Supervised Agricultural Experience Handbook: How to Graft Tomatoes

A Senior Project

presented to

the Faculty of the Agricultural Education and Communication Department

California Polytechnic State University, San Luis Obispo

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Agriculture Science

by

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Abstract

The Purpose of this project was to create a handbook that could be used by high school agricultural programs to implement grafting of tomatoes. It could be used as a Supervised Agricultural Experience entrepreneurship project for a student or a fundraiser for the high school program as a whole. The handbook provides a resource with step-by-step procedures for the entire process grafting tomatoes entails. It is hoped that the handbook gives guidance but also leaves room for interpretation for educational purposes.

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Chapter One

Introduction

Grafting of tomatoes is not a new idea, but has actually been used in Asian countries since the early 1900s. Tomatoes are grafted in order to control soil-borne diseases, increase yield, and improve overall plant health for less than great environmental conditions (Hanna, 2013). This is why teaching students how to properly graft a tomato could help them further develop their vocational skills that will help them in their future career paths. Teaching students this process will take their horticultural techniques to a higher level. Grafting tomatoes is also an opportunity to start a successful Supervised Agricultural Experience. In a time where high school agricultural programs are having a difficult time finding fundraisers, grafting tomatoes could be the answer (Basham, 2012). This senior project will be dedicated to creating a handbook those high school agriculture students and teachers can use to implement grafting of tomatoes into their program. This possible Supervised Agriculture Experience will help develop students horticulture skills, teach them more about operating a business and how to go about marketing their finished product.

Statement of the Problem

High school agricultural programs today have shown that there is a need for new fundraising ideas. There is a need to find new projects students can undertake in the horticulture area that will help them learn more advanced skills. The problem begins with the difficulty in finding Supervised Agriculture Experiences (S.A.E.) that can be managed by a student and is profitable for the student or program. It is difficult as well to find unique projects that can be

done with limited resources, since not all high schools have top of the line greenhouses, or any horticulture facilities period, there is a need for projects that can be done with out all the pricey facilities.

The Importance of the Project

This is an important project because it will create a simple and straightforward handbook that can be used by the agriculture education community to implement a new Supervised Agriculture Experience their students can undertake and learn more advanced horticultural skills. This project of grafting tomatoes will help students understand the importance of concise and well-planned horticulture practices. Not only will this project further develop students horticulture skills, but will also give them an opportunity to learn more about business, marketing, and what it takes to sell a finished product.

Purpose(s) of the Project

The Purpose of this project is to create a handbook that will help high school agriculture programs and students implement grafting of tomatoes. This handbook will give detailed and photographed steps to how go about starting this project, going about the actual grafting, and how to market and sell the finished product. The project will also give steps that can be done with no facilities and other ideas if the high school program does have greenhouses and such. Overall, the handbook will be useful for a range of agriculture programs as well as easy to read for high school students.

Objectives of the Project

1. Develop a straightforward system that will make implementing grafting of tomatoes attainable for high school students and high school agriculture teachers.
2. Research best methods for grafting of tomatoes.
3. Create a handbook that will useful for high school agriculture programs to help start a new Supervised Agriculture Experience for students.

Definition of Important Terms

- Grafting: a shoot or scion inserted into a slit of stock, from which it receives sap.
- SAE: Supervised Agriculture Experience made up of four possibilities- Entrepreneurship, placement, research and experimentation and exploratory.
- FFA: Future Farmers of America- Youth organization that is dedicated to helping future leaders in the agriculture field.
- Horticulture: The science and art of growing fruits, vegetables, flowers, or ornamental plants.

Summary

Finding successful SAE's can be difficult for high school agriculture programs. Through this senior project they will gain a tool they can hopefully use to start grafting tomatoes and make it a profitable SAE and possible fundraiser for the program. This handbook will have clear and straightforward steps that will make this project attainable and hopefully successful in any chapter. Grafting of tomatoes will be able to take students basic horticulture knowledge and bring it to the next level. These practices will teach them proper care of tomatoes, genetic

selection, sanitation techniques, propagation, and the valuable skill of being able to graft. The project would also teach students business skills on how to start up the business, deciding what tomatoes would sell, as well as marketing their final product and selling it to the public.

Chapter Two

Review Of Literature

Grafting of tomatoes is not a new idea, but has actually been used in Asian countries since the early 1900s. Tomatoes are grafted in order to control soil-borne diseases, increase yield, and improve overall plant health for less than great environmental conditions (Hanna, 2013). This is why teaching students how to properly graft a tomato could help them further develop their vocational skills that will help them in their future career paths. Teaching students this process will take their horticultural techniques to a higher level and give them an opportunity to start a successful Supervised Agricultural Experience. In a time where high school agricultural programs are having a difficult time finding fundraisers, grafting tomatoes could be the answer (Basham, 2012).

Horticulture in the High School

In 1917 the Smith-Hughes Act became law, which is what truly started high school agricultural education classes and the beginnings of FFA (Talbert, 2007, p.74). Dr. Charles Prosser once said, "The purpose of vocational education is to help a person secure a job, train him so that he can hold it after he gets it, and assist him in advancing to a better job"(Talbert, 2007, p.65). This quote portrays the point that agricultural education is powerful agriculture education can have on a student. Supervised Agricultural Experience commonly called SAE is one of the three vital components of agriculture education. According to Talbert (2007) "Knowledge gained through experience is often easier to remember than that gained through memorization" (p.417). Projects related to horticulture can be a great experience for students to

learn hands on about the field.

Tomatoes

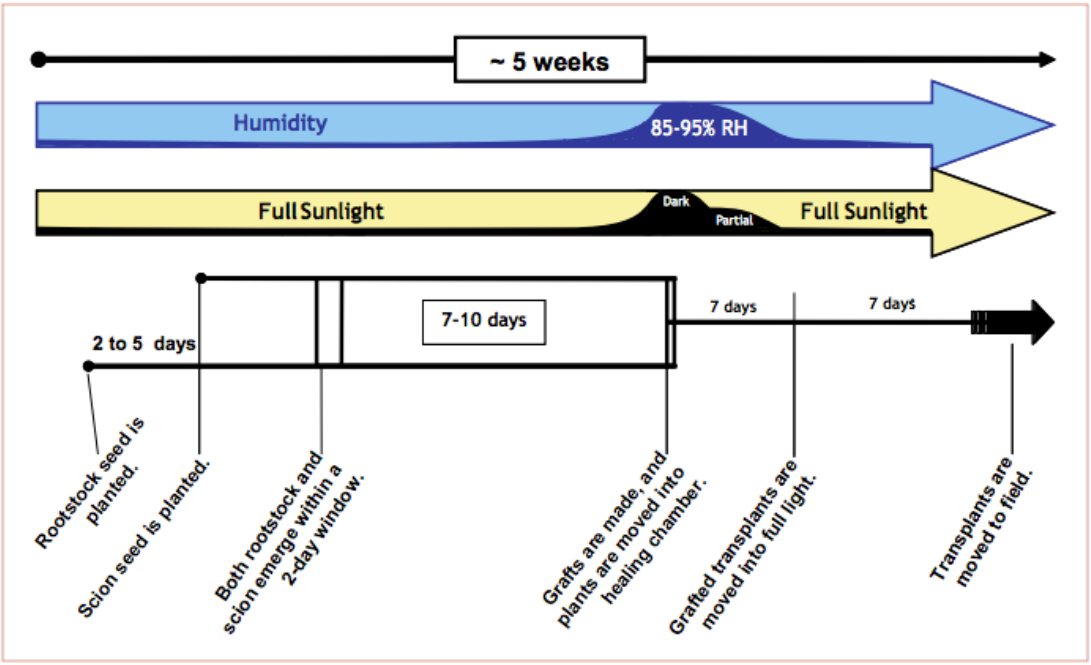
The tomato is a member of the Solanaceae family commonly known as the potato family. There are endless amounts of varieties that grow in different climates, have varying growth habits, but in the end they all produce some sort of fruit called a tomato (Brenzel, 2007, p.651-2). Tomatoes are treated like annuals since they are not cold resistant and die when fall/winter comes along. If tomatoes are grown in greenhouses or an environment that keeps the plant from freezing, it is a perennial. Determinant tomatoes are ones that grow in a bush form and stay at a compact height around four feet tall. They can be grown in containers that are five to six gallons. Indeterminate tomatoes are the vining type of tomatoes. They can reach heights of six to ten feet tall and require some sort of caging or form of support to grow (Brenzel, 2007, p.651). The USDA zones should be taken into account when planning for a tomato-grafting project. Zones allow the grower to find the correct varieties that will grow in their climate (Brenzel, 2007, p. 41-42).

Tomato Growing Factors

Fertilization must also be taken into consideration since tomatoes are heavy feeders to have peak production. Proper amounts of nitrogen, phosphorous, potassium, boron, and calcium are critical to a healthy tomato crop (Hanson). The substrate is another main component when growing a successful grafted tomato. Tomatoes need a well-drained soil that maintains a pH between 6.0 and 6.8. The EC should not exceed 2.5Ms/cm because after this level their growth rate will be influenced in a negative matter (National Gardening Association Editors, 2014). For

the first 7-9 days after completing a graft on a tomato they should be places in a hospital chamber. A hospital chamber is a facility ranging from a small greenhouse with shade cloth to a plastic dome with shade cloth that keeps humidity at 95% and the temperature between 80-85 degrees Fahrenheit (Grubinger). After the healing of the graft has been successful the tomato should be moved to a growing area. The growing area can be either a greenhouse or an outdoor growing system. The growing area should allow for 6-8 hours of full sun daily and give the tomato regular watering. In Figure 1 the timeline of sunlight and humidity for grafted tomatoes is shown (Rivard).

Figure 1. Humidity and Sunlight Timeline for Grafting Tomatoes.



Grafting of a Tomato

Grafting a tomato consists of choosing a rootstock and a scion. For the rootstock you want to find a variety of tomato that has the root growth or/and the disease resistance you need as well. When selecting the scion you want to look for a tomato that has the taste you want, appearance, or whatever characteristics you are looking for in the tomato itself (Hanna, 2013). There are different techniques that can be done in order to successfully graft a tomato. Sanitation during the entire process must be taken extremely seriously since the tomatoes will be cut open and tomatoes are susceptible to disease. There is the rootstock attach the scion method where you cut the two pieces and then reconnect what you want together. A healing chamber is also critical to provide your newly grafted tomatoes in order for them to heal properly (Rivard). You can also do a side cut where you connect two tomato plants for the time it takes the wound to heal, and then after it has healed you clip off the rootstock of the scion (Grubinger). Overall, grafting of tomato is an advanced skill that will be a beneficial asset for students able to accomplish and use in the future.

Handbook Development

Publisher by Microsoft Word will be one of the possible the software used for the handbook on implementing grafting tomatoes into high school programs. This software will make it possible to make the handbook be a seamless combination of text and images. The set up will make the handbook be easy for anyone to pick up and be able to understand the basics and procedures in order to graft a tomato (Getting Started). The handbook could then be put into booklet form using the program Create Booklet downloaded. This allows for the Publisher formatted handbook to easily be formatted into a printable handbook. Another option would be

to use InDesign by Adobe Acrobat where it would be possible to have an easy combination of texts and images, which is critical to this handbook (InDesign 101). Microsoft word could also be used in order to have a widely used program that would be easy to share.

Summary

It is important to have an educated foundation on the subject of tomatoes and grafting of tomatoes before beginning the project. There are multiple factors that come affect the success of a grafted tomato. This possible Supervised Agricultural Experience should serve as a means of fundraising or as a successful entrepreneurship project for a high school agriculture student. It is advisable that the tomato grafter does proper research in order that the right steps are

Chapter Three

Methods and Materials

The purpose of this senior project is to create a beneficial and user-friendly Supervised Agricultural Experience (SAE) handbook. This handbook is developed for high school agriculture teachers to promote SAE in their agricultural programs. High school students can start an enterprise project of grafted tomato sales with use of this handbook**.** The reader will learn how to graft a tomato all the way from the seed selection to the sellable product.

Handbook Content

The handbook will consist of a graphic and written depiction of grafting a tomato. There will be a section that explains the significance of grafting a tomato and why a student should find the project worthwhile as a Supervised Agriculture Experience. The handbook will identify the steps of a grafting project, starting with the selection of seeds or plugs to selling the final product. There will be step-by-step illustrated instruction on how to graft a tomato as well as clear direction on how to grow the grafted tomato until it is a sellable product. Lastly, there will be a section that helps the reader learn how to market and sell their product. This handbook will be short, concise, and leave room for interpretation by students in order that they gain more knowledge through their experiences.

Format

The dimensions for the handbook will be small in size by folding an 8-½ inch by 11-inch paper in half. This will be done to save paper and reduce the cost, which is a key concern with this project. The finished handbook will have dimensions of 8-½ inches x 5-½ inches. The font

will be Times New Roman with a font size 14 so that it is easily read. There will be color photos that clarify grafting a tomato step-by-step for beginners. Pictures will be acquired by professional and credible horticultural sources that will be taken off the web and sourced properly. The photography will have a minimum of 600 dots per inch (dpi) to ensure quality images when the photos are shrunk to fit the handbook dimensions, as shown in Figure 2 (2013 Resolution).

Figure 2. The 600 DPI Compared to 300 DPI Image.

The handbook will be written in 9th grade reading level, so that all high school students can comprehend the project at hand. This set grade level will make it available to a wide range of students including those starting as freshman. The grade level will be checked by a free online service called Writing Tester in order to ensure desired 9th grade reading level. The online service allows you to cut and paste your writing and instantly obtain the results.

The handbook will be short and concise. The goal is to keep the handbook no longer than 20 pages (half pages) total in order to ensure the project still challenges the student in an educational and productive way. The outline of the handbook will include 10 sections to ensure all content is included within the 24-page maximum:

1. Introduction (1 page)
2. Significance of grafting (1 page)

3. Materials (2 pages)
4. Tomato selection (2 page)
5. Substrate (1 pages)
6. Facilities (2 pages)
7. Preparation (1 pages)
8. Execution (6 pages)
9. Recovery (1 page)
10. Tomato Care (2 pages)
11. Marketing and sales (2 pages)
12. Additional Resources (1 page)

Distribution of Handbook

Distribution of the handbook will be accomplished via multiple distribution avenues. One distributor of the handbook will be Digital Commons when the senior project is submitted to the University. Digital Commons is an online database available through California Polytechnic State University, San Luis Obispo Robert E. Kennedy library website. The handbook will be put in Portable Document Format (PDF) form and given to the Agriculture Education and Communication Department at California Polytechnic State University, San Luis Obispo to keep in their reserves. This will be done to facilitate that anyone who requests the handbook can easily receive the handbook by email. The Agricultural Education and Communication Department will also be contacted to put it on their website. This handbook will be readily available to anyone who may request the material.

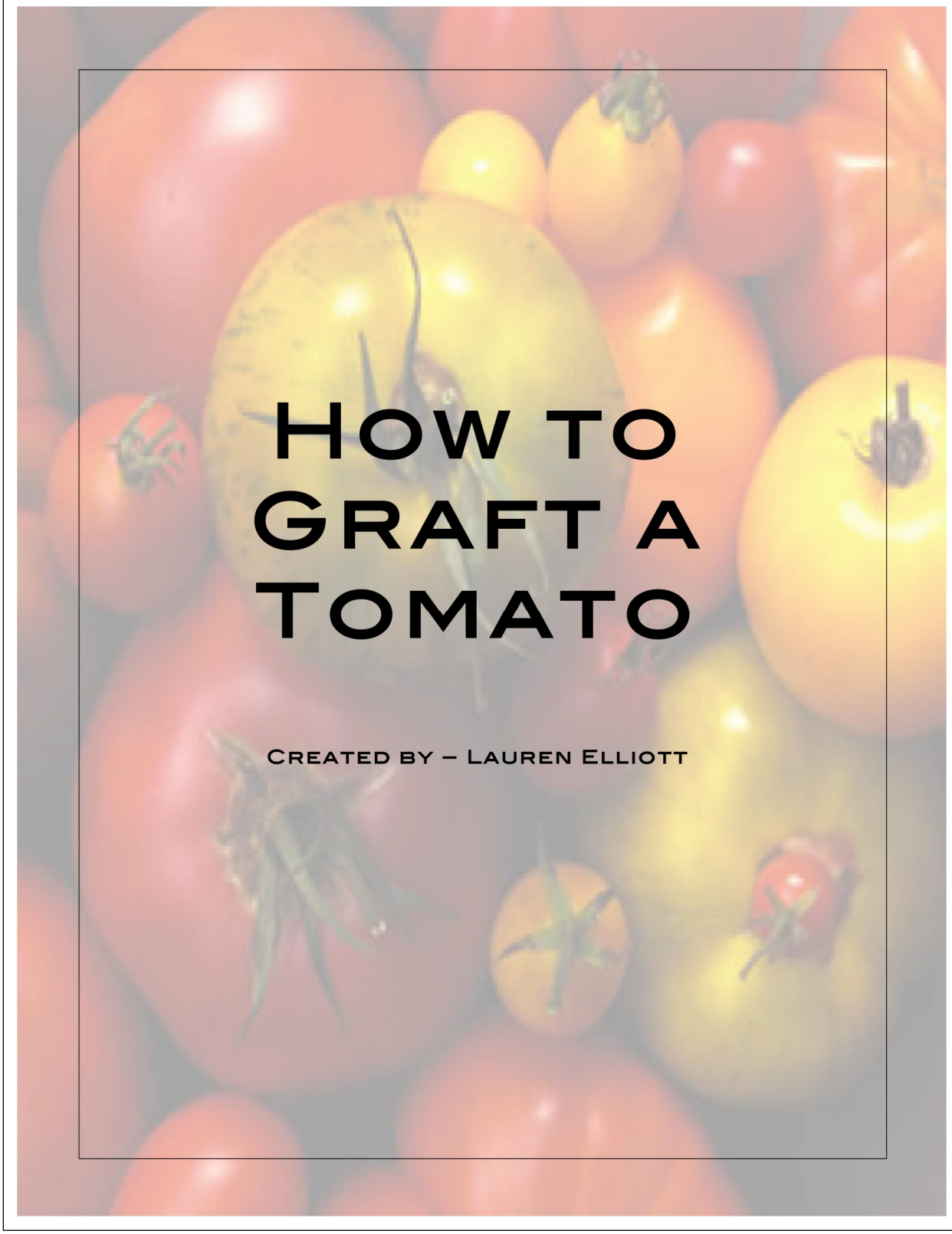
Summary

The goal of this senior project is to create an accessible handbook for implementing grafting of tomatoes as a high school agriculture student's Supervised Agriculture Experience (SAE). The handbook shall be straightforward and at a reading level that the majority of high school students will understand. This handbook will be used to start up a new means of gaining horticultural technique and begin an enterprise project for agriculture students. Overall, this handbook is made to encourage SAE projects in high school agriculture programs.

Chapter Four

Supervised Agricultural Handbook: How to Graft Tomatoes

In the following chapter you will find the Supervised Agricultural Experience handbook dedicated to showing the steps to a successful tomato graft. The handbook outlines ten areas needed in order to graft a tomato. This handbook is intended to be instructional, but also leave room for interpretation in order to insure a positive and challenging learning opportunity.



How to Graft a Tomato

Created by – Lauren Elliott

Introduction

The purpose of this handbook is to provide high school educators and students an instructional handbook on how to graft a tomato. The production of grafted tomatoes could be a successful Supervised Agriculture Experience (SAE) where students develop their horticultural skills to the next level. This could also be a fundraiser for an agriculture program or a profitable entrepreneurship project for a student. The goal of this handbook is to provide an outline of the necessities and steps needed to produce a successful grafted tomato. Within the handbook you will find the following topics covered:

- Significance of grafting
- Materials needed
- Tomato selection
- Substrate
- Facilities
- Preparation
- Step by step instruction on grafting a tomato
- Recovery of tomato
- Tomato care
- Marketing and sales

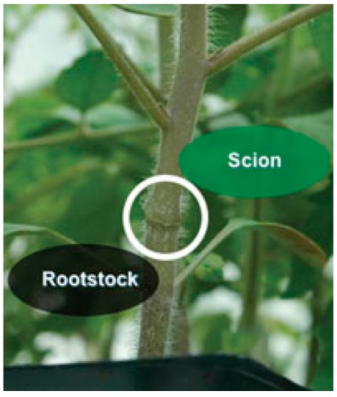
Significance of Grafting

- Grafting of tomatoes is not a new idea, but has been in practice in Asian countries since the early 1900's.
- Tomatoes are grafted in order to control soil-borne diseases.
- Grafting increases vigor by allowing the plant to uptake more nutrients.
- Grafting improves overall plant health when subjected to less than ideal environmental conditions.
- There have been multiple studies done that prove grafting leads to a significantly higher yield.
- Grafting allows the grower to skip over breeding and achieve the desired results in one year.

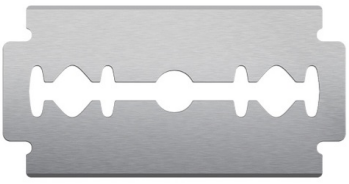
Nongrafted 'Big Beef' vs. grafted 'Big Beef' – Super Naturals Grafting Vegetables, LLC

Materials

1. Tomato scion
    - *Scion – shoot grafted onto another plant.*
2. Tomato rootstock
    - *Rootstock – a plant onto which another variety is grafted.*
3. Double-edged razor blade (recommended), regular razor blade, or grafting knife
4. Grafting clips (recommended) or plastic straws
5. Spray bottle or humidifier
6. Bleach
7. Black nursery production containers
    - Six-pack
    - 1 gallon



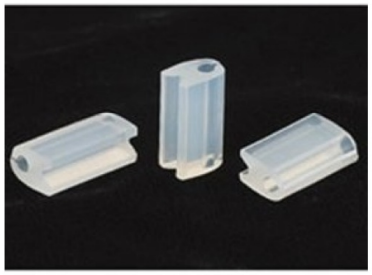
Materials 1 and 2



Double Edged Razor Blade

Materials

Grafting clips



Grating clip tube style

Spray bottle

Bleach

Black nursery containers

5 Photos gathered from Google Images

Tomato Selection

Selecting the scion and rootstock for your project is dependent on the end goal. There are endless options when grafting, the following charts have recommendations of possible scion and rootstocks. The possibilities are endless and are not limited to what's given in this handbook. You can decide on what end product you need through a series of questions like the following:

1. What end product of a grafted tomato do I need?
2. Do I need disease-prone varieties?
    - Do I need this in the rootstock due to soil borne diseases and/or do I need a disease-prone scion?
3. What root structure will benefit most in my growing system?
    - Will it be in the soil or in a confined container?
4. Is there a certain variety of tomato that will sell more over another?

Tomato Selection

Scion Recommendations	
Scion Cultivar Name	**Qualities**
Black Krim	Heirloom. Medium-sized dark colored fruit and rich flavored. Interminate.
Brandywine	Heirloom. Large beefsteak like fruit with sweet flavor. Indeterminate.
San Marzano	Plum shaped fruit, famous for cooking. Indeterminate.
Mortgage Lifter	Heirloom. Huge beefsteak fruit with great taste. Indeterminate.
Yellow Pear	Fruit is yellow and pear shaped with delcious flavor. Indeterminate.

Rootstock Recommendations	
Rootstock Resistances	**Qualities**
C	Cold (Sub-optimum temperature)
TMV	Tobacco Mosaic Virus
V	Verticillium Wilt
F2	Fusarium Wilt (Races 1 & 2)
FOR	Fusarium Crown and Root Rot
PL	Corky Root Rot

7 Descriptions from Burpee.com

Substrate

Ideal tomato substrate depends on the growing system you plan on and on your resources as a grower. For high success rates you want to analyze pH and EC for nutrient availability. The desired pH for tomatoes is in between 6.0 and 6.8. Do not allow EC to go above 2.5 mS/cm. Scouting problems is critical to a healthy crop because it allows problems to be caught before a large percentage of the crop is affected.

Questions to ask when deciding on a substrate:

1. Will I be growing the tomato primarily in a greenhouse or an outdoor growing system?
2. What resources do I currently have that will decrease costs?
3. What is my budget for substrate?

Facilities

Facilities for after the graft is completed can range from simple structures to top of line. The purpose of the facilities is to improve the survival rate of the grafted tomato. Each facility can be customized and designed to work best for your growing system. There are two systems needed for the production of grafted tomatoes, which includes the following:

Hospital chamber

- Needed for 7-9 days after grafting. This chamber cuts down on light, increases humidity and retains moisture needed to reduce the transpiration rate.
- Options:
    1. Small greenhouse structure made from plastic and shade cloth with attached humidifier.
    2. Plastic clear dome that fits snug over the tomato tray with shade cloth on top.
    3. Plastic wrap that is in a location with minimal lighting.

Growing area

- After the graft has been successfully healed the tomato should be moved into a growing system that will support the needed requirements. This can be done in either a greenhouse or in an outdoor growing area.

Facilities



Above are examples of hospital chambers, typically more expensive.


Plastic domes are a less expensive option than a hospital chamber.

10 Photos courtesy of Gathering Together Farms and Lynn Byczynski

Preparation

1. Work space
    - Have cleared off workbench that is sterilized decreasing risk of contamination via pathogens.
2. Sterilization tools
    - Bleach
    - Antibacterial soap
    - Alcohol wipes (optional)
3. Tomato selection
    - From seed – plan accordingly with growth rates to make sure your rootstock and scion have matching stem diameter. This may mean starting one a couple days earlier to give it a head start in germination.
    - From starts – If you buy tomato starts make sure the scion and rootstock have similar stem diameter and that they are not too large making the process more difficult.
    - Do not water the plants the day you plan on grafting!
4. Facilities
    - Make sure hospital chamber is ready to go for right after the graft is completed.

Grafting a Tomato

METHOD ONE – Top Grafting is the method of making a 60-degree cut all the way through and then connecting the scion to the rootstock.

Step One –

- Find appropriate rootstock for your desired grafted tomato.
- Make sure the diameter of the stem is equal to the stem of the scion.

Step Two –

- Use razor blade to cut a 60-degree cut downward through the stem of the rootstock.
- Make sure to not damage the tissues by not having a sharp enough blade or going to fast.

Step Three –

- Place the rootstock to the side while you complete Step Four.

12 Photos courtesy of Johnny's Selected Seeds

Grafting a Tomato

Method One

Step Four –

- Defoliate the scion so there is only one leaf remaining.
- Complete this before or after cutting the scion off of its original rootstock.
- Make sure you have matching angles in order to have rootstock and scion line-up correctly.

Step Five –

- Line up the scion to the desired rootstock.
- Make sure the diameter matches both the scion and rootstock.

Step Six –

- Once matched up hold connection while attaching grafting clip or tube around the graft.
- Make sure there is no air gap in between the scion and rootstock.

13 Photos courtesy of Johnny's Selected Seeds

Grafting a Tomato

Method One

Step Seven –

- Double check everything is lined up correctly and let go of the clip or tube holding it in place.

Step Eight –

- Place tomato back into the container it was previously in, or plant in desired container.

Step Nine –

- Place finished grafted tomato into your hospital chamber.

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Photos courtesy of Johnny's Selected Seeds

Grafting a Tomato

Method Two – Side grafting is the process of connecting the desired scion to the rootstock without separating either the rootstock or the scion from their original stem. This is done to reduce plant stress but is a more intricate process to complete. This process can lead to a higher success rate but will take longer to transition to a sellable product.

Step One –

- Find appropriate rootstock for your desired grafted tomato
- Make sure the diameter of the stem is equal to the stem of the scion

Step Two –

- Defoliate the tomatoes so there are only a couple leaves left.

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Grafting a Tomato

Method Two

Step Three–

- Use your razor blade to make a 45-degree cut downwards on the rootstock making sure to stop half way through the stem.
- Do not cut all the way through!

Step Four –

- Repeat step three for the scion.
- Make sure to line up the cuts prior to cutting to insure they will match.

Grafting a Tomato

Method Two

Step Five –

- Line up the cuts on both the scion and rootstock.
- Connect the two and hold them in place.

Step Six –

- Use a grafting clip or any workable contraption to connect the graft and hold it in place while healing.
- Leave roots and leaves connected on both until the graft heals.
- After the graft heals you can cut the scion and rootstock that's appropriate.

Recovery Stage

The recovery stage is critical for a successful tomato graft. The goal of this stage is to reduce all transpiration stress so that the tomato can focus on healing the graft.

Place the tomatoes into the hospital chamber while meeting the following standards:

- Time Period – 7 – 9 days
- Humidity - at least 95 percent
- Temperature - between 80-85 degrees Fahrenheit
- Lighting – you want to gradually bring up the lighting in order to reduce transpiration and stress on the healing graft unions.
    - Day 1-3 – Full shade
    - Day 3-5 – Partial shade
    - Day 6-9 – 75 percent full sun
- Method Two grafts – once healed you may cut off the unwanted scion and rootstock to complete the desired grafted tomato.

Tomato Care

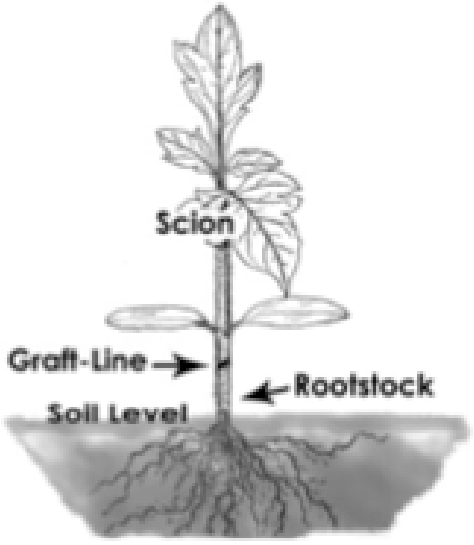
After the tomato has made a successful graft you can begin transitioning it into regular tomato care and allow the tomato to grow at its full rate.

Tomato growing factors:

- Light
  - Keep tomatoes in full sun to promote vegetative and fruit growth.
  - 6 - 8 hours of full sun a day.
- Watering
  - Water regularly – depends on environmental conditions how often watering occurs.
  - Do not allow the tomatoes to dry out completely.
- Fertilization
  - Maintain individually determined fertilization schedule in order to keep needed nutrient levels.
  - Research your tomato varieties nutrient recommendations.
  - Take into account your growing system and how that may affect your nutrient availability and depletion.

Tomato Care

- Transplanting
  - When the tomato is out growing the container it was originally in it is recommended to transplant into a one-gallon container or its final destination.
  - Make sure when planting that the graft union never goes in the ground. If this occurs the scion will form roots which will have negative affects on disease resistance and any other goal being accomplished by grafting.
  - Make sure to prune off any rootstock growth as well because it will also defeat the purpose of grafting.



20 Photo courtesy of Ezra's Organics

Marketing and Sales

Making sure to market your product is critical to having successful sales of the grafted tomatoes. There has been a recent dramatic increase in grafted tomatoes especially among home gardeners. Being able to educate your community about the positive implications of grating will serve you well.

Steps to successful sales:

1. Educate the public
    a. This can be done through social media, your website, newspapers and any other possibility you think of that will allow consumers to see the benefit in buying grated tomatoes.
2. Plan a plant sale
    a. Set a date that the public can come and buy your grafted tomatoes.
3. Advertise
    a. Inform the public about your plant sale or how buy the grafted tomatoes.
    b. Consider pre-sales in order to estimate the tomato sales.

Marketing and Sales

4. Calculate price
    a. Depends on resources costs will vary from grower to grower and year to year so each time a new price will have to be set.
    b. Formulate price by finding your costs and then decide on the mark up you that would still be affordable for your consumers. To high of a price could decrease sales, while you still want to make back your expense.
5. Keep Records
    a. Use records books or some form of accounting log in order to insure you have correct numbers.
    b. Use each year's numbers to give you a better idea how to better prepare the next year.

Additional Resources

Burpee –
http://www.burpee.com/grafted-tomato-plants/garden-ready-grafted-tomato-plants-article10590.html

Byczynski, Lynn –
http://www.growingformarket.com/articles/Grafted-Tomatoes/print

Gathering Together Farm –
http://blog.gatheringtogetherfarm.com/2012/03/15/how-to-graft-tomatoes-gathering-together-farm-method/

Johnny's Selected Seeds –
http://www.johnnyseeds.com/t-tomatografting.aspx

SF Gate –
http://homeguides.sfgate.com/graft-two-different-varieties-tomatoes-same-rootstock-28224.html

Super Naturals Grafted Vegetables, LLC -
http://graftedvegetables.com/wp/?page_id=57

University of Vermont -
http://www.uvm.edu/vtvegandberry/factsheets/graftingGHtomato.html

Chapter Five

Summary, Recommendations and Conclusion

This chapter will serve as the conclusion for the project of creating a handbook on how to graft a tomato. The goal of this handbook was to have a resource students and their educators could use to implement grafting of tomatoes into their agriculture program. This handbook can also be used as a Supervised Agricultural Experience (SAE) guide so that the student can begin an entrepreneurship project. Overall, this handbook should serve as an instructional guide but have room for interpretation by the audience so that each project can be individualized and educational.

Summary

The purpose of this project was to create a Supervised Agricultural Experience (SAE) handbook for students interested in grafting tomatoes. This project could be implemented at an agricultural high school program to further develop student's horticultural skills. This project should be taken under consideration by programs that are looking for more advanced SAE opportunities for horticulture students. Also, this project could be a successful means of fundraising for departments that lack funding. With a never ending decrease in high school funding for agricultural programs there has to be new ideas of fundraising that can help support the programs financially. With the increase popularity of grafted tomatoes students or agriculture programs should be able to sell this product successfully and make a profit if executed well.

Recommendations

The following recommendations should be considered before completing another horticultural related handbook:

1. Plan accordingly time wise before taking on the project.
    - Had this project been done at the right time of year there would have been less references and more original sources done by the author.
2. Create a more detailed handbook that gives the audience a clear definition of how to execute the project.
    - This handbook had the purpose of creating an outline of the basics to grafting a tomato but purposefully left room for interpretation. If the project were done again it may be useful to go into more detail about each topic and give the reader a clear guide to the process.
3. Meet regularly with your senior project advisor.
    - Meeting with your advisor on a consistent basis will keep the project on track. This is important during your last quarter of the project to make sure the project isn't pushed off and done in a fast manner. Always schedule an appointment at each meeting to ensure there will be more completed by the next meeting.
4. Have multiple people read over your project.
    - It would have benefited the handbook if more people had read over and gave their critique. Having multiple perspectives will help alter how the project is conveyed and create a well-rounded finished product.
5. Take each quarter seriously by not leaving all the main editing to the last quarter.

- Making sure to finalize and make all the edits for each chapter during the quarter it is due is pertinent to a successful senior project. Otherwise, the third quarter will come and all of the chapters will have to edited and changed which is time consuming and takes away from the project itself.

Conclusions

This handbook will hopefully serve as an educational resource for high school agricultural educators as well as their students. This should help increase horticulture skills at the high school level and give students an advanced skill before they graduate. Students should gain not only an advanced horticultural skill but also experience in sales, marketing and responsibility that running a project entails. Hopefully the Agricultural Education and Communication Department can use this handbook in the future for agricultural educators seeking fundraising or horticulture project ideas that could benefit their department.

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Appendices

Appendix A – Supervised Agricultural Handbook: How to Graft Tomatoes

How to Graft a Tomato

Created by - Lauren Elliott

Introduction

The purpose of this handbook is to provide high school educators and students an instructional handbook on how to graft a tomato. The production of grafted tomatoes could be a successful Supervised Agriculture Experience (SAE) where students develop their horticultural skills to the next level. This could also be a fundraiser for an agriculture program or a profitable entrepreneurship project for a student. The goal of this handbook is to provide an outline of the necessities and steps needed to produce a successful grafted tomato. Within the handbook you will find the following topics covered:

- Significance of grafting
- Materials needed
- Tomato selection
- Substrate
- Facilities
- Preparation
- Step by step instruction on grafting a tomato
- Recovery of tomato
- Tomato care
- Marketing and sales

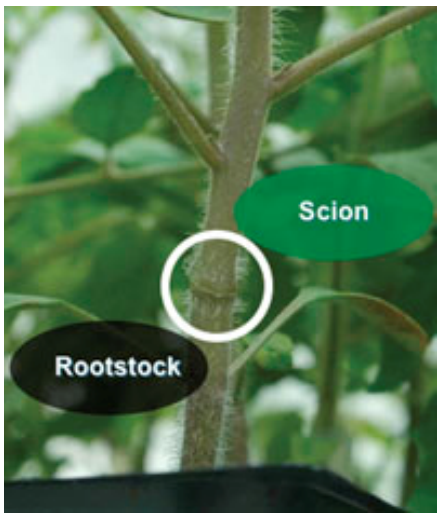
Significance of Grafting

- Grafting of tomatoes is not a new idea, but has been in practice in Asian countries since the early 1900's.
- Tomatoes are grafted in order to control soil-borne diseases.
- Grafting increases vigor by allowing the plant to uptake more nutrients.
- Grafting improves overall plant health when subjected to less than ideal environmental conditions.
- There have been multiple studies done that prove grafting leads to a significantly higher yield.
- Grafting allows the grower to skip over breeding and achieve the desired results in one year.

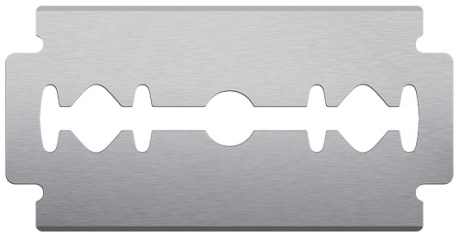
Nongrafted 'Big Beef' vs. grafted 'Big Beef' – Super Naturals Grafting Vegetables, LLC

Materials

1. Tomato scion
    - *Scion – shoot grafted onto another plant.*
2. Tomato rootstock
    - *Rootstock – a plant onto which another variety is grafted.*
3. Double-edged razor blade (recommended), regular razor blade, or grafting knife
4. Grafting clips (recommended) or plastic straws
5. Spray bottle or humidifier
6. Bleach
7. Black nursery production containers
    - Six-pack
    - 1 gallon

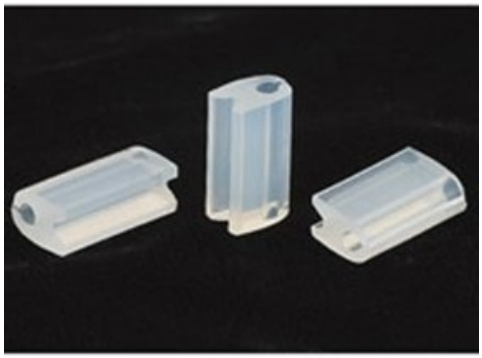


Materials 1 and 2


Double Edged Razor Blade

Materials

Grafting clips



Grating clip tube style

Spray bottle

Bleach

Black nursery containers

Photos gathered from Google Images

Tomato Selection

Selecting the scion and rootstock for your project is dependent on the end goal. There are endless options when grafting, the following charts have recommendations of possible scion and rootstocks. The possibilities are endless and are not limited to what's given in this handbook. You can decide on what end product you need through a series of questions like the following:

1. What end product of a grafted tomato do I need?
2. Do I need disease-prone varieties?
    - Do I need this in the rootstock due to soil borne diseases and/or do I need a disease-prone scion?
3. What root structure will benefit most in my growing system?
    - Will it be in the soil or in a confined container?
4. Is there a certain variety of tomato that will sell more over another?

Tomato Selection

Scion Recommendations	
Scion Cultivar Name	**Qualities**
Black Krim	Heirloom. Medium-sized dark colored fruit and rich flavored. Interminate.
Brandywine	Heirloom. Large beefsteak like fruit with sweet flavor. Indeterminate.
San Marzano	Plum shaped fruit, famous for cooking. Indeterminate.
Mortgage Lifter	Heirloom. Huge beefsteak fruit with great taste. Indeterminate.
Yellow Pear	Fruit is yellow and pear shaped with delcious flavor. Indeterminate.

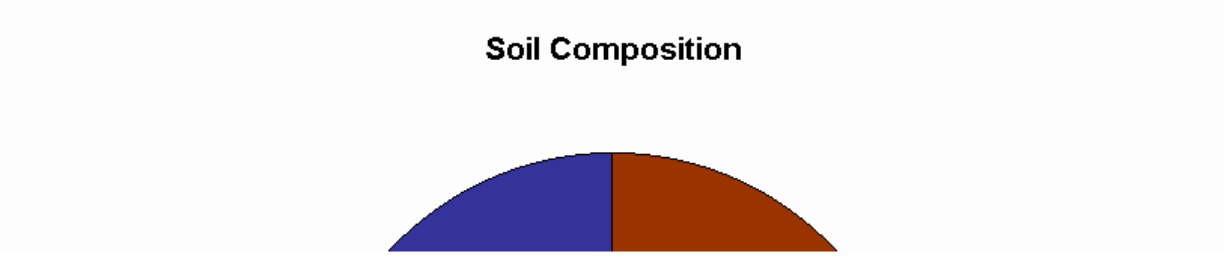
Rootstock Recommendations	
Rootstock Resistances	**Qualities**
C	Cold (Sub-optimum temperature)
TMV	Tobacco Mosaic Virus
V	Verticillium Wilt
F2	Fusarium Wilt (Races 1 & 2)
FOR	Fusarium Crown and Root Rot
PL	Corky Root Rot

Substrate

Ideal tomato substrate depends on the growing system you plan on and on your resources as a grower. For high success rates you want to analyze pH and EC for nutrient availability. The desired pH for tomatoes is in between 6.0 and 6.8. Do not allow EC to go above 2.5 mS/cm. Scouting problems is critical to a healthy crop because it allows problems to be caught before a large percentage of the crop is affected.

Questions to ask when deciding on a substrate:

1. Will I be growing the tomato primarily in a greenhouse or an outdoor growing system?
2. What resources do I currently have that will decrease costs?
3. What is my budget for substrate?



Facilities

Facilities for after the graft is completed can range from simple structures to top of line. The purpose of the facilities is to improve the survival rate of the grafted tomato. Each facility can be customized and designed to work best for your growing system. There are two systems needed for the production of grafted tomatoes, which includes the following:

Hospital chamber

- Needed for 7-9 days after grafting. This chamber cuts down on light, increases humidity and retains moisture needed to reduce the transpiration rate.
- Options:
    1. Small greenhouse structure made from plastic and shade cloth with attached humidifier.
    2. Plastic clear dome that fits snug over the tomato tray with shade cloth on top.
    3. Plastic wrap that is in a location with minimal lighting.

Growing area

- After the graft has been successfully healed the tomato should be moved into a growing system that will support the needed requirements. This can be done in either a greenhouse or in an outdoor growing area.

Facilities



Above are examples of hospital chambers, typically more expensive.


Plastic domes are a less expensive option than a hospital chamber.

Photos courtesy of Gathering Together Farms and Lynn Byczynski

Preparation

1. Work space
    - Have cleared off workbench that is sterilized decreasing risk of contamination via pathogens.
2. Sterilization tools
    - Bleach
    - Antibacterial soap
    - Alcohol wipes (optional)
3. Tomato selection
    - From seed – plan accordingly with growth rates to make sure your rootstock and scion have matching stem diameter. This may mean starting one a couple days earlier to give it a head start in germination.
    - From starts – If you buy tomato starts make sure the scion and rootstock have similar stem diameter and that they are not too large making the process more difficult.
    - Do not water the plants the day you plan on grafting!
4. Facilities
    - Make sure hospital chamber is ready to go for right after the graft is completed.

Grafting a Tomato

METHOD ONE – Top Grafting is the method of making a 60-degree cut all the way through and then connecting the scion to the rootstock.

Step One –

- Find appropriate rootstock for your desired grafted tomato.
- Make sure the diameter of the stem is equal to the stem of the scion.

Step Two –

- Use razor blade to cut a 60-degree cut downward through the stem of the rootstock.
- Make sure to not damage the tissues by not having a sharp enough blade or going to fast.

Step Three –

- Place the rootstock to the side while you complete Step Four.

 Photos courtesy of Johnny's Selected Seeds

Grafting a Tomato

Method One

Step Four –

- Defoliate the scion so there is only one leaf remaining.
- Complete this before or after cutting the scion off of its original rootstock.
- Make sure you have matching angles in order to have rootstock and scion line-up correctly.

Step Five –

- Line up the scion to the desired rootstock.
- Make sure the diameter matches both the scion and rootstock.

Step Six –

- Once matched up hold connection while attaching grafting clip or tube around the graft.
- Make sure there is no air gap in between the scion and rootstock.

Photos courtesy of Johnny's Selected Seeds

Grafting a Tomato

Method One

Step Seven –

- Double check everything is lined up correctly and let go of the clip or tube holding it in place.

Step Eight –

- Place tomato back into the container it was previously in, or plant in desired container.

Step Nine –

- Place finished grafted tomato into your hospital chamber.

Photos courtesy of Johnny's Selected Seeds

Grafting a Tomato

Method Two – Side grafting is the process of connecting the desired scion to the rootstock without separating either the rootstock or the scion from their original stem. This is done to reduce plant stress but is a more intricate process to complete. This process can lead to a higher success rate but will take longer to transition to a sellable product.

Step One –

- Find appropriate rootstock for your desired grafted tomato
- Make sure the diameter of the stem is equal to the stem of the scion

Step Two –

- Defoliate the tomatoes so there are only a couple leaves left.

Grafting a Tomato

Method Two

Step Three–

- Use your razor blade to make a 45-degree cut downwards on the rootstock making sure to stop half way through the stem.

- Do not cut all the way through!

Step Four –

- Repeat step three for the scion.

- Make sure to line up the cuts prior to cutting to insure they will match.

Grafting a Tomato

Method Two

Step Five –

- Line up the cuts on both the scion and rootstock.
- Connect the two and hold them in place.

Step Six –

- Use a grafting clip or any workable contraption to connect the graft and hold it in place while healing.
- Leave roots and leaves connected on both until the graft heals.
- After the graft heals you can cut the scion and rootstock that's appropriate.

Recovery Stage

The recovery stage is critical for a successful tomato graft. The goal of this stage is to reduce all transpiration stress so that the tomato can focus on healing the graft.

Place the tomatoes into the hospital chamber while meeting the following standards:

- Time Period – 7 – 9 days
- Humidity - at least 95 percent
- Temperature - between 80-85 degrees Fahrenheit
- Lighting – you want to gradually bring up the lighting in order to reduce transpiration and stress on the healing graft unions.
    - Day 1-3 – Full shade
    - Day 3-5 – Partial shade
    - Day 6-9 – 75 percent full sun
- Method Two grafts – once healed you may cut off the unwanted scion and rootstock to complete the desired grafted tomato.

Tomato Care

After the tomato has made a successful graft you can begin transitioning it into regular tomato care and allow the tomato to grow at its full rate.

Tomato growing factors:

- Light
    - Keep tomatoes in full sun to promote vegetative and fruit growth.
    - 6 - 8 hours of full sun a day.
- Watering
    - Water regularly – depends on environmental conditions how often watering occurs.
    - Do not allow the tomatoes to dry out completely.
- Fertilization
    - Maintain individually determined fertilization schedule in order to keep needed nutrient levels.
    - Research your tomato varieties nutrient recommendations.
    - Take into account your growing system and how that may affect your nutrient availability and depletion.

Tomato Care

- Transplanting
    - When the tomato is out growing the container it was originally in it is recommended to transplant into a one-gallon container or its final destination.
    - Make sure when planting that the graft union never goes in the ground. If this occurs the scion will form roots which will have negative affects on disease resistance and any other goal being accomplished by grafting.
    - Make sure to prune off any rootstock growth as well because it will also defeat the purpose of grafting.

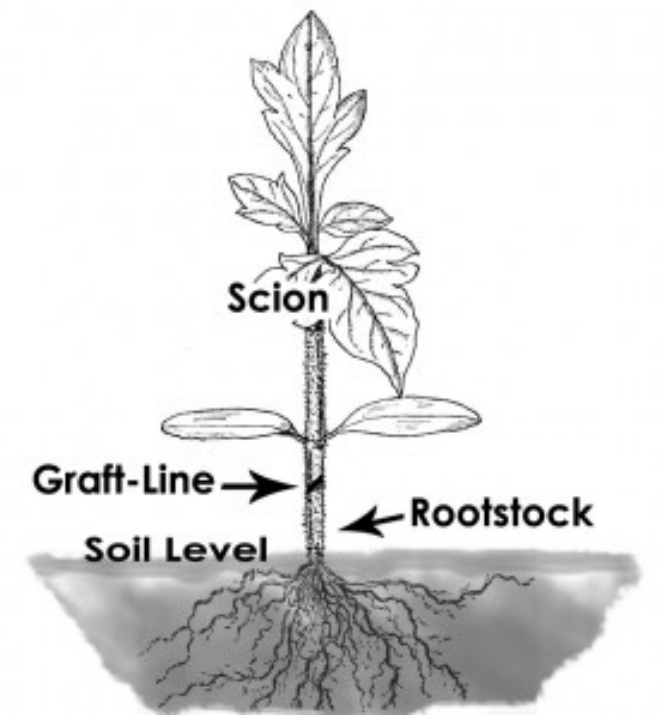


 Photo courtesy of Ezra's Organics

Marketing and Sales

Making sure to market your product is critical to having successful sales of the grafted tomatoes. There has been a recent dramatic increase in grafted tomatoes especially among home gardeners. Being able to educate your community about the positive implications of grating will serve you well.

Steps to successful sales:

1. Educate the public
    a. This can be done through social media, your website, newspapers and any other possibility you think of that will allow consumers to see the benefit in buying grated tomatoes.
2. Plan a plant sale
    a. Set a date that the public can come and buy your grafted tomatoes.
3. Advertise
    a. Inform the public about your plant sale or how buy the grafted tomatoes.
    b. Consider pre-sales in order to estimate the tomato sales.

Marketing and Sales

4. Calculate price
    a. Depends on resources costs will vary from grower to grower and year to year so each time a new price will have to be set.
    b. Formulate price by finding your costs and then decide on the mark up you that would still be affordable for your consumers. To high of a price could decrease sales, while you still want to make back your expense.
5. Keep Records
    a. Use records books or some form of accounting log in order to insure you have correct numbers.
    b. Use each year's numbers to give you a better idea how to better prepare the next year.

Additional Resources

Burpee –
http://www.burpee.com/grafted-tomato-plants/garden-ready-grafted-tomato-plants-article10590.html

Byczynski, Lynn –
http://www.growingformarket.com/articles/Grafted-Tomatoes/print

Ezra's Organics –
http://www.ezrasorganics.com/how-to-grow/how-to-plant-grafted-tomatoes/

Gathering Together Farm –
http://blog.gatheringtogetherfarm.com/2012/03/15/how-to-graft-tomatoes-gathering-together-farm-method/

Johnny's Selected Seeds –
http://www.johnnyseeds.com/t-tomatografting.aspx

SF Gate –
http://homeguides.sfgate.com/graft-two-different-varieties-tomatoes-same-rootstock-28224.html

Super Naturals Grafted Vegetables, LLC -
http://graftedvegetables.com/wp/?page_id=57

University of Vermont -
http://www.uvm.edu/vtvegandberry/factsheets/graftingGHtomato.html