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| **Lesson Overview:**  This hands-on lesson delves into the fascinating world of soil, exploring how different soil types impact water and nutrient retention, ultimately affecting the growth of soybeans, a vital agricultural crop. Students will conduct experiments, analyze data, and design solutions to optimize soil conditions for thriving soybean production. | | | | | | **Essential Question:**  How can we ensure that soil provides the water and nutrients needed for healthy soybean growth? | | |
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| **Lesson Breakdown (Lessons are based on 45 minute classes)**  **Lesson 1:** Soybeans and Soil  **Lesson 2:** Design Challenge  **Lesson 3:** Design: Build and Test | | | | | | **Subjects**   * Science * Technology * Engineering * Math * ELA * Art * SS | | |
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| **I CAN statements**   * define key vocabulary related to soil properties. * describe the importance of water and nutrients for soybean growth. * conduct an experiment to test the water retention capacity of different soil types. * analyze data to compare water and nutrient retention in different soils. * explain how modifying soil properties can improve conditions for soybeans. * communicate my findings in a clear and concise way. | | | | | **Performance Expectations/ Standards**  **NGSS**  **MS-LS1-3:** Use models to describe the relationship between photosynthesis and cellular respiration in plant and animal cells. (Connects to water needs for photosynthesis)  **MS-LS2-1:** Analyze and interpret data to provide evidence for the interaction between organisms (soybeans) and their environment (soil).  **MS-ETS1-1:** Define and refine a simple design problem related to soybean growth. (Improve water retention in soil)  **MS-ETS1-2:** Generate and compare multiple possible solutions to a problem based on what is known about soil properties. (Choose best way to amend soil for soybeans)  **CCSS Math Standards:**  6.SP.A.1: Describe data with summary statistics and graphical displays.  7.SP.A.2: Analyze data using statistical measures.  8.SP.A.3: Investigate patterns in bivariate data.  **CCSS ELA Standards:**  6.W.2: Write informative/explanatory texts to explain scientific concepts related to soil and soybeans.  7.W.2: Conduct research projects to answer a question about soybean growth and soil health.  8.W.2: Write informative/explanatory texts to examine the challenges of soybean production and propose solutions.  **WI Social Studies Standards**  **Inquiry Practices and Processes**  **SS.Inq1.b.m** Identify additional questions that support the research and possible resources to guide the  inquiry.  **SS.Inq2.a.m** Explore evidence from multiple reliable sources representing a range of perspectives and media that have been selected through research to guide the  Inquiry  **SS.Inq4.a.m** Communicate conclusions using a variety of media (i.e. video or online, documentaries, exhibits,  research papers, or web pages).  **SS.Inq4.b.m** Analyze and evaluate the logic, relevance, and accuracy of others’ claims, taking into consideration  potential bias.  **Economy**  **SS.Econ2.c.m** Categorize factors of production and how they are combined to make goods and deliver services | | | |
| **Teacher Background**  Soybeans, a vital global food source, have specific requirements for healthy growth. One of the most critical factors influencing their success is soil quality. Soil is a complex ecosystem teeming with life and rich in minerals. It provides not only physical support for the plant but also serves as a reservoir of water and nutrients essential for soybean development.  The composition of soil particles, often a mix of sand, silt, and clay, significantly impacts its ability to retain water and nutrients. Sandy soils, with large particles, drain quickly and struggle to hold onto essential resources. Conversely, clay-rich soils can become waterlogged, restricting oxygen flow to soybean roots. Achieving a balanced soil structure is crucial. Farmers often employ soil amendments, like compost or organic matter, to improve the water retention capacity of sandy soil or enhance drainage in clay-heavy soils. By optimizing soil quality, farmers can ensure soybeans have the necessary foundation for optimal growth and yield. | | | | | | | | |
| **Essential Vocabulary**   * Soil texture (sand, silt, clay) * Leaching * Legume (soybean classification) * Nutrient retention * Organic matter * Porosity (space between soil particles) * Water retention | | | **Materials (per group)**   * Three beakers (500 mL each) * Three different types of dry soil (sand, potting soil, and a local soil sample, if possible) * Coffee filters * Water * Graduated cylinders * Measuring spoons * Paper towels * Markers or labels * Stopwatch | | | | | |
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| **Lesson 1: Soybeans and Soil** | | | | | | | | |
| **Time** | | **Materials** | | | **Activity** | | | |
| 5 mins | |  | | | Begin with a discussion about soybeans in general - what do the students already know about them? Discuss their uses in food, animal feed, and industrial products and the importance of soybeans as a global crop. | | | |
| 10 mins | | [What Do You Know about Soybeans](https://docs.google.com/presentation/d/1FO4nnGGQUdDlZjVkGt0ICiw_w87loEUz1e2a4EKm-Lo/edit?usp=sharing) | | | Using this presentation, introduce key vocabulary related to soil properties, focusing on soil texture (sand, silt, clay), porosity (space between soil particles), organic matter, and their impact on water and nutrient retention. Emphasize the connection between soil health and healthy soybean growth.  Explain the concept of water and nutrient retention in soil and how it affects soybeans' ability to access crucial resources throughout their growth cycle. Explain that water carries nutrients through the soil, and soils with good water retention are also better at holding onto nutrients.  Explain that soybean production can be significantly impacted by water availability, especially in regions prone to droughts or with sandy soil. | | | |
| 5 mins | | [Digging Deeper: Exploring Water and Nutrient Retention in Soil to Improve Soybean Growth Student Worksheet](https://docs.google.com/document/d/12_7Su_wH3WdCGFkwEdIhSJ6U8GHvRtj8MUFNPzMTRU0/edit?usp=sharing) | | | Introduce the Essential Question: How can we ensure that soil provides the water and nutrients needed for healthy soybean growth?  Explain that they will be testing different types of soil to determine which has the greatest water retention rate.  Guide students through the scientific method, including defining the question, identifying variables (independent: soil type, dependent: water retention), and controls (amount of soil being tested). | | | |
| 25 mins | | * Three beakers (500 mL) * Three different types of dry soil (sand, potting soil, and a local soil sample, if possible) * Coffee filters * Water * Graduated cylinders * Measuring spoons * Paper towels * Markers or labels   [Digging Deeper: Exploring Water and Nutrient Retention in Soil to Improve Soybean Growth Student Worksheet](https://docs.google.com/document/d/12_7Su_wH3WdCGFkwEdIhSJ6U8GHvRtj8MUFNPzMTRU0/edit?usp=sharing) | | | Review the procedure before allowing students to begin: **Procedure:**   1. **Setup:**     1. Fold a piece of filter paper so that it creates a cone. Place the cone into each of the beakers. You may wish to secure the filter with a rubber band- do not make the filter tight, though, make sure there is a “well”.    2. Label the containers. 2. Using the graduated cylinder, measure out 125 mL each of soil types. 3. Pour one sample of soil into each of the filters , and compact the sample by gently tapping the beaker on the table. 4. **Simulate Rainfall:**  * Start a timer. * Slowly and evenly pour water over the surface of one of the soils. * **Monitor Drainage:** Stop the timer once water stops dripping from the bottom for at least 10 seconds. This indicates the water has saturated the soil. * Make qualitative observations about the percolation. * Note the volume of water used (e.g. 200 ml).  1. **Record Data**: Record the time it took for the water to drain (in minutes) and the total volume of water used in a data table.  * **Record** the amount of water in the beaker. Calculate the amount of water absorbed by subtracting the amount of water in the baker from the amount of water you added. * **Calculate Drainage Rate**: (how quickly water drains through the material),   Drainage Rate = Amount of Water (mL) / Time (minutes)   1. **Repeat** for the remaining soil types | | | |
| OPTIONAL | | [Digging Deeper - Student Reading Passage](https://docs.google.com/document/d/1G2y_EOazP7Ctv-lyK-345kY-mSNUOJ3V84xdfmMBNzk/edit?usp=sharing) | | | Assign the reading passage to students to complete for homework.  [Digging Deeper - Student Reading Passage Answer Key](https://docs.google.com/document/d/1BzQl-6xI4JrWVfvwCkDQVYTDr36y_pUC0ya35Ck4uuU/edit?usp=sharing) | | | |
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| **Lesson 2: Design Challenge** | | | | | | | | |
| **Time** | | **Materials** | | | **Activity** | | | |
| 10 mins | | [Digging Deeper: Exploring Water and Nutrient Retention in Soil to Improve Soybean Growth Student Worksheet](https://docs.google.com/document/d/12_7Su_wH3WdCGFkwEdIhSJ6U8GHvRtj8MUFNPzMTRU0/edit?usp=sharing) | | | Review the results of the experiment- allow students to share their results- were the group’s results similar?  Focus the experiment discussion on the impact of soil type on water availability for soybeans. Highlight that sandy soil drains quickly, potentially depriving soybeans of needed moisture, especially during critical growth stages. | | | |
| 10 mins | | [Digging Deeper: Exploring Water and Nutrient Retention in Soil to Improve Soybean Growth Student Worksheet](https://docs.google.com/document/d/12_7Su_wH3WdCGFkwEdIhSJ6U8GHvRtj8MUFNPzMTRU0/edit?usp=sharing) | | | Introduce the Design Challenge:  **You are a team of agricultural engineers tasked with designing a soil amendment that specifically improves water retention in sandy soil to optimize conditions for healthy soybean growth.**  Explain that a soil amendment is like an extra ingredient you can add to the soil to improve it in some way. For soybeans, we're especially interested in amendments that can help the soil hold onto more water.  **Review the criteria**  **Criteria:**  **Improved Water Retention:** Your design should significantly increase the water holding capacity of sandy soil compared to untreated sand. This can be achieved through the chosen materials and their proportions in the amendment.  **Plant Growth:** The amended soil should promote healthy soybean growth by providing sufficient water for root development and overall plant health. Consider how the amendment might impact nutrient availability as well.  **Sustainability and Cost-Effectiveness:** Use readily available and affordable materials that are safe for the environment. Focus on materials that can be easily obtained or produced locally.  Presentation: Prepare a clear and concise presentation explaining your design, testing methods, results, and the potential benefits for sustainable soybean production.  **Allow time for the students to research and brainstorm.**  If students are struggling as they brainstorm and research, you can make these suggestions:   * **Organic Matter:**   + Compost: Decomposed organic material rich in nutrients and beneficial microbes. It improves soil structure and water retention.   + Shredded leaves: Provide organic matter that slowly decomposes, improving water holding capacity and soil fertility.   + Worm castings: Nutrient-rich castings promote plant growth and improve soil aeration and drainage. * **Clays:**   + Kaolin clay: A fine-grained clay that can increase water retention and improve soil structure. However, too much clay can restrict drainage.   + Bentonite clay: Similar to kaolin clay but with even stronger water-holding properties. Use it sparingly to avoid creating a compacted soil texture. * **Hydrogels:**   + These water-absorbing polymers can be mixed into the soil to create pockets that store water and release it slowly to plants. Research the appropriate type and application rates for soybean production. * **Biochar:**   + A charcoal-like substance created by burning organic matter in a low-oxygen environment. Biochar can improve water retention, soil fertility, and drainage when used in moderation.   **Consider the following while designing:**   * + **Target ratio of chosen materials:** Experiment with different ratios of organic matter, clays, hydrogels (if used), and biochar (if used) to optimize water retention without compromising drainage or nutrient availability for soybeans.   + **Impact on soil structure:** The amendment should improve the overall structure of sandy soil, creating a balance between water holding capacity and air circulation for healthy root development. | | | |
| 25 mins | | [Digging Deeper: Exploring Water and Nutrient Retention in Soil to Improve Soybean Growth Student Worksheet](https://docs.google.com/document/d/12_7Su_wH3WdCGFkwEdIhSJ6U8GHvRtj8MUFNPzMTRU0/edit?usp=sharing) | | | Support the students as they build their designs. If you are not building and testing their designs, supervise their diagrams to make sure they are detailed and labeled.  Even if they are not testing, they should still write a detailed procedure for testing that includes data collection tables. | | | |
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| **Lesson 3: Design: Build and Test** | | | | | | | | |
| 20 mins | | [Digging Deeper: Exploring Water and Nutrient Retention in Soil to Improve Soybean Growth Student Worksheet](https://docs.google.com/document/d/12_7Su_wH3WdCGFkwEdIhSJ6U8GHvRtj8MUFNPzMTRU0/edit?usp=sharing) | | | Build and test the designs. | | | |
| 10 mins | | [Digging Deeper: Exploring Water and Nutrient Retention in Soil to Improve Soybean Growth Student Worksheet](https://docs.google.com/document/d/12_7Su_wH3WdCGFkwEdIhSJ6U8GHvRtj8MUFNPzMTRU0/edit?usp=sharing) | | | Students create short presentations about their designs (and results if tested). In their presentations, students should explain how their design can benefit soybean farmers by improving water retention and ensuring optimal crop growth.  If time permits, encourage them to research existing practices used by soybean farmers to conserve water, such as irrigation techniques or cover cropping. Discuss how their engineered soil amendment could complement these strategies. | | | |
| 15 mins | | [Digging Deeper: Exploring Water and Nutrient Retention in Soil to Improve Soybean Growth Student Worksheet](https://docs.google.com/document/d/12_7Su_wH3WdCGFkwEdIhSJ6U8GHvRtj8MUFNPzMTRU0/edit?usp=sharing) | | | Students share their designs with their class. | | | |
| **Differentiation**  **For students who need additional support:**   * Simplify data analysis by using pictures or icons instead of graphs. * Provide pre-selected materials or limit the number of variables students can explore in their designs. Focus on the basic concept of improving water retention for plant growth.   **For students who need additional challenges**:   * Plant seeds in containers filled with different soil types and observe their growth over time. Discuss how water and nutrient retention might affect germination and overall plant health. * Research different methods for soil analysis, including measuring organic matter content or pH levels. Discuss how these factors also contribute to soil health. | | | | | | | | |
| **Extension**   * Have the students research **Irrigation Technique**s: Explore different irrigation methods (drip irrigation, sprinklers) and discuss how proper watering practices can ensure soybeans receive the water they need without wasting resources. * Have the students research **Crop Rotation:** Explain the importance of crop rotation in maintaining soil health. Research the benefits of rotating soybeans with other crops like corn or wheat. * Have the students research the **Economic Impact** of droughts on soybean production and how improved soil health can contribute to a more resilient agricultural system. * Create a **prototype** for a simple tool or device that could be used by farmers to easily test soil water retention in the field. | | | | | | | | |
| **Assessment**   | **Criteria** | **4 - Exemplary** | **3 - Proficient** | **2 - Developing** | **1 - Beginning** | | --- | --- | --- | --- | --- | | Variables | Accurately identifies the independent, dependent, and controlled variables in the experiment. | Identifies some variables but may be confused about their roles or lack clarity. | Mentions variables but inaccurately identifies their roles. | Does not identify the variables. | | Hypothesis | Clearly states a testable hypothesis | Hypothesized relationship between the variables and the predicted results is reasonable | Hypothesis uses the IF ..THEN format but is vague or incomplete | Hypothesis does not use the IF…THEN statement | | Data Collection | All data is accurately  recorded | Most data is accurately  recorded | Some inaccuracies in data  recording | Major inaccuracies or missing data  in the data table | | **Graph** | Graph is accurately  constructed | Graph is mostly accurate  and well-constructed | Some inaccuracies in  graph construction | Major inaccuracies or missing graph  construction | | | | | | | | | | **Analysis Questions** | Thorough and insightful  responses demonstrating  deep understanding of  concepts and implications | Adequate analysis with  some insightful points  Clear understanding of  concepts and implications | Superficial analysis with  limited insight | Minimal or no analysis; demonstrates  lack of understanding | | | | | | | | | | **Design Challenge** | Creates an original and well-designed design that demonstrates understanding of the scientific principles involved. | Creates a design but may lack originality or effectiveness, or may not fully demonstrate understanding of the science. | Attempts to create a design but it is not well-designed or effective, or lacks connection to the scientific concepts | Does not create a design or the design is not relevant to the task. | | **Presentation** | Presentation is well-organized with a clear logical flow. Information is presented in a way that is easy to understand and follow. | Presentation is mostly organized with a logical flow. Information is generally clear, but there may be some minor jumps or confusing points | Presentation lacks clear organization and may be difficult to follow. Information may be presented in a confusing or jumbled manner. | Presentation lacks a clear structure and is difficult to understand. Transitions between points are unclear or missing | | | | | | | | | |