Study on the Effect Difference of Two Kinds of Control Techniques on Cracking Fruit of Qingcui Plum

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Abstract: In this experiment, Qingcui plum in Xuanhan County of Dazhou City was used as the material. Aiming at the problem of fruit cracking, the cracking rate of different prevention measures was investigated by surface mulching, root irrigation, and foliar spraying of three different Ca fertilizers. The cell growth rate and cell wall composition were determined. The results showed that surface mulching and foliar spraying had significant effects on reducing fruit cracking rate; root irrigation greatly aggravating fruit cracking; the effect of foliar spraying calcium glycol was significantly better than that of foliar spraying calcium nitrate and calcium amino acid. During the second rapid fruit expansion period, the growth rate of pulp cells was always higher than that of pericarp cells, the pectin content of the fruit showed a downward trend, and the pectin content of the cracked fruit was significantly lower than that of the normal fruit; the cellulose content of the cracked fruit was significantly lower than that of the normal fruit. Therefore, the fruit cracking may be caused by the uncoordinated growth of pulp and peel, and the lack of pectin and cellulose.

1. Introduction
Qingcui plum (Prunus salicina Lindl.) is a Prunus plant of Rosaceae. It has been cultivated for a long time in Sichuan Province with a wide range of distribution, has a strong adaptability and resistance to severe cold and high heat. The fruit is soft, juicy, sweet and without astringent [1][3].

Fruit cracking is affected by many factors, including nutrient elements [4], cell growth rate [5], water change [6][7], pectin, cellulose content [5]. When the fruit is deficient in Ca, the pericarp becomes thinner. During the mature period, the growth rate of pulp cells is higher than that of epidermal cells, the content of pectin and cellulose decrease, leading to fruit cracking [5]. Water is the main driving factor affecting plum fruit cracking [8][9]. In the year with heavy rainfall, the fruit cracking rate is higher.

Studies have shown that ground covering, reasonable drainage and irrigation, and application of Ca fertilizer could effectively prevent fruit cracking. The use of ground cover technology can effectively inhibit the drastic change of soil moisture [10] and the anti-cracking effect is very significant [11][12]. Reasonable drainage and irrigation can slow down fruit cracking caused by improper soil moisture [13].

Mineral nutrition is closely related to the normal growth and development of fruit trees [14]. Ca can change the peel tissue structure and enhance the crack resistance of the peel [15]. Results found that the content and change of Ca and other elements in soil are directly related to the occurrence of cracks [16]-[19]. Ca fertilizer treatment maintained a very low fruit cracking rate [20]-[21].

In order to solve the problem of fruit cracking, this study adopted irrigation, foliar spraying with Ca fertilizer to explore the causes of fruit cracking and evaluate the prevention effect of different technologies, so as to improve fruit quality and economic benefits.
2. Materials and Methods

2.1. Test materials
The experimental materials were selected from the orchard of miao'an township government, Xuanhan County, Dazhou city. The distance between plants was 2.5 m × 4 m. The local average annual temperature was 16.8 ℃, the annual precipitation was 1230 mm, and the annual sunshine hours was 1462.5 H. Sixteen healthy Qingcui plum trees with the same age, crown size, growth and orchard management conditions were selected as samples. There were 16 treatments, with 1 tree in each treatment, and a single tree as a plot. Observation and sampling started from the second rapid fruit expansion period (about 70 days after flowering), sampling every 10 days, 5 times per treatment.

2.2. Test methods

2.2.1. Root irrigation
Four Qingcui plum trees were selected and numbered A1, A2, A3 and CK2 respectively. A1, A2 and A3 were irrigated 5 L, 10 L and 15 L respectively [12]. CK2 was treated with conventional irrigation. The experiment started from the second rapid fruit expansion stage (about 70 days after anthesis). The interval of every two irrigation treatments was 10 days, a total of 3 times. After fruit ripening, 15 fruits from different directions of southeast, southwest, north and central were picked from each tree, repeated three times. Fruit cracking rate was counted and the difference was analyzed for significance. The same below.

2.2.2. Foliar spraying calcium fertilizer
Four Qingcui plum trees were selected and numbered B1, B2, B3 and CK2 respectively. The nutrient solution with 0.3 g·L⁻¹ of chemically pure sugar alcohol calcium, calcium nitrate and amino acid calcium was sprayed from the second rapid fruit expansion stage. At the beginning of the experiment, B1, B2 and B3 were sprayed with sugar alcohol calcium, calcium nitrate and calcium amino acid respectively (until the leaves drip), and CK2 was sprayed with the equal amount of water. The interval between two spraying treatments was 10 days, a total of 3 times [19].

2.2.3. Determination of fruit cell growth rate
The fruit samples were dissected to observe the changes and differences of pericarp cells and pulp cells in the growth process. After the fruit was dissected, slices were prepared by conventional paraffin section method, and the radial and tangential sizes of cells were measured by microscope micrometer. Three cells were measured for each slice, a total of 30 cells. The difference in cell size between the two samplings was divided by the interval days, which was the growth rate [5].

2.2.4. Determination of cell wall components in fruits
Cellulose content was determined by 72% concentrated sulfuric acid hydrolysis method, pectin content was determined by carbazole reaction colorimetry [22].

3. Results and analysis

3.1. Effects of different treatments on fruit cracking

| Table 1 Cracking rate of root irrigation treatment |
|-----------------------------------------------|
|     | A1    | A2    | A3    | CK1   |
|---|-------|-------|-------|-------|
| 1  | 73.3% | 73.3% | 86.7% | 60.0% |
| 2  | 86.7% | 80.0% | 80.0% | 66.7% |
| 3  | 73.3% | 86.7% | 86.7% | 73.3% |
| Average value | 77.8%a | 80.0%a | 84.5%a | 66.7%b |
Table 2 Fruit cracking rate of spraying different Ca fertilizers on leaves

| repeat | B1  | B2  | B3  | CK2  |
|--------|-----|-----|-----|------|
| 1      | 26.6% | 40.0% | 46.7% | 80.0% |
| 2      | 46.7% | 53.3% | 53.3% | 73.3% |
| 3      | 40.0% | 53.3% | 60.0% | 86.7% |
| Average value | 37.8%<sup>c</sup> | 48.9%<sup>b</sup> | 53.3%<sup>b</sup> | 80.0%<sup>a</sup> |

Note: The letter abc indicates that the difference was statistically significant at the level of P < 0.05.

The results showed that the fruit cracking rate of root irrigation treatments was significantly higher than that of CK1 and increased with the irrigation amount. The fruit cracking rate of foliar spraying was significantly lower than that of CK2; the effect was as follows: sugar alcohol calcium > calcium nitrate, sugar alcohol calcium > calcium amino acid. In conclusion, root irrigation would significantly aggravate fruit cracking rate, and foliar spraying of sugar alcohol calcium fertilizer has the best effect on preventing fruit cracking.

3.2. Effect of cell growth rate change on fruit cracking

![Fig. 1 Comparison of cell growth rate](image)

It can be seen from Fig. 1 that the growth rate of flesh cells was always higher than that of peel cells. The growth rate of them is not coordinated.

3.3. Variation of pectin and cellulose contents and their relationship with fruit cracking

3.3.1. Variation of pectin content and its relationship with fruit cracking

![Fig. 2 Variation of pectin content](image)

Figure 2 showed that the pectin content of Qingcui plum fruit showed a downward trend in the second rapid expansion period, and the pectin content of cracked fruit was significantly lower than that of normal fruit.
3.3.2. Variation of cellulose content and its relationship with fruit cracking

It can be seen from Fig. 3 that during the second rapid fruit expansion period, the cellulose content in cracked fruit was significantly lower than that in normal fruit. It showed insufficient cellulose content has a certain relationship with fruit cracking.

4. Discussion and conclusion

The fruit cracking rates of root irrigation was significantly higher than that of CK2, and directly proportional to the irrigation amount, indicating that excessive root water content would aggravate the fruit cracking. The fruit cracking rates of foliar spraying of Ca fertilizer were significantly lower than those of CK3, and the effect of sugar alcohol calcium was the best, indicating that foliar spraying of Ca fertilizer could effectively prevent the fruit cracking. The results are basically consistent with those of Wang Zhihui [10], Liu Fanglan [11] and Wang Yan [12].

In the second rapid expansion stage of fruit, due to the uncoordinated growth rate of flesh cells and pericarp cells, the pulp cells continued to squeeze the pericarp cells, causing pericarp broke and fruit crack. During the fruit ripening period, the contents of pectin and cellulose in cracked fruit were significantly lower than that of normal fruit. The lack of pectin content would decrease the adhesion and elasticity of cell wall, and the insufficient cellulose will reduce the toughness of peel. Therefore, the lack of pectin and cellulose is one of the causes of fruit cracking. The results were similar to those of Wen Mingxia [22] and Sun Guochao [5].

In view of the above research results, the measures to prevent fruit cracking of Qingcui plum can be summarized. 1. Reasonable fertilization: the application of suitable concentration of Ca fertilizer is beneficial to prevent Qingcui plum fruit cracking. 2. Control moisture: reasonable drainage and irrigation according to actual conditions. 3. Protected rain-avoiding cultivation: artificially control the growth environment of Qingcui plum to avoid factors causing fruit cracking.

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