Effects of Different Canopy and Tree Shape on Fruit Quality of Huangguogan

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Abstract: In this paper, the fruit of Huangguogan was used as the test material. The fruit quality was measured according to different canopies and tree shapes. The results showed that the quality of fruits in upper canopy layers was superior to that in lower canopy layers. The difference of intrinsic quality, like soluble solids, Vitamin C and sugar content, was significant in different canopies; but the difference of appearance quality was small. And on different tree shapes, the fruit quality of round-headed tree was the best, followed by the open-center tree.

1. Introduction
In recent years, Citrus cultivar (Huangguogan), which is especially suitable for planting in dry-hot valleys, is a new citrus hybrid in Shimian County, Sichuan Province[1]. The fruit of Huangguogan is of high yield and good quality, late maturity and strong stress resistance[2]. The fruit ripens in March of the following year, just in the off-season of fruit and can be stored in mid-April without chemical treatment.

However, in recent years, there is a significant difference in fruit quality between plants or within one plant. The difference of fruit quality is very common. This experiment aimed to investigate the differences of fruit quality between different canopies in citrus trees in Shimian County, and to study the relationship between different tree shapes and fruit quality, to provide a theoretical basis for further research and promote the development of citrus industry.

2. Materials and methods

2.1 Test materials and treatment
In Shimian County, nine robust citrus trees with a row spacing of 3×4 m and tree age of eight years and basically growth, which are three round-headed trees, three open-center trees, and three natural-shaped trees.

According to the methods of Wertheim[2] to divide one tree into upper, middle and lower canopies (top: 2.0 m above the base of the trunk; medium: 1.0-2.0 m above the base of the trunk; bottom: less than 1.0 m from the base of the trunk). Each layer was harvested in four directions: east, south, west and north, and three fruits are harvested at each direction, and the mixture was sampled as one layer. The fruit quality of 12 points was mixed for the fruit quality of one tree.

2.2 Determination method
The weight of single fruit was measured by electronic balance, and the average value was obtained after three measurements. The same below. The transverse and longitudinal diameters were measured...
with a vernier caliper, and the fruit shape index (fruit shape index = fruit longitudinal diameter / fruit transverse diameter) was calculated. Soluble solids were determined by WYT-4 hand-held refractometer [3]. The content of vitamin C was determined by 2,6-dichlorophenol indophenol titration [4]. The titratable acid content was determined by NaOH neutralization titration. The contents of reducing sugar and convert sugar were determined by FeIII in solution redox titration [5], and the total sugar content (total sugar = invert sugar * 0.95 + reducing sugar * 0.5) was calculated. Excel and DPS software are used to analyze variance and significance of data.

3. Results and analysis

Table 1. Effect of different canopy on appearance quality of Huangguogan fruits

| Different canopies | Single fruit weight (g) | Longitudinal diameter (cm) | Transverse diameter (cm) | Fruit shape index |
|-------------------|-------------------------|-----------------------------|--------------------------|------------------|
| upper             | 132.07a                 | 6.60a                       | 6.47a                    | 1.02             |
| middle            | 131.98a                 | 6.58a                       | 6.46a                    | 1.02             |
| lower             | 130.15a                 | 6.56a                       | 6.40a                    | 1.03             |

Note: Using the LSD method for differential significance test, the same letter indicates that the difference is not significant, the lower-case letter indicates 5% significant level, the same below.

The average single fruit weight, longitudinal and transverse diameters in upper layer were the largest, while these were the smallest in lower layer; however, there was no significant difference in the appearance quality of fruit among upper, middle and lower canopy layers, and the fruit shape index of lower layer was the largest (Table 1).

Table 2. Differences in intrinsic quality of Huangguogan fruits from Different Canopy Layers

| Different canopies | TSS (%) | Vitamin C (mg/100ml) | Acid (g/100ml) | Reducing sugar (g/100ml) | Invert sugar (g/100ml) | Total sugar content (g/100ml) | Sugar to acid ratio |
|--------------------|---------|----------------------|----------------|--------------------------|------------------------|-------------------------------|-------------------|
| upper              | 11.24a  | 30.78a               | 0.86a         | 4.75a                    | 9.59a                  | 9.34a                         | 10.96             |
| middle             | 10.98ab | 29.84a               | 0.85a         | 4.51a                    | 9.20ab                 | 8.97ab                        | 10.43             |
| lower              | 10.62b  | 28.28b               | 0.82a         | 4.17b                    | 9.03b                  | 8.79ab                        | 10.71             |

The soluble solids, vitamin C, titratable acid and sugar content in upper layer were all more than that of the middle and lower layer; and the ratio of sugar to acid in the upper layer was higher than the lower layer than the middle layer, but the difference was small. Among the different canopies: the content of soluble solids, vitamin C and reducing sugar in the upper layer was the highest, which was significantly higher than that in the lower layer. Invert sugar and total sugar content had the same trend. The least titratable acid content was in the lower layer, but the difference in titratable acid content between different canopies was not significant (Table 2).

Table 3. Differences in appearance quality of Huangguogan fruits with different tree shapes

| Tree shape      | Single fruit weight (g) | Longitudinal diameter (cm) | Transverse diameter (cm) | Fruit shape index |
|-----------------|-------------------------|-----------------------------|--------------------------|------------------|
| open-center     | 129.66a                 | 6.49a                       | 6.47a                    | 1.00             |
| round-headed    | 140.20a                 | 6.76a                       | 6.60a                    | 1.03             |
| natural         | 122.17a                 | 6.49a                       | 6.49a                    | 1.00             |

The fruit appearance quality of round-headed trees was slightly better than that of the other two types of trees, but there was no significant difference in the fruit appearance quality of the three shapes of trees (Table 3).
The soluble solids content in fruits of round-headed trees was higher than that of open-headed trees; vitamin C content in fruits of open-center tree was the highest; titratable acid content in fruits of natural growth shape was the highest. Fruits have no significant differences in soluble solids, vitamin C and titratable acid contents among different tree shapes; but there was a significant difference in sugar content: fruits of the natural growth shape have the lowest reducing sugar content, which was significantly lower than the round-head and open-center trees. There was a significant difference in invert sugar and sugar content between each of the two tree shapes: fruits of round-head tree have the highest content, while the fruits of natural growth shape was the lowest content (Table 4).

**4. Discussion and summary**

There are many factors affecting the quality of citrus, including fertilization and irrigation\(^6\). And over-dense canopy could reduce the soluble solids content. In the present study, the intrinsic quality of the fruit indifferent canopy layers was significant different, while the difference in appearance quality was small and not significant. Overall, the fruit quality of upper and middle canopy was better than that of lower canopy, which was consistent with the results of most studies\(^7\)\(^8\).

The orientation and position of citrus canopy had a significant effect on environmental factor\(^9\). The relative light intensity and leaf temperature decreased from upper to lower part of the crown and from outer to inner part. The heterogeneity of leaf assimilation products in different parts of the crown may be the direct cause of differences in fruit size and quality.

Different tree shapes mainly affect the distribution of light and other conditions. The results showed that the fruit quality of round-headed citrus tree was better than that of the other two tree shapes, which was consistent with the results of Zhang\(^10\).

On the whole, the fruit quality of Huangguogan in the upper layer was better than the lower layer. The fruit quality of the round-headed tree was the best, followed by the open-shaped tree, which was related to the distribution of light, temperature and wind in the canopy. The quality of citrus fruits could be improved by pruning and laying reflective film, improving the transparency of trees, regulating the distribution of light energy and nutrition. However, the causes of these differences and the ways to improve them need to be further studied.

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