Introduction performance of four excellent and new citrus varieties in Jintang, Sichuan

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Abstract. In order to further enrich the structure of citrus varieties in the Jintang area of Sichuan, and to solve the problems of old and single varieties and relatively concentrated listing periods. In this experiment, four excellent and new citrus varieties, ‘Kanpei’, ‘Niahinoka’, ‘Or’ and ‘Qingfeng’ is introduced, and the local cultivar ‘Shiranui’ is used as a control. The traits and fruit quality indicators are investigated, measured and analyzed. The results show: The ‘Kanpei’ and ‘Or’ trees are strong, the ‘Niahinoka’, ‘Qingfeng’ and ‘Shiranui’ are medium, ‘Or’ has the highest ratio of sugar to acid, ‘Niahinoka’ has the highest vitamin C and soluble solids. Compared with the control, the ratio of sugar to acid and the per mu yield in the ‘Niahinoka’ is 27.78% and 13.62% higher than ‘Shiranui’, ‘Qingfeng’ performance is poor. According to a comprehensive analysis, ‘Kanpei’, ‘Niahinoka’ and ‘Or’ are suitable for introduction, and ‘Qingfeng’ is not suitable for introduction.

1. Introduction
Jintang is affiliated to Chengdu City, Sichuan Province, and is located in the northeastern part of the Chengdu Plain. It is a key development county within the “Chengdu Plain Economic Circle” and a “characteristic industrial development zone” in Chengdu. With its unique location, Jintang’ climate that meets the needs of most citrus, it’s citrus has also been awarded the title of famous product for many times. In recent years, there are problems such as aging, singleness and weak brand awareness in citrus cultivation in Jintang area and most citrus products can only be sold in the low-end market, which further leads to a gradual decrease in the share of citrus sales, which restricts the development of local citrus industry. In order to improve this situation, adapting the modern high-grade and diversified consumption characteristics of citrus [1], and improving the economic benefits of local citrus. In this experiment, four kinds of excellent and new citrus varieties are introduced in Jintang. Through the analysis of their biological characteristics and fruit quality, we intend to select suitable varieties of orange for planting in jintang area with excellent performance for promotion.

2. Materials and Methods

2.1. Materials
2.1.1. Test site situation. The test site is located in the Sichuan Citrus Mother Garden in Jintang County, Chengdu City, Sichuan Province. It has a subtropical monsoon climate with an average elevation of 468m, an average annual temperature of 16.4°C, an average January temperature of 6.0°C, an average temperature of 16.4°C in July. The soil type is mainly red-purple soil; the annual average rainfall is 845.4mm, the annual frost-free period is about 296d, the average annual sunshine hours is 1210.4h, the effective accumulated temperature (≥10°C) is 5450°C, and the annual average relative humidity is 84%.

2.1.2. Test materials and design. Test materials: the experiment is conducted from January 2017 to March 2018. In January 2017, the three-year-old citrus ‘Qingfeng’, ‘Or’, ‘Kanpei’, ‘Niahinoka’ and the local main variety ‘Shiranui’, which are robust and have the same level of cultivation management, are selected as test materials. Test design: the experiment used ‘Shiranui’ as the control, ‘Qingfeng’, ‘Or’, ‘Kanpei’, ‘Niahinoka’ as the test subjects, and each variety selected 9 plants with the same age, tree potential and tree shape and no pests and diseases. The plant spacing is 3m×4m, and the 3 plants are one plot, and 3 replicates is set.

2.2. Measurement and Analysis of Test Indicators

2.2.1. Measurement of Test Indicators. Observation of phenological period and tree status: The phenological period mainly observes the germination stage, the bud stage, the flowering stage, the fruit color change stage and the fruit ripening stage. Each phenological period is observed 3-5 times, the method is based on Lifeng Liang’s standard [2].

2.2.2. Analysis of Test Indicators. The data is collated using Excel 2013, and the results are statistically analyzed using SPSS 20.0.

3. Results and analysis

3.1. Phenophase and tree status analysis

It can be seen from Table 1 that in the Jintang area, ‘Qingfeng’, ‘Kanpei’ and ‘Niahinoka’ are characterized by medium maturity, and ‘Or’ and ‘Shiranui’ are late maturity. In the germination, bud and flowering period, ‘Niahinoka’ is the earliest, and ‘Shiranui’ is the latest. In the color change period and maturity period, ‘Kanpei’ is the earliest, and ‘Shiranui’ is the latest. It can be seen that the phenological periods of the tested varieties are not nearly overlapping, and the maturity period is staggered, which is conducive to the market supply of citrus in Jintang area.

| Cultivars     | germination | bud  | Flowering period | Fruit coloring period | Fruit ripening |
|--------------|-------------|------|------------------|-----------------------|---------------|
| Qingfeng     | Early February | Early March | Late March | Mid-November | Late December |
| Or           | Mid-February | Mid-March | Early April | End of November | February of the following year |
| Kanpei       | Late February | Early March | Early April | Early November | Mid-December |
| Niahinoka    | Mid-January  | Early February | Mid-March | Late November | Late December |
| Shiranuhi    | Mid-March   | Late March | Mid-to-late April | Early December | Mid-February of the following year |

Table 2 shows that: The tree height and crown diameter of ‘Kanpei’ are the largest, significantly larger than ‘Shiranuhi’, 11.74% and 23.60% higher respectively; Compared with the control ‘Shiranuhi’, the tree height and crown diameter of ‘Niahinoka’ and ‘Or’ are significantly higher than ‘Shiranuhi’ by 5.68%, 18.03% and 6.47%, 17.58% respectively; The tree height of ‘Qingfeng’ is significantly lower than ‘Shiranuhi’, 9.57% lower, and the difference of crown diameter is not significant; Taken together, ‘Qingfeng’, ‘Niahinoka’ and ‘Shiranuhi’ have medium tree potential, while ‘Or’ and ‘Kanpei’ have strong tree potential.
Table 2. Canopy and tree potential of the tested varieties

| Cultivars    | Tree potential | Tree height/cm     | Crown diameter/cm |
|--------------|----------------|--------------------|-------------------|
| Qingfeng     | medium         | 170.002 ± 3.055cC  | 143.677 ± 5.481cB |
| Or           | strong         | 201.005 ± 2.647bAB | 182.000 ± 3.468bA |
| Kanpei       | strong         | 213.000 ± 2.643aA  | 196.333 ± 0.883aA |
| Niahinoka    | medium         | 199.336 ± 5.044bAB | 183.000 ± 5.192bA |
| Shiranuhi    | medium         | 188.003 ± 2.512cB  | 150.000 ± 4.351cB |

Note: different lowercase letters indicate P <0.05 significant level, and different uppercase letters indicate P <0.01 significant level. The following table is the same.

3.2. Analysis of the number of capsules and seeds of the fruit

Table 3 shows that: The number of vesicles in ‘Niahinoka’ is the largest, with an average of 12, while that in ‘Shiranuhi’ is 11. There is no significant difference between the two; ‘Qingfeng’ is significantly less than ‘Shiranuhi’, 18.18%. There is no significant difference between ‘Or’ and ‘Kanpei’ and ‘Shiranuhi’. The number of seeds of ‘Shiranuhi’ is higher than that of ‘Niahinoka’, ‘Kanpei’, ‘Or’ and ‘Qingfeng’, which is 5.80%, 11.82%, 29.45% and 58.91% higher than that of ‘Niahinoka’, ‘Kanpei’, ‘Or’ and ‘Qingfeng’, respectively. There are significant differences in the number of petals and seeds among different varieties, which can meet the different needs of consumers and processing industry.

Table 3. Number of fruit seeds and number of lobes

| Cultivars    | Number of sac      | Number of seed   |
|--------------|--------------------|------------------|
| Qingfeng     | 9.002 ± 0.577cB    | 2.333 ± 0.331eA  |
| Or           | 9.673 ± 0.338bcB   | 4.000 ± 1.154dA  |
| Kanpei       | 10.000 ± 0.577bcB  | 5.000 ± 1.533cA  |
| Niahinoka    | 12.333 ± 0.333aA   | 5.333 ± 2.216bA  |
| Shiranuhi    | 11.000 ± 0.557abAB | 5.677 ± 1.457aA  |

3.3. Analysis of fruit diameter and shape index

Table 4 shows that: There are significant differences in vertical and horizontal diameter and fruit shape index among the five varieties. The fruit shape index of ‘Shiranuhi’ is the largest, with an average value of 1.268, which is significantly higher than that of the other four varieties, 15.87%, 26.19%, 28.57% and 32.54% higher than ‘Qingfeng’, ‘Or’, ‘Niahinoka’ and ‘Kanpei’, respectively. The fruit shape of ‘Shiranuhi’ is oblong or pear-shaped, ‘Qingfeng’ is elliptic, ‘Kanpei’ is near circular, ‘Or’ and ‘Niahinoka’ are flat circular.

Table 4. Vertical and horizontal diameter and fruit shape index of 5 kinds of mandarin orange

| Cultivars    | Longitudinal diameter/cm | Cross diameter/cm | Fruit shape index |
|--------------|--------------------------|-------------------|-------------------|
| Qingfeng     | 6.454 ± 0.045cC          | 6.145 ± 0.050dD   | 1.065 ± 0.003bB   |
| Or           | 8.743 ± 0.063aA          | 9.145 ± 0.206aA   | 0.934 ± 0.004cC   |
| Kanpei       | 6.056 ± 0.921dD          | 7.207 ± 0.045cC   | 0.854 ± 0.003eE   |
| Niahinoka    | 6.956 ± 0.056bB          | 7.876 ± 0.038bB   | 0.906 ± 0.006dD   |
| Shiranuhi    | 6.866 ± 0.051bB          | 5.506 ± 0.018eE   | 1.268 ± 0.004A    |

3.4. Internal quality analysis of fruit

Table 5 shows that: The Vc content of ‘Niahinoka’ is the highest, 43.526±0.002 mg · 100mL⁻¹, which is significantly higher than that of ‘Shiranuhi’ (18.93%). Compared with the control group, the Vc content of ‘Or’, ‘Kanpei’ and ‘Qingfeng’ is significantly higher than it, 11.95%, 9.28% and 4.36% higher respectively. The soluble solid content of ‘Niahinoka’ is the highest, 12.835±0.145%, which is significantly higher than that of ‘Shiranuhi’, 10.37% higher. The soluble solids of ‘Or’ and ‘Qingfeng’ are significantly lower than those of ‘Shiranuhi’, 9.57% and 15.04% respectively. There is no significant difference between ‘Kanpei’ and ‘Shiranuhi’. The sugar-acid ratio of ‘Or’ is the highest, 11.687±0.774, which is significantly higher than that of ‘Shiranuhi’, 51.03% higher. Compared with the control group, ‘Niahinoka’ is significantly higher than ‘Shiranuhi’ by 27.78%, and ‘Qingfeng’ is
significantly lower than ‘Shiranuhi’ by 27.45%. There is no significant difference between ‘Kanpei’ and ‘Shiranuhi’.

Table 5. Intrinsic quality of 5 kinds of oranges

| Cultivars   | Soluble saccharide / (g·100mL⁻¹) | Titratable acid / (g·100mL⁻¹) | Vc / (mg·100mL⁻¹) | Total soluble solids /% | Sugar to acid ratio |
|-------------|----------------------------------|-------------------------------|-------------------|------------------------|--------------------|
| Qingfeng    | 2.742 ± 0.0766D                  | 0.664 ± 0.029B                | 36.895 ± 0.003D   | 9.772 ± 0.088C        | 4.152 ± 0.087D     |
| Or          | 6.133 ± 0.086aA                  | 0.533 ± 0.030cC               | 40.074 ± 0.003bB  | 10.404 ± 0.265cC      | 11.687 ± 0.774aA   |
| Kanpei      | 4.474 ± 0.029bB                  | 0.722 ± 0.027bB               | 38.899 ± 0.002cC  | 11.879 ± 0.233bB      | 6.244 ± 0.052cC    |
| Niahinoka   | 3.934 ± 0.033dC                  | 0.502 ± 0.011cC               | 43.526 ± 0.002aA  | 12.835 ± 0.145aA      | 7.928 ± 0.159bB    |
| Shiranuhi   | 4.654 ± 0.011bB                  | 0.817 ± 0.017aA               | 35.284 ± 0.003eE  | 11.503 ± 0.058bB      | 5.726 ± 0.111cCD   |

3.5. Average fruit weight per fruit and yield analysis

Table 6 shows that: The average fruit weight of the control ‘Shiranuhi’ is the largest, 332.332±2.603g, which is significantly higher than that of ‘Niahinoka’, ‘Or’, ‘Kanpei’ and ‘Qingfeng’, which are 18.15%, 24.58%, 39.52% and 51.75% respectively. The highest yield per mu is ‘Niahinoka’, with an average yield of 1144.008±20.185 kg, which is significantly higher than that of ‘Or’ (13.62%); ‘Or’ is significantly higher than that of ‘Shiranuhi’ (8.71%); ‘Kanpei’ and ‘Qingfeng’ are not significantly different from that of ‘Shiranuhi’.

Table 6. Average fruit weight and yield per mu of 5 varieties

| Cultivars   | Average single fruit weight /g | Yield per mu /kg |
|-------------|--------------------------------|------------------|
| Qingfeng    | 160.333 ± 2.603eE              | 871.675 ± 27.954cC |
| Or          | 250.677 ± 3.283cC              | 1100.003 ± 41.251aAB |
| Kanpei      | 201.000 ± 7.095dD              | 988.333 ± 29.791bBC |
| Niahinoka   | 272.000 ± 3.786bB              | 1144.008 ± 20.185aA |
| Shiranuhi   | 332.332 ± 2.603aA              | 947.670 ± 24.969bcC |

3.6. Comprehensive evaluation and analysis of fruit quality

As can be seen from Table 7: The comprehensive scores of fruit quality of five kinds of hybrid citrus are different. From the internal quality score, ‘Niahinoka’ is the highest, ‘Shiranuhi’ is the lowest; from the appearance score, ‘Kanpei’ is the highest, ‘Qingfeng’ is the lowest; from the comprehensive point of view, ‘Kanpei’ is the highest, 12.9 points higher than ‘Shiranuhi’. Compared with the control species ‘Shiranuhi’, ‘Kanpei’, ‘Niahinoka’, ‘Or’ have higher comprehensive scores, 90.9, 88.3 and 86.1 respectively, and ‘Qingfeng’ have the lowest comprehensive score, 77.3.

Table 7. Comprehensive scores of fruit quality of five varieties

| Treatment | Exterior (55 points) | Inner (45 points) | Total score (100 points) |
|-----------|----------------------|-------------------|--------------------------|
|           | Fruit shape | Color | Peel roughness | Neat level | Peel thickness | Quality of fruit | fruit juice Flavor | seed |                      |
| Shiranuhi | 8.0        | 12.8  | 11.4          | 12.6       | 1.3            | 7.6              | 7.2              | 15.2  | 1.9                  | 78.0 |
| Qingfeng  | 7.8        | 12.1  | 12.1          | 12.5       | 1.2            | 7.4              | 7.4              | 14.8  | 2.0                  | 77.3 |
| Or        | 8.3        | 13.5  | 12.5          | 13.2       | 1.8            | 8.4              | 8.6              | 17.5  | 2.3                  | 86.1 |
| Kanpei    | 9.2        | 14.3  | 13.8          | 14.2       | 1.6            | 8.7              | 8.7              | 17.9  | 2.5                  | 90.9 |
| Niahinoka | 8.7        | 14.1  | 13.5          | 13.8       | 1.6            | 9.3              | 9.1              | 18.4  | 2.4                  | 88.3 |

4. Conclusion and discussion

(1) Among the four varieties introduced in Jintang, ‘Or’ showed late maturity. Compared with ‘Shiranuhi’, the germination period of ‘Or’ is earlier than one month, and the fruit ripening period is February of the next year. It also has the characteristics of vigorous tree vigor, early fruiting and high yield, excellent flavor quality, high sugar, residue and aroma. Thus, it can be seen that ‘Or’ has excellent comprehensive properties and can be marketed at the same time as ‘Shiranuhi’. It can meet people’s needs for different flavors and is suitable for planting in Jintang area.
(2) The ripening period of ‘Kanpei’ fruit is earlier, in mid-December. Compared with ‘Shiranuhi’, ‘Kanpei’ have strong potential, high yield, sweet and sour taste and high nutritional value. It can make up for the shortage of market supply in the off-season without ‘Shiranuhi’ by two months earlier.

(3) ‘Qingfeng’ is medium ripening, the germination stage is mid-February, and the fruit ripening stage is late December. Tree vigor is moderate, susceptible to brown spot. Compared with the control, the content of $V_c$ is significantly higher than that of ‘Shiranuhi’, which is 4.36%, but the content of soluble solids is 15.04%, the ratio of sugar to acid is 27.45%, the average weight of single fruit is 51.76%, and the yield per mu is 8.02%. The comprehensive performance is poor, probably due to the inadaptability to the climate in Jintang area.

(4) The earliest germination period of ‘Niahinoka’ is in mid-January and the fruit maturity is in late December. Among the tested varieties, ‘Niahinoka’ has the highest $V_c$ content and soluble solids content, which are significantly higher than ‘Shiranuhi’, 18.93% and 18.93% respectively. The sugar-acid ratio and yield per mu are significantly higher than ‘Shiranuhi’, 27.78% and 13.62% respectively. The market date is about 1.5 months ahead of schedule, the sweetness is high and the comprehensive adaptability is strong. It is suggested that introduction be made.

In the study of citrus varieties, high sugar, low acid and high $V_c$ content are ideal fruit quality traits [8]. Through this experiment, ‘Or’, ‘Kanpei’ and ‘Niahinoka’ are more suitable for the environmental conditions of Jintang area, and their comprehensive cultivation performance is excellent, and they have the characteristics of making up for the current off-season market of Citrus in Jintang area and regulating the concentration of citrus fruit on the market. It is suggested to introduce them. Because of the poor comprehensive performance of ‘Qingfeng’, it is not recommended to introduce them.

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