Effect of mutual grafting on the growth and moisture content in post-grafting of two varieties cherry tomato seedlings

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Abstract. The effects of mutual grafting on growth and moisture content in post-grafting generations of two varieties cherry tomato seedlings (yellow cherry tomato and red cherry tomato) under stress of Cd were studied in a pot experiment involving the following: un-grafted yellow cherry tomato and red cherry tomato (Yellow CK and Red CK), yellow cherry tomato as rootstock and red cherry tomato as scion (Yellow Rootstock, Red Scion), yellow cherry tomato as scion and red cherry tomato as rootstock (Yellow Scion, Red Rootstock). Mutual grafting increased plant height, stem weight of post-grafting of yellow cherry tomato; however, stem diameter, root and leaf weight and moisture content were no significantly effects compared with Yellow CK. As for red cherry tomato seedlings, mutual grafting increased root length of post-grafting; plant height and moisture content of post-grafting of Red Rootstock were increased, while in Red Scion, the these parameters decreased or showed no significant effects. These results imply that mutual grafting may improve or no effect in growth and moisture content of post-grafting generations.

1. Introduction
Grafting is a common asexual breeding method can overcome abiotic stress (such as heavy metals) and improve plant yield [1]. Grafting increases physiological index and decreases Cd concentration in shoots of Cyphomandra betacea [2], eggplant [3] and different scion-rootstock combinations in grapevine improve fruit qualities [4]. Another study indicates that growth and fruit yield of the tomato grafting on wolfberry are reduced [5]. Grafting on different rootstocks decreases the shoot biomass of the G. parviflora post-grafting generation compared with un-grafted [6] and mutual grafting increases growth and shoot biomass of post-grafting of two Bidens pilosa ecotypes (farmland and mining) [7]. These results indicate that different rootstocks have different effect on growth in post-grafting generations of plants, but it remains unclear what the effects are on cherry tomato species. In this study, we collected the seeds of mutual grafting two varieties tomato seedlings (rootstock and scion respectively) and grew post-grafting plant. Then to determine whether mutual grafting increased growth and moisture content in the post-grafting generations of two varieties cherry tomato.

2. Materials and methods

2.1. Plant and soil materials
Two varieties of cherry tomato, yellow (RTY-3-2) and red (red cherry 5-5-1-1), are all self-contained
strains in the Institute of Pomology and Olericulture, Sichuan Agricultural University, which belong to multiple generations of inbred lines with stable homozygosity.

The tested soil is from paddy soil of farmland around Chengdu campus of Sichuan Agricultural University, its basic physical and chemical properties are as follows: pH 6.29, organic matter 21.16 g/kg, total nitrogen 1.09 g/kg, total phosphorus 1.2 g/kg, total potassium 22 g/kg, total cadmium 0.10 mg/kg, alkali hydrolyzed nitrogen 68.12 mg/kg, available phosphorus 16.22 mg/kg, available potassium 156.2 mg/kg, available cadmium 0.028 mg/kg [8].

2.2. Plant grafting
Seeds of tomato mutual grafting were collected. In April 2017, full cherry tomato seeds were selected, disinfected in 10% (m/m) hydrogen peroxide solution for 10 min, and then washed with ultrapure water. Evenly placed it in the culture dish with filter paper, kept enough water and accelerated germination in the artificial incubator at 28 °C. When the radicle length was 5 mm, the germinated seeds were sown in 32 holes tray and grafted when the plant height was about 20 cm. Grafting treatment: un-grafted yellow cherry tomato (Yellow CK) seeds were collected for preservation; un-grafted red cherry tomato (Red CK) seeds were collected for preservation; grafting of yellow cherry tomato as rootstock and red cherry tomato as scion (Yellow Rootstock, Red Scion): the seedlings of red cherry tomato and yellow cherry tomato were cut from about 12 cm above the ground, the lower seedling (12 cm) of yellow cherry tomato was used as rootstock, the upper seedling (8 cm) of red cherry tomato was used as scion for grafting, and the leaves and buds of rootstock were preserved, and collected the seeds of rootstock and scion respectively for preservation; grafting of red cherry tomato as rootstock yellow cherry tomato as scion (Red Rootstock, Yellow Scion): the method of grafting and seeds collecting were same as yellow cherry tomato. Split grafting was used and then kept 80% of the soil water capacity in the field, covered with plastic film to keep moisture and used sunshade net for shading. When the grafting was completed, all of the seedlings were transplanted into the soil without heavy metal pollution and soil water capacity kept at about 80%. When cherry tomatoes are in their first blooming stage, choose the best growing branches to bag to prevent outcrossing. When fruits were mature, seeds of plants not grafted, rootstocks and scions with mutual grafting were collected respectively and reserve.

2.3. Plant planting
According to the actual situation of heavy metal Cd pollution in farmland in Sichuan Province, the concentration of heavy metal Cd pollution in the tested soil is in accordance with the soil environmental quality standard (GB15618-1995) and the method of Lin [9]. Reference similar research experiment on others vegetables under Cd stress, Cd concentration of 10 mg/kg was selected for present experiment. In March 2017, the air-dried test soil was screened through a 5 mm sieve and put into a bucket (30-cm diameter, 40-cm height) with 18 kg of soil in each bucket. According to the pollution concentration of 10 mg/kg designed in the experiment, add heavy metal Cd into the tested soil in the form of CdCl₂· 2.5H₂O analysis pure solution. After being kept wet for 30 days, full mix all contaminated soil together, and put it into plastic basin (18-cm height, 26-cm diameter) with 6 kg in each basin.

Selecting full seeds of post-grafting cherry tomato disinfected in 10% (m/m) hydrogen peroxide solution for 10 min, and then washed with ultrapure water. Evenly placed it in the culture dish with filter paper, kept enough water and accelerated germination in the artificial incubator at 28 °C. When the radicle length was 5 mm, the germinated seeds were sown in 32 holes tray, then transplant in plastic basin (18-cm height, 26-cm diameter) with tested soil.

There were 6 treatments: Yellow CK, Yellow Rootstock, Yellow Scion, Red CK, Red Rootstock, Red Scion in the experiment, each treatment was 3 pots, repeated 6 times.
2.4. Sample collection and data determination

The seedlings of post-grafting were transplanted and grown for 30 days to collect samples. Determination of growth index of whole plant after collection: plant height and root length were measured with millimeter scale, and stem diameter was measured with vernier caliper. The weight of fresh weight of root, stem and leaf measured with electronic balance. Then killed with oven at 105 °C for 15 minutes and dried to constant weight at 75 °C to calculate moisture content.

2.5. Statistical analyses

Excel 2010 was used to record and sort out the test data, and SPSS 20.0 system was used to analyse the significance difference of Duncan new range method ($P < 0.05$).

3. Result

3.1. Growth of post-grafting of two varieties cherry tomato seedlings

The order of plant height of post-grafting of yellow cherry tomato seedlings was Yellow Rootstock > Yellow Scion > Yellow CK, and the rank of root length was Yellow CK > Yellow Scion > Yellow Rootstock (Table 1). Mutual grafting reduced the stem diameter of post-grafting of yellow cherry tomato seedling by 4.73% ($P < 0.05$) and 7.77% ($P < 0.05$) respectively that compared with Yellow CK and increased the stem fresh weight. While the fresh weight of root and leaf of Yellow Rootstock and Yellow Scion were not significantly different in comparison to Yellow CK (Table 1).

The plant height of post-grafting of red cherry tomato seedlings followed the rank on Red Rootstock > Red CK > Red Scion. Mutual grafting increased root length compared with Red CK (Table 1). While the stem diameter of Red Rootstock and Red Scion were not significantly different in comparison to Red CK. The order of fresh weight of stem and leaf were similar: Red Rootstock increased the two parameters, while Red Scion decreased two parameters (Table 1).

| Treatments                  | Plant height (cm) | Root length (cm) | Stem diameter (mm) | Root (g/plant) | Stem (g/plant) | Leaf (g/plant) |
|-----------------------------|-------------------|------------------|--------------------|----------------|----------------|----------------|
| Yellow cherry tomato        |                   |                  |                    |                |                |                |
| Yellow CK                   | 90.4±2.6c         | 34.3±0.7a        | 5.28±0.13a         | 12.26±0.27a    | 30.39±1.21b    | 42.35±0.53a    |
| Y. Rootstock                | 104.7±2.8a        | 31.6±0.8b        | 5.03±0.14ab        | 12.99±0.93a    | 34.77±1.32a    | 39.94±1.62a    |
| Yellow Scion                | 97.6±2.9b         | 34.0±1.5a        | 4.87±0.27b         | 12.41±0.38a    | 33.02±0.96a    | 42.45±1.73a    |
| Red cherry tomato           |                   |                  |                    |                |                |                |
| Red CK                      | 112.5±1.2b        | 25.7±2.0b        | 6.62±0.39a         | 12.69±0.17b    | 47.20±2.24b    | 44.16±0.21b    |
| R. Rootstock                | 116.3±1.9a        | 34.3±0.8a        | 6.45±0.08a         | 13.86±0.07a    | 51.46±1.03a    | 49.50±1.23a    |
| Red Scion                   | 107.5±0.8c        | 33.5±1.9a        | 6.13±0.19a         | 11.50±0.33c    | 47.42±2.44b    | 42.54±1.58b    |

Y. Rootstock represents Yellow Rootstock. R. Rootstock represents Red Rootstock. Different lowercase letters in the same column indicate significant difference ($P < 0.05$).

3.2. Moisture content of post-grafting of two varieties cherry tomato seedlings

Under stress of Cd, mutual grafting increased root and stem moisture content of the post-grafting of yellow cherry tomato seedlings, the rank respectively was Yellow Rootstock > Yellow Scion > Yellow CK and Yellow Scion > Yellow Rootstock > Yellow CK (Table 2). The moisture content of leaf of Yellow Rootstock and Yellow Scion were not significantly different in comparison to Yellow CK. The order of moisture content of shoot was Yellow Scion > Yellow CK > Yellow Rootstock.

The moisture content of root of Red Rootstock and Red Scion were not significantly different compared with Red CK. Mutual grafting significantly decreased moisture content of stem, leaf, shoot of Red Rootstock, while moisture content of stem, leaf, shoot of Red Scion showed no significantly effect in comparison to Red CK (Table 2).
Table 2. Water content of reciprocal post-grafting generation of two cherry tomato seedlings

| Treatments          | Root (%)   | Stem (%)   | Leaf (%)  | Shoot (%)  |
|---------------------|------------|------------|-----------|------------|
| Yellow cherry tomato|            |            |           |            |
| Yellow CK           | 90.23±0.56b| 83.73±0.56b| 86.32±0.63a| 85.24±0.44ab|
| Y. Rootstock        | 92.03±0.66a| 84.36±0.25ab| 85.71±0.87a| 85.09±0.38b|
| Yellow Scion        | 91.41±0.55ab| 85.22±0.59a| 86.51±0.34a| 85.95±0.30a|
| Red cherry tomato   |            |            |           |            |
| Red CK              | 90.54±0.52a| 84.38±0.88a| 86.12±1.00a| 85.23±0.49a|
| R. Rootstock        | 90.13±0.58a| 83.29±0.21b| 84.20±1.08b| 83.74±0.56b|
| Red Scion           | 89.70±0.48a| 83.20±0.22a| 86.35±0.30a| 85.74±0.25a|

Y. Rootstock represents Yellow Rootstock. R. Rootstock represents Red Rootstock. Different lowercase letters in the same column indicate significant difference ($P < 0.05$).

4. Conclusion
Mutual grafting of yellow cherry tomato seedlings had no effect on moisture content and growth of post-grafting generation, except plant height and fresh weight of stem. However, mutual grafting increased growth and moisture content of post-grafting generation seedlings of Red Rootstock. The mutual grafting showed the difference between varieties of tomato, thus, future studies should be investigated that the mechanisms underlying the effects of mutual grafting on the growth of post-grafting generation plant species.

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