

^{Z}DAFB refers to the days after full bloom * means significant at one way ANOVA (P< 0.05) NS = non-significant Different letters within the same column indicates a significant difference by Tukey`s test at the 5% level

Table 2. Fruit thinning effects on TSS, TA and skin colour in the peach cultivar 'KU-PP2'

Fruit thinning time (DAFB)	T.S.S (°Brix)	Titratable acidity(%)	Skin colour		
			L*	a*	b*
7 DAFB^z	10.3 b	0.32	56.6 b	15.9 b	33.9
14 DAFB	10.3 b	0.32	55.8 b	12.5 ab	33.6
21 DAFB	10.0 b	0.32	53.9 ab	14.5 ab	32.5
28 DAFB	10.3 b	0.34	48.1 a	16.0 b	36.6
Control	7.7 a	0.32	56.8 b	8.4 a	33.9
Significance	*	NS	*	*	NS

^{Z}DAFB refers to the days after full bloom. * means significant at one way ANOVA (P< 0.05) NS = non-significant Different letters within the same column indicates a significant difference by Tukey`s test at the 5% level.

fruit skin colour value a* (redness) was recorded highest (16.0) in 28 DAFB treatment followed by 21 DAFB treatment (15.9). The b* value, which determines the yellowness of fruit was not significantly different between the treatments. L* value, which determines the lightness of fruit was observed highest in control (Table 2).

Table 3. The weekly change in length, width and fruit shape of 'KU-PP2' fruit after fruit thinning treatments

Treatments	Date	DAFB[z]				Control
		7	14	21	28	
Fruit length (mm)	16-Apr	27.2a	27.2a	27.1a	30.2a	28.9a
	23-Apr	32.3ab	32.2b	31.8a	34.7b	33.6b
	30-Apr	35.6b	36.3b	36.4b	39.0b	36.7b
	7-May	46.8c	45.8c	45.2c	46.0c	44.3c
	14-May	50.6c	47.0c	48.6c	48.3cd	46.9cd
	21-May	51.8c	49.5c	49.8c	50.6d	48.7d
Fruit width (mm)	16-Apr	24.5a	23.8a	23.7a	24.9a	23.7a
	23-Apr	30.0ab	29.8b	29.7b	32.8b	32.9b
	30-Apr	36.0b	36.5c	35.6c	38.1b	38.7c
	7-May	46.7c	47.8d	45.4d	47.4c	45.6d
	14-May	50.3c	48.0d	50.2de	50.2c	48.6d
	21-May	52.3c	49.8d	52.5e	51.0c	50.4d
Fruit shape	16-Apr	1.11a	1.15b	1.14c	1.23b	1.25b
	23-Apr	1.08a	1.08bc	1.07bc	1.06a	1.02a
	30-Apr	0.99a	0.97ab	1.02ab	1.03a	0.96a
	7-May	1.00a	0.96a	0.99ab	0.97a	0.97a
	14-May	1.01a	0.98a	0.97a	0.96a	0.96a
	21-May	0.99a	0.99ab	0.95a	0.99a	0.97a

[z]DAFB refers to the days after full bloom Different letters within the same column indicates a significant difference by Tukey`s test at the 5% level.

The total outcome of present investigation concludes that the thinning of new low-chill peach cultivar 'KU-PP2' at 7 DAFB was highly effective for enhancing fruit size, fruit length, cheek, TSS and quality attributes.

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