Effects of different combinations of "Baoshiling" on soil physical and chemical properties of Huangguogan

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Abstract: The research is done on the Huangguogan (unique citrus breed in Sichuan, China). The experiment setted 27 groups of "Baoshiling" (self-study compound fertilizer) fertilization treatment to explore the "Baoshiling" different combinations on soil physical and chemical properties of Huangguogan. The results showed that all the combinations had improved the soil of Huangguogan orchard. The combination of A3B2C2 had the best effect. The best Fertilization management measures was "Baoshiling" bud flowering fertilizer 2kg, stable fruit fertilizer 2kg, strong fruit fertilizer 2kg. It could reduce the pH of soil and the bulk density of soil, increase the available nitrogen, available phosphorus, available potassium and urease activity.

1 Introduction

1.1 Huangguogan orchard
Huangguogan is a unique and resource-rich orange and orange natural hybrids in Sichuan [12]. At present, Huangguogan planted in Sichuan Province Ya'an Hanyuan County with high economic value. It has late maturity, no seed, high quality, high yield and other excellent economic traits [5, 6]. In recent years, people use fertilizer for a long time, the amount of fertilizer and the proportion of unreasonable. This phenomenon leads to Huangguogan orchard soil compaction, unbalanced soil fertility and relatively lacking or locally enriched nutrients. These seriously affect the fruit quality and yield of Huangguogan, but also pollute the environment and affect human health.

1.2 Organic - inorganic compound fertilizer
Organic - inorganic fertilizer is compound fertilizer and mixed fertilizer collectively by chemical methods and physical processing. Compound fertilizer can improve soil fertilizer efficiency, reduce the number of fertilization and save fertilizer costs [13]. It is possible to improve the soil fertility level, reduce the loss of soil nutrients and environmental pollution, improve soil compaction and promote the balanced absorption of Huangguogan through the best combination of compound formula and scientific fertilization management technology [1, 2, 4, 11].

According to the fertilizer characteristics of Huangguogan to design the fertilization experiment with different formula combination fertilizer and the corresponding fertilization technique can improve the soil fertility and productivity. It can make the plant and soil balance development by scientific fertilization. These improve the economic benefits of Huangguogan and market competitiveness.
2 Materials and Methods

2.1 Supply of orchards, plants and fertilizers
The experimental orchard is a demonstration garden of Huangguogan in Shimian County. The soil of the test site is slightly acidic and belongs to the climate type of the subtropical dry valley. The plant was planted in the garden for 9 years and moderate growth potential. The tree shape was basically the same. Previous management standards are consistent. Experimental fertilizer is the "Baoshiling" compound fertilizer formula. They are including A formula (N: P: K = 13: 7: 10), B formula (N: P: K = 12: 8: 10), C formula (N: P: K = 11: 4: 15).

2.2 Experimental design
The experiment in March 2015-March 2016 in Shimian Huangguogan agriculture demonstration garden. A total of 27 treatments were conducted with conventional fertilization as control (CK) with a single plant as a plot. The amount of fertilizer applied in each formulation was set to three gradients, like table 2. Fertilization scheme in table 1.

Table 1 Specific fertilization scheme.

| Approach | A(kg/plant) | B(kg/plant) | C(kg/plant) | Approach | A(kg/plant) | B(kg/plant) | C(kg/plant) |
|----------|-------------|-------------|-------------|----------|-------------|-------------|-------------|
| A₁B₁C₁   | 1           | 1.5         | 1.5         | A₂B₂C₁   | 1.5         | 2           | 2.5         |
| A₁B₂C₂   | 1           | 1.5         | 2           | A₂B₁C₁   | 1.5         | 2.5         | 1.5         |
| A₁B₂C₃   | 1           | 2           | 2.5         | A₂B₂C₂   | 1.5         | 2           | 2           |
| A₁B₃C₁   | 1           | 2           | 1.5         | A₂B₂C₃   | 1.5         | 2.5         | 2.5         |
| A₁B₃C₂   | 1           | 2           | 2           | A₂B₁C₁   | 1.5         | 1.5         | 1.5         |
| A₁B₃C₃   | 1           | 2           | 2.5         | A₂B₁C₂   | 1.5         | 1.5         | 2           |
| A₂B₁C₁   | 1           | 2.5         | 1.5         | A₂B₂C₁   | 1.5         | 2           | 2           |
| A₂B₁C₂   | 1           | 2.5         | 2           | A₂B₂C₂   | 1.5         | 2           | 2           |
| A₂B₃C₃   | 1.5         | 1.5         | 1.5         | A₂B₂C₃   | 2           | 2           | 2.5         |
| A₂B₂C₃   | 1.5         | 1.5         | 2.5         | A₂B₁C₁   | 2.5         | 2           | 2.5         |
| A₂B₃C₂   | 1.5         | 2           | 2           | A₂B₂C₂   | 1.5         | 2           | 2           |
| A₂B₃C₃   | 1.5         | 2           | 2           | A₂B₁C₁   | 1.5         | 1.5         | 1.5         |

Table 2. Fertilizer gradient of different formulations.

| Number | A(Kg/plant) | B(Kg/plant) | C(Kg/plant) |
|--------|-------------|-------------|-------------|
| 1      | 1           | 1.5         | 1.5         |
| 2      | 1.5         | 2           | 2           |
| 3      | 2           | 2.5         | 2.5         |

*Conventional fertilization method: budding and flowering stage of organic fertilizer 1.5kg / plant + inorganic fertilizer 1.5kg / plant; stable fruit application of organic fertilizer 1kg / plant + inorganic fertilizer 1kg / plant; strong fruit season application of organic fertilizer 1kg / plant + inorganic fertilizer 1.5kg / plant. (Organic fertilizer: fermented chicken manure, nitrogen, phosphorus, potassium ≥8%; inorganic fertilizer: urea and superphosphate Russian potash).
3 Results and Analysis

3.1 Analysis of Soil Physical Properties of Different Treatments
As can be seen from table 3, the soil bulk density was lower than that of the control (CK). The soil bulk density of A3B2C3, A2B3C1 and A2B1C3 was the lowest, which was 18.7%, 17.6% and 17.1% lower than that of the control.

The soil water content of each treatment compared to the control was generally similar or increased. The soil water content of A3B2C3, A3B2C2 and A3B1C1 was the lowest, which was 0.5% higher than that of the control. The soil water content of A3B1C3 and A3B2C1 was the second, which was 0.4% higher than that of the control.

Huangguogan can produce high quality and high yield characteristics in environments with a pH of about 6 [3]. The soil pH of A3B1C3, A3B2C1 and A3B2C2 were 6.12, 6.13 and 6.19 respectively. The micro-acid was suitable for the cultivation of Huangguogan. The soil pH of A3B1C2, A2B1C3 and A2B2C1 was the lowest. They were 5.8, 5.76 and 5.79 respectively. So low acidity is not suitable for cultivation of Huangguogan.

3.2 Analysis of Soil Chemical Properties of Different Treatments
As can be seen from table 4, the content of soil organic matter was significantly higher than the control. The contents of soil organic matter in A3B2C2, A3B2C1 and A3B1C3 were significantly increased by 56%, 54% and 46%.

The contents of available nitrogen (AN) in the treated soils were not consistent with those of the control. The contents of AN nitrogen in the treatments were significantly increased by 43.6%, 40.3% and 39.4% compared with the control. However, the contents of AN in soil treated with A1B1C1, A1B2C1 and A1B2C3 were lower than those in the control group. This may be due to budding flowering fertilization can’t meet the needs of trees. It can’t be coordinated development in trees and soil.

The content of available phosphorus in each treated soil was higher than that in control. The contents of available phosphorus in A3B2C1, A3B2C2 and A3B1C3 were significantly increased by 20.74mg/kg, 20.35mg/kg and 15.92mg/kg respectively compared with the control.

The content of available potassium in each treated soil were higher than those in the control group. The content of available potassium in A3B2C1, A3B2C2 and A3B1C3 were significantly increased by 124mg/kg, 110mg/kg and 98mg/kg respectively compared with the control. In this way, different fertilizers can be used to increase the content of potassium in soil.

The activities of soil urease were not consistent with the control. The soil urease activity of A3B2C2, A3B1C3 and A3B2C1 was the highest, which was 140.05mg / 100g, 139.87mg / 100g and 139.21mg / 100g respectively. The soil urease activity of A3B1C3 was 90.04mg / 100 lower than that of the control group. This may be due to the low nutrient content of the treated soil caused by insufficient soil fertility and low microbial activity.
Table 3 Different fertilizer treatments of Huangguogan orchard soil physical properties.

| Approach | bulk density (g/cm³) | Water Content (%) | pH | Approach | bulk density (g/cm³) | Water Content (%) | pH |
|----------|----------------------|-------------------|----|----------|----------------------|-------------------|----|
| CK       | 1.527a               | 9.9cd             | 6.79a | A1:B1:C1  | 1.359ijk             | 10.3ab            | 6.47abcde |
| A1:B1:C1 | 1.411gh              | 9.9cd             | 6.4abcdef | A1:B1:C2  | 1.324efghi          | 10.3cd            | 6.02fghijk |
| A1:B1:C2 | 1.474bcd             | 10.1abcd           | 6.39abcdef | A1:B1:C3  | 1.471bcde           | 10.1abc           | 5.99fgijk |
| A1:B1:C3 | 1.497abc             | 10.1abcd           | 6.49abcde | A2:B1:C1  | 1.408fgh            | 10.1abcd           | 6.26cdefg |
| A2:B1:C1 | 1.514ab              | 10.3ab             | 6.05fghijk | A2:B1:C2  | 1.383hij            | 10.4a             | 6.31bcdefg |
| A2:B1:C2 | 1.477bcd             | 10.2abc            | 6.18defghijk | A1:B1:C4  | 1.323kkm            | 10.3ab            | 6.67ab |
| A1:B1:C4 | 1.464cde             | 9.8d               | 5.92ghijk | A2:B1:C2  | 1.353ijk            | 10.2abc           | 6.3cdefgh |
| A1:B1:C3 | 1.428efg             | 10bced             | 6.11defghijk | A1:B1:C5  | 1.306lmon           | 10.3ab            | 6.12defghij |
| A1:B1:C5 | 1.393ghi             | 9.9cd              | 5.87ijk | A1:B1:C1  | 1.278mnop           | 10.3ab            | 6.13defghij |
| A1:B1:C1 | 1.378hij             | 10.2abc            | 5.91hijkl | A1:B1:C2  | 1.283mnop           | 10.4a             | 6.19cdefghi |
| A1:B1:C2 | 1.316klmn            | 10.2abc            | 5.84ijkl | A1:B1:C3  | 1.343jkl            | 10.2abc           | 6.34bcdefg |
| A1:B1:C3 | 1.299lmonp           | 10.1abcd           | 5.8jk | A2:B1:C1  | 1.275lmonp          | 10.4a             | 6.34bcdefg |
| A2:B1:C1 | 1.267nqop            | 10.1abcd           | 5.76k | A2:B1:C2  | 1.307lmno           | 10.2abc           | 6.6abc |
| A2:B1:C2 | 1.259nqop            | 9.9cd              | 5.79jk | A2:B1:C3  | 1.242q              | 10.1abcd           | 6.34bcdefg |

Note: The same indicators of different treatment between the lowercase letters that the difference between the two significant levels (P < 0.05). The same below.

Table 4 Different fertilizer treatments of Huangguogan orchard soil chemical properties and urease activity.

| Approach | Organic Matter (g/kg) | AN (mg/kg) | Available phosphorus (mg/kg) | Available potassium (mg/kg) | Urease (mg/100g) |
|----------|-----------------------|------------|-----------------------------|---------------------------|-----------------|
| CK       | 21.93q                | 76.055q    | 15.24t                      | 91.5y                     | 92.72n          |
| A1:B1:C1 | 29.94d                | 75.76r     | 16.66r                      | 102y                      | 138.95b         |
| A1:B1:C2 | 29.26c                | 73.543t    | 16.29s                      | 108.5t                    | 138.24c         |
| A1:B1:C3 | 28.19g                | 75.337s    | 17.46q                      | 141.5r                    | 126.18e         |
| A1:B1:C4 | 27.8h                 | 66.727x    | 29.99f                      | 146.0z                    | 123.63g         |
| A1:B1:C5 | 26.21j                | 75.49r     | 19.32p                      | 160.5m                    | 119.01i         |
| A1:B1:C6 | 25.2i                 | 67.803w    | 26.91h                      | 168.5k                    | 117.08j         |
| A1:B1:C7 | 23.65n                | 74.978s    | 19.87o                      | 178i                      | 124.65f         |
| A1:B1:C8 | 22.82p                | 72.826u    | 31.62d                      | 185f                      | 92.92n          |
| A1:B1:C9 | 22.84q                | 69.956v    | 16.04s                      | 94x                       | 90.04o          |
| A1:B1:C10| 25.76k                | 77.772op   | 20.11o                      | 95.5w                     | 126.71e         |
| A1:B1:C11| 28.75f                | 97.356g    | 20.75n                      | 138.5s                    | 123.95t         |
| A1:B1:C12| 29.61d                | 95.929h    | 20.04g                      | 143.5q                    | 138.62bc        |
| A1:B1:C13| 27.88gh               | 93.41j     | 28.18g                      | 146.5o                    | 123.85g         |
| A1:B1:C14| 26.67i                | 82.985m    | 30.02f                      | 163l                      | 119.69h         |
| A1:B1:C15| 25.23j                | 93.186j    | 31.31de                     | 185.5e                    | 117.23j         |
| A1:B1:C16| 24.47m                | 99.778f    | 30.24f                      | 182h                      | 114.47k         |
| A1:B1:C17| 22.91o                | 94.975i    | 31.06e                      | 187.5d                    | 93.91m          |
| A1:B1:C18| 23.56n                | 88.387k    | 32.12c                      | 158.5n                    | 100.01i         |
| A1:B1:C19| 27.98gh               | 80.853n    | 24.28j                      | 168.5k                    | 128.76d         |
| A1:B1:C20| 29.72d                | 103.455e   | 25.08i                      | 141r                      | 138.77bc        |
| A1:B1:C21| 32.08c                | 115.787a   | 31.16e                      | 189.5c                    | 139.87a         |
| A1:B1:C22| 33.89b                | 107.805c   | 35.98a                      | 215.5a                    | 139.21b         |
| A1:B1:C23| 34.53a                | 108.522b   | 35.59b                      | 201.5b                    | 140.05a         |
| A1:B1:C24| 25.78k                | 104.172d   | 23.37k                      | 171.5j                    | 118.93i         |
| A1:B1:C25| 25.05l                | 81.078n    | 21.87m                      | 184g                      | 115.05k         |
| A1:B1:C26| 23.02o                | 87.671     | 25.12i                      | 145p                      | 119.27h         |
| A1:B1:C27| 26.34ij               | 78.118o    | 22.25l                      | 103u                      | 94.04m          |
4 Conclusions
The demand for nitrogen, phosphorus and potassium in different growth processes is different. The appropriate fertilization management of fruit trees can improve the soil fertility of orchard, fruit quality, enhance tree vigor and increase yield. From the experimental results, it can be seen that the combination of different formulations can effectively reduce the soil pH and soil bulk density, improve the alkali nitrogen, available phosphorus, available potassium and urease activity. This is consistent with the result of Yang Cheng [10], Xu Zuxiang [9] and so on. Therefore, different combinations of "Baoshiling" organic-inorganic fertilizer can achieve the purpose of improving soil fertility and improving soil compaction in Huangguogan orchard. "Baoshiling" organic-inorganic fertilizer can’t only improve the physical and chemical properties of the soil to the level of the growth of Huangguogan to maintain a higher soil nutrient content, but also enhance microbial metabolic activity of Huangguogan orchard soil. This is consistent with the results of Xu Peizhi[7, 8], Zhuang Yimei [14] on citrus.

The results show that the treatment of A1B2C2 is the best combination of formulations. the regulation of soil physical properties of the best can improve soil nutrient content and microbial metabolic activity. The quality of the processed Huangguogan is also the best. Therefore, according to Huangguogan three key phenological period to apply the "Baoshiling" bud flowering fertilizer 2kg, stable fruit fertilizer 2kg, strong fruit fertilizer 2kg fertilization management measures the best. It has a great effect on the improvement of the economic benefit of Huangguogan. It is worth popularizing and applying.

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