The influence of fruit thinning on fruit drop and quality of citrus

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Abstract. This experiment aims to know the effects of fruit thinning on fruit drop and fruit quality of citrus. The research was conducted in a citrus orchard in Purbalingga, Central Java, Indonesia in 2016/2017 and 2017/2018. There were nine observed ways of fruit thinning namely 15 days after full bloom (DAFB) by maintaining one fruit per branch, two fruits per branch, three fruits per branch, at 30 DAFB by maintaining one fruit per branch, two fruits per branch, three fruits per branch, at 45 DAFB by maintaining one fruit per branch, two fruits per branch, and three fruits per branch. The result showed that fruit thinning did not influence to the quality of citrus fruits (diameter and weight of fruits, vitamin C and sugar content, total acid, and soluble solids). The lowest fruit drop per branch was showed at thinning at 45 DAFB by maintaining one fruit per branch, whereas the lowest fruit drop per tree was achieved by fruit thinning at 45 DAFB by maintaining two fruits per branch.

1. Introduction
Citrus is an important fruit in the world having a wide range of growing area from subtropical to tropical regions. This fruit has been noted for nutritional and antioxidant content. A number of studies have been reported that citrus is an important natural source of vitamin C (ascorbic acid), which has several human health-related benefits [1]. Citrus contains appreciable amounts of carotenoids (some capable of conferring to vitamin A, folate, and fiber [2].

The primary objective of fruit thinning is an increase of fruit quality by getting larger and more uniform fruits [3]. Thinning fruits within clusters was most effective in increasing fruit size, indicating that fruit distribution, as well as total number of fruits, is crucial in determining size. Hand thinning of citrus fruits is one of many techniques to increase fruit size and other qualities parameters of citrus. The elimination of a part of the developing fruitlets makes more photosynthate available which are in part diverted to the remaining fruitlets thus leading to an increase in fruit size [4].

Fruit thinning is very important for improving fruit quality [5, 6]. It is impossible to maximize all quality factors simultaneously, because there are positive and negative interrelations among them. Therefore, a reasonably balanced compromise between quality and quantity must be achieved. The objective of the study was to evaluate the effect of fruit thinning on fruit drop and quality of citrus.

2. Materials and methods
This study was carried out from October until August in 2016/2017 and 2017/2018 in a four-years old Citrus nobilis ‘Pontianak’ orchard in Central Java, Indonesia. The location of this orchard is at 60 m
above sea level, 7.44°S and 109.43°E. Soil of plots contained 0.125% N, 0.072% P₂O₅, and 0.052% K₂O. The dry season at this location is from April to October, whereas the rainy season is from October until April. The average rainfall was 148 mm per month, average sunshine was seven h per day, and average air temperature was 24-37°C, as measured at a local meteorological station.

This non-factorial experiment was arranged by a completely randomized design. There were nine observed ways of fruit thinning namely 15 days after full bloom (DAFB) by maintaining one fruit per branch, at 15 DAFB by maintaining two fruits per branch, at 15 DAFB by maintaining three fruits per branch, at 30 DAFB by maintaining one fruit per branch, at 30 DAFB by maintaining two fruits per branch, at 30 DAFB by maintaining three fruits per branch, at 45 DAFB by maintaining one fruit per branch, at 45 DAFB by maintaining two fruits per branch, and at 45 DAFB by maintaining three fruits per branch. Each treatment was replicated three times, so there were 27 trees of citrus. The trees received agricultural treatments typical for this locality.

The observed variables were fruit diameter, weight of fruit, fruit drop per branch and per tree, also observed in vitamin C, sugar, total acid, and soluble solids content. Vitamin C and total acid were measured by a titrimetric method [7]. Sugar content was measured by refractometer, whereas soluble solids were measured by electrical conductivity method. Data were analyzed statistically by one-way analysis of variance (ANOVA), separately for each season of study. Means were separated using the Duncan’s Multiple Range Test (DMRT) (p=0.05).

### 3. Results and discussions

Table 1 showed that fruit thinning did not influence fruit diameter and weight of fruits. This result indicated that citrus trees can supply photosynthate sufficiently for growth and development of fruit although there were three fruits per branch for relatively along time. In general, there are more competition due to more number of fruits and more time in competition. Citrus trees have autoregulation mechanisms to maintain the balance between supply and demand of photosynthate. One of the them is by dropping a part of number of fruits. Similar to our experiment, the average weight of citrus fruit when panicle had one or two fruits was the same, so trees did not require thinning [8]. Fruit thinning 50% gave no effect on peel and pulp dry weight [9]. In contrast, reported that increased number of fruits per panicle decreased the weight and diameter of fruits [10]. Pawapaw, as in other tree fruits, fruit thinning increases fruit size by reducing competition among and within clusters [4].

#### Table 1. Effect of fruit thinning on diameter and weight of fruit

| Fruit thinning | Fruit diameter (cm) | Weight of fruits (g) |
|----------------|---------------------|----------------------|
|                | 2016/2017   | 2017/2018   | 2016/2017   | 2017/2018   |
| W1J1           | 4.91       | 4.95       | 80.31       | 81.40       |
| W1J2           | 5.47       | 5.50       | 78.98       | 80.85       |
| W1J3           | 5.08       | 5.09       | 88.17       | 88.97       |
| W2J1           | 5.38       | 5.39       | 76.29       | 77.29       |
| W2J2           | 5.60       | 5.58       | 83.08       | 81.38       |
| W2J3           | 5.46       | 5.49       | 78.32       | 77.92       |
| W3J1           | 5.51       | 5.27       | 73.82       | 74.77       |
| W3J2           | 5.57       | 5.59       | 93.35       | 95.82       |
| W3J3           | 5.45       | 5.54       | 76.09       | 77.89       |

*F value*: ns means are not significant at p = 0.05; W1J1 = fruit thinning at 15 days after full bloom (DAFB) by maintaining one fruit per branch, W1J2 = fruit thinning at 15 DAFB by maintaining two fruits per branch, W1J3 = fruit thinning at 15 DAFB by maintaining three fruits per branch, W2J1 = fruit thinning at 30 DAFB by maintaining one fruit per branch, W2J2 = fruit thinning at 30 DAFB by maintaining two fruits per branch, W2J3 = fruit thinning at 30 DAFB by maintaining three fruits per branch, W3J1 = fruit thinning at 45 DAFB by maintaining one fruit per branch, W3J2 = fruit thinning at 45 DAFB by maintaining two fruits per branch, and W3J3 = fruit thinning at 45 DAFB by maintaining three fruits per branch.
Fruit drop per branch and per tree influenced by fruit thinning. The lowest fruit drop per branch (14.67 and 16.00% for 2016/2017 and 2017/2018 respectively) showed by fruit thinning at 45 DAFB by maintaining one fruit per branch (W3J1) whereas the lowest fruit drop per tree (34.67 and 36.00%) showed by fruit thinning at 45 DAFB by maintaining two fruits per branch (Table 2). Lower fruit drop due to lower competition among fruits in using photosynthate because there were little of fruits per branch or per tree [5]. Fifty percent fruit thinning decreased 20% fruit drop compared to non-thinning [9].

**Table 2. Effect of fruit thinning on fruit drop**

| Fruit thinning | Fruit drop per branch (%) | Fruit drop per tree (%) |
|----------------|----------------------------|-------------------------|
|                | 2016/2017                  | 2017/2018               | 2016/2017 | 2017/2018 |
| W1J1           | 32.00 c                    | 32.33 cd                | 50.67 b   | 52.33 a   |
| W1J2           | 44.67 b                    | 44.83 b                 | 55.67 a   | 53.67 a   |
| W1J3           | 54.13 a                    | 53.23 a                 | 43.00 cd  | 42.33 c   |
| W2J1           | 25.00 d                    | 26.33 d                 | 46.00 c   | 47.00 b   |
| W2J2           | 36.17 bc                   | 36.17 c                 | 40.33 de  | 40.67 c   |
| W2J3           | 33.57 cd                   | 34.13 d                 | 46.33 c   | 47.00 b   |
| W3J1           | 14.67 e                    | 16.00 e                 | 53.00 ab  | 52.00 a   |
| W3J2           | 29.83 c                    | 30.50 cd                | 34.67 f   | 36.00 d   |
| W3J3           | 31.33 c                    | 31.90 cd                | 36.67 ef  | 37.33 d   |
| **F value**    | 13.28**                    | 15.50**                 | 25.28**   | 39.47**   |

Note: **means are significant at p = 0.01

Table 3 showed that vitamin C (only in 2017/2018) influenced by fruit thinning but did not influence sugar content. The similar result was found in the previous reports [8, 10] that number of fruits per panicle did not influence sugar content of citrus fruits.

**Table 3. Effect of fruit thinning on vitamin C and sugar content**

| Fruit thinning | Vitamin C (mg 100g⁻¹) | Sugar (Brix) |
|----------------|------------------------|--------------|
|                | 2016/2017 | 2017/2018 | 2016/2017 | 2017/2018 |
| W1J1           | 3.17      | 3.07 c    | 10.10     | 10.17     |
| W1J2           | 3.42      | 3.45 bc   | 10.33     | 10.40     |
| W1J3           | 3.60      | 3.63 ab   | 10.57     | 10.60     |
| W2J1           | 3.45      | 3.43 bc   | 9.47      | 9.53      |
| W2J2           | 3.83      | 3.97 a    | 10.53     | 10.57     |
| W2J3           | 3.37      | 3.30 bc   | 9.53      | 9.60      |
| W3J1           | 3.58      | 3.57 ab   | 10.00     | 10.07     |
| W3J2           | 3.25      | 3.32 bc   | 10.00     | 10.10     |
| W3J3           | 3.40      | 3.40 bc   | 9.60      | 9.67      |
| **F value**    | 2.09ns    | 3.62*     | 1.12ns    | 1.23ns    |

Note: * means are significant at p = 0.05; ns = non significant
Table 4. Effect of fruit thinning on total acid and soluble solids

| Fruit thinning | Total acid (%) | Soluble solids (ppm) |
|----------------|---------------|----------------------|
|                | 2016/2017     | 2017/2018            | 2016/2017     | 2017/2018            |
| W1J1           | 12.73         | 12.07 b              | 1194.33       | 1184.00              |
| W1J2           | 17.07         | 18.07 b              | 1309.67       | 1275.00              |
| W1J3           | 17.50         | 16.10 b              | 1371.67       | 1298.00              |
| W2J1           | 13.25         | 13.72 b              | 1308.33       | 1354.33              |
| W2J2           | 20.73         | 20.73 b              | 1204.00       | 1213.67              |
| W2J3           | 14.53         | 14.97 b              | 1195.67       | 1199.67              |
| W3J1           | 13.95         | 14.92 b              | 1220.67       | 1263.00              |
| W3J2           | 29.73         | 30.33 a              | 1141.67       | 1250.67              |
| W3J3           | 15.67         | 15.07 b              | 1295.00       | 1386.67              |
| F value        | 2.40<sup>ns</sup> | 3.58<sup>*</sup>     | 0.49<sup>ns</sup> | 1.60<sup>ns</sup>     |

Note: *means are significant at p = 0.05; ns = non significant

Fruit thinning also did not influence total acid and soluble solids (Table 4). The effect of fruit thinning on quality of citrus depend on time of fruit thinning application [11]. In pummelo cultivar Thong Dee, 50% fruit thinning had no effect on titratable acidity and total soluble solid [9].

4. Conclusion
Fruit thinning did not effect on fruit diameter and weight of fruit, but influenced fruit drop per branch and per tree. The lowest fruit drop per branch was showed by fruit thinning at 45 DAFB by maintaining one fruit per branch, whereas the lowest fruit drop per tree was showed by fruit thinning at 45 DAFB by maintaining two fruits per branch. The significantly effect of fruit thinning on vitamin C and total acid content were only at 2017/2018.

Acknowledgements
The authors thank the General Directorate of Higher Education, Ministry of Research, Technology and Higher Education for research funding as written in the implementation contract of competitive loan from Institute for Research and Community Services No.2350/UN23.14/PN.01/00/2018.

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