THE LAND INSTITUTE

Civic Science Field Guide:

Sainfoin

Welcome to the 2021 Civic Science Season!

Just as perennial plants' roots are allocating their resources for growth this spring, the civic science team is looking forward to growing with you and your plants as well. We're grateful for the plants that return year after year and the return of the people that care for them. The 2021 season brings new additions to the program, through which we're excited to continue learning how to do this research with communities well. We are expanding our educational materials, data collection tools, and capacity!

How to Use this Field Guide

This guide features key reference materials to assist your field work. Feel free to read the field guide cover to cover at the beginning of the season, or reference as you're taking data throughout the season, or both! You might like to keep it in the dashboard of your vehicle or consult it when talking to family, friends, or neighbors about the project. The field guide is designed to support your engagement with our more robust, detailed, and interactive digital materials and data collection platform.

The print data sheets are provided for your convenience, in case it's easier to take weekly observations with paper and pen out in the field. You will then need to enter those observations into the online platform each week so that our research team can utilize the valuable data you collect. Finally, the guide is accompanied by envelopes for seed harvest. You will mail your harvest back to The Land Institute in the fall.

Contributors:

We want to thank and recognize the team of collaborators who made this publication possible through their care, knowledge, and creativity.

Anna Andersson, Civic Science Research Technician
Spencer Bariball, Perennial Legumes Research Technician
Amy Cole, Director of Development
Edy Chérémond, Crop Protection Ecology Research Technician
Abbi Han, Research Resident
Ebony Murrell, Lead Scientist, Crop Protection Ecology
Siena Polk, Research Resident
Brandon Schlautman, Lead Scientist, Perennial Legumes
Linsey Sieger, Creative Director, Third Sector Creative
Aubrey Streit Krug, Director of Ecosphere Studies
Rachel Stroer, Acting President
Amanda Wagner, Development Associate

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About The Land Institute

Founded in 1976, The Land Institute is a non-profit organization working to ignite a global reinvention of agriculture by developing diverse, perennial grain agroecosystems that produce ample food while achieving levels of ecosystem functions needed to make human life sustainable.

We envision a resilient future in which humans flourish as members of a thriving ecosphere. Achieving this future requires reconciling the human economy with nature's economy, and we believe focusing on food and how we produce it is a transformative first step. In this future, agriculture regenerates the soil, water, and air upon which all life depends. The agriculture we seek equitably provides for human needs within ecological limits over the long term.

The Land Institute is working to develop an ensemble of perennial cereal, legume, and oilseed crops and cropping systems that nourish people and that build soil, use water more efficiently, reduce reliance on inputs, and sequester carbon. We collaborate with research partners and advocates around the world to advance new perennial grain crop development, ecological intensification of perennial grain cropping systems, and socioeconomic transition and cultural transformation for a perennial future.

About Civic Science

PHOTO: JULIANNE WARREN

The Land Institute's civic science communities bring people together to learn as they grow, observe, care for, and study perennial grain crops. Our civic science projects are designed to gather data across multiple locations for use in plant breeding and ecology, and to broaden and sustain public participation and social learning.

Civic science is an integrative, transdisciplinary method to grow perennial grain agriculture research and education. It weaves together science, story, and community. Agroecological data and new stories, experiences, and knowledge gained by participants and researchers shape the development of a perennial future.

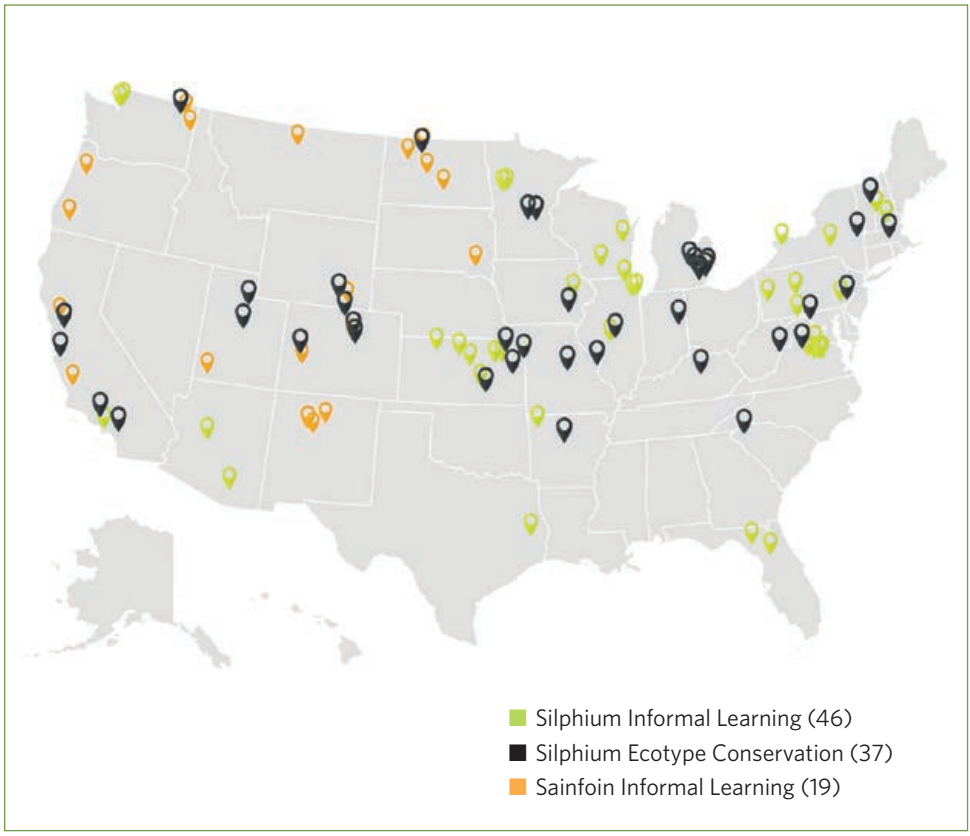
Our approach to civic science is grounded in ethnobotany—the systematic study of human social groups' botanical knowledge—so we can support and engage participants in many cultural contexts and understand their learning as they care for and scientifically study sainfoin. Involving people from a wider spectrum of society in crop domestication may help drive cultural change and crop valuation from the grassroots.

The Land Institute launched its first pilot silphium civic science community in 2019, as a collaboration between our research teams in plant breeding, ecology, and ecosphere studies. We currently have three active pilot projects, and we maintain a waitlist for people interested in joining future perennial civic science communities.

At this experimental stage of the program, we are testing the feasibility of civic science in order to understand how to build and sustain positive outcomes, for both participant learning and high quality scientific data collection.

Lessons and results from our pilot studies will shape how we scale and grow larger perennial civic science communities in our next stage of work. In the long term, we hope that by creating a broader and more diverse and equitable network of people caring for perennial grains, we can generate data and relationships that increase the probability of these plants being successfully domesticated, broadly adapted to many environments, and adopted as food crops when they are ready to be commercially released.

Civic Science Participants Across the United States



The Civic Science Team


Anna Andersson


Aubrey Streit Krug


Brandon Schlautman


Ebony Murrell


Edy Chérémond


Kathryn Turner


Spencer Bariball


Abbi Han


Siena Polk

Contact information

(785) 914-5262 or sainfoin@landinstitute.org

We welcome emails and calls at any time. During the 2021 growing season (from April through October), we will also staff open phone hours every Monday from 1-2 p.m. CST.

About Sainfoin

The Land Institute is breeding sainfoin (*Onobrychis viciifolia*), a species used for hundreds of years in Eurasia as a forage, to be a new perennial pulse/grain legume.

Sainfoin has a deep tap root and thrives in low fertility soils and semi-arid climates where other perennial forage legumes are unproductive or unadapted. Like many legumes, it obtains much of the nitrogen it needs via biological nitrogen fixation. Using sainfoin as a dual-purpose forage and grain legume could diversify both farmer fields and farmer economic returns. Honeybees used as pollinators could supply a third potential revenue stream for sainfoin growers. Preliminary food science research suggests that sainfoin seeds might be nutritious for humans, and archaeological evidence suggests humans were collecting and eating seeds from wild sainfoin plants thousands of years ago. However, more investigations are needed to confirm the seeds are safe to eat before it becomes a grain crop.

The legume team began exploring sainfoin as a potential perennial grain legume in 2017 along with several other species including lupins and alfalfa. Sainfoin has larger seeds than other perennial grain legume candidates, respectable seed yields, and certified seed for is available for forage producers. We are currently building a core set of germplasm and optimizing breeding pipelines at The Land Institute in hopes of releasing new varieties for sainfoin grain production by 2030.

Long-term, the goal is to design multifunctional sainfoin cropping systems that produce forage for livestock and nutritious seeds and honey for humans while sequestering carbon, preventing soil loss, and requiring minimal external inputs. In the near term, we are beginning to use civic science and other methods to cultivate a network of key researchers, farmers, and stakeholders to identify target populations of environments suitable for sainfoin grain production, develop best management practices, and explore the potential role of sainfoin seeds in the plant-based protein food industry.

Maintenance:

In areas with regular rainfall, sainfoin plants may need no irrigation, but if plants look deflated or leaves are not standing upright, or if leaves begin to dry out, the plants must be watered immediately. This is especially important to ensure successful establishment after they are first planted. Monitor for drought stress and water accordingly.

Plants don't like competing with other, taller plants for nutrients, soil water, or sunlight, therefore sainfoin plants should get weeded once weekly using something like a garden hoe, or by pulling larger plants by hand. Small plants around and between sainfoin plants can be managed by mowing (e.g. with a lawn mower or string trimmer).

In the winter, cut back any dead stems and leaves. You can mow right over sainfoin plants in the winter. The growing points for next spring are safely belowground.

Introduction to the 2021 Season

Welcome to the 2021 season of civic science with The Land Institute. This marks the third year in which TLI has been engaging across the country in pilot studies, and our second year of work with sainfoin. In the second year plants will grow quicker, progressing from leaf to seed maturity quicker, as they're established. Overall vigor and plant biomass production should be greater.

As members of a pilot study, you are not only sainfoin data collectors—you are our key research collaborators and trusted partners. We are grateful for your time, effort, knowledge, and willingness to learn alongside and care for perennial crops. We aim to provide various ways to engage with the crop, with scientists, and with one another, by weaving together **science**, **community**, and **story**. We hope to build a durable social-ecological fabric to sustain perennial crops and people.

Our 2021 season goals are to:

1) **test our educational materials and data collection activities to evaluate the quality and quantity of learning, engagement, and scientific data collection**. This will help us demonstrate feasibility, and refine and improve our approach as we grow civic science.

2) **continue building a novel data set of sainfoin survival, growth stages, insect and pathogen interactions, and seed production across the U.S.** This will help us understand how sainfoin responds to a wide range of growing environments and support sainfoin domestication.

This season we're introducing two new materials for sainfoin civic science learning and data collection: the field guide you're holding in your hands and an online platform hosted via CitSci.org.

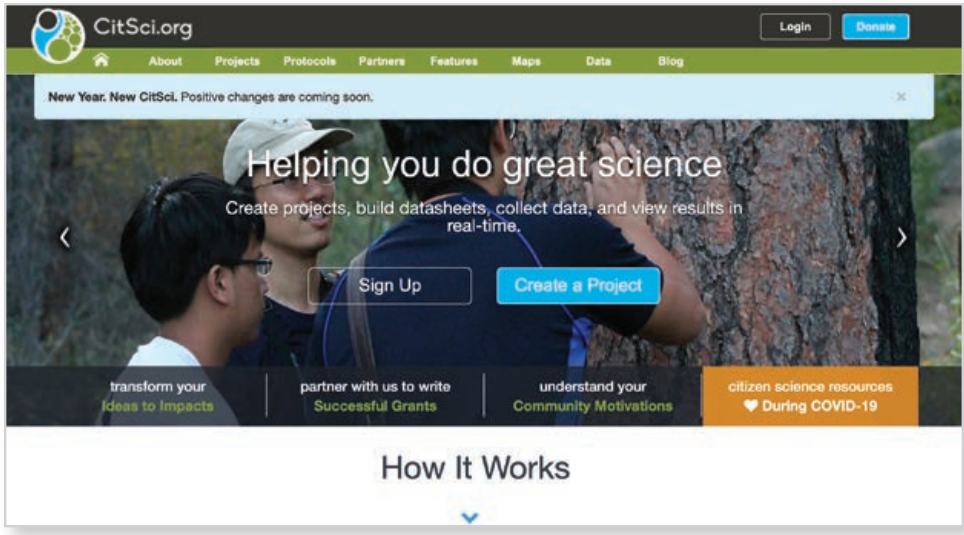
How to Use This Field Guide

This guide features key reference materials to assist your field work. Feel free to read the field guide cover to cover at the beginning of the season, or reference as you're taking data throughout the season, or both! You might like to keep it in the dashboard of your vehicle or consult it when talking to family, friends, or neighbors about the project.

The field guide is designed to support your engagement with our more robust, detailed, and interactive digital materials and data collection platform. The print data sheets are provided for your convenience, in case it's easier to take weekly observations with paper and pen out in the field. You will then need to enter those observations into the online platform each week so that our research team can utilize the valuable data you collect. Finally, the guide is accompanied by envelopes for seed harvest. You will mail your harvest back to The Land Institute in the fall.

CitSci Platform

This year we are transitioning our projects to a digital platform that allows us to streamline data collection, learning, and communication. On the platform you will be able to access more in-depth educational materials that evolve in response to the season; receive timely updates and help; enter scientific data from your observations; complete surveys to share your experiences, stories, learning, and feedback; upload and submit photos; and interact with fellow participants and scientists through discussion forums. This platform will be accessible via web browser. We will provide much more detailed information via email and our season kick-off webinar on April 12 to help you join the platform, and help us all get oriented and become comfortable using it! For your reference, here are the basic steps to join.

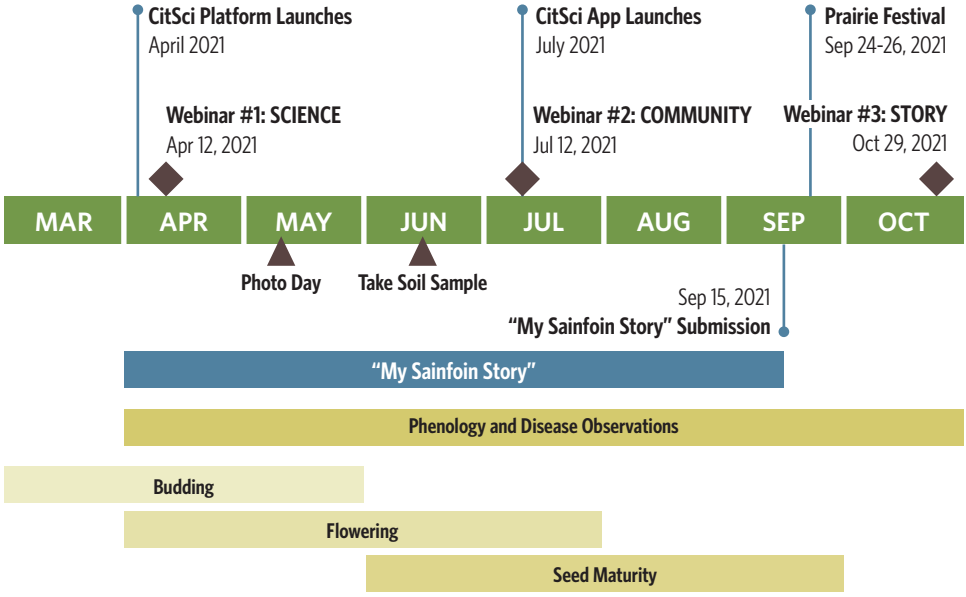


How to Join the CitSci Platform

- Visit **CitSci.org**.
- **Click "Sign Up"** to create an account.
- Once an account has been created, **click on "Projects" on the main page header**.
- Search for **"TLI" in the search box**.
- **Find the pilot project**(s) in which you belong and **click "Ask to Join."**
- Explore the datasheets and resources posted. In our **civic science webinar on April 12**, we'll explain the functionalities of the platform in greater detail.
- Our team is always available to help with tech support and troubleshooting. **Please reach out with questions!**

We are looking forward later this season to the release of an accompanying app that will make our civic science data collection accessible on your phone or tablet. Together, we'll learn about the functionalities of the app during our second webinar on July 12, 2021.

Season Timeline



Together, we'll collect data on our plants and convene to build community around perennials and civic science through webinars and storytelling. Keep in mind that plants' development stages vary across the country and, in some cases, stages may persist for many weeks. The timeline simply provides a range for when these morphological events are likely to occur.

Be sure to also mark your calendars for our three civic science community webinars:

- **Science** — April 12, 2021 at 7 pm CST
- **Community** — July 12, 2021 at 7 pm CST
- **Story** — October 29, 2021 at 7 pm CST

Zoom links for each webinar will be shared in advance by email and via our online platform.

Season Components: "Science, Community, Story"

Science:

Data collection takes many forms in civic science. Our research team is investigating how sainfoin plants interact with unique environments while also learning how people and plants interact with one another. Therefore, we are gathering both qualitative and quantitative data. As part of your ongoing care and maintenance, we strongly encourage you to establish a regular habit of observing your sainfoin plants. Looking closely at your plants will also help you gather relevant data, since with practice you may become able to notice more details about your particular plants and their changes over time. If there are any problems with your plants' health, your observations could help us troubleshoot. Use the guides provided to revisit any information that would be helpful in your data collection.

*During these **weekly** visits, ask yourself these questions and enter your answers either directly into the online platform, or first by hand on the print data sheets that you will then need to enter into the online platform when you're back from the field.*

- *Assess the growth stage of the sainfoin plant. Are you observing the first bud date, first open flower date, first raceme harvest date? If so, record the date and take a photo! More information can be found in the Phenology Guide.*
- *What is the overall health and vigor of my plants this week? What aspects are particularly interesting? Use the journal space provided for that week to record what you notice. There are many things to observe with your senses, including sight and touch. A few ideas to get you started: leaf size and shape, plant coloration, plant growth rate, response to watering or weather events, presence or evidence of insects . . .*
- *Do I see any damage to any of my plants? If yes, record some notes about what you see and take a photo.*
- *Upload photos to the online platform!*

Some observations and data collections will occur **one time** during the season.

- **Pollinator Observation:** Surveying the amount and types of pollinators will occur at peak flowering. See the protocol for observing pollinators for more information.

- **Sainfoin Photo Day:** Sainfoin civic scientists across the country will be taking photos of their plants on the same day, 5/10/2021. This data collection will provide a visual representation of the varying growth stages in different geographic locations for the scientists at TLI.
- **Harvest:** Harvest each raceme as it becomes mature. You can read more about this collection in the Harvest Guide. Once seed maturation occurs, many visits to each plant will be required as there are multiple racemes per stem which may mature at different times.
- **Soil Sample:** Provide 2 cups of soil (1.5 pounds). A sample from 0-8 inches using a spade, trowel, or shovel free of any plant material (leaves, stems, grass, etc.)

Community:

Webinars Webinars will be interactive in nature and allow for civic scientists to meet other people across the country also engaged in learning about perennial crops. Scientists will share their research and teach various concepts related to agroecology, domestication, and perennial crops.

Discussion forums on the CitSci platform will allow for peer-to-peer interaction throughout the season. You can still email us, but we especially invite you to ask questions and share your insights on these forums, so that everyone can benefit from the exchanges and learn from and with each other. TLI staff will answer questions and help facilitate conversations via the discussions forums this year.

Social Media: If you use social media, the hashtag **#sainfoincivicscience** can be used to stay connected with other sainfoin plants and civic scientists across the country. The Facebook group will also remain available.

Story: "My Sainfoin Story"

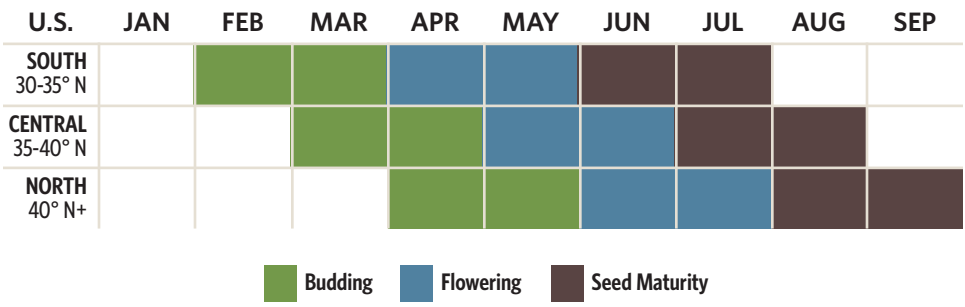
With more than a season of experience with these plants, we're excited to hear your story as a sainfoin grower, caretaker, and civic scientist. We welcome stories in the form of essays, poems, photos, songs, videos, and more. We have created some reflective prompts (see the online platform and the print data sheets) in case they are helpful in the process of crafting your own sainfoin story. We will ask all participants to submit "My Sainfoin Story" on September 15, 2021, and we are exploring ways to share submissions at The Land Institute's 2021 Prairie Festival!

Phenology Guide

Phenology, also referred to here as growth stages, is the study of an organism's life cycle. Plants and animals respond to a range of biological and environmental stimuli throughout time and changing seasons.

The collection of accurate dates for **first bud date**, **first open flower date**, and **first raceme harvest date** are of high importance to the sainfoin breeding program at The Land Institute this season. Your collection of these dates helps sainfoin researchers understand how sainfoin responds to temperature and photoperiod during growth and development across locations and helps breeders understand differences in response within locations.

Sainfoin Growth Stages Timeline



The growth stage timeline above shows the approximate time in which various morphological stages occur in different latitudes. As you record the growth stages of your plants, you can compare your findings to the timeline above.

Guide

This guide serves as a resource to learn the varying developmental stages of sainfoin plants. It will help identify the three stages of development the sainfoin research team is surveying — **first bud date**, **first open flower date**, and **first raceme harvest date**. At the end of the season, each plant will have been photographed three times and have corresponding dates recorded at the three stages mentioned above.

There are more stages of development besides the stages we are surveying. However, they are out of the scope of this project. Below are the accepted morphological stages for the development of individual stems of sainfoin from the vegetative stage to seed maturity. Feel free to use this as a reference as you anticipate the plant's changes this season.

Sainfoin Morphological Development

Vegetative growth


Until appearance of buds

Reproductive development



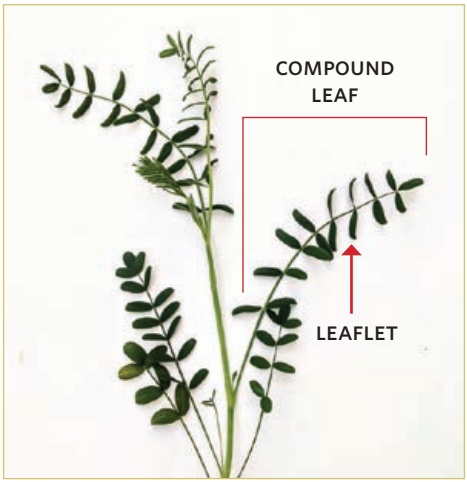
Early: Budding, first open flower, full bloom


Late: pod development

Seed maturity

Visual Representations/Botanical Terminology

Leaf



Bud

Sainfoin leaves are compound with 5-14 pairs of oval-shaped leaflets and a single leaflet at the tip.

Raceme

Sainfoin is an *indeterminate flowering* herbaceous legume, meaning that the sainfoin racemes mature starting with the bottom flowers up to the top flowers. The figure below illustrates the indeterminate flowering of a single raceme. [infloresence + penducle = raceme]

Bottom ⅓ of raceme has open flowers

Middle ⅓ of raceme has open flowers

Top ⅓ of raceme has open flowers

Protocol

Observe your plants **weekly**.

1. Record the first bud date for each plant.

- Take a photo of each plant on it's first bud date.
- Once you have collected all the dates and photos for your plants on their first bud date, upload the data to the online platform.

Once you have recorded the first bud date for all of your plants, the next data points are when the *first open flower* date occurs.

2. Record the first open flower date of each plant.

- Take a photo of each plant on its first open flower date.
- Once you have collected all the dates and photos for your plants on their first open flower date, upload the data to the online platform.

3. Record the first raceme harvest date of each date of each plant.

- Take a photo of each plant on its first raceme harvest date.
- Once you have collected all the dates and photos for your plants on their first raceme harvest date, upload the data to the online platform.

Pollinator Guide

Introduction

In addition to sainfoin's potential for use as our first perennial grain legume crop, sainfoin shows great promise in its ability to attract pollinators and provide nectar for honeybees. The role sainfoin could play in creating pollinator habitats, whether in a home garden or on a larger scale, as part of a diverse mixture of food crops, is something we look forward to exploring.

The following guide includes information on some of the sainfoin pollinators you may see in your plots. Becoming familiar with these pollinators will help you identify them and help us explore some of these questions. However, there may be more sainfoin pollinators to discover than presented in this guide.

Through your observations, we hope to continue gaining a better understanding of pollinators' interactions with sainfoin.

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Field Notes

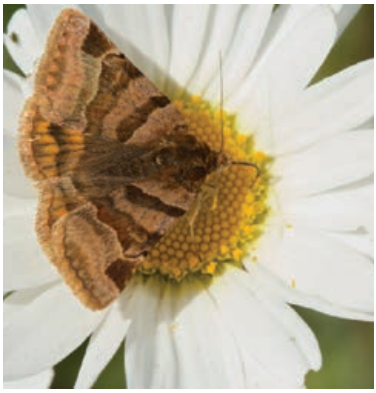
Leafcutter bee:

- Most important legume seed crop pollinator in the US

CREDIT: ED JACOBSON

Painted Lady Butterfly

PHOTO: SARA BRIGHT



Brown moth

PHOTO: DUSTY GEDGE

White Lined Sphinx Moth

PHOTO: LARRY LAMSA

Butterflies and Moths

- Two pairs of wings covered in scales.
- Long body.
- Mouthpart is a curled tube that uncurls to feed on flower.
- Most land on the flower to feed, but sphinx moths hover like hummingbirds.

Flies

- Large eyes, sometimes touch on top of the head.
- Antennae very short.
- Hairless body or coarsely haired, with a few exceptions.
- Only 1 pair of wings.
- Some land on flower to feed; others, like hoverflies, hover like hummingbirds.

Hover Fly

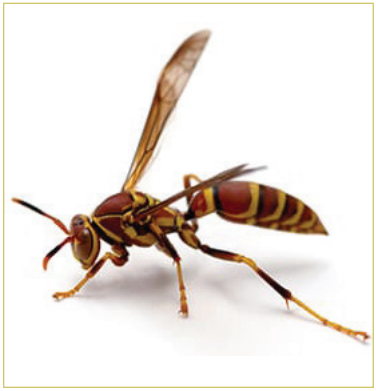
PHOTO: VERONICA CALLES-TORREZ

Bee Fly

PHOTO: VERA BUHL

Green Bottle Fly

PHOTO: VERONICA CALLES-TORREZ



Paper Wasp

PHOTO: ACTIVE PEST CONTROL

Wasps

- Most have a distinct skinny, pinched waist (called a pedicel).
- Antennae long enough to be visible.
- Two pairs of wings.
- Hairless body.
- Always lands on flower to feed.

Ichneumon Wasp

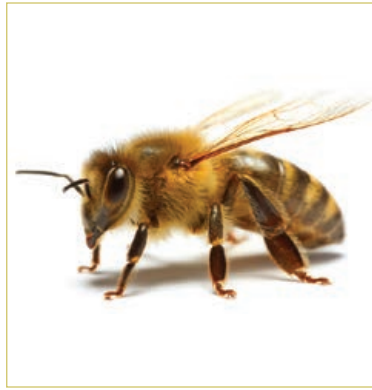
PHOTO: LYNETTE ELLIOTT

Blue Mud Dauber

PHOTO: TEXAS A&M AGRILIFE EXTENSION

Bees

- Do not have a pinched waist like wasps.
- Antennae long enough to be visible, usually have a club at the end.
- Usually hairy, some more than others.
- Two pairs of wings.
- Collects pollen on its body and/or legs.
- Always lands on flower to feed.

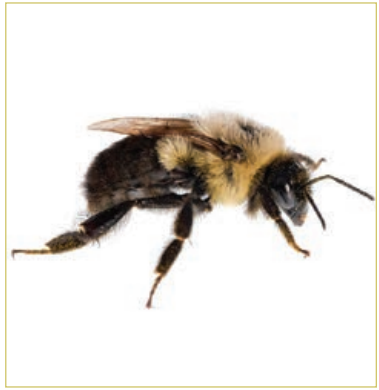


Honey Bee

PHOTO: GETTY IMAGES

Eastern Carpenter Bee

PHOTO: SHERYL POLLOCK



Eastern Bumble Bee

PHOTO: CLAY BOLT

Honey Bee.
PHOTO: GETTY IMAGES

Honey Bees

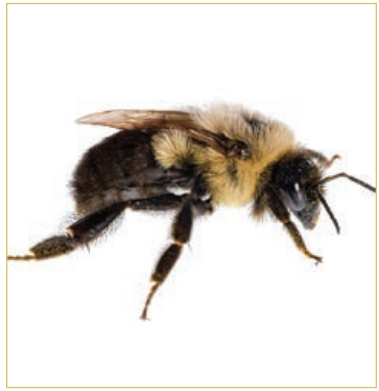
- Medium-sized bee.
- Yellow-brown head and thorax (the "body"), black and yellow stripes on abdomen (the "back end").
- Hairy all over.
- Back legs large and flattened to carry pollen.

Bumble Bees

- Similar length to a honeybee or a little large, but much rounder.
- Very hairy all over.
- Black and yellow coloration, sometimes with an orange or white patch on the abdomen.

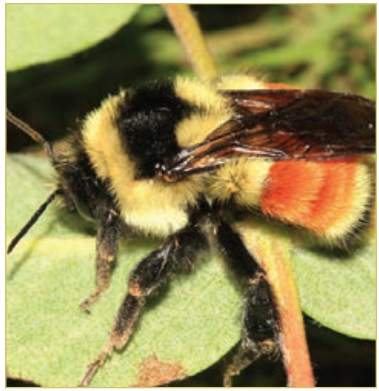
Yellow-fronted Bumblebee

PHOTO: CHERYL MOOREHEAD



Eastern Bumblebee

PHOTO: CLAY BOLT

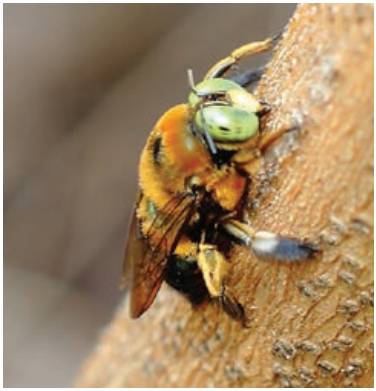


Tricolored Bumblebee

PHOTO: TOM MURRAY

Western Carpenter Bee
PHOTO: STEVEN MLODINOW

Eastern Carpenter Bee
PHOTO: SHERYL POLLOCK



Southern Carpenter Bee
PHOTO: CHRISTOPHER TOZIER

Carpenter Bees

- Resembles a very large bumblebee.
- May be black, yellow and black, or yellow.
- Hairy head and thorax, but shiny hairless abdomen.

Other Bees

- Most, but not all, are smaller than honeybees and bumblebees.
- Some are shiny blue.
- May be very hairy or mostly hairless.

Orchard Bee

PHOTO: KILEY

Cuckoo Bee

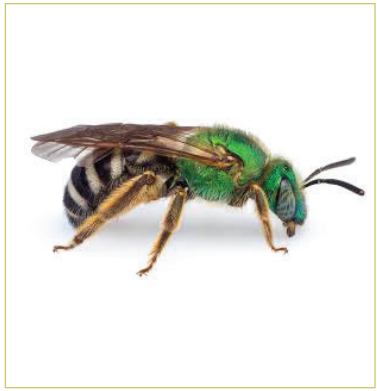
PHOTO: LEE HUA MING

Furrow Bee

PHOTO: DAVID GOULD

Halictids

- Bright to dull metallic green over the entire body, or sometimes only the head and thorax. The color can also be black or a dark metallic color.
- The largest species are about the size of a honeybee.
- Some species are very small, less than ¼ inch.



Sweat Bee

PHOTO: DEPT. OF AGRICULTURE

Furrow Bee

PHOTO: DAVID GOULD

Protocol for Observing Pollinators

Observing pollinators around your sainfoin will likely occur many times throughout the season as you're tending to the plants. You're encouraged to take photos if you're able to capture the pollinators visiting the sainfoin plants. If you'd like to take data on the number and types of pollinators visiting the plants, follow the protocol below. This observation is optional. Record the data on the provided data sheet titled "Observing Pollinators" and submit on the Citsci.org platform.

- Choose a day that is sunny or partly cloudy, and with low windspeed (10 mph or less).
- Gather your data observation sheet (provided in your season start-up packet) and place it on a clipboard, book, or other flat surface.
- Stand within a few feet of your flowering sainfoin plants. If your plants are spaced widely, choose just a few flowering plants to observe and focus on those plants.
- For 10 minutes, mark down any of the listed types of pollinators that land on the flowers OR hover just in front of them. Use hash marks instead of numbers. If you must get closer to identify a pollinator, do so slowly and carefully. They will often fly away if you get too close.
- If the same pollinator flies to more than one flower, only count that pollinator once. If a pollinator flies away and returns but you're not certain if it's the same individual, count it a second time.
- At the end of 10 minutes, add up the hash marks for each category of pollinators and write it down in the "Total" column.
- If you don't get the same pollinators during each observation, don't fret! Different pollinators are abundant at different times of the year.

Do Not

- **Swat at or try to capture any pollinators.** They will not bother you if you just watch them, but many of them can sting and will defend themselves if you try to catch them or swat them away.
- **Wear bright yellow clothing while observing.** The pollinators may mistake you for a flower and buzz around you instead of the sainfoin.
- **Focus on taking pictures during the observation instead of recording data.** Pollinators often move fast, and if you spend too much time trying to photograph one pollinator you may miss observing others. It is best to wait to take pictures AFTER you are finished with your observation!

Harvest Guide

Many components comprise sainfoin seed yield, all of which contribute to our understanding of total yield. While the total number of seeds per plant is important at an agronomic level, other aspects of seed yield are important for plant breeders. Plant breeders aim to categorize and select plants based on the diversity of trait characteristics; therefore, it is essential to understand the variation within populations for these traits. We are trying to understand the relationship of seeds per raceme, seeds per stem stems per plant, and the timeline from flowering, pollination, and seed maturity to inform our concept of an ideal plant (ideotype). Once variation is identified, plant breeding can enhance or eliminate desired or undesirable variation.

Field Notes

Determining whether a raceme is ready to be harvested can be difficult, particularly when becoming familiar with the plant and its development. When harvesting, harvest racemes shortly after they have turned completely brown before they start to shatter or drop their seeds off the raceme. Due to the successive nature of seed maturation on the same plant, one may harvest from the same stem multiple times before harvest is complete! Below are visual examples representing the ideal time to harvest racemes on the sainfoin plants.

Take note of racemes that are still showing hints of green like the photos below. These racemes are not quite ready to be harvested.

Very Green

Less Green

Half and Half

The raceme that is brown and has not shattered yet, like the one shown at right, is **ready to harvest.** ▶

Brown and minimal shattering

Shattered

Harvest Protocol

Materials

- Envelopes: labeled 1 through 12 for each plant number, provided in the season start-up kit.
- Scissors or hand pruner.
- Writing utensils to record data.
- Harvest data sheet provided in the season start-up kit.

Protocol

1. Sainfoin **seed harvest** will occur weeks to months after the first flower date. Racemes will have their seed mature at different rates based on available soil moisture, daily temperatures and genetic disposition. Once you see that all seed pods on a single raceme have matured from green to brown, clip the raceme just below the first flower/seed pod.
    - Place raceme in an envelope provided and record the date and number of racemes harvested per date.
    - Keep the plant specific envelope on hand as you'll add more mature seed and racemes to the envelope as the plants successively mature.

2. In addition to the seeds, count the **reproductive stems** per plant.
    - After final seed harvest, clip reproductive stems (those bearing racemes that you collected) at the base of the plant and count the total number of stems per plant. Make sure to count only the stems in which you harvested. Vegetative stems do not need to be counted.

3. Count the total seeds per plant and upload your data for each plant on the online platform.
    - Transfer the raceme count and dates from your envelope onto the online platform.
    - Additionally, count the number of seeds per envelope.

Returning Seeds

Return the seed to the plant breeders at The Land Institute in the envelopes included in your season start-up packet. Thank you for your collection of sainfoin seed this season!

Notes

Notes

2440 E. Water Well Road
Salina, KS 67401

(785) 823-5376

info@landinstitute.org

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