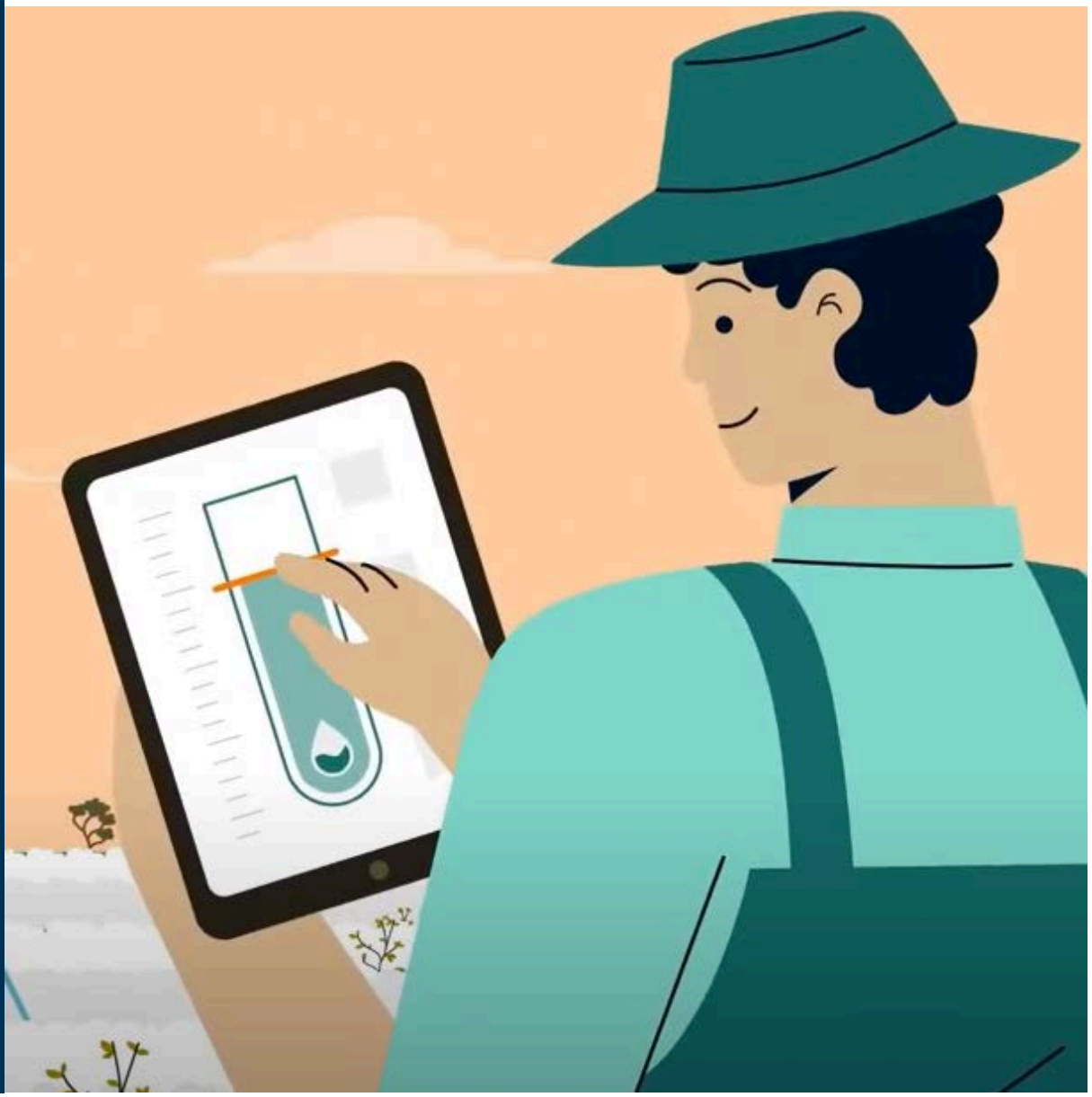
Data-driven Cotton Crops



Lesson & Activity Guide
Years 7 to 10
Design and Technologies, and Science

COTTON AUSTRALIA

Primary Industries Education Foundation Australia

Lesson Objective

Students will investigate the variables that affect cotton production and explore the ways in which data collection and analysis can help to improve yield rates and increase profitability. They will plan and conduct a scientific investigation to observe the impact of a chosen variable on cotton plant growth. After analysing the results of this investigation, students will further explore the role of scientific data collection in crop management on a global, national, and local scale. They will engage with real-world scenarios showcasing how precision agriculture technologies are used to collect and manage this data.

Lesson Overview

Activity 3.1 - Planning a Scientific Investigation (20 minutes)
Activity 3.2 - Conducting a Scientific Investigation (30 minutes plus observations over approx. 4 weeks)
Activity 3.3 - Using Data to Improve Yield (30 minutes)

CONTENTS

Australian Curriculum Content Years 7- 10

Design and Technologies

- Analyse how people in design and technologies occupations consider ethical and sustainability factors to design and produce products, services and environments (AC9TDE8K01)
- Analyse the impact of innovation and the development of technologies on designed solutions for global preferred futures (AC9TDE8K02)
- Analyse how food and fibre are produced in managed environments and how these can become sustainable (AC9TDE8K04)
- Analyse how people in design and technologies occupations consider ethical, security and sustainability factors to innovate and improve products, services and environments (AC9TDE10K01)
- Analyse the impact of innovation, enterprise and emerging technologies on designed solutions for global preferred futures (AC9TDE10K02)
- Analyse and make judgements on the ethical, secure and sustainable production and marketing of food and fibre enterprises (AC9TDE10K04)

Science

- Examine how proposed scientific responses to contemporary issues may impact on society and explore ethical, environmental, social and economic considerations (AC9S7H03) (AC9S8H03)
- Investigate how advances in technologies enable advances in science, and how science has contributed to developments in technologies and engineering (AC9S9H02) (AC9S10H02)
- Develop investigatable questions, reasoned predictions and hypotheses to explore scientific models, identify patterns and test relationships (ACS7I01, ACS8I01)

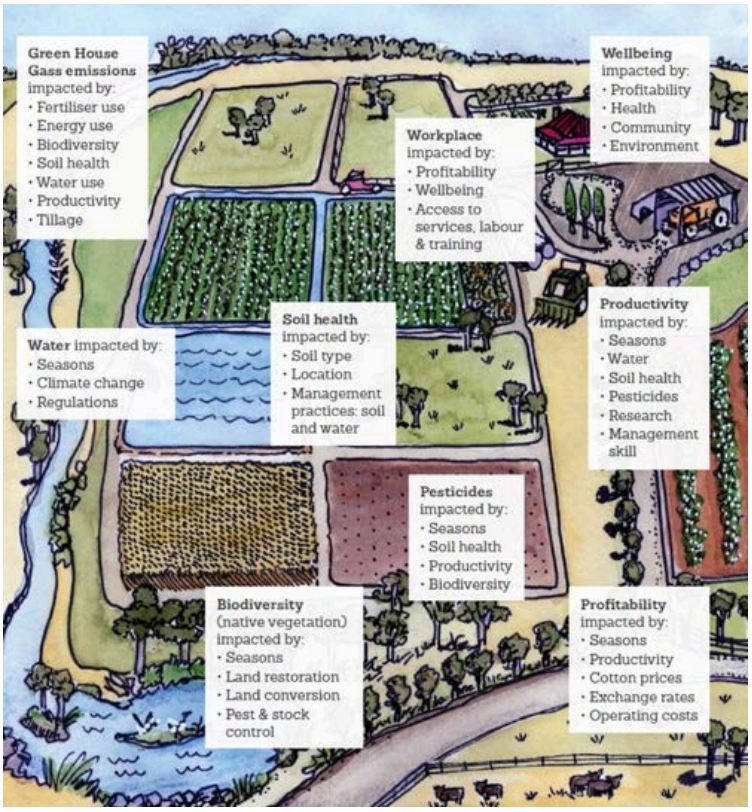
Science (cont.)

- Develop investigable questions, reasoned predictions and hypotheses to test relationships and develop explanatory models (ACS9I01, ACS10I01)
- Plan and conduct reproducible investigations to answer questions and test hypotheses, including identifying variables and assumptions and, as appropriate, recognising and managing risks, considering ethical issues regarding heritage sites and artefacts on Country/Place (AC9S7I02, AC9S8I02)
- Plan and conduct valid, reproducible investigations to answer questions and test hypotheses, including identifying and controlling for possible sources of error and, as appropriate, developing and following risk assessments, considering ethical issues, and addressing key considerations regarding heritage sites and artefacts on Country/Place (AC9S9I02, AC9S10I02)
- Select and use equipment to generate and record data with precision, using digital tools as appropriate (AC9S7I03, AC9S8I03)
- Select and use equipment to generate and record data with precision to obtain useful sample sizes and replicable data, using digital tools as appropriate (AC9S9I03, AC9S10I03)
- Select and construct appropriate representations, including tables, graphs, models and mathematical relationships, to organise and process data and information (AC9S7I04, AC9S8I04)
- Select and construct appropriate representations, including tables, graphs, descriptive statistics, models and mathematical relationships, to organise and process data and information (AC9S9I04, AC9S10I04)

Australian Curriculum Content Years 7- 10

Science (cont.)

- Analyse data and information to describe patterns, trends and relationships and identify anomalies (AC9S7I05, AC9S8I05)
- Analyse and connect a variety of data and information to identify and explain patterns, trends, relationships and anomalies (AC9S9I05, AC9S10I05)
- Analyse methods, conclusions and claims for assumptions, possible sources of error, conflicting evidence and unanswered questions (AC9S7I06, AC9S8I06)
- Assess the validity and reproducibility of methods and evaluate the validity of conclusions and claims, including by identifying assumptions, conflicting evidence and areas of uncertainty (AC9S9I06, AC9S10I06)



ACTIVITY 3.1 - Planning a Scientific Investigation

Computer/digital device access
Worksheet 3.1a - Variables Affecting the Growth of Cotton Plants (Research activity)
How Cotton is Grown (online education kit)
Worksheet 3.1b - Planning a Scientific Investigation (Template activity)
Worksheet 3.1c - Instructions for Cotton Seed Depth Investigation (Procedural activity)
Cotton Info: Planting Tips for Cotton (2:19)
Cotton Info: Seed Placement (2:16)

ACTIVITY 3.2 - Conducting a Scientific Investigation

Students' completed versions of **Worksheet 3.1b - Planning a Scientific Investigation** (Template activity)
Materials and equipment relevant to the scientific investigation being undertaken (if option 1 is chosen by teachers, materials and equipment are listed in **Worksheet 3.1c - Instructions for Cotton Seed Depth Investigation** (Procedural activity)
You can request ONE free Cotton Sample Kit per school annually:
https://cottonaustralia.com.au/education-kit
Worksheet 3.2a - Investigation Results (Template activity)

ACTIVITY 3.3 - Using Data to Improve Yield

Computer/digital device access
Worksheet 3.3a - Cotton Yield Data: Large Scale (Question and answer activity)
Australian Cotton Data Dashboard
Worksheet 3.3b - Cotton Yield Data: Small Scale (Question and answer activity)
Cotton Info Fact Sheet

Note: Schools are responsible for generating their own risk assessment for activities.

Planning a Scientific Investigation

Lesson Guide for Activity 3.1

Students will learn about the various environmental and agricultural variables that can impact the growth of healthy cotton plants and affect crop yield. They will plan a scientific investigation to examine the effect of one of these variables on the germination of seeds and plant growth. In planning for this investigation, students consider scientific inquiry concepts: independent, dependent, and controlled variables, replication & reliability.

a) As a class, consider the various environmental and agricultural factors that may impact the cotton growth. List variables and discuss the impact each variable may have on yield.

b) Distribute **Worksheet 3.1a - Variables Affecting the Growth of Cotton Plants** (Research activity). Using an online education kit, 'How Cotton is Grown' (p 1-9), students research the variables listed, commenting on the optimum conditions for plant growth and the potential impact on yield rates if these conditions are not present (Answers page 10).

c) Distribute **Worksheet 3.1b - Planning a Scientific Investigation** (Template activity). Students will plan an investigation examining **ONE** of the variables listed in **Worksheet 3.1a**. Students will observe the impact of their chosen variable on the development of cotton seeds into plants.

d) Consider the following options and select the most suitable option for your students.

Option	**Option 1 - Complete a seed depth investigation (instructions provided)**	**Option 2 - Design your own investigation**
Description	Students follow the instructions provided in Worksheet 3.1c - Instructions for Cotton Seed Depth Investigation (Procedural activity) to test the impact of planting cotton seeds at various depths.	Students propose their own variable to investigate, eg. the effect of soil type on healthy plant growth or the effect of waterlogged/drought stricken soil on germination rates etc.
Recommend-ed for:	Year 7 - 8 students. Students with limited experience in conducting and designing experiments and identifying elements of experimental design.	Year 9 - 10 students. Extension task for high-ability Year 7 - 8 students. Students with experience in conducting and designing experiments and an understanding of the elements of experimental design.

Option 1

e) If Option 1 is chosen by teachers, students will plan their investigation using the information provided in **Worksheet 3.1c – Instructions for Cotton Seed Depth Investigation** (Procedural activity).

f) Divide students into practical groups and provide time for group discussion, planning, and completion of **Worksheet 3.1b – Planning a Scientific Investigation** (Template activity).

g) Assist students in completing their investigation plan by discussing key scientific investigation concepts including replication, controlled, independent, and dependent variables.

Option 2

h) If Option 2 is chosen by teachers, students will plan their own investigation. Divide students into practical groups and provide time for group discussion, planning, and completion of **Worksheet 3.1b – Planning a Scientific Investigation** (Template activity). During this time, groups select one variable to investigate. Groups should then consider and record:

- The investigation question
- Research and findings relevant to the investigation question
- A hypothesis/prediction of the outcomes
- The independent variables, dependent variables, and controls used to ensure a fair test
- How replication and reliability of results will be addressed
- The aim for the investigation
- The materials and equipment needed to conduct the investigation
- The investigation methodology
- How results could be recorded and presented (both qualitatively and quantitatively, e.g., photographs or tables/graphs)
- Any risks that may be relevant during the experiment and ways to mitigate the risks.
  Note: Schools are responsible for completing their own risk assessments for this task.

i) Provide feedback to students once the scientific investigation plan has been completed. Assist students in making adjustments if required.

Conducting a Scientific Investigation

Lesson Guide for Activity 3.2

Students will conduct a scientific investigation to answer the investigation question chosen in Activity 3.1. They will follow their investigation plan to set up and conduct the investigation, recording relevant data and results over a period of weeks. Upon completion of the investigation, students will analyse the results to draw a conclusion and reflect on the success of the investigation.

a) Allocate a practical lesson for students to prepare and set up their scientific investigation.

b) Assist students in setting up investigations. Students use their completed versions of **Worksheet 3.1b - Planning a Scientific Investigation** (Template activity) as a guide. **Note**: If Option 2 has been chosen, it is important that teachers have reviewed and consulted with students about their planned investigation before the investigation is conducted.

c) Over a period of weeks, allocate regular and consistent time for students to measure, collect, and record data and results. **Note**: Cotton seeds generally take at least 5-14 days to sprout.

d) Consult with students about the best way to record the relevant data. Examples may include tables, diagrams etc.

e) Provide students with **Worksheet 3.2a - Investigation Results** (Template activity) to record data throughout the investigation.

f) Upon completion of the investigation, students analyse and reflect on the results, drawing a conclusion to the investigation question based on their findings. Students are asked to consider:

- The relationships identified between variables
- The results in relation to the original hypothesis
- The things that worked well/could be improved in the investigation
- The real-world implication of the investigation's findings in relation to cotton crop growth and yield rates.

Students will investigate how cotton data is collected, presented, and used in various ways to help improve yield rates and increase profitability. They will explore how precision agriculture technologies help to provide this data for farmers and agronomists. Students will analyse and compare yield data collected on a global, national, and local scale.

a) As a class, reflect on the data, results, and conclusions of the scientific investigations conducted in previous lessons. What are the real-world implications of the findings in relation to cotton production?

b) Discuss the importance of data collection for the sustainability and viability of agricultural enterprises. Construct a list of the types of information for which data may be collected on a cotton farm (answers may include number of bales harvested, amount of fertiliser used, growth rate of plants, weather and rainfall patterns etc).

c) Highlight the importance of collecting yield data in order to track information about the amount of cotton that is being produced. This can be useful both on a large scale (e.g., collecting global and national cotton production data) and on a smaller scale (e.g., collecting data on yield rates within individual fields on a farm).

d) Distribute **Worksheet 3.3a - Cotton Yield Data: Large Scale** (Question and answer activity). Using information provided on the Australian Cotton Data Dashboard, students analyse graphs to answer questions about national and global cotton yield rates. Additional research questions are provided for Year 9 - 10 students or Year 7 - 8 students requiring extension. (Answers page 11).

e) As a class, discuss the reasons why farmers and agronomists might collect specific yield data about individual fields on their farm (answers may include learning more about the variables affecting their crops, improving profitability, informing management decisions about future crops, etc).

f) Distribute **Worksheet 3.3b - Cotton Yield Data: Small Scale** (Question and answer activity). Using information provided on the Cotton Info Fact Sheet, students respond to questions about two scenarios involving the use of precision agriculture technology to collect and record yield data on individual fields. Additional activities are provided for Year 9 - 10 students or Year 7 - 8 students requiring extension. (Answers page 11).

ACTIVITY 3.1 - Planning a Scientific Investigation

Worksheet 3.1a - Variables Affecting the Growth of Cotton Plants (Research activity)

Page 1

Soil type

Optimum conditions **-** Cotton is mostly grown on cracking and self-mulching clay soils
Potential effect on crop yield - Plants may not thrive in unsuitable soil types

Soil temperature

Optimum conditions - 14°C at 10 cm depth for at least three days in a row
Potential effect on crop yield - Seed germination and crop establishment is hindered if soil temperature is unsuitable

Soil nutrients

Optimum conditions - Nitrogen is the main nutrient needed by cotton plants (also phosphorus, potassium, sulphur, and zinc)
Potential effect on crop yield - Plants may not thrive in soils lacking nutrients

Page 2

Day/night temperatures

Optimum conditions - Day temperatures 27-32°C; Night temperatures 16-20°C
Potential effect on crop yield - Cold shock or hot shock can impede plant development

Moisture

Optimum conditions - Rainfall during summer months for dryland cotton; reliable supply of water from rivers, dams etc. for irrigated cotton
Potential effect on crop yield - Plants may not survive or will produce less yield with inadequate water supply

Seed depth

Optimum conditions - 4 cm deep
Potential effect on crop yield - Seeds may germinate at different rates if planted at incorrect depths

Seed density

Optimum conditions - 10-12 seeds per metre
Potential effect on crop yield - Plants may be crowded if planted too densely; yield is not maximised if planted too sparsely

ACTIVITY 3.3 - Using Data to Improve Yield

Worksheet 3.3a - Cotton Yield Data: Large Scale (Question and answer activity)

Page 1

1. The average global yield has steadily increased from 1945 to 2023 with only small declines being seen in certain years. Based on this data, we could predict that global yield rates may continue to increase in the future.
2. More bales/hectare are produced in irrigated crops compared with dryland crops. Dryland crops see greater fluctuations in yield from year to year. This could be because they are dependent on natural rainfall patterns, while irrigated crops have a more consistent yield due to ongoing water supply.

Page 2

3. Highest yield years - 2012, 2009, 2003; Lowest yield years - 1992, 1993, 2016. Possible reasons may include periods of drought/low rainfall, extreme weather including storms, hail etc.

Answers will vary depending on individual research, but may include:

- Australia's average rainfall was higher than usual in 2012, meaning dryland crops thrived and produced higher yields
- Australia experienced severe drought conditions in the early 1990's, heavily impacting the yield of many agricultural crops that were reliant on rainfall
- In 2016, cotton crops were severely affected by cold shock shortly after planting, followed by heat shock in January and February

Worksheet 3.3b - Cotton Yield Data: Small Scale (Question and answer activity)

Page 1

1. Yield maps are created from a cotton picker's yield monitor, which uses a series of sensors in the machine.Variables that may impact the yield from each field include soil characteristics, availability of nutrition, weed and pest pressures, topography, water availability.
2.

- Step 1 - Compare data to understand where the highly productive areas and less productive areas are within the farm
- Step 2 - Consider how the issues in the lower yielding areas can be addressed
- Step 3 - Analyse the cost effectiveness of implementing strategies to fix the issues

Page 2

3. a) Green
   b) Yellow and orange
   c) Red

4. a) Drainage
   b) Laser levelling the field

5. a) The farmer conducted deep ripping (cutting and opening the soil with a machine) before planting seeds
   b) Compaction was caused by feral pigs

References

AgEcon. (n.d.). Fact sheet. Retrieved February 29, 2024, from https://cottoninfo.com.au/sites/default/files/documents/Using%20cotton%20yield%20maps%20to%20improve%20profitability_FINAL_with%20CottonInfo%20logo.pdf

Cotton Australia. (n.d.). How cotton is grown. Retrieved February 29, 2024, from https://cottonaustralia.com.au/assets/general/Education-resources/CA-resources/Education-Kit/2021-Education-Kit/Educational_Kit_Cotton_Australia_Chapter05.pdf

CottonInfo. (2014). Planting tips for cotton. www.youtube.com. https://www.youtube.com/watch?v=m6uo7-77yi4

CottonInfo. (2016, May 27). Seed placement. www.youtube.com. https://www.youtube.com/watch?app=desktop&v=kypMqI5F51s

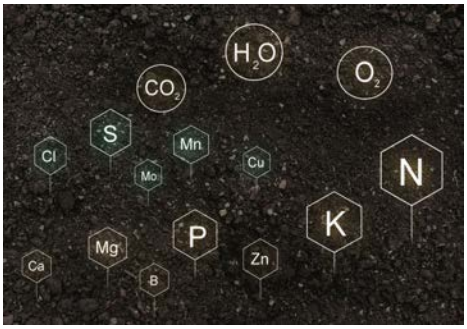
Home · Cotton Australia. (2022). www.cottondata.com.au. https://www.cottondata.com.au/?nav=paddock/yield

Variables Affecting the Growth of Cotton Plants

Student Worksheet 3.1a

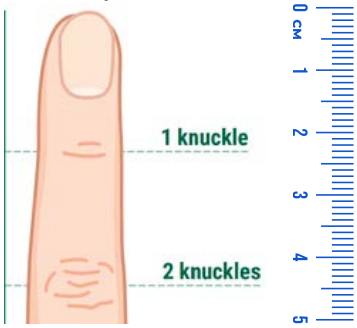
View the resource '[How Cotton is Grown](https://cottonaustralia.com.au/assets/general/Education-resources/CA-resources/Education-Kit/2021-Education-Kit/Educational_Kit_Cotton_Australia_Chapter05.pdf)' to learn about the optimum conditions for cotton planting and growth. Complete the table below to summarise relevant information.

https://cottonaustralia.com.au/assets/general/Education-resources/CA-resources/Education-Kit/2021-Education-Kit/Educational_Kit_Cotton_Australia_Chapter05.pdf

Variable	Optimum conditions	Potential effect on crop yield
Soil Type 		
Soil Temperature 		
Soil Nutrients 		

Variables Affecting the Growth of Cotton Plants

Student Worksheet 3.1a

Variable	Optimum conditions	Potential effect on crop yield
Day/night Temperatures 		
Moisture 		
Seed Depth 		
Seed Density 		

Planning a Scientific Investigation

Student Worksheet 3.1b

COTTON AUSTRALIA

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Team members:	Date:

Investigation question, research and hypothesis	
Investigation Question *What is the question you would like this investigation to answer?*	
Relevant Research *Research and learning about what other people have discovered helps you discover more about your investigation question.*	
Hypothesis *Make a prediction about the results you expect to see.*	

Variables	
Independent Variable *(I will measure …)*	
Dependent Variable *(I will measure …)*	
Controlled Variables *(I will keep the same …)*	

Planning a Scientific Investigation

Student Worksheet 3.1b

Replication and Reliability

*Replication is the repetition of an experiment/investigation in the same or similar conditions to ensure **reliability** of results. How will you ensure reliability in your investigation?*

Aim

Make a statement explaining what the experiment/investigation is attempting to achieve.

Method

Write a series of numbered steps that are clear and detailed.

Method (continued)

Write a series of numbered steps that are clear and detailed.

Materials and Equipment

*List the **materials** (substances and objects that are used up) and **equipment** (instruments and tools) that are needed to complete this investigation.*

Investigation Set-Up

*Draw a **labelled diagram** of how you will set up the materials and equipment.*

Risk Assessment	
Possible Risk	**Ways to Mitigate Risk**

Collection and Recording of Results

Explain how you plan to collect and record the results of your investigation.

Instructions for Cotton Seed Depth

Option 1 - Student Worksheet 3.1c

Use the information below to assist in completing **Worksheet 3.1b – Planning a Scientific Investigation.**

1

Investigation question

How does the depth of seed placement during planting affect the growth of cotton plants?

2

Research

What relevant background information can we discover through research? Use the links (below) as a starting point to your research.

Link:https://www.youtube.com/watch?v=m6uo7-77yi4

Link:https://www.youtube.com/watch?app=desktop&v=kypMqI5F51s

3

Hypothesis, variables ,and reliability

Consider and record your predictions. Record information about the independent and dependent variables and controls in your investigation. Consider ways to ensure reliability in the study.

4

Materials and equipment

- 4 x large containers (for example, 50L plastic storage tubs) filled with soil OR
- 4 x 1x1m quadrats in garden/agriculture plot
- Soil (if using containers)
- 40-50 x cotton seeds*
- Ruler
- Gardening trowel
- Watering can & water

*You can request ONE free Cotton Sample Kit per school annually: https://cottonaustralia.com.au/education-kit

Method

5 1. Transfer soil into four large containers, filled 2-3 cm from the top. The containers
should be placed alongside each other, with similar access to shade and sunlight.
Alternatively, prepare four 1 m x 1 m quadrats in a garden or agriculture plot. The quadrats should be located alongside each other.

2. Mark containers/plots with signs: SEED DEPTH 1 cm; SEED DEPTH 3 cm; SEED DEPTH
5 cm; SEED DEPTH 10 cm.

3. In the first container/plot, use a ruler to measure 1 cm beneath the surface of the soil. Use a trowel to create a shallow trench spanning the length of the container/plot at a consistent depth of 1 cm.

4. Plant multiple seeds along the trench, spacing each seed 10 cm apart. Gently cover the seeds with soil.

5. Repeat steps 3 and 4 in the remaining containers/plots, measuring the trench depths at 3 cm, 5 cm and 10 cm respectively.

6. Water each container/plot using a watering can. Ensure the same quantity of water is provided to each.

7. Monitor, measure, and record plant growth over a period of weeks (seeds generally take at least 4-5 weeks to sprout). Water regularly, always ensuring the same amount of water is provided to each container/plot.

6

Results

Consider how to record your observations and results. Diagrams, tables, charts, and graphs are often used to display results in scientific investigations.

7

Conclusion

Draw a conclusion based on your results. The conclusion should answer the investigation question: How does the depth of seed placement during planting affect the growth of cotton plants?

Investigation Results

Option 1 - Student Worksheet 3.2a

Use the space provided to record data gathered during the investigation. Results may be recorded in the form of graph, chart, table, or diagram.

Investigation Results

Option 1 - Student Worksheet 3.2a

Use the space provided to record data gathered during the investigation. Results may be recorded in the form of graph, chart, table, or diagram.

Discuss the relationships you have identified between the variables in your investigation.

Do your results support your hypothesis? Explain.

Reflect on your investigation and identify what worked well and what you could improve.

Investigation Results

Option 1 - Student Worksheet 3.2a

Write a conclusion for your investigation. The conclusion should answer your original investigation question.

How could the information you have gathered throughout your investigation be used by cotton farmers or agronomists to improve crop yield?

Cotton Yield Data: Large Scale

Student Worksheet 3.3a

Use the Australian Cotton Dashboard to analyse data on global and national cotton yields.

Linkhttps://www.cottondata.com.au/?nav=paddock/yield:

Follow the instructions below to answer the questions.

1. Click the 'Select a yield type' drop-down menu. Select **Global - Average**

Describe the trend identified in the average global yield data. What predictions could you make about future global yield rates based on this data?

2. Click the 'Select a yield type' drop-down menu. Select **Dryland - Australia and Irrigated - Australia.**

Compare and analyse the dryland yield and irrigated yield graphs. What differences can you note between the two sets of data? Suggest possible reasons as to why these differences have occurred.

Cotton Yield Data: Large Scale

Student Worksheet 3.3a

Use the Australian Cotton Dashboard to analyse data on global and national cotton yields.

Linkhttps://www.cottondata.com.au/?nav=paddock/yield:

Follow the instructions below to answer the questions.

3 Click the 'Select a yield type' drop-down menu. Select **Dryland - Australia**.

During which years were the lowest/highest dryland yield rates recorded? Suggest possible reasons for these rates.

Conduct research to locate rainfall/weather data for the years listed in the previous data. Make connections between the rainfall/weather data and the yield data.

Cotton Yield Data: Small Scale

Student Worksheet 3.3b

COTTON AUSTRALIA

Primary Industries Education Foundation Australia

Variable yield maps: making the most of data

Use the fact sheet to answer the questions below.

Link: https://cottoninfo.com.au/sites/default/files/documents/Using%20cotton%20yield%20maps%20to%20improve%20profitability_FINAL_with%20CottonInfo%20logo.pdf

1 Variable yield maps

How are yield maps created?

_ _

_ _

List the variables that may impact the yield from each field.

_ _

_ _

_ _

2 Using yield maps to improve enterprise profitability

Summarise the three-step process outlined on page 1.

_ _

_ _

_ _

_ _

_ _

3 Interpreting yield maps

Look at Figure 1: Yield map legend. The numbers in the left-hand column indicate the amount (in kilograms) of cotton harvested per hectare.
Which colour/s represent

a) the highest yield _____

b) the lowest yield _____

c) a medium yield _____

4 Scenario 1

Read Scenario 1. The yield map (Figure 2: Irrigated cotton yield map with key as kg/ha) indicates lower yield rates in the middle of the field (red areas).

a) Which variable was identified as being the issue for the lower yield rate in this area?

_____

b) What remediation option (way to fix the issue) was investigated?

_____

5 Scenario 2

Read Scenario 2. The yield map (Figure 6: Variable yield map #2: Irrigated cotton) indicates a high yield rate on the left-hand side of the dotted line (green areas). It also indicates lower yield rates in the south-west (SW) corner of the field (red areas).
a) What did the farmer do prior to the cotton season which helped to **increase** the yield rate?

_____

b) What was the cause of the compacted soil in the SW corner of the field, leading to a **decrease** in yield rates?

_____

Additional Activities

6 Graphing map yield data

a) Look at Figure 1: Yield map legend. Using digital technologies, present the data provided as a **pie graph** to create a visual representation of the percentages of the field achieving high, medium, and low yield rates.
b) Create a second pie graph using data provided in Figure 6: Variable yield map #2:
Irrigated cotton (kg/ha). Print and glue below, or submit your graphs digitally.