

	<b>Sustainable Agriculture</b>	<b>Unit</b>	<b>Integrated Pest Management</b>
<b>ESSENTIAL STANDARD:</b>	<b>8.00</b>	<b>10%</b>	<b>Pest Management</b>

#### **Suggested Activities 8.00**

1. Pest Identification Cards 8.01.01
2. Pests and Beneficial Organisms in Agriculture 8.02.01
3. IPM Infographic 8.02.02
4. Kahoot.it Integrated Pest Management 8.02.03
5. Insect Diagnosis 8.02.04
6. Tomato Grafting Lab 8.02.05

**Activity 8.01.01**

<b>List one organism per Pest Identification Card. Use index card size of your choice.</b>				
<b>Susceptible Organism</b>	<b>Plants as Toxins</b>	<b>Insects</b>	<b>Diseases</b>	<b>Predators</b>
Livestock	Goat weed	Flies	Rabies	Coyotes
	White snake root	Mosquitoes	Hoof and Mouth	Opossum
	Carolina Jessamine	Ticks	Bluetongue	Hawks
<b>Susceptible Organisms</b>	<b>Weeds</b>	<b>Insects</b>	<b>Diseases</b>	<b>Predators</b>
Greenhouse, Horticulture and Agronomic Plants	Oxallis	Aphid	Damping Off	Moles
	Henbit	Mealybug	Blight	Voles
	Nutsedge	Thrip	Botrytis	Woodchucks
	Pigweed	Spider Mites	Mosaic	Crows
	Kudzu	Japanese Beetles	Smut	Raccoons
	Chickweed	Tomato Horn Worm	Rust	Rabbits
<b>Susceptible Organism</b>	<b>Weeds</b>	<b>Insects</b>	<b>Diseases</b>	<b>Predators</b>
Agroforestry	Microstegium	Wooly Adelgid	Galls	Deer
	Tree of Heaven	Asian Longhorn Beetle	Canker Rot	Woodpeckers
	Smilax	Emerald Ash Borer	Anthracnose	Fox

## Activity 8.01.01

### Pest Identification Cards

Students will create a set of index cards to help them correctly identify and understand these four sets of organisms, including: toxic plants/weeds, insects, diseases, and predators. Each card will have two sides. Side one will have a color picture of the pest. Side two will have the common and the scientific name of the organism in addition to five identifying factors.

The instructor will determine a date to have the Pest Identification Cards finalized, but it is suggested that the cards be completed sometime during the last quarter to ensure that all organisms have been covered in class.

An additional option is to have a weekly set of pests to discuss from the beginning of class and through the semester/year. Much like plant identification, a teacher could offer a weekly pest identification day and have a quiz every so often or have different groups of students teach the pests to the rest of the class (like a jigsaw activity).

Organism Identification Rubric					
	5	4	3	2	1
Picture of Pest	Picture is in color, focused, and documents the organism.	Picture is somewhat focused and documents the organism.	Picture is somewhat focused and does not document the organism well.	Picture is not in color but is focused and documents the organism well.	Picture is not in color and does not document the organism well.
Name of Pest	The Latin name has the Genus capitalized and the species lowercased and it is italicized. The common name is also written. All is correctly spelled.	The Latin and the common name of the organism are correctly spelled but there is italicization lacking or Genus is not capitalized.	The Latin and the common name of the organism or either misspelled or the name is not written in a formal manner.	The Latin and/or the common name is misspelled. The Latin name is not written in a formal manner.	The Latin and/or common name is only partially written.
Factors of Identification	There are five identifying characteristics for each organism.	There are at least four identifying characteristics for each organism.	There are at least three identifying characteristics for each organism.	There are at least two identifying characteristics for each organism.	There is at least one identifying characteristic for each organism.
Professionalism	Index cards are done at grade level and have a quality appearance. There are clean edges and all cards are typed or written in clean ink.	Almost all index cards are done at grade level and have a professional appearance with clean writing.	The index cards are not at grade level. The cards are lacking cleanliness.	The index cards are messy and have a somewhat rough appearance.	The index cards are unclean and little effort has been put forth to make them appear professional.
Totals					
Overall Score (multiply totals by 5)=					

## Activity 8.02.01

## Pests and Beneficial Organisms in Agriculture 8.02

Research five horticultural/forestry/or livestock and poultry pests and beneficial organisms. This could include, but is not limited to: diseases, insects, vermin, and nematodes.

<p>Pest #1</p> <p>Drawing or image of pest:</p>	<p>Who (description of pest):</p> <p>What does this pest do:</p> <p>When does this pest attack (time of year, part of plant's life cycle):</p> <p>Where does this pest attack:</p> <p>Why is this pest a problem?</p> <p>How do you control this pest?</p> <p>Works cited (web site where you found info):</p>
<p>Pest #2</p> <p>Drawing or image of pest:</p>	<p>Who?</p> <p>What?</p> <p>When?</p> <p>Where?</p> <p>Why?</p> <p>How do you control this pest?</p> <p>Works cited (web site where you found info):</p>
<p>Pest #3</p> <p>Drawing or image of pest:</p>	<p>Who?</p> <p>What?</p> <p>When?</p> <p>Where?</p> <p>Why?</p> <p>How do you control this pest?</p> <p>Works cited (web site where you found info):</p>

<p>Pest #4</p> <p>Drawing or image of pest:</p>	<p>Who?</p> <p>What?</p> <p>When?</p> <p>Where?</p> <p>Why?</p> <p>How do you control this pest?</p> <p>Works cited (web site where you found info):</p>
<p>Pest #5</p> <p>Drawing or image of pest:</p>	<p>Who?</p> <p>What?</p> <p>When?</p> <p>Where?</p> <p>Why?</p> <p>How do you control this pest?</p> <p>Works cited (web site where you found info):</p>
<p>Beneficial #1</p> <p>Drawing or image</p>	<p>Who?</p> <p>What does this control?</p> <p>How does this beneficial work?</p> <p>Work cited:</p>
<p>Beneficial #2</p> <p>Drawing or image</p>	<p>Who?</p> <p>What does this control?</p> <p>How does this beneficial work?</p> <p>Work cited:</p>

<p>Beneficial #3</p> <p>Drawing or image</p>	<p>Who?</p> <p>What does this control?</p> <p>How does this beneficial work?</p> <p>Work cited:</p>
<p>Beneficial #4</p> <p>Drawing or image</p>	<p>Who?</p> <p>What does this control?</p> <p>How does this beneficial work?</p> <p>Work cited:</p>
<p>Beneficial #5</p> <p>Drawing or image</p>	<p>Who?</p> <p>What does this control?</p> <p>How does this beneficial work?</p> <p>Work cited:</p>

Capture an image of one beneficial and one pest to your agricultural education program at your school. Teachers can use your school's grounds, greenhouses, gardens, barns, cafeterias or anywhere that there is a probability you can catch one of these on film. Show the images to your instructor. He or she will sign off that you caught them on camera.

Pest identification:		
Location:		
Teacher's signature:		

**Activity 8.02.02**

## **IPM Infographic**

### Activity 8.02.03

## Kahoot.it Integrated Pest Management 8.02

If you are trying to get more technology savvy, then this is the easiest way to get students to use their phones for a great purpose. This is an interactive trivia game. Just follow these simple directions and your class will be off to the races.

1. Create a Kahoot. Go to: <https://create.kahoot.it/#login>
2. At the top, click on public.
3. In the Search box, type "Integrated Pest Management 8.02."
4. Click "duplicate" on the one authored by jriedelwcpss.
5. This will now show up under the Me button.
6. Click play.
7. Click launch.
8. Have everyone use their phone, a computer, tablet or anything that has wifi or internet connection. Have students go to kahoot.it and type in the game-pin.
9. When all of your students show up on the game board, click "Start now."
10. You could play this on a LCD projector that would show the board, however, all students will see the same screen on their device.
11. The students will be awarded points based on the speed and accuracy of their answers.

## Activity 8.02.04

### Insect Diagnosis



You are a team of plant diagnosticians, specifically you are entomologists (insect scientists). You are employed by the North Carolina State University Plant Disease and Insect Clinic in Raleigh, NC. At your workplace, homeowner, plant growers, businesses, schools and others are welcome to submit samples of disease or insect infested plants for diagnosis. Your job is to look at the samples, determine what the pest is, and then describe how to treat or prevent the pest.

Today, you have been sent these samples from a high school. You and your team of entomologists must work together using a variety of informational sources to help you determine what your pest is and how you treat it.

1. Look at the sample submission sheet your old high school submitted along with their sample. Read the background information on this plant and some of the symptoms they are noticing.
2. Now, as a team begin determining what your pest is by using the following web site or use some of the books on the resource cart.  
<http://www.ipm.ucdavis.edu/PMG/GARDEN/flowermenu.html>
3. You and your group will now need to fill out your form. Here you will determine the correct identity of your insect and each of you will initial that you agree this is the correctly identified insect. Additionally, you will need to give two reasons why you believe this is the correct insect.
4. Your high school has requested some information about the life cycle and mouth part. Please fill in the information accordingly.
5. Now that you have determined the insect, how can you treat and control this pest without using chemicals. You should give the high school some ideas about organic methods of pest control. For your pest, find five organic methods of control. You will need to search the internet or use one of the manuals on the resource cart. Use your diagnosis page to fill in the required information about the organic pest controls for the high school.
6. Maybe these methods won't work, you will need to use the North Carolina Agricultural Chemicals Manual to determine one appropriate chemical control for this insect. Go to the following website to help you find two appropriate chemicals. Use your diagnosis page to fill in the required information about the chemicals for the high school to use.

<http://ipm.ncsu.edu/Agchem/agchem.html>

Client Information	Name:
	Address:
	City, State, and Zip Code:
	Phone Number:
	Contact Person:

Name of plant that is infested	
Symptoms	
Pest identification	
Image or drawing of pest found	
Characteristics of identified pest	<ol style="list-style-type: none"> <li>1.</li> <li>2.</li> </ol>
Insect's life cycle	
Insect's mouthpart	
Part of the insect's life cycle when it is a pest	
Entomologists' initials	

Chemical that can be used to control this pest	
Section of the NC Agricultural Chemical Manual	
Page Numbers where each chemical was found	
Recommendations	
What are two regulations associated with the chemical label?	<ol style="list-style-type: none"> <li>1.</li> <li>2.</li> </ol>

Name of organic control or other treatment recommended	Description of control method	How to implement method of control or treatment

**Activity 8.02.05**

**Tomato Grafting Lab**

**Materials**

- Tomato seeds for rootstocks and scions
- Soilless potting media
- Growing containers
- Mist nozzle
- Razor blades
- Silicon grafting clips (1.5-2.0 mm)
- Healing Chamber supplies

## **Introduction**

Heirloom vegetables are old, open-pollinated cultivars that have often been passed down within families from generation to generation. Heirlooms tend to be cherished for their superior taste and offer a connection to a gardening heritage. Gardeners would often select plants that thrived in local conditions and suited individual tastes. Heirlooms tend to keep their true-to-type characteristics year after year and allow gardener's to conserve money by collecting seed and saving it for next year. Heirlooms contribute to the genetic diversity of a particular crop, enabling a wider array of breeding possibilities.

Hybrid tomatoes have been selected by breeders to offer numerous benefits to gardeners including increased yield, disease and pest resistance. For the home gardener, choosing tomatoes with disease and pest resistance can reduce and eliminate the need for chemical treatments of pesticides. Commercial growers benefit from hybrids developed for uniformity in size, shape and ripening as well as durability in shipping. Flavor and texture, however, can be lost in this transaction as evidenced by tasteless supermarket tomatoes.

Tomatoes are one of the most popular heirloom vegetables. Compared to their supermarket cousins, heirloom tomatoes tantalize with scrumptious taste characteristics. Heirloom tomatoes offer a high-quality marketable fruit that can be a profitable niche for growers, but they are often susceptible to disease. Grafting an heirloom tomato onto a hybrid bred for soil borne disease resistance brings together the desirable taste traits of heirlooms with the enhanced vigor of hybrids.

### *Grafting: Old Technology with Modern Application*

Tomatoes are plagued with all sorts of nefarious pests and diseases. Among the most virulent and destructive are bacterial wilt, fusarium wilt, root knot nematodes, and tomato mosaic virus. A hybrid cultivar developed with tolerance to soil borne diseases is selected to use as the rootstock – or the bottom portion of the graft with the roots and stem. The heirloom with the desirable taste qualities serves as the scion – or top portion of the

graft with the stem and leaves. Rootstock selection can also produce grafted plants that are tolerant of environmental stressors that can reduce yields. Rootstocks might confer salt-tolerance or soil temperature extremes, extending the growing season on either end. Some rootstock varieties can increase productivity by increasing water and nutrient uptake in grafted plants.

## **Background Information for Teachers**

### Tomato Grafting

#### *Choosing scion and rootstock cultivars*

Any **cultivar** (specific tomato varieties bred with unique traits) can be used to produce scions for grafting. Finding the right type of tomato for your taste bud desires can be easily achieved by researching seed catalogs. There are thousands of seed cultivars. Some historic favorites are ‘Early Girl’ because of the first fruit, ‘Beefsteak’ because of the large steak-like slices, and ‘Sweet Grape’ because of the extra sugary cherry sized tomatoes. Popular heirloom choices include German Johnson, Cherokee Purple and Brandywine. Search through the catalogs and find some seeds and just give it a try until you find your favorite

Select the rootstock based on its potential for resisting soil borne diseases in your garden. To choose the right rootstock, identify persistent problems in your garden. Bacterial wilt, verticillium wilt and root knot nematodes are the most common issues that arise from the soil. Work with your local extension agent to diagnose problems or if you are unsure, try a couple of rootstocks and evaluate their performance throughout the growing season. Research offerings by different seed companies and select cultivars that provide soil borne disease resistance.

#### *Sowing the Seeds*

When sowing the scion and rootstock seeds, begin with a sterile, lightweight soilless potting mix. The potting media should consist primarily of peat moss and vermiculite or perlite and allows for sufficient moisture retention, good drainage, is free of disease organisms and weed seeds and resists compaction. Pre-moisten the potting mix by filling a large bucket with the media and mixing enough water so the soilless mix is moist, and not too saturated or too dry. Fill a pot with the moistened potting media and label each pot with the cultivar name. Evenly sprinkle your seeds on top of the soil, and then lightly cover with the potting media. Tomato seeds prefer to germinate in warm, humid environments. The seeds should be grown under a plastic grow dome, within a plastic covered germination chamber or even a clear plastic bag. Once the tomato seedlings have germinated and developed their dicotyledonous leaves, they can be transplanted into individual containers, preferably into small pots (2”) or plastic cell trays.

Plant a few test seeds of the rootstock and scion cultivars to determine the germination period for each and if needed, stagger the planting times to adjust for the difference. If either the rootstock or scion seedlings are



exhibiting faster growth, manage the growing conditions by decreasing the temperature, limiting nutrient application to help

slow seedling development. Once the tomato seeds are sown, they will take 2-3 weeks to germinate and reach a suitable size for transplanting.

Once transplanted, another 2 weeks or so are needed for the seedling to develop 2-4 pairs of true leaves and a stem diameter of 1.5-2.0 mm.

### **Make the Graft:**

To make a successful graft, the rootstock and scion stems need to be a similar size, allowing the vascular tissue to align and grow together enabling water and nutrient uptake. To prepare for grafting, create a sanitary environment to limit the graft wounds exposure to pathogenic bacteria, fungus and virus. Grafting should occur indoors or in a shaded environment to limit water stress in the plants. To make a rootstock graft, gently hold the top half of the seedling and using a sterile razor blade, make a 45-degree cut on the stem above the cotyledon. On the scion seedling, find a spot on the stem that has a similar diameter of the rootstock and make the same 45-degree cut. Attach the rootstock to the scion with a rubber or silicon clip. After the tomatoes have been grafted, they should be immediately placed in the healing chamber to encourage the formation of callus tissue and reconnect the vascular bundles to provide a pathway for water and nutrients.

### **Healing Chamber**

The healing chamber provides an environment of high humidity and low light to reduce water loss and subsequent wilting from the grafted plants. Some signs of wilting, particularly on the first day is typical as the graft union heals. Within 2-4 days, unsuccessful grafts will wilt permanently, while successful grafts will exhibit normal turgor levels. Once the grafts have taken, moderate light can be slowly introduced. This can be done using a shade cloth or fabric that allows only indirect light to reach the grafts. Humidity can be slowly decreased once the grafted plants have shown no signs of stress from exposure to light. Easing misting or marginally lifting the sides of the healing chamber can reduce humidity levels, hardening off the grafted seedlings. Any physical disturbance to the plants may damage the graft union. Avoid overhead watering or any action that could separate the scion from the rootstock.

### *PVC Frame and Plastic*

-pvc scrap, pvc elbow joints, cool air humidifier

(see NCSU Tomato Grafting publication for more



Information about construction)

### *Plastic Grow Domes*

An inexpensive and easy healing chamber uses a high plastic dome that fits over a standard plastic growing flat. The grafted tomatoes should fit easily under a 7" dome lid (see resources section for specific product information). Cover the dome with black plastic to eliminate any light penetration to the grafts. Gently mist inside the dome to increase the humidity levels. Open the healing chamber twice a day for gas exchange. Mist regularly.



These tomatoes were grafted seven days before and left in complete darkness with nearly 100% humidity. This can be done by misting under a humidity dome or by creating a plastic grow chamber that has a cool-mist humidifier.

Eventually the plastic clips will fall off after the union between the scion and rootstock forms (cambium aligns).



Union forming where scion and rootstock meet. Graft was a success.

### **Growing the Tomato Transplants**

The grafting clip will eventually fall off as the grafted seedlings grow and develop and the stem expands. The seedlings can then be grown and managed like nongrafted tomato transplants. When planting the grafted plants into the garden, ensure the graft union remains well above the soil line. Any adventitious roots that might develop from the scion material makes the entire plant susceptible to the soil borne disease. Remove any suckers or branches that form below the graft union. Suckers will rob the fruiting branches of water and nutrients, diminishing fruit number and size.



The union of this tomato graft (just below the blue tape) must remain above the soil. If any of the suckers or adventitious roots from the scion reaches the ground, the purpose of the graft will then be void.

Remove all suckers.

Planting under plastic or another geotextile with a drip tube is an excellent way to grow tomatoes sustainably.

This will:

- Reduce water consumption and evaporation
- Reduce weeds
- Moderate soil temperatures
- Reduce soil borne disease from tomato leaves coming into direct contact with the soil

### **Entrepreneurial Exercise:**

Besides getting the satisfaction of growing that perfect fruit, why not try making a few bucks in the process? People are always willing to fork over a couple of bucks for a delicious homegrown mater. Students can easily earn money for their cultivation efforts.

1. Have a plant sale- Sell hanging basket tomatoes, unique heirloom or disease resistant varieties, or best yet: sell those grafted heirloom and disease resistant tomatoes. Wakefield High School students in Raleigh, NC have an annual plant sale in early April. They sell over 60 varieties of tomatoes in sizes from small cells, 10" hanging baskets, and 1 gallon pots. Consumers love to buy plants with flowers and fruit. It will be no time until they are ripe with fruit and ready to be eaten. Wakefield students also sold the grafted tomatoes for

some serious cash. Consumers are willing to pay more for the plants, once they have been educated about what they are and how they work.

2. Sell your tomatoes to local greenhouses and nurseries. Many nurseries want to have tomatoes and unique varieties of tomatoes, especially something as unique as a grafted tomato, available for customers throughout the entire growing season. People can plant tomatoes until just weeks before the last frost for plants with quick maturity. This is an easy plant to grow for greenhouses in the classroom, grow lab, or the greenhouse.
3. Farmer's markets are a fabulous outlet for students to market plants. Not only will students offer a unique niche of tomatoes but they will also get the opportunity to work with the community and further educate them about the cultivation of tomatoes and the art of grafting. People at farmer's markets are there to learn. They want to know how the plants and commodities were grown, what are the inputs, and how is this plant unique. Not only can students sell the plants, but they can also sell the fruits of their labor- the ripest, most delicious tomato.

## Activity 8.02.05

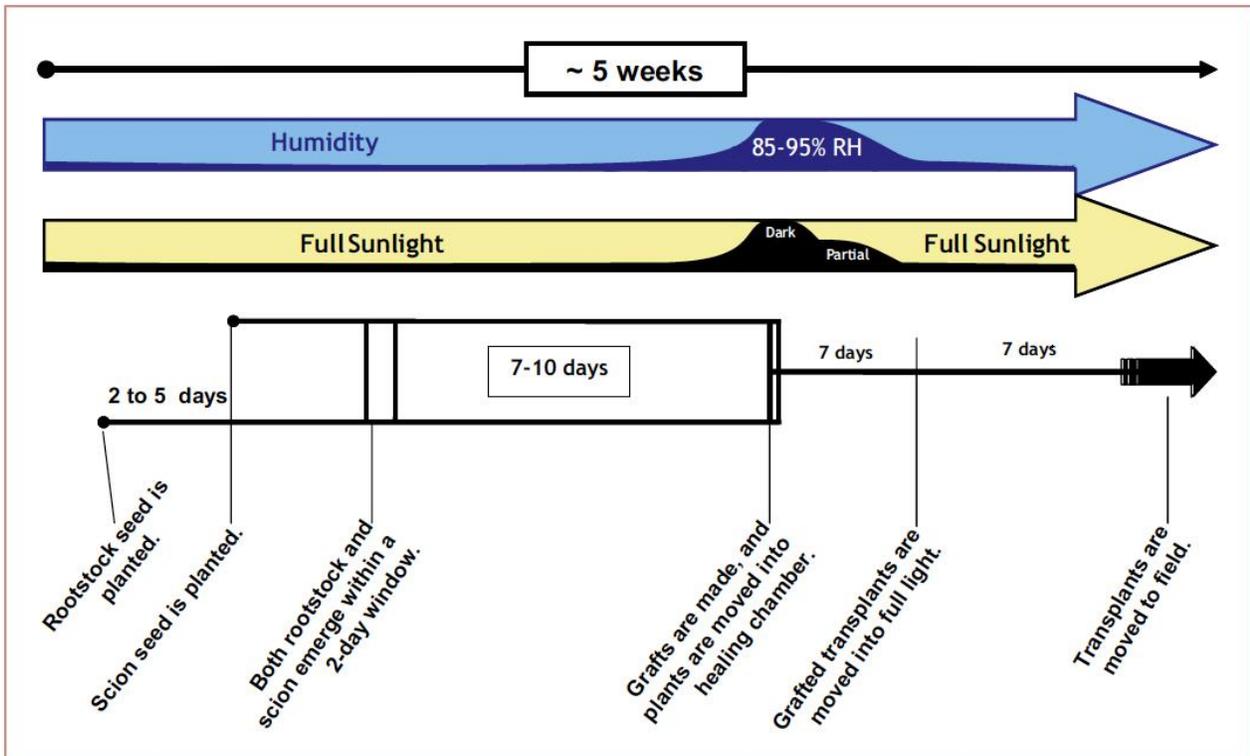
Name:

### Student Tomato Grafting Protocol

Follow the grafting instructions to learn how to successfully graft tomatoes.

1. Pre-moisten potting media by adding small amounts of water to the soil until evenly moistened, making sure the media is not too wet or too dry.
2. Fill a shallow pot or tray with the moistened potting soil and insert a label with the tomato cultivar written clearly on it.
3. Make a crease in the flap of the seed envelope. Sow the seeds by gently tapping on the seed packet and evenly dispersing them onto the soil.
4. Lightly cover the seeds with  $\frac{1}{4}$ " of potting media and water using a mist nozzle.
5. Cover the seeds with a plastic germination dome or place in a high humidity environment with high light.
6. Transplant seedlings in 2-3 weeks, when they have fully formed two dicotyledonous leaves.
7. To transplant, loosen the soil underneath the seedlings and scoop out. Peel away a seedling by grasping one of the leaves and gently tugging it free.
8. Transplant seedlings into small pots or plastic cell trays filled with pre-moistened potting soil. Make a hole in the media with your finger or a pencil and tuck the tomato seedling into the hole, gently tucking soil around the seedling.
9. Continue to grow transplants until they develop 2-4 pairs of true leaves and have a stem diameter of 1.5 – 2.0mm
10. To make the graft, begin by finding a rootstock and scion seedling that have stems of similar diameters. On the rootstock, make a 45-degree cut above the cotyledon, severing the top half from the bottom half. Discard the rootstock's top half.
11. On the scion material, find a space on the stem that has a similarly sized diameter and make a 45-degree cut similar to that of the rootstocks.
12. Attach the scion to the rootstock using a rubber or silicon grafting clip.
13. Place graft into the healing chamber immediately to limit water loss.
14. Keep humidity levels high and light levels low while the graft heals for 2-4 days.
15. After the grafts have healed and show few signs of wilting, slowly introduce indirect light over the next week.
16. If the grafts continue to show little signs of stress from the increasing light levels, slowly decrease the humidity to surrounding ambient levels.
17. After the grafts have successfully acclimated, continue to limit any physical disturbance that might damage the developing graft union. Avoid overhead watering or jostling the seedlings.
18. Once the grafting clips have fallen off, the transplants can be planted into the garden. Plant the transplants so that the graft union remains well above the soil line.
19. Water and provide nutrients to develop a delicious tomato!

## Tomato Graft Timeline



Publications for additional reading or handouts:

Search “NCSU Tomato Grafting”

### Extension Activity

Consider having the students create a calendar along with details for other students to replicate their work.

Additionally, students could create a time lapsed video or just a simple video that chronicles their tomato grafting.

Tweet it out: write a daily tweet or an Instagram to show what is happening with their tomato grafting project. This will act as a journal. Tweets must be no more than 140 characters, so they will have to really think about what needs to be said and communicate that with their tweet and image.