Effects of different formulations of fertilization on Fruit quality of 'Phoenix Plum'

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Abstract. Using 5-year-old 'Phoenix plum' as experimental material, the effects of different formula fertilization on the fruit quality of 'Phoenix plum' were studied. The results showed that compared with the control, the appearance quality and internal quality of the fruit treated with formula 2 were better than those of the control, and the comprehensive quality of the fruit treated with formula 2 was the best. Therefore, using formula 2 to treat 'Phoenix plum' can effectively improve the fruit appearance quality and internal quality of 'Phoenix plum', which can be popularized in the cultivation area.

1. Introduction
Plum, Rosaceae plum plants, a wide variety, extremely high yield, strong adaptability [1]. The fruit is sour, sweet and delicious, rich in nutrition, containing a variety of vitamins and trace elements, high content of antioxidants, anti-aging and disease prevention. The 'Phoenix plum' matured very early and began to mature in mid-June. The pericarp was purplish red, separated from the nucleation residue and rich in gas.

The fertilizer and water management of plum phenology has a very important effect on fruit prematurity, ratio of sugar to acid, soluble solids and vitamin C. Chen Jiezhong et al. [2] showed that different kinds of fertilizers had different effects on plum fruit quality. In recent years, foreign scholars have carried out related studies on the effects of one or more nutrient elements on plum flower, fruit color and yield [3-4], but there are few studies on the mechanism of increasing plum yield and improving fruit quality under formula fertilization treatment [5-6].

In this experiment, the fertilization formula of 'Phoenix plum' was found out by studying the effect of different formula fertilization on the fruit quality of 'Phoenix plum'. To help take reasonable measures in production to provide theoretical and practical basis for the growth and development, fruit ripening and cultivation techniques of 'Phoenix plum' were studied.

2. Materials and methods
2.1. Test site and materials
Phoenix plum' is planted in Xiuwen Town, Meishan City, and is located in Sichuan Basin and the southwest of Chengdu Plain. Twelve five-year-old 'Phoenix plum' fruit trees with robust growth, consistent tree potential, no diseases and insect pests and 3m × 4m spacing were selected.
2.2. Experimental treatment and method

2.2.1. Experimental design
In the experiment, there were 3 treatments, with a single plant as a treatment, 3 repetitions, and local empirical fertilization as the control. The treatments were applied once at 25 days after flowering (fruit expansion period) and 51 days (fruit ripening period), respectively, for a total of 2 times.

According to the yield, fertilizer demand law, soil condition and local fertilization situation in previous years, two fertilization formulas were set up with reference to the fertilizer application amount of Zhang Yuxing[1]. Specific fertilization amount: with the target yield of 1500kg per mu and plant growth of 5kg per year, 10.4kg per mu of nitrogen, 5kg of phosphorus per mu and 12.5kg of potassium per mu were determined. The present situation of local fertilization is shown in Table 1, and the content of nutrient elements in the formula is shown in Table 2.

| Table 1. current situation of local fertilization (amount of fertilizer per plant, unit: g) |
|-----------------------------------------------|
| Pig manure | Compound fertilizer 1 | Compound fertilizer 2 | Calcium fertilizer | Zinc fertilizer |
| Base fertilizer | | | | |
| Topdressing | | | | |
| Pig manure | 30000 | 500 | 1000 | 0.5 | 0.5 |
| Compound fertilizer 1 | 500 | 85 | 85 | 0.25 | 0.25 | 15 | 0.25 | 2 |
| Compound fertilizer 2 | 1000 | 100 | 100 | 250 | 0.50 | 0.50 | 30 | 0.50 | 2 |
| Spraying fertilizer | 1000 | 0 | 0 | 0 | 0.50 | 0 | 0 | 0.50 | 0 |
| Total | 365 | 305 | 467 | 17.25 | 16.75 | 61 | 5.25 | 10 |

Table 2. content of nutrient elements in local fertilization formula (amount of fertilizer per plant, unit: g)

| Types of fertilization | Application amount | N | P₂O₅ | K₂O | Ca | Mg | S | Zn | B |
|------------------------|---------------------|---|------|-----|----|----|---|----|---|
| Pig manure             | 30000               | 180 | 120 | 132 | 16 | 16 | 16 | 4 | 6 |
| Compound fertilizer 1  | 500                 | 85 | 85 | 85 | 0.25 | 0.25 | 15 | 0.25 | 2 |
| Compound fertilizer 2  | 1000                | 100 | 100 | 250 | 0.50 | 0.50 | 30 | 0.50 | 2 |
| Spraying fertilizer    | 1000                | 0 | 0 | 0 | 0.50 | 0 | 0 | 0.50 | 0 |
| Total                  | 365                 | 305 | 467 | 17.25 | 16.75 | 61 | 5.25 | 10 |

2.2.2. Experimental fertilizer
Compound fertilizer 1 is a balanced compound fertilizer with total nutrient content ≥ 51%. Compound fertilizer 2 is a high potassium compound fertilizer with total nutrient content ≥ 45%. The application of nitrogen fertilizer is urea, the nitrogen content is 46%; the application of phosphate fertilizer is calcium superphosphate, the content of phosphorus is 20%; the application of potassium fertilizer is potassium chloride, the content of potassium is 60%.

2.2.3. Experimental method
The experiment adopts the method of ring fertilizer application, which is carried out around the water dripping line of the tree crown during fertilization, with a ring depth and width of 20-30 cm. It is appropriate to see the root without harming the root, and the fertilizer applied is well mixed with the soil. The specific fertilization formula is shown in Table 3 and Table 4. Other management measures were consistent among each treatment.

| Table 3. fertilization formula of base fertilizer per plant (unit: g) |
|-----------------------|-----------------|-------|------|
| Deal with | N | P₂O₅ | K₂O |
| 1 | 265 | 205 | 217 |
| 2 | 265 | 205 | 217 |
3 265 205 217
CK 265 205 217

Note: this formula is fertilized before flowering and applied after fruit harvest.

Table 4. fertilization formula for topdressing per plant (unit: g)

| Deal with | N  | P₂O₅ | K₂O |
|----------|----|------|-----|
| 1        | 46 | 40   | 90  |
| 2        | 64 | 60   | 150 |
| 3        | 73 | 70   | 180 |
| CK       | 55 | 50   | 120 |

Note: fertilization was applied once 25 days after anthesis (fruit expansion period) and 51 days (fruit ripening period). This experiment focused on the effect of topdressing after anthesis on the fruit quality of 'Fenghuang plum', and the application of basal fertilizer before anthesis was consistent.

2.3. Sampling
After the fruit of 'Phoenix plum' was ripe, the fruit materials were collected in four treatment plots. According to the east, south, west, north and middle five directions, a total of 10 fruits were randomly selected from a single tree, and a total of 30 fruits were collected from each community. After harvest, it was placed in a low temperature environment and quickly brought back to the laboratory to determine the external quality and internal quality of the fruit.

2.4. Determination index and method
The total fruit weight was weighed by balance, the average single fruit weight was calculated, the transverse and longitudinal diameters of each fruit on each standard branch were measured, the fruit shape index was calculated, the flesh weight and core weight were measured by electronic balance, and the edible rate was calculated. The soluble solid content was determined by WYT-4 hand-held refractometer, and the titratable acid content was determined by NaOH neutralization titration[7]. The content of vitamin C was determined by 2mae6-dichloroindophenol method[8], and the content of total sugar was determined by film reagent method[9]. The determination of each index was repeated three times.

2.5. Data processing
The data are sorted out and counted with the help of Excel2010, and the data are analyzed by DPS7.05.

3. Results and analysis

3.1. Effects of different fertilization treatments on Fruit appearance quality of 'Phoenix Plum'
As can be seen from Table 5, among the four different formula fertilization treatments, the average fruit weight of treatment 2 was the largest, which was significantly different from that of treatment 1. The results showed that increasing the amount of fertilizer application could effectively improve the appearance quality of single fruit weight, vertical diameter and transverse diameter of 'Phoenix plum' to a certain extent, and the formula fertilization effect of treatment 2 was the best.

Table 5. effects of different treatments on fruit appearance quality of "Phoenix plum"

| Deal with | Single fruit weight (g) | Longitudinal diameter (mm) | Transverse diameter (mm) | Fruit shape index (%) | Edible rate (%) | Fruit firmness (kg cm⁻¹) |
|----------|-------------------------|---------------------------|--------------------------|-----------------------|----------------|--------------------------|
| CK       | 30.59 ± 0.25ab          | 33.70 ± 0.90bc           | 37.00 ± 0.20ab           | 91.08 ± 1.00a         | 96.50 ± 1.55a | 3.78 ± 0.05a             |
| 1        | 24.32 ± 1.61bc          | 31.90 ± 0.90ce           | 34.40 ± 1.40b            | 92.73 ± 3.00a         | 96.80 ± 1.25a | 3.65 ± 0.13a             |
Table 6. effects of different treatments on the internal quality of "Phoenix plum" fruit

| Deal with | Total sugar (g · 100 mL⁻¹) | Titratable acid (g · 100 mL⁻¹) | Vitamin C (mg · 100 mL⁻¹) | TSS (%) | Sugar-acid ratio (%) |
|-----------|-----------------------------|-------------------------------|--------------------------|---------|---------------------|
| CK        | 14.87 ± 0.55ab              | 0.69 ± 0.10a                  | 12.73 ± 3.83a            | 18.77 ± 0.06b | 21.55 ± 3.74a     |
| 1         | 15.02 ± 1.00a               | 0.66 ± 0.04a                  | 16.27 ± 4.45a            | 19.83 ± 0.00a | 22.76 ± 2.70a     |
| 2         | 14.07 ± 0.51ab              | 0.52 ± 0.05b                  | 18.30 ± 5.51a            | 20.03 ± 0.12a | 27.06 ± 1.85a     |
| 3         | 13.25 ± 1.14a               | 0.49 ± 0.04b                  | 13.23 ± 1.96a            | 17.67 ± 0.06c | 27.04 ± 4.47a     |

Note: the lowercase letters after the numbers in the same column indicate a significant difference at the P < 5% level. The same below.

3.2. Effects of different fertilization treatments on Fruit quality of 'Phoenix Plum'

Table 6 shows that compared with the control, three different fertilization formulations have greater effects on the internal quality of 'Phoenix plum' fruit. Compared with the control, after formula fertilization, the sugar content of treatment 1 was the highest, which was significantly different from that of other treatments. The results showed that treatment 2 and treatment 3 could significantly reduce the titratable acid content of fruit.

Compared with the control, treatment 2 and 3 could effectively improve the sugar-acid ratio of fruit, and the formula of treatment 2 could increase the vitamin C content of 'Phoenix plum' fruit. The results showed that excessive fertilizer application could reduce the content of soluble solids in fruit, and treatment 2 could increase the content of soluble solids in fruit.

4. Discussion and conclusion

After using different formula fertilization, the fruit performance of treatment 2 was the best. Compared with the control, the weight of single fruit, soluble solids, ratio of sugar to acid and vitamin C increased significantly, while the content of titratable acid decreased significantly. The study of Ji Yanzhi et al [9] showed that N had a great effect on yield, with the increase of nitrogen application, the single fruit weight of plum increased, but excessive N would inhibit the yield to a certain extent, which was consistent with the results of this study.

This study also found that, after the treatment of formula fertilization, the fruit quality of 'Phoenix plum' was greatly improved, especially the single fruit weight, soluble solids, sugar-acid ratio and vitamin C content increased significantly. By measuring the external quality and internal quality of the 'Phoenix plum' fruit with different formula fertilization, it was considered that formula 2 had the best effect in improving the fruit quality of 'Phoenix plum'.

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