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A Review on Grafting in Tomato: Importance and Practical Implications

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Grafting of vegetable seedlings is a unique horticultural technology practiced for many years in East Asia to overcome issues associated with intensive cultivation using limited arable land. This technology was introduced to Europe and other countries in the late 20th century along with improved grafting methods suitable for commercial production of grafted vegetable seedlings. Tomato grafting is becoming a well-developed practice worldwide with many horticultural advantages. The primary motivation for grafting tomato has been to prevent the damage caused by soil borne pathogens under intensive production system. However, recent reports suggest that grafting onto suitable rootstocks can also alleviate the adverse effects of abiotic stresses such as salinity, water, temperature, and heavy metals besides enhancing the efficiency of water and nutrient use of tomato plants. This review gives an overview of the scientific literatures on the various aspects of tomato grafting including important steps of grafting, grafting methods, scion–rootstock interaction, and rootstock-derived changes in vegetative growth, fruit yield, and quality in grafted plants under different growing conditions.

Introduction

The cultivated tomato, Solanum lycopersicum L., is the world's most highly consumed vegetable due to its status as a basic ingredient in a large variety of raw, cooked or processed foods. It belongs to the family Solanaceae, which includes several other commercially important species. Tomato is grown worldwide for local use or as an export crop. In 2014, the global area cultivated with tomato was 5 million hectares with a production of 171 million tonnes, the major tomato-producing countries being the People's Republic of China (hereafter "China") and India (FAOSTAT, 2017). Tomato can be grown in a variety of geographical zones in open fields or greenhouses, and the fruit can be harvested by manual or mechanical means. Under certain conditions (e.g. rejuvenation pruning, weeding, irrigation, frost protection), this crop plant can be perennial or semi-perennial, but commercially it is considered an annual

Vegetable grafting has attracted tomato growers' attention as an approach to control soil borne diseases and improve crop yield. By grafting scion plants that have desirable fruit characteristics onto rootstock plants that have disease resistance, stress tolerance, or vigorous root system characteristics, grafted plants combine beneficial traits from both the scion and rootstock plants. Many growers who are interested in growing grafted tomatoes may be hindered by the high cost of already grafted plants. Growers may prefer to graft their own tomato plants to reduce costs or increase cultivar selection (including the selection of organic seeds). This publication introduces tomato grafting techniques that are particularly suitable for small-scale production. Successful tomato grafting includes three steps: 1. Raising healthy

seedlings (pre-graft) 2. Grafting 3. Post-graft plant healing Each of these steps is important to ensure the final success of the graft.

Grafting

You can successfully graft tomato seedlings with a wide range of sizes. However, plants at a younger stage generally heal faster and require less stringent conditions for post-graft plant healing.

At a minimum, the stem diameters of both rootstock and scion must be at least 1.5 millimeters — the smallest grafting clips are 1.5 millimeters. Grafting will require silicone grafting clips, which come in diameters from 1.5 to 3.0 millimeters. You can also use side grafting clips (which are often used for grafting cucurbits) to graft larger tomato plants, but they are more expensive.

Tomato plants normally need two to three weeks to reach a stem size of 1.5 to 2 millimeters after sowing. The best way to determine if the timing is right to graft is to put a grafting clip on the stem. If it fits tightly, the plants are ready to graft . We recommend using transparent grafting clips. Transparent clips allow you to see how well you match the cut surfaces of the rootstock and scion plants through the clip .

To make graft cuts, you have options. Grafting knives are designed to ensure consistent cutting angles, but they are more expensive than common razor blades. A half-size double-edge razor blade works well for tomato grafting, and its low cost allows you to replace them after a few grafts, which prevents potential contamination if pathogens are present on the graft tool. If you use a grafting knife, it is very important to sanitize it frequently.

Choosing the rootstock and scion

When grafting tomato, careful rootstock selection, timing, and attention to healing and planting in the field are essential for successful production of healthy transplants. Rootstocks that are specifically chosen for disease resistance should be selected based on disease pressure at the planting location. Assistance in the identification of diseases can be obtained by contacting your county extension agent or contacting a local plant disease diagnostic facility (https://www.apsnet.org/members/directories/Documents/ SoilLabsandPlantClinics. pdf). Scions are chosen based on desired fruit characteristics and quality. Scion and rootstock compatibility is important when selecting plant material. One important consideration, particularly when using heirloom tomato cultivars as the scion, is the presence or absence of genes for resistance to Tomato mosaic virus (ToMV).

Grafting method, equipment, and procedures

Splice grafting, also known as “Japanese top grafting” or “tube-grafting,” is the most commonly used technique when grafting Solanaceous crops. Cleft and side grafting are the other two main grafting techniques used to graft tomato. Before starting to graft, it is important to arrange a clean and functional grafting area and make sure you have all the required equipment and tools: · Healing chamber · Disposable razor blades or scalpels to cut scion and rootstock plants. · Silicone grafting clips to secure the rootstock and scion together and minimize water loss at the graft union. · Antibacterial soap to sanitize hands. · Spray bottles to mist plants with water during the grafting process. Sanitation is extremely important for successful grafting, as plant pathogenic bacteria and viruses can be passed plant-to-plant from hands, cutting surfaces, and tools

How to Splice Graft

The most common grafting method for tomato is splice grafting.

Step 1: Cut the Rootstock Stem With splice grafting, the first step is to cut the rootstock at the stem at a deep angle The deep angle creates more surface area on the cut than a flat cut

would, which allows more cells from the cut surfaces of rootstocks and scions to fuse together (an essential step in graft healing).

You can cut the rootstock either above or below the cotyledons. The advantage of cutting above the cotyledons is that you will have more space between the graft union and soil, which means grafted plants are less likely to develop adventitious roots from the scion. However, cutting the rootstock above the cotyledons can create the problem of rootstock regrowth (that is, rootstock suckers).

If you cut the rootstock below the cotyledons, it completely eliminates the sucker problem because that completely removes the rootstock's meristem tissue. It is critical however, to pay close attention during transplanting to ensure that the grafting union stays above the soil .

Step 2: Place a Grafting Clip on the Rootstock Second, after you cut the rootstock place a grafting clip halfway over the cut stem (Figures 3B and 3C). It is important to orient the grafting clip along the side of the graft cut so that it holds the graft union securely .

Step 3: Cut the Scion Stem Next, cut the scion stem at the same angle as the rootstock.

Step 4: Insert Scion Stem into Grafting Clip Then, insert the scion stem into the grafting clip. As you do, make sure the cut surfaces of the rootstock and scion are oriented correctly and in full contact with each other . If you cut the rootstock and scion stems at different angles, they may not come into contact sufficiently and may not heal.

Tips to ensure success

Before transplanting grafted plants, it is important to scout for and remove any rootstock suckers you find. You must remove these suckers by hand.

To increase graft efficiency, experienced grafters normally conduct one step for all plants before moving to the next step .However, you need to make sure that the cut surfaces of the plants do not dry out before you graft them, or it will reduce grafting success. Placing scion cuttings in sterile water can extend the time from cutting to insertion

Graft tomato plants in a shaded area where there is no wind and the temperature is between 72°F and 85°F. Also, it is best to perform the grafting operations close to the area where post-graft plants will heal.

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