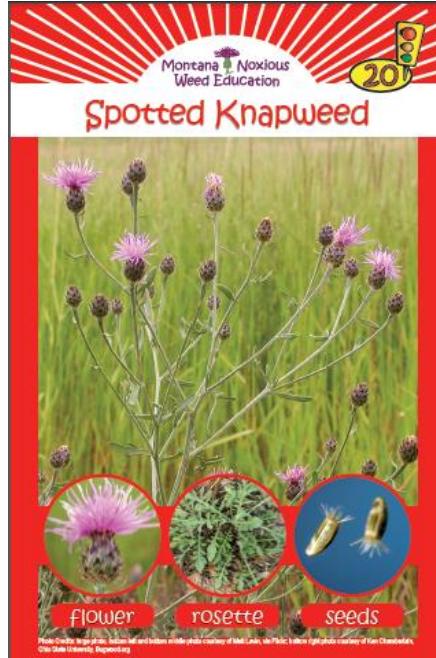
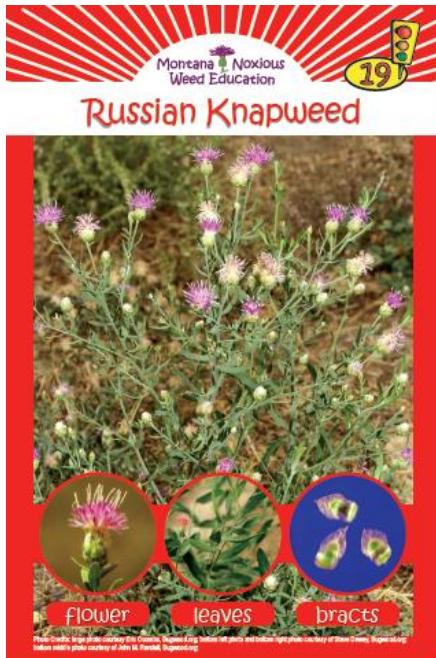




Lesson Title: Allelopathy & Invasion

Grades: 6-9

Duration of Lesson: 2- 50 minute classes
4- 30 minute labs



Brief: Students will investigate plant's abilities to suppress or hinder the growth of other plants

Materials:

Access to What Plants Talk About: <http://www.pbs.org/wnet/nature/episodes/what-plants-talk-about/video-full-episode/8243/>

Montana Noxious Weed Education folder and card set (included in folder)

Montana Noxious Weed Education

Montana Noxious Weed Education poster

MSU Plant Identification Basics MontGuide

Four empty plastic CD cases with clear covers for each group

Alfalfa seeds – ½ teaspoon for each group

Raw sunflower seeds - 1 tablespoon for each group (bird food variety works well)

Radish seeds and cucumber seeds - 5 seeds for each group

Bounty choose a size paper towels (sheets are perforated at 1/2 sheet size) or another brand cut into 1/2 sheets

MONTANA COMMON CORE STANDARDS:

ELA 6. Reading Informational Texts

7. Integration of Knowledge and Ideas: Integrate information presented in different media or formats as well as in words to develop coherent understandings of a topic or issue.

ELA 7. Reading Informational Texts

7. Integration of Knowledge and Ideas: Compare and contrast a text to audio, video, or multimedia version of the text, analyzing each medium's portrayal of the subject.

ELA 8. Speaking and Listening

4. Presentation of Knowledge and Ideas: Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

NGSS MS. Growth, Development, and Reproduction of Organisms

MS-LS1-4: Use argument based empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

NGSS MS. Growth, Development, and Reproduction of Organisms

MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

NGSS MS. Natural Selection and Adaptations

MS- LS4.4: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

Math 7. Ratios and Proportional Relationships

2. A. Decide whether two quantities are in a proportional relationship, e.g., by testing equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin.

Students will know:

Plants have the ability to suppress or inhibit the growth of other plants

Students will be able to: recognize macroscopic changes in seedling growth when exposed to residue of other seedlings

Performance / Observations

Performance Task(s):

Set up and complete a simple science experiment showing the effects of plant chemicals on other plant varieties

Other Evidence:

Students will summarize and report on their findings

Learning / Inquiry Activities

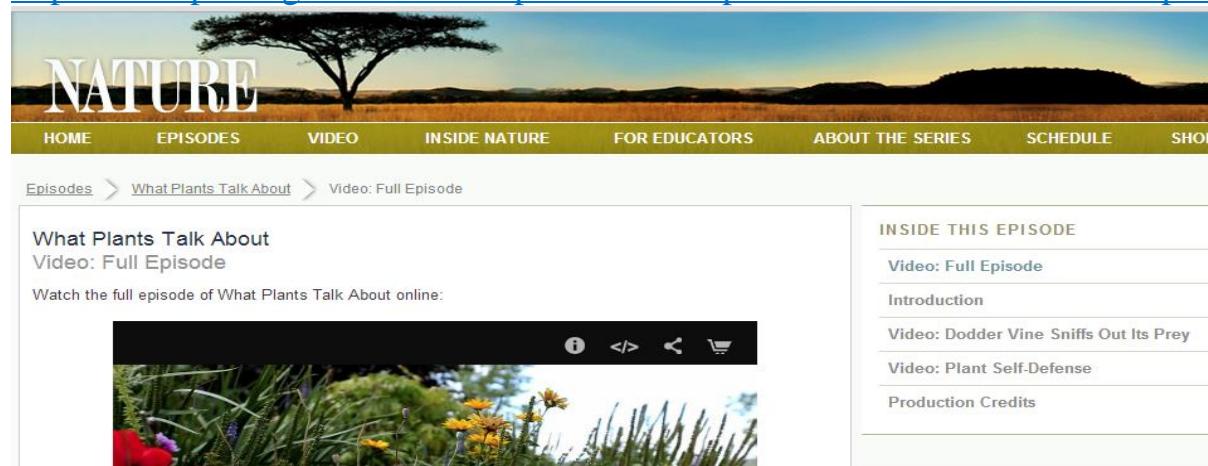
Introduction

Plants interact with each other and with insects in a much more social and diverse way than was ever recognized in the past due to recent research conducted by several plant scientists. In this video you will learn about plant interactions with each other, with insects, and with their environment.

Hand out the vocabulary list (key terms) and ask students to study the definition of each term prior to beginning lesson plan. Many terms are part of the Montana Noxious Weed Education vocabulary list which they can use for reference and a deeper understanding of noxious weeds.

Show the following 53 minute video below using this link:

<http://www.pbs.org/wnet/nature/episodes/what-plants-talk-about/video-full-episode/8243/>



The screenshot shows the PBS Nature website. At the top, there is a banner with a tree and the word 'NATURE'. Below the banner, there is a navigation bar with links: HOME, EPISODES, VIDEO, INSIDE NATURE, FOR EDUCATORS, ABOUT THE SERIES, SCHEDULE, and SHOP. The main content area shows the title 'What Plants Talk About' and a link 'Video: Full Episode'. Below this, there is a video player showing a close-up of various flowers and plants. To the right of the video player, there is a sidebar with the heading 'INSIDE THIS EPISODE' and a list of video segments: 'Video: Full Episode', 'Introduction', 'Video: Dodder Vine Sniffs Out Its Prey', 'Video: Plant Self-Defense', and 'Production Credits'.

Learning / Inquiry Activities:

Show students the Montana Noxious Weed Education packet, cards, and poster. Let them know that you will be talking about plant survival and allelopathy, and will focus on cards #19 Russian Knapweed and #20 Spotted Knapweed. After showing the photo on the front, read and discuss the information on the back of the card. Ask students if they recognize the plant and if they have ever seen Knapweed infestations. Let them know they will be conducting a science experiment which reveals changes in seedling growth of common plants based upon exposure to chemicals released by other seedlings.

Step 1: Distribute the following to each student or group of students (4 is a recommended size group for this experiment):

½ sheet of a paper towel



4 plastic CD cases with clear cover



1 heaping tablespoon of sunflower seeds

$\frac{1}{2}$ teaspoon alfalfa seeds

5 radish seeds and 5 cucumber seeds

Step 2: Fold the $\frac{1}{2}$ sheet paper towel in half again.



Step 3: Firmly press the folded paper towel into the circular portion of tray, make firm pressing marks on the paper towel along the inner circle of the CD case.



Step 4: Cut out the circle shape pattern from the paper towel and place in the bottom of the CD case.



Step 5: Repeat steps 2-4 three more times so that each group has 4 cases ready. SET TWO OF THE CD CASES ASIDE FOR USE IN ABOUT A WEEK.

Step 6: Place 1 heaping tablespoon of sunflower seeds on top of the paper in one of the four cases. Gently pour in enough water to saturate the paper towel and close the lid. Label the container "sunflowers" and write the date on the back of the CD case.



Step 7: Place 1/2 teaspoon of alfalfa seeds on top of the paper towel in one of the other four cases. Gently pour in enough water to saturate the paper towel and close the lid. Label the container "alfalfa" and write the date on the back of the case.



Step 8: Lay the cases flat and watch daily for seed germination. Do not add water again during this stage. Keep cases out of direct sunlight. In about a week or 10 days the seeds will have germinated and the roots will be long enough to clearly view as shown in this example:



Step 9: After viewing scrape the seeds from the paper towels into a trash bin, make sure not to scrape away any of the paper towel, there may be some small roots imbedded into the paper towel, it is ok to leave them. Retrieve the two blank CD cases you made in step 5.

Step 10: Plant all 4 cases in the following manner, starting with case 1.

Case 1: Sunflower Case

Plant 5 radish seeds in the top half of the sunflower case, on top of the paper towel which was used for sprouting sunflower seeds.

Plant 5 cucumber seeds in the bottom half of the sunflower case, on top of the paper towel which was used for sprouting sunflower seeds.



Case 2: Alfalfa Case

Plant 5 radish seeds in the top half of the alfalfa case, on top of the paper towel which was used for sprouting alfalfa seeds.

Plant 5 cucumber seeds in the bottom half of the alfalfa case, on top of the paper towel which was used for sprouting alfalfa seeds.



Case 3: (Use one of the unused CD cases)

Place 5 cucumber seeds on the fresh paper towel in one of your unused CD cases.



Case 4: (Use the last of the unused CD cases)

Place 5 radish seeds on the fresh paper towel, using the same pattern as in the photo above.

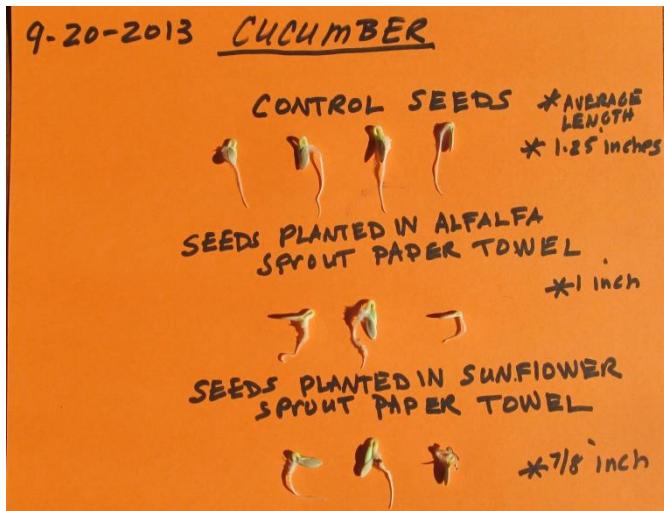
Step 11: Add just enough water to each case to dampen the paper towel, do not use excess water!

Step 12: Check daily and watch as the seeds germinate, see if you can detect any differences between the radishes and cucumber seeds as they germinate in each of the cases. Keep cases out of direct sunlight.

Step 13: Create two copies of Appendix 1 for each group; cross out the sample name and fill it in with the correct information.

Step 14: In 5-7 days open each of the 4 cases and gently remove the seedlings from ONE case at a time, placing them in the correct place on the documents you created.

Example:



Step 15: Carefully review your sheet of data while the seedlings are still firm and fresh as they will decay in just a few hours. Use a ruler to measure the length of the roots and average them for additional data to record. Make notes on root shapes and any differences between the three sets on each page

Step 16: Ask each group to present their findings using the vocabulary list as much as possible when explaining their findings.

Step 17: Conduct a classroom discussion comparing any parallel or similar results of their investigations to the investigations seen in the video "What Plants Talk About."

NOTE: From our set of data we were able to see that the seedlings from the control CD cases which had not been used to sprout any other seeds did considerably better than the seedlings sprouted in cases where alfalfa and sunflowers had been previously sprouted. We can also see that the chemical residue in the paper towels previously used for sunflower seed germination had a stronger effect on the overall growth of our radish seeds than those previously used for alfalfa sprouting, however they both seemed to stunt the growth of the seeds to some degree.

We also noticed how thickened and twisted the sprouts of both the radish and cucumber were when planted on the alfalfa and sunflower germination paper towels as compared to the ones in the control cases. These may well be examples of allelopathy. Allelopathy is believed to be one of the major factors contributing to the success of Spotted Knapweed infestation as seen in the video in the presentation by Dr. Callaway of the University of Montana. Many plants are believed to have allelopathic qualities.

We also noticed that all four cases exhibited typical seedlings responses to geotropism. For more on geotropism lessons in a CD case visit: agr.mt.gov and choose the K-8 Garden Science lesson plan *Geotropism, Roots to the Center of the Earth*.

Extension Ideas and Questions:

1. Something New. Try other kinds of garden seeds with the sunflower and alfalfa residue; does it affect other varieties such as lettuce, spinach, etc.?

2. Second Time Around: If you repeat the experiment using the same paper towels, do the chemicals from the sunflowers and alfalfa seed beds lose their inhibiting potency on cucumbers and radishes?
3. Visa-Versa. First plant the cucumber and radish seeds and then use these cases to investigate if the alfalfa and sunflower seeds exhibit any changes to their seedling growth when planted in residue of cucumbers or radishes.
4. Critical Thinking Extension: Discuss the application of the ideas from the video and this experiment to recreation, wildlife, food production, and the economy.
5. Look and Learn: Have you ever noticed anything different about the grass below a bird feeder where sunflower seed hulls tend to fall?
6. Pick a Career: Learn more about careers with plant science at:
<http://www.agriculture.purdue.edu/usda/careers/agronomist.html> Use the dropdown list on the left to investigate each science, technology, engineering, and math careers. For a classroom set of career posters please contact lbrenneman@mt.gov.

After finishing the activity discuss the following weed control with students, you can help stop the spread of noxious weeds by following a few simple steps:

Check your shoes, shoelaces, clothing, tires, and any gear you had along for weed seeds and plant parts: Throw the weed seeds and plant parts away in a trash receptacle. Do not throw them on the ground as they can start new infestations.

Contact your local Weed District Coordinator <http://www.mtweed.org/> for more information.

Many thanks to Dr. Ray Callaway for his work with plants, and his review of this lesson plan. Dr. Ray Callaway teaches at the Division of Biological Sciences at the University of Montana and also runs the Callaway Lab on Community Ecology. <http://plantecology.dbs.umt.edu/>

Thank you for being part of the solution to noxious weed control in Montana!

Appendix 1

DATE: _____

Seed Variety: Sample: Cucumber—National Pickling American Seed Company

Packed for 2012/2013

Control seeds planted in unused control case

Average root length

Seeds planted in alfalfa sprout paper towel

Average root length

Seeds planted in sunflower sprout paper towel

Average root length