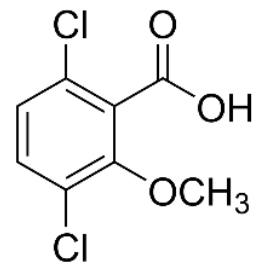


Suggested Arkansas NGSS State Standards:

Integrated Chemistry

CI-PS1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.



CI1-ETS1-2: Design a solution to a complex real-world problem by breaking it down into small, more manageable problems that can be solved through engineering.

Science and Engineering Practices: Developing and Using Models. (CI-PS1-1). Constructing Explanations and Designing Solutions (CI-PS1-6)

Disciplinary Core Ideas: Chemical Reactions (PS1.B), Optimizing the Design Solution (ETS1.C)

Crosscutting Concepts: Energy and Matter (CI-PS1-7), Stability and Change (CI-PS1-6)

Connections to the Arkansas Disciplinary Literacy Standards: WHST.11-12.9, WHST.11-12.7

Connections to the Arkansas English Language Arts Standards: SL.11-12.5

Connections to the Arkansas Mathematics Standards: MP2, MP4, HSN.Q.A.1, HSNQ.A.2, HSNQ.A.3

CI-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

CI3-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Science and Engineering Practices: Constructing Explanations and Designing Solutions (CI-ESS3-4), Asking Questions and Defining Problems (CI3-ETS1-1).

Disciplinary Core Ideas: Conservation of Energy and Energy Transfer (PS3.B), Human Impacts on Earth Systems (ESS3.C), Defining and Delimiting Engineering Problems (ETS1.A), Developing Possible Solutions (ETS1.B).

Crosscutting Concepts: Energy and Matter (CI-PS1-4, CI-ESS1-2, CI-ESS2-3), Systems and Models (CI-PS3-1), Stability and Change (CI-ESS3-4).

Connections to Engineering, Technology, and Applications of Science: Interdependence of Science Engineering and Technology, Influence of Engineering, Technology and Science on Society and the Natural World.



Objective:

Students will be able to research a current event issue (the use of Dicamba in soybean and other fields), use critical thinking to make an informed decision in regards to that issue and then debate the reason for their decision in a town hall meeting session.

Key Points:

- 1). How to research a current events topic.
- 2). Presenting the data learned to a group.
- 3). Engaging in a debate about the information.

Materials:

- Stakeholder cards (at end of lesson)
- Notebooks for notes
- Research material for stakeholder information
- Various media/graphic material for town hall meeting

Teacher Preparation Time:

Make up cards before the lesson. The lesson time varies depending on the amount of time you want to give to the students to research their position. This lesson should be a minimum of one week to give students at least a few days for research. The town hall meeting will take a full class period.

Assessment:

Students will be assessed on the research summary of the topic they received and on participation in the town hall debate. They will also be required to write a letter of reflection with a final decision on the Dicamba issue.

Elicit:

Implement a graphic organizer with students about what they know about farming in Arkansas; how is farming done today? Do the students know any farmers? What crops are grown in Arkansas and why is farming important? Ask students how farmers manage crops (what do they do to curtail weeds and pests) and why is this an essential part of farming? How exactly do herbicides chemically affect weeds? What are some advantages to chemical management of weeds and pests in farming? What are some drawbacks to chemical management of weeds and pests in farming?



Engage:

Tell the students they will be participating in a town hall session involving the use of the herbicide Dicamba. Each student group will be given a 'stakeholder' in the Dicamba concern and their job will be to defend the stakeholder position they received.

Explore:

Ask the students what they have eaten lately (most should mention something made with grains) and then ask them where their food comes from. The most obvious answer will be the grocery store but dive deeper into the question, where does the grocery store get their food? Tie this back into the farming questions, and how do farmers grow enough for us to eat and at a price we can afford to pay? Point out that organic food is more expensive than regular food, why?

Explain:

Now teach how farmers manage input and production costs and maximize yield of their crops with herbicides and pesticides. This allows farmers to get more 'bang for their buck' so to speak. Herbicides affect weeds by attacking certain areas of the plant, the most common being the growth hormone Auxin. This would be a good time to talk about the formulation of Dicamba and how it chemically works.

This lesson focuses on the herbicide Dicamba. Dicamba is a broad-spectrum herbicide that mimics Auxin, causing the plant to grow so fast it dies of starvation. Dicamba is very effective in controlling pest crops, especially in ranges that cattle feed on. There is a downside to Dicamba, it is highly volatile (vaporizes easily into the air) and is quickly spread by the wind to neighboring fields. While the chemical company Monsanto (who makes Dicamba) has released crop varieties that are resistant to Dicamba, most other crops are sensitive to this herbicide and a tiny amount can negatively impact whole fields. Soybeans are highly sensitive to Dicamba, dying with just a fraction of what affects other plants. Dicamba is lethal to conifers (pines, cedar, firs, etc.) and is absorbed readily into acidic soil. Dicamba also takes longer than expected to break down in swamps and redwood forests.

So why use Dicamba? It's all about costs, yield, and production efficiency. It can be used on ranges and fields to eliminate highly invasive pest weeds such as Glyphosate Resistant Pigweed, it attacks all broadleaf weeds, is cost effective and it works well.

Some farmers have expressed concern using this herbicide as several weeds have developed resistance after only a few generations (bring up mutation-adaptation here) plus the concern of having to grow genetically modified crops to resist the Dicamba (explain what is a genetically modified plant; you can explain how GMO plants resist Dicamba). Other farmers and Monsanto representatives support the use of Dicamba, noting the drift is



directly related to application error (not following treatment protocols), and state without Dicamba, highly invasive weeds like Pigweed would literally take over a field in one season. Arkansas recently limited the use of Dicamba to mid-October through mid-April after several farmers had crops adversely affected due to Dicamba drift. Monsanto has recently released a less volatile form of this herbicide to offset this issue.

NOTE: The 'Explain' section is meant to give an overview of Dicamba and its relevance and issues to Arkansas crops. This is a good time to bring in several different concepts of your own, both chemical and biological. Feel free to add topics here that pertain to the lesson and not mentioned in the 'Explain' section.

Elaborate:

There are nine different stake holders that will be involved in this town hall meeting. Cards explaining each stakeholder's side on the Dicamba controversy are attached to this lesson. Group students into at least groups of two (three is recommended) for each stakeholder group. Each group is to research the stakeholder's opinion they have randomly picked in order to debate this belief in the town hall meeting. Groups are expected to be prepared to defend their position and a research summary is required from each student or group (you decide). Encourage the students to make notecards in preparation for the meeting and to come with visuals to prove their point; posters, graphs and signs are great and it can even be taken further to each stakeholder group coming dressed for the part. The students will debate their 'point of view' against the other stakeholders and in the end after the dust clears, decide if their point of view is valid or invalid based on the information gained from the other participants. Questions that need to be addressed are:

Q: What is the position of the stakeholder?

Q: What research backs up the stakeholder's position?

Q: What data has been acquired to defend this position to the other stakeholders?

A 'board' of teachers in the meeting can be used to make a final decision but ultimately the students need to be the ones who critically think through the evidence presented and decide what they feel is the right answer.

NOTE: students may want to 'group up' at the meeting with those whose stakeholders believe like they do. You as the teacher may decide if this is a viable option.



Evaluate:

How well the students debate each other in the town hall meeting will determine how well prepared they were for the assignment. In the reflection letter, students need to state why they either believe in their stakeholder claim or have decided against it, citing several reasons brought up in the meeting.

Extend:

This lesson can be tied into several different new concepts such as biodiversity, population dynamics, adaptation, phase changes and Bernoulli's Principle. It is a good lead into engineering and how to make sprayers more efficient and less messy when releasing spray. Mathematics can be brought in to determine spray volume per acre, temperature levels for volatility and atmospheric pressure concerns when spraying.

There are several websites that are worth checking out for this lesson. Here are some examples:

<http://scholarworks.uark.edu/cgi/viewcontent.cgi?article=1608&context=etd> Covers Pigweed and herbicide usage.

<https://www.extension.purdue.edu/extmedia/WS/WS-51-W.pdf> A good explanation of Pigweed.

<https://www.uaex.uada.edu/yard-garden/resource-library/weed-id/pigweed-smooth-common.aspx>

Pigweed information

<https://www.uaex.uada.edu/farm-ranch/pest-management/weed/2017-dicamba.aspx>
Dicamba in Arkansas

<https://pubchem.ncbi.nlm.nih.gov/compound/dicamba#section=Top> This discusses Dicamba affects in the body. Very technical though



<https://www.bing.com/images/search?q=photos+of+dicamba+damaged+crops&qvvt=photos+of+dicamba+damaged+crops&FORM=IGRE> Photos of Dicamba damaged crops

<https://cen.acs.org/articles/95/i33/Widespread-crop-damage-dicamba-herbicide.html>
Dicamba damage

<https://www.usnews.com/news/best-states/arkansas/articles/2018-02-16/judge-considers-companys-challenge-to-arkansas-dicamba-ban> Arkansas lawsuits

STAKEHOLDER SHEETS

Sensitive Sam, Farmer: While you are not against herbicides and pesticides in general (and use pesticides on your soybeans to control the Red Banded Stinkbug), you do have an issue with Dicamba. Your soybeans are very sensitive to Dicamba and with your life savings growing out in the field, one drift would wipe you out financially. Certainly, there are other alternatives that don't threaten your pocketbook! So not only will you be bringing reasons why you are against Dicamba, you also plan on bringing up those alternatives at the meeting.

Tolerant Tom, Farmer: You grow Dicamba resistant soybeans and Dicamba has literally saved your bacon in the Pigweed department! Glyphosate resistant Pigweed literally had you hog tied financially as it took over your soybean fields. Dicamba took out the plant and gave you back a crop producing farm, causing you to squeal with happiness! Not only are you for Dicamba but now that there is a less volatile version available, you believe that it should be reinstated for use all year round and will expound on this at the meeting. You understand other's concerns. Your concern is that outside folks who don't farm listen more to the internet than to folks like yourself who have worked and protected the land for generations. Your land is your future and hopefully will provide a future for your children. The banker who holds your farming loan for this year's crop expects his repayment on time. Don't these folks understand that if yield is



decreased, more folks around the world who depend on soy protein will die? You have nothing against organic producers as they give the consumer choices, but organic practices simply won't feed the world's growing population. You do the math.

Al Naturale, Organic Farmer: You are all about the 'no artificial chemicals' part of farming. It's natural fertilizer and homeopathic pesticides for you! Not only do you feel organic food is better for the body, it's also better for the environment! Dicamba has been used so much it is now showing up in the soil and waterways. Plants absorb Dicamba that is present in the soil meaning people are eating Dicamba for dinner. You are against using an artificial chemical that not only has the potential to harm the environment (killing beneficial broadleaf plants due to spray drift, plus new resistant invasive species created due to Dicamba use) but we really don't know the overall human health impact Dicamba can have long term. You are going to hit Monsanto and Dicamba users with health and holistic facts why Dicamba is bad. The fact that organic farming is much more expensive (meaning higher prices at the grocery store) and not using Dicamba would bring normal crop prices more in line with organic (thus making organic more competitive) is also a strong point but you are hoping it won't be brought up at the meeting!

Beau Vine; Cattle Rancher: You own a large cattle ranch and love Dicamba. Dicamba has done wonders in keeping noxious invasive weeds out of your grazing areas and your cattle have never been fatter! You consider Dicamba a godsend for grazing animals and welcome its use. You will be at the meeting with facts in hand as to the benefits of Dicamba to local ranchers.

Samore Sales, Monsanto Company Representative: As the representative for the company, you obviously feel Dicamba has been given a bum rap. Without Dicamba, Pigweed and other highly invasive pest weeds would have taken over Arkansas and we would be singing the 'Woo Pigweed Sooie' song at Razorback games! The issues with Dicamba are due to application error and not applying at the right times. Besides, Monsanto has come out with a less volatile chemical so the whole drift problem is solved right? You plan to bring all the advantages of Dicamba to the meeting and more!

Kris Kringle, Christmas Tree Farmer: You produce Conifers (mainly firs and pines) on a local tree farm for Christmas and your farm is located next to a large soybean field. You have had dealings with Dicamba drift in the past, with many of your trees dying from the spray. You are not seeing the big 'change' that Monsanto is crowing about regarding a lower drift potential as your soybean neighbors have told you they are now using the improved spray but you



are still dealing with dead trees. You are planning on grilling Monsanto at the meeting about this new formulated spray and what they are going to do about your dead tree problem.

Connie Consumer: You are the local advocate for responsible farming. You and your cohorts worry about what exactly are we eating at the dinner table. While there is the understanding that herbicides are necessary for weed control, what do we really know about Dicamba and its effect on the human body? Plus, there is all this talk about Dicamba Drift so could organic food have Dicamba spray on it? As a participant in this meeting you come prepared to ask lots of questions about the risks of Dicamba in our food and our bodies and to argue your concerns.

Debbie Dicot, Plant Pathologist: As the local expert on invasive weeds and how Dicamba works, you have the distinction of being the only stakeholder who is trying hard not to take sides. You see the benefits of Dicamba as Glyphosate Resistant Pigweed (*Amaranthus palmeri*) is an extremely invasive species that outcompetes every crop known. It's fast growing, has high genetic variability (that leads to resistant plants) and produces on average over 500,000 small seeds per plant. Dicamba is one of the few herbicides on the market that can control this Pigweed in soybeans, so you know the benefits of this chemical. You are also aware of the damage this herbicide can do to neighboring fields due to drift and the economic impact this has on the affected farmers. You come to the meeting ready to defend both opinions but to also offer alternatives that will help lower Dicamba usage and hopefully benefit both sides.

Lau Suit, Attorney: You represent those people who have been affected by Dicamba Drift. Your specialty is Agriculture Law and it is you against the big corporate lawyers on this one. Not only do you represent farmers, but you also represent homeowners and other innocent victims of this herbicide. You plan to come to this meeting armed with facts about the legal ramifications of this spray's issues and plan on citing the latest legal activity here in Arkansas that focuses on Dicamba.

