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**4-H AG  
INNOVATORS  
EXPERIENCE**  
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# Healthy Soils C.S.I. Challenge



**NATIONAL 4-H  
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**THE OHIO STATE UNIVERSITY**  
COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES



## Teen Facilitator Guide



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# Healthy Soils C.S.I. Challenge

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*“A nation that destroys its soil destroys itself.”*

Franklin D. Roosevelt



# Welcome to



## Healthy Soils C.S.I. Challenge

The *4-H Ag Innovators Healthy Soils C.S.I. (Carbon Soil Investigation) Challenge* focuses on a critical natural resource – soil – and the need to be good stewards of the land. “Soil” doesn’t just mean “dirt.” It is a mixture of minerals like rocks and clay, organic material like dead leaves, living organisms like worms, microbes, and insects, and even air and water. There is an entire world beneath your feet!

Soil quality is important because it helps to sustain an ecosystem responsible for our food and fiber needs, environmental quality, and human health.

The *Healthy Soils C.S.I. Challenge* is an ideal activity for 3rd to 8th grade youth at summer camps, childcare settings, festivals and fairs, and library reading programs. As a Teen Facilitator for this activity, you will help youth learn that:

- Healthy soils are essential for a sustainable future.
- Modern agricultural practices can build and hold carbon in the soil, which improves soil health..
- Scientific research, engineering, and technological developments and farmers are and will continue to be the answer to solving real-world issues like climate change.
- Soil quality is important in helping sustain an ecosystem responsible for our food and fiber needs.
- Transitioning more acres from conventional tillage systems to no-till systems would make a big difference in building soil health.



# Background

Approximately 400 million acres of land in the U.S. are used to grow the food we eat. Even though that sounds like a lot, it's actually less than 20% of the 2.3 billion total U.S. acreage. Farmers know that healthy soil is important for crop production. Soil health (quality) is the ability of a soil to perform various functions such as supporting plant growth and biological diversity, regulating and filtering water flow, and providing an environmental buffer against hazardous compounds.

An acre of healthy soil can contain up to 900 pounds of earthworms, 2,400 pounds of fungi (mushrooms and similar organisms), 1,500 pounds of bacteria, and 890 pounds of arthropods (insects) and algae.

In the past, farmers mostly plowed their fields to prepare the ground and plant seeds. However, tilling uses fossil fuels. It also breaks apart glomalin (soil protein from fungus), a kind of organic "glue" that holds healthy soil together. Tilling disrupts the soil, which causes carbon to release into the air.

Today, more and more farmers use conservation tillage and no-till methods on their acres to prepare a seed bed, kill weeds, incorporate nutrients, and manage crop residues. No-till systems disrupt the soil very little, except to plant crops. No-till farming allows the creation of glomalin, creating spaces for carbon and water to collect, thereby adding to soil health and reducing water runoff. Both soil health and carbon sequestration (the storage of carbon dioxide from the air to the ground) improve with no-till practices because they improve soil structure and biological activity.

About half of the land used to grow the major crops in the U.S. (like corn, wheat, soybeans, and cotton) employs no-till or conservation tillage methods.



Due to past farming methods, the world's cultivated soils have lost 50% to 70% of their original carbon stock. You're probably asking, SO WHAT? Organic carbon in soil is the basis for its fertility. Carbon in the soil releases nutrients for plant growth, promotes biological and physical health of soil, and is a buffer against erosion. Transitioning more acres from conventional tillage systems to no-till and conservation tillage systems can help build soil carbon. More carbon in the soil reduces carbon dioxide in the air, boosts crop yields, and increases resilience to floods and drought. This is called "carbon sequestration."

Keeping soil healthy for today and the future means using best practices, enhancing the soil we have, controlling carbon release into the air, and controlling soil loss through erosion. This can be done through no-till and conservation tillage planting, proper fertilization, and growing cover crops or re-foresting marginal farmland.

# The Importance of Soil Conservation

## The Human Advantage

Humans have a huge advantage over all life on Earth — the ability to grow food. Every other lifeform spends most of their day hunting for and gathering nourishment. Today, billions are sustained by what farmers grow. When it comes to survival, growing food is clearly an asset. However, this advantage is fragile.

## Nutrient-Rich Soil vs. Infertile Dirt

Just like the air we breathe or the water we drink, soil needs to be protected. The dirt on a baseball field and the soil in your garden may look similar—but they're worlds apart. Soil is complicated. It comes in many forms, from many places with a variety of names. Infertile dirt is everywhere and easy to find while the lively, nutrient-rich soil that grows our food is rare and precious.

### Soil Feeds

Healthy soils = higher yields, more efficiencies, and better outcomes.

### Soil Cleans

Healthy soil can help keep the environment cleaner.

### Soil Protects

When properly managed, soil can protect plants from harm and help them grow vigorously.

### Soil Provides

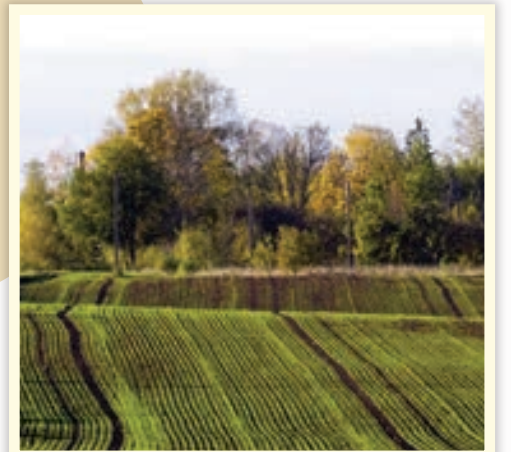
Plants absorb carbon and soil stores it, providing a nutrient-rich environment in which to grow our food.

## Soil Unlocks Human Potential

Since the dawn of agriculture, food has become more accessible to more people. This is largely due to soil. Fertile soil leads to better harvests, which helps meet our most basic needs. Those living in countries with healthy soil are then free to think, invent, create, and imagine new possibilities. When humans are properly nourished, they can do amazing things.

## Restoring Soil

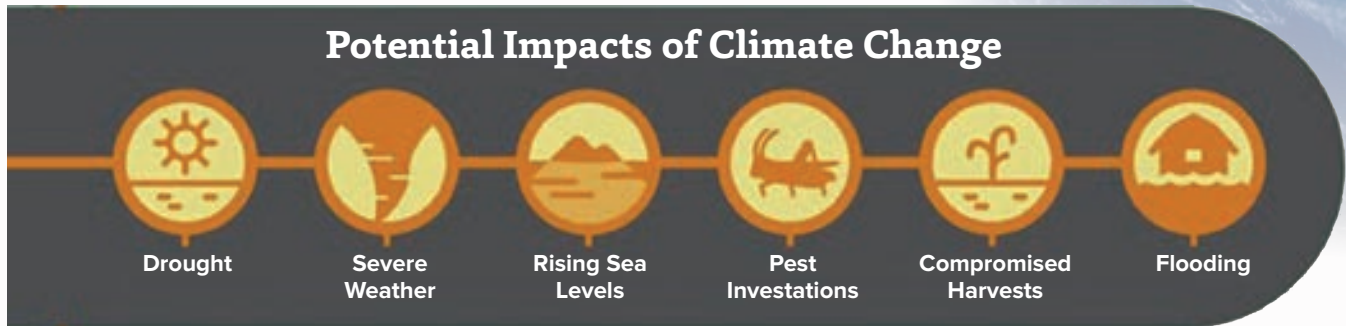
The more active and vibrant the soil, the more alive and nutritious the food. We must invest in soil conservation not just for farmers and people, but for all life on Earth. Less than 3% of all land on earth has fertile, nutrient-rich soil. We seek to share, collaborate, and innovate new ways of protecting and restoring this natural resource.



# Feeding a Growing Population in a Changing Climate

**Climate change** is caused by high levels of **greenhouse gases** accumulating in the atmosphere.

- **Climate Change** refers to significant, long-lasting changes in temperature, precipitation, wind patterns, and other measures of climate.
- **Greenhouse Gases**, like carbon dioxide, methane, and nitrous oxide are emitted, in part, through human activities like burning fossil fuels.



## How We Grow Our Food Helps Tip The Scale: Carbon-Neutral Crops

Great strides have been made to reduce the intensity of agriculture’s carbon footprint. Still, agriculture accounts for approximately 13% of global greenhouse gas emissions. To sustainably feed more than 9 billion people by 2050 while reducing emissions, we must work collectively to do even more.

That’s where **carbon-neutral crop production** comes in. With the right products and practices, some crop production systems have the potential to absorb and store as much or more greenhouse gases than are emitted from the practices used to produce them. It means that farmers have been and will continue to be a positive force in the fight against climate change.



## The dynamic duo of carbon-neutral crop production:

*Plants absorb carbon and soil stores it.*

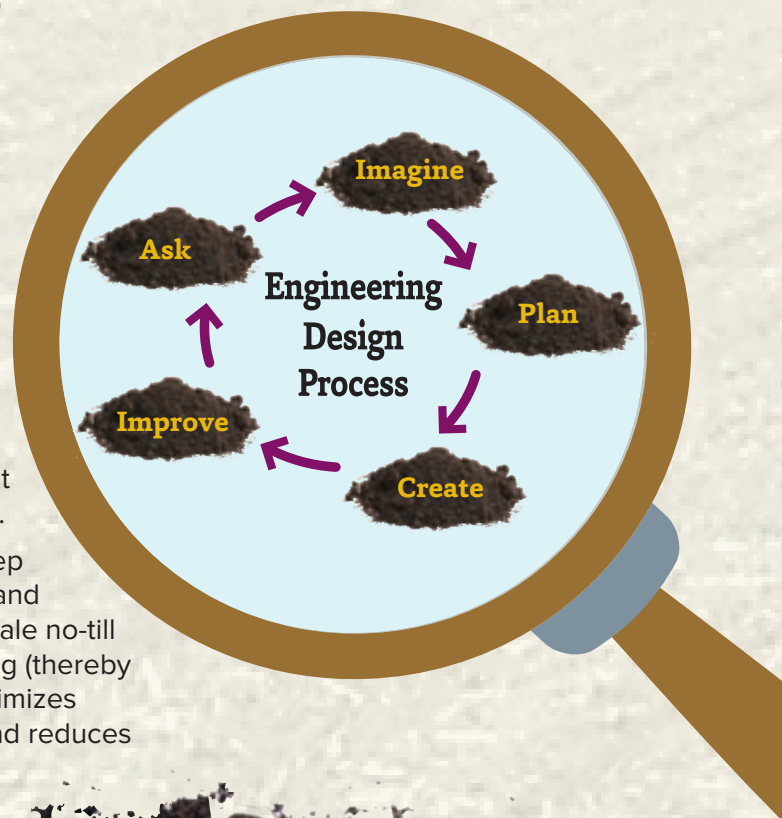


# Activity Preparation and Facilitation

The *Healthy Soils C.S.I. Challenge* is a two-part activity that engages youth in exploring soil health through STEM.

In **Part 1** of the Challenge, youth work in teams as Soil Sleuths to discover what healthy soil looks like. Using the materials provided, youth conduct the prescribed tests (pages 12 & 13 - Slake Test, Chemical Test, and Visual Inspection) to determine if their soil sample is "guilty" of poor health. Once they reach a conclusion, teams recycle their soil sample in potting containers, plant their seeds, and make the containers ready to take home.

In **Part 2**, the Soil Sleuths engineer a C.S.I. solution to keep good soils from going bad. Using a micro-robot platform and selected materials, teams design, build, and test a 1:64 scale no-till planter that disrupts the least amount of soil when planting (thereby reducing the release of carbon into the atmosphere), minimizes equipment drag (which reduces the use of fossil fuels), and reduces soil compacting.



As the Facilitator for this activity, you will help youth learn:

- Soil is not just dirt or "dead soil", but a rich ecosystem filled with living and non-living matter.
- Healthy soil supports plant growth, microbial activity, protects water resources, and improves the environment.
- Physical, biological, and chemical tests enable soil scientists to evaluate overall soil health.
- Conservation tillage and no-till systems help improve soil health.
- Minimizing soil disturbance during planting is critical to maintaining a rich soil ecosystem that can clean the water we drink, protect the air we breathe, and produce the food we eat.
- Solutions can be developed to increase energy efficiency and enhance performance. That decreases production costs, increases productivity, and minimizes environmental impact.
- Agriculture engineers use creativity, innovation, teamwork, and communication to solve real-world problems.
- Youth can tap into their own creativity to solve problems and learn from other's solutions.
- Understanding climate change and the release of carbon into the atmosphere is everyone's responsibility.



# Preparing for the Activity (1 hour)

## Step 1.

### Familiarize yourself with the challenge

- Watch the *4-H Healthy Soils C.S.I. Challenge* video:  
<http://4-h.org/professionals/marketing-resources/ag-innovators-experience/>
- Review the contents of the *4-H Healthy Soils C.S.I. Challenge* kit as well as the other items needed for the activity that are not included in the kit. (see materials list on page 9 & 10)
- Read through this Facilitator Guide, thinking about how you will facilitate Parts 1 & 2 of the challenge.
- Plan how you will gather all the necessary items for the activity including copies of the Soil Sleuth Discovery Worksheets (pages 12-15), consumables, equipment, and cleanup supplies.

## Step 2.

### Organize materials and set up the room

- Sort contents of the *4-H Healthy Soils C.S.I. Challenge* kit into the specified quantities for each team.
- Set out the necessary materials that are not included in the kit. Get a broom and dustpan to clean up spilled materials after the activity.
- Make sure each team has a flat workspace, large enough to accommodate the various soil tests and potting activity.
- Think about the needs of younger participants. They may need additional guidance to complete the challenges, especially Part 2, the No-Till Planter Challenge.



# Facilitating the Activity

(60 minutes)

## Step 1. Set the Stage

Set the Stage for the activity by sharing the 4-H Healthy Soils C.S.I. Challenge video.

## Step 2. State the Problem and Challenge

### The Problem

Hard Acre Farm is having trouble with its corn and soybean yields. For the past several years, yields have steadily declined and more of the topsoil is eroding after heavy rain. And yet, corn and soybean harvests from the neighboring Blue Ribbon Farm continue to remain high thanks to no-till planting and soil conservation methods. It's suspected that 30 years of continuous tilling at Hard Acre Farm has contributed to its problem and jeopardized soil health. Recently a soil sample arrived at the lab unlabeled. It's suspected the sample came from one of these two farms. Become a C.S.I. Soil Sleuth and solve the mystery.

### The Challenge

In **Part 1** of the challenge, youth work in teams of two as C.S.I. Soil Sleuths to discover what healthy soil looks like. Using the materials provided, youth conduct the prescribed tests (Slake Test, Chemical Test, and Visual Inspection) to determine if their soil sample came from Blue Ribbon Farm or Hard Acre Farm. Once a determination is made, teams place the soil sample in small potting containers, plant their package of seeds, and make the containers ready to take home.

In **Part 2**, the Soil Sleuths engineer a C.S.I. solution to keep Hard Acre Farm soils from going bad to worse. Using a micro-robot platform and selected materials, teams design, build, and test a 1:64 scale no-till planter that disrupts the least amount of soil when planting, minimizes equipment drag, and reduces the compaction of soil.



# Part 1-Testing

## Materials List

**Note:** Items listed in color are NOT included in the 4-H Healthy Soils C.S.I. Challenge kit

**Each team of two needs:**

- Soil Sleuth Discovery Worksheets, Part 1 (Reproducibles on page 12-13)
- One 9 oz clear plastic cup with bottom removed
- 1 quart plastic storage bag
- 1 gallon plastic storage bag
- 1 standard plastic spoon; ½ teaspoon, 1 teaspoon
- Access to 0.75 cubic foot bag of Scotts Miracle Gro® Garden Soil (keep source of soil a mystery) One bag = 17 teams
- 1 Chemical Test Color Test Chart
- Potassium Permanganate (avoid direct contact with skin). Keep soil quality reagent in dropper bottle; store in dark place. 1 full bottle = 15 teams
- Hand lens - one per person
- Small potting container with printed seed paper for simulating cover crops - one per person

## Part 1 (15 minutes)

Direct youth to work in teams of two as Soil Sleuths to learn what healthy soils look like.

- Explain that soil scientists gather, interpret, and evaluate information about soil's chemistry, biology, and structure to understand issues as diverse as agricultural production, biodiversity, climate change, environmental quality, and human health. As Soil Sleuths, teams perform some of the same tests used by soil scientists to help Hard Acre Farm use best practices for maintaining soil health.
- Distribute testing materials and Soil Sleuth C.S.I. Discovery worksheets. (Reproducibles, pages 12-13)



**After the activity is completed, youth recycle the soil. Have them:**

- Fill small containers with soil and label with their names.
- Review and follow instructions for planting on the printed seed sheet. Close box and get ready to take it home. At home, water and care for seeds.

## Part 2 (30 minutes)

Assign youth to work in teams of two as Soil Sleuths to create a solution for Hard Acre Farm to reduce erosion and improve soil quality.

### Step 1: Engage the Learner

- Hand out the Soil Sleuth Discovery Worksheet, No-Till Planter Challenge and Reference and Rules page. (Reproducibles, Pages 14-15)
- Present the problem and the challenge and explain the testing criteria for their no-till design.
- Engage youth with these questions as they design a no-till planter which is *not to exceed 12 inches in width*.
  - What have you learned about soils that will help you design a no-till planter?
  - What types of equipment are used to plant crops?
  - What materials will BEST assist you in your design to minimize soil disturbance?
  - How will you balance your design to have minimal soil disturbance and prevent compaction?



## Part 2-No-Till Planter Challenge

### Materials List

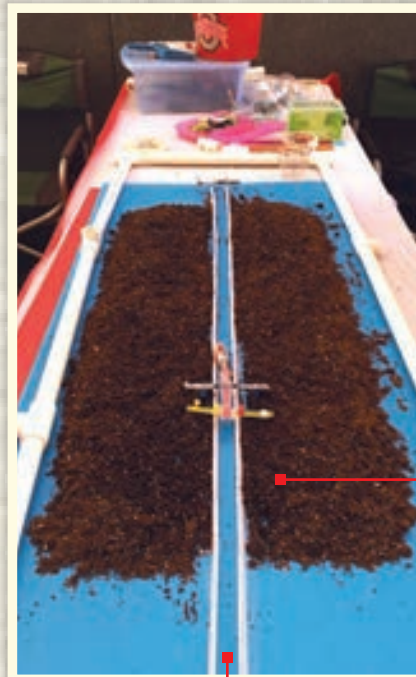
**Note:** Items listed in color are NOT included in the 4-H Healthy Soils C.S.I. Challenge kit.

- Soil Sleuth Discovery Worksheets, Part 2 (Reproducibles on page 14 - 15)
- Masking tape
- Ruler
- Scissors
- Pencils
- Paper clips; 14 per team
- Plastic beverage straws; 4 per team
- Bamboo skewers; 4 per team
- Large-hole round beads; 14 per team
- 1.5 inch ball-head straight pins; 14 per team
- Hexbug micro-robot (one per team member)
- Remaining Scotts Miracle Gro® Garden Soil from Part 1 Testing Activity
- Small broom and dustpan

### Field Test Site Set-up

Set up test site on a table.

One test site can be used for multiple teams.



Soil  
8 in. wide

Path  
3 ft. long x 1 in. wide

#### Current Real World No-Till Equipment

Range in Width – 30 ft. to 60 ft.

#### C.S.I. No-Till Design Scale: 1/64

1 in. = 64 in. or 5.3 ft.



### Step 2: Test the C.S.I. No-Till Designs

- Have each team test their design on one of the field test sites.
- Have teams evaluate their design on:
  1. Total area covered on one pass across the test site . \_\_\_\_ width X \_\_\_\_ length
  2. Uniformity of soil disturbance. \_\_\_\_\_ opening and closing of the soil the same on both sides.
  3. Ability of equipment to pull no-till planter design through soil without stopping or getting bogged down .

Begin a new line for "\_\_\_\_times equipment stopped" and again for "\_\_\_\_ times equipment

### Step 3: Observations and Conclusions

- Engage youth with these questions:
  1. *What worked? What didn't?*
  2. *How much soil area was your no-till planter design able to cover in one pass across the test plot?*
  3. *How would you rate your design on reducing soil disruption? (less disruption reduces carbon release)*
  4. *What might you do differently to increase surface area planted?*

### Step 4: Recognition and Evaluation

- Congratulate youth on their success in role-playing soil scientists and agricultural engineers.
- Recognize and thank Monsanto and the National 4-H Council, sponsors of the *4-H AIE Healthy Soils C.S.I. Challenge*.
- Hand out and direct youth to complete the Participant Evaluation Sheet. (Reproducible on page 16)
- Congratulate yourself on a job well done!



## Soil Sleuth Discovery Worksheet

# Part 1 Testing and Visual Inspection

## A Slake Test

1. Using your 9 oz. clear plastic cup with the bottom removed, pack it full with the soil sample provided and place it on the bottom of a 1-gallon plastic storage bag.
2. With help from your team member, fill the bag halfway with water so the cup is submerged.
3. Hold the bag open for at least a minute then gently lift the cup out of the water. Observe if the soil stays in the cup or falls through the hole in the bottom. If most of the soil stays in the cup, it's a good sign that it's healthy.
4. Seal the bag with the soil inside then set it aside to recycle.



(How might you use this soil for another purpose?)

## B Chemical Test\*

1. At the soil test table, take 2.0-ml or ½ teaspoon of colored reagent solution in a one-quart plastic storage bag along with 4 teaspoons of water while your team member holds the bag open (avoid direct contact with skin).
2. Seal the bag, then mix up the reagent solution and water by shaking. Open the bag while your team member puts 1 teaspoon of air-dried crumbled soil into the bag.
3. Seal the bag, mix up all the ingredients by shaking for 2 minutes and let it sit undisturbed for 5 to 10 minutes.
4. After 5 to 10 minutes, check the color of the liquid in the bag against the provided Chemical Test color chart. The lighter the color, the healthier the soil, and a higher presence of carbon.



\*Rafiq Islam and Alan Sundermeier (2008)

Soil quality test kit - A simple test for active organic matter as a measure of soil quality. <http://ohioline.osu.edu/factsheet/SAG-4>.



## Part 1 Testing and Visual Inspection Cont'd

# C Visual Inspection

1. Use your hand lens to examine the soil. Record what you see.
2. Place your name on your small potting container and fill it with the soil sample

Team Member Names

### Our Results

Soil looks like \_\_\_\_\_

Soil smells like \_\_\_\_\_

Soil feels like \_\_\_\_\_

Types of life found: \_\_\_\_\_

Based on our discovery, (Slake Test, Chemical Test and Visual Inspection), we agree the soil tested came from a farm with:

Healthy Soil     Poor Soil

## Recycle your soil

Recycle the remaining soil in your container by planting seeds and taking them home to grow.



1. Write your name on the container.
2. Place soil in container and plant seeds using provided seed paper.
3. Take home, water, and place by a window.

Once your plants start growing, you may transfer them to a larger container or plant in your garden or sunny spot outside.



## Soil Sleuth Discovery Worksheet

# Part 2 No-Till Planter Challenge

## The Problem

Hard Acre Farm is having trouble with declining crop yields. It's suspected that 30 years of continuous tillage has threatened soil health and caused the problem. Thanks to no-till planting and soil conservation practices, Blue Ribbon Farm remains prosperous. Become a C.S.I. Sleuth to help find a solution for Hard Acre Farm.

## The Challenge

To find a solution to improve soil health by minimizing soil disruption through the opening and closing of soil during the planting process.

## Things to Consider

1. How does the soil's texture, structure, water-holding capacity, soil life, and organic matter impact planting decisions?
2. How will the planter's size impact soil compaction? (Number of passes across the field, weight, planting depth, etc.)
3. How will geometric shapes and angles factor into your design goals?
4. What design features will allow you to make modifications to adjust to changes in terrain, slope, residue cover, soil type, moisture content, etc.?

## The Engineering Design C.S.I. No-Till Planter

- **Two-Member Team:** Design and test the cutter and press wheel components for a no-till planter while minimizing disruption to the soil ecology and reducing carbon release into the atmosphere.
- **C.S.I. No-Till Platform:** A Hexbug (commercially produced micro-robot ) will serve as the motorized robot for attaching your no-till planter to field test. Two-member teams may combine their Hexbugs for additional power.
- **Design Materials:** Plastic straws, beads, paper clips, ball head straight pins, bamboo skewers, masking tape.
- **Field Test Site:** A hard surface area like a table top will be used as the testing site. A 3-foot long x 1-inch wide travel path with an 8-inch wide soil plot on each side of the path will serve as your no-till design test site.

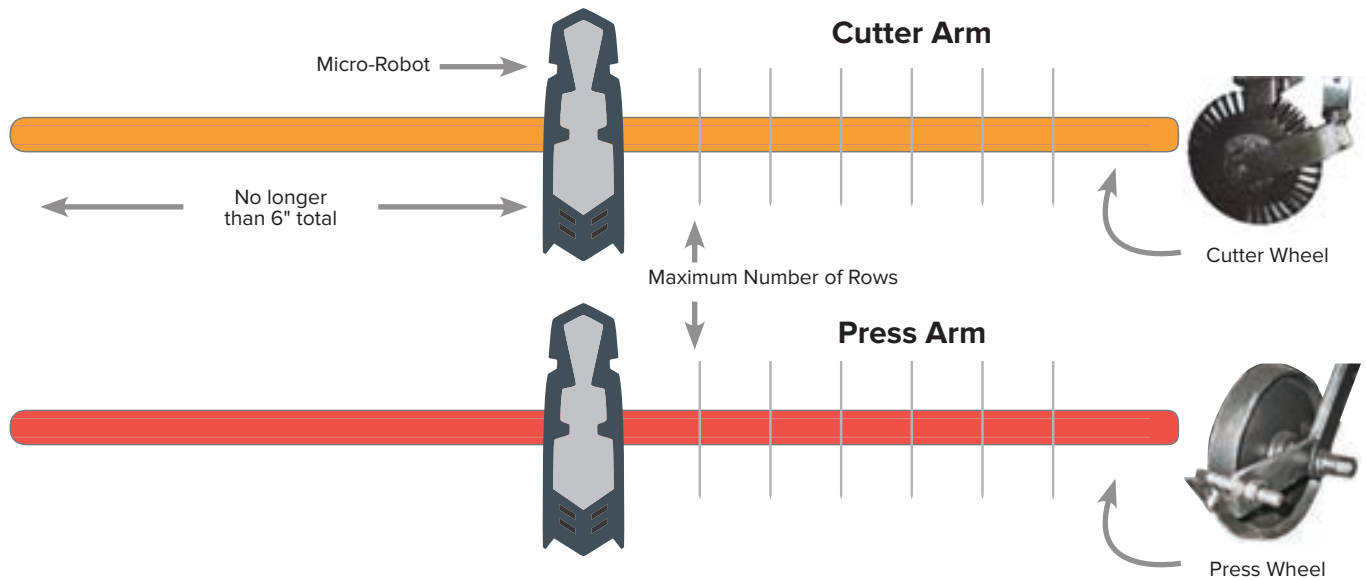


**SAFETY ALERT:** Scissors and pins are sharp.  
Please be careful not to cut or stick yourself or others.

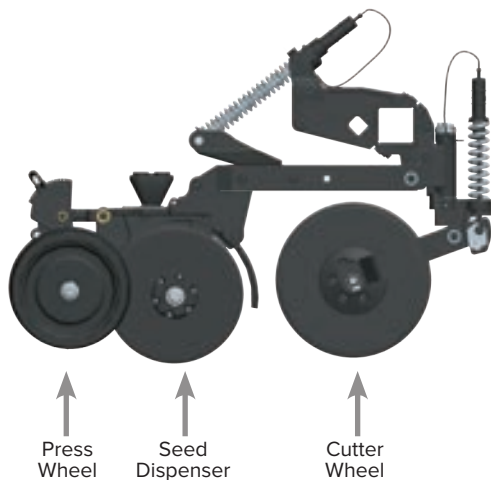


## Reference and Rules

Design and create your micro-robot planter.



### No-Till Planter Mechanism



### The Rules

- Use only the materials provided
- 2 micro-robots per planter, placed side by side or end to end
- 2 sets of planter arms per planter; forward arms for opening soil; rear arms for closing soil
- Maximum length per set of planter arms is 12 inches
- No more than 6 rows of planter tools per set of planter arms
- Tools used must open and close soil with minimal disturbance
- Success is measured in the time it takes to travel the course with minimal touching



## Participant Evaluation Sheet

### Note to Participants:

You are being given this survey because you are a part of a 4-H program or project, and we want to learn more about your experiences.

- **This survey is voluntary.** If you do not want to fill out the survey, you do not need to. Still we hope you will take a few moments to fill it out because your opinions are important.
- **This survey is private.** No one at your school, home, or 4-H program will see your answers. Please answer all of the questions as honestly as you can. If you are uncomfortable answering a question, you may leave it blank.
- **This is NOT a test.** There are no right or wrong answers, and your answers will not affect your participation or place in 4-H in any way.

### Section 1: Healthy Soils Challenge

Please select one response to each of the five questions below regarding your experiences in the *Healthy Soils C.S.I. Challenge*.

- I think it was important to work in a group to complete the Healthy Soils Challenge.  
 Yes       Kind of       No
- My teammates and I used good communication to complete the Challenge.  
 Yes       Kind of       No
- After completing the Challenge, I understand why creating and protecting healthy soils is important.  
 Yes       Kind of       No
- I am more interested in science and agriculture after participating in the Challenge.  
 Yes       Kind of       No
- After completing the Challenge, I have a better understanding of how science and engineering help solve real life problems.  
 Yes       Kind of       No

### Section II: Tell Us About Yourself

- How old are you? \_\_\_\_\_  
(age in years)
- Which of the following describes your gender?  
(Check one box.)  
 Female       Male
- Which of the following best describes your race? (Check each box that applies to you.)  
 American Indian or Alaskan Native  
 Asian  
 Black or African American  
 Native Hawaiian or other Pacific Islander  
 White
- Which of the following best describes your ethnicity? (Check one box.)  
 Hispanic or Latino  
 Not Hispanic or Latino
- Which of the following best describes the primary place where you live?  
(Check one box.)  
 Farm  
 Rural (non-farm residence, pop. <10,000)  
 Town or City (pop. 10,000-50,000)  
 Suburb of a City (pop. >50,000)  
 City (pop.>50,000)

## Adaptations for Participants

This Facilitator Guide has been reviewed, tested, and modified to accommodate youth with special needs. Considerations such as materials prep, tactile stimulation, proximity to the learners, coaching for success, and celebrating outcomes have been accommodated in each activity description. The following are some additional adaptations based on audience type.

- **Limited Literacy Skills:** Youth with limited literacy skills may benefit from reading the background content or group instructions together. If possible, have the site pre-teach the technical vocabulary to orient youth with lower reading skills to the terminology.
- **Auditory Impairment:** Youth with auditory impairment will be able to participate fully in the activity but may have difficulty reading instructions. For example, if the instructions say “Plant the seed in the pot” a hearing-impaired child might read this as “plant seed pot.” In those sections of the handouts where reading is required and signing is not an option, try highlighting mostly NOUNS and VERBS.
- **Physical Limitations:** Youth with physical limitations can participate in the majority of the Healthy Soils activities. Physical activity can be done in a wheel chair or moving on a crutch.

**Facilitator:** After introducing the No-Till challenge, take your students to a separate area to begin the challenge. Assign only two people per team. Explain they are going to be science investigators, but we will give them a special name. They are now called Soil Sleuths!

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Monsanto is a sustainable agriculture company that delivers technology-based solutions and agricultural products that support farmers all around the world. As the population increases and access to land and water for agriculture decreases, Monsanto remains focused on enabling farmers to produce more from their land while conserving the world’s natural resources. Monsanto is supporting the 4-H Ag Innovators Experience because today’s participants will provide tomorrow’s foundation for a prosperous, knowledgeable, and innovative agricultural workforce.

Visit [www.monsanto.com](http://www.monsanto.com) for more information, read the company blog at [www.monsantoblog.com](http://www.monsantoblog.com), and follow us on Twitter: [twitter.com/MonsantoNews](https://twitter.com/MonsantoNews).

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## The 4-H Pledge

I pledge

My Head to clearer thinking,  
My Heart to greater loyalty,  
My Hands to larger service, and  
My Health to better living,  
For my club, my community,  
my country, and my world.

4-H is the youth development organization of our nation's Cooperative Extension System and USDA.  
No endorsement of this partner's product or services is granted or implied by 4-H.