project calibrate

Summative Assessment Resources for Practical Science

Biology

Plant growth and distribution

DEPARTMENT OF EDUCATION
UNIVERSITY OF OXFORD

About Project Calibrate
Project Calibrate is a research and development collaboration between University of Oxford and AQA, and aims to foster effective teaching, learning and assessment of practical science. The resource pack contains five summative assessments developed as part of the project to assess learners' understanding of and skills in GCSE practical science. The underlying framework of practical science is Brandon's matrix which highlights a variety of methods used in science. According to Brandon, there are four main categories of scientific methods (described on the next page). Four assessment tasks were designed using each category. The fifth assessment task includes all four categories and engages the learners in an evaluation of the different scientific methods.

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Funding
Project Calibrate is jointly funded by the Wellcome Trust, the Gatsby Foundation and the Royal Society (Grant number: 209659/Z/17/Z)

Duration
January 2018-December 2020

Citation
The resources are cited as follows:
Project Calibrate (2020). *Summative Assessment Resources for Practical Science: Plant growth and distribution.* Oxford: University of Oxford.

Brandon's Matrix

Brandon provides an account of diversity in scientific methods. His framework has been adapted by Project Calibrate (see Table 1) and illustrates that not all experiments rely on hypothesis testing, and that not all descriptive work is non-manipulative. Brandon represents the connections between experiments and observations in terms of a matrix (i.e. two-by-two table) in which an investigation (experiment/observation) is related to whether or not it involves manipulation, and whether or not it involves hypothesis testing or parameter measurement.

Table 1. Adaptation of Brandon's matrix

	Experiment or observation	
	Change variable	**Don't change variable**
Test hypothesis	Manipulative hypothesis testing	Non-manipulative hypothesis testing
Describe or measure	Manipulative description or parameter measurement	Non-manipulative description or parameter measurement

The importance of the matrix is that it challenges the traditional linear model of the scientific method in the science curriculum. A fairly typical depiction in school of how science is done involves the so-called 'scientific method', which is described as a process through which scientists produce robust evidence by applying procedures such as experimentation and observation. According to this model, scientists begin with a question they want to answer. They then design an experiment and, by carefully tracing independent and dependent variables, they produce findings that help them answer the question. However, such a step-wise and linear description of the scientific method is simplistic and hardly a realistic representation of how scientists actually do science. Rather, scientists engage in a wide array of methods some of which include hypothesis testing, and some other approaches including those where there is no manipulation of variables (Erduran & Dagher, 2014).

A contemporary example about Brandon's matrix involves the Covid-19 pandemic (Erduran, Childs & Baird, 2020). Scientists collect data on how the virus might be influencing a patient's breathing over a period of time. Such observation is simply based on the recording of parameters where there is no manipulation of variables in the sense of an experimental design. Sometimes the data might be subjected to hypothesis testing about correlation between incubation period and extent of lung disease, but without an experiment resulting in non-manipulative hypothesis testing. Scientists may conduct randomised control trials in which a drug could be treated as a variable in interventions that also include control groups to test the placebo effect. All of these different approaches are used in science, and there is no one single method but rather a diversity of scientific methods.

References

Brandon, R. (1994). Theory and experiment in evolutionary biology. *Synthese*, 99, 59-73.

Erduran, S., Childs, A., & Baird, J. (2020). Practical science and pandemics. https://www.bera.ac.uk/blog/practical-science-and-pandemics

Erduran, S., & Dagher, Z. (2014). *Reconceptualising the nature of science for science education: Scientific knowledge, practices and other family categories*. Dordrecht: Springer.

Biology: Plant growth and distribution

Question 1 [manipulative hypothesis testing]

Selective weed killers kill broad leaved weed plants, but do not kill grass plants.

A student said the more concentrated the weed killer solution is the more weeds it will kill.

The student investigated this hypothesis.

This is the method used.

1. Mark five 1m x 1m squares on a lawn.
2. Count the number of weed plants growing in each area.
3. Spray 500 cm^3 of water onto one square.
4. Leave for 2 weeks and count the number of weeds still growing.
5. Calculate the percentage decrease in the number of weeds.
6. Repeat steps 2 to 5 using different concentrations of weed killer solution.

1.1 Why did the student put water onto one of the squares?

[1 mark]

_____

_____

1.2 Give **two** control variables in this investigation.

[2 marks]

1. _____

2. _____

Table 1 shows the student's results.

Table 1

Percentage concentration of weed killer solution	Number of weed plants		Percentage (%) decrease in number of weed plants
	At start	After 2 weeks	
0 (water)	9	9	0
10	8	7	13
20	10	6	40
30	12	4	
40	9	1	89
50	8	1	88

1.3 Calculate the percentage decrease in the number of weed plants at a weed killer concentration of 30 %.

Give your answer to 2 significant figures.

[2 marks]

_____

_____

Percentage decrease in the number of weed plants = _____ %

1.4 Why did the student calculate the percentage decrease in the number of weed plants?

[1 mark]

_____

_____

1.5 **Do the data in Table 1 support the student's hypothesis that the more concentrated the weed killer solution is the more weeds it will kill?**

Give a reason for your answer.

[1 mark]

_____

_____

_____

1.6 Suggest **two** improvements to the student's method that would lead to a more valid conclusion.

[2 marks]

1.

_____

_____

2.

_____

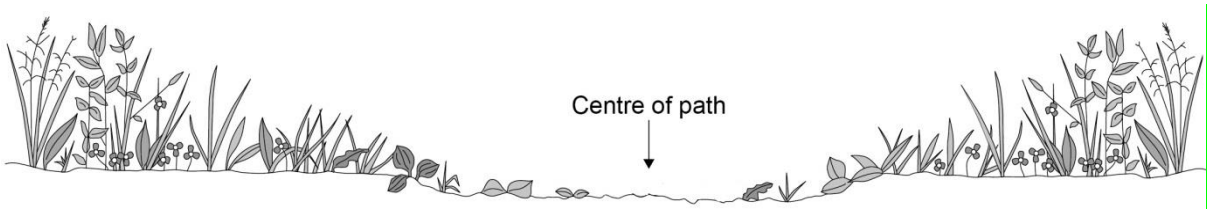
_____

Question 2 [manipulative parameter measurement]

Where people walk on a path can affect the growth of plants.

Figure 1 shows how the growth of plants varied across one path.

Figure 1



Some students were asked to investigate how the distribution and abundance of plant species varied across the width of the path.

Describe a method the students could use.

[6 marks]

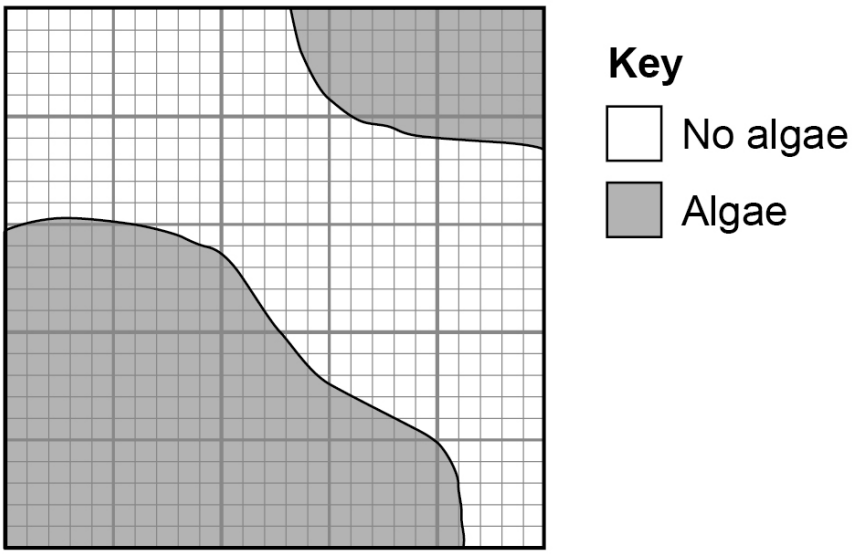
Question 3 [non-manipulative hypothesis testing]

Algae are simple plants. Some types of algae live on the bark of trees.

A quadrat divided into 25 small squares can be used to estimate the percentage cover of algae.

Figure 2 shows the algae growing in one quadrat.

Figure 2



3.1 Calculate the percentage cover of algae shown in **Figure 2**.

You should count the number of squares in which the algae cover more than half the square.
Use this number to calculate the percentage cover of algae in the whole quadrat.

[2 marks]

_____

_____

_____

Percentage cover of algae = _____ %

One student said he thought the distribution of algae would vary around the tree.

He set up an investigation to test this hypothesis.

This is the method used.

1. Sample 20 trees in one area.
2. Use a quadrat to measure the percentage cover of algae on the north-east, south-east, south-west and north-west sides of each tree.
3. Calculate the mean percentage cover for each side.

Figure 3 shows the sides of the trees sampled.

Figure 3

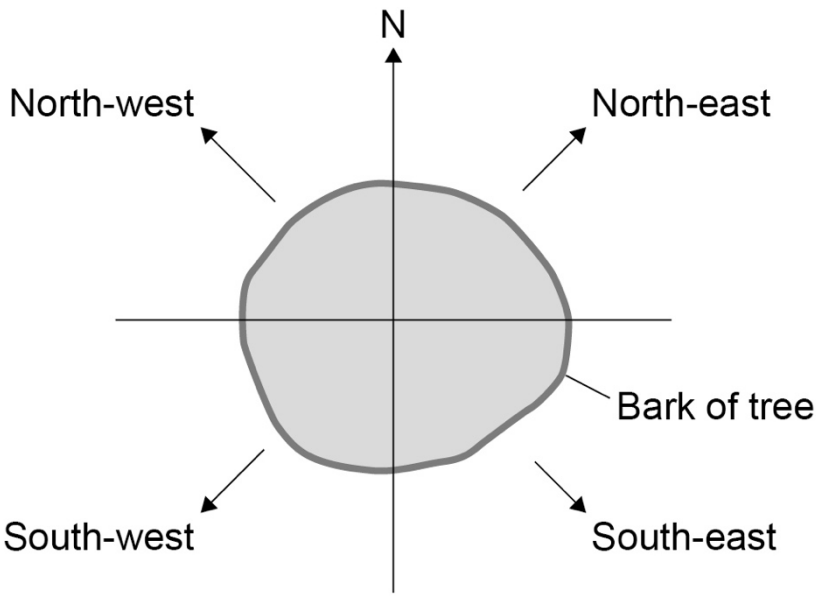


Table 2 shows the student's results.

Table 2

Side of tree	Mean percentage cover of algae
North-east	68
South-east	24
South-west	35
North-west	62

3.2 What were the dependent and independent variables in this investigation?

[2 marks]

Dependent variable: _____

Independent variable: _____

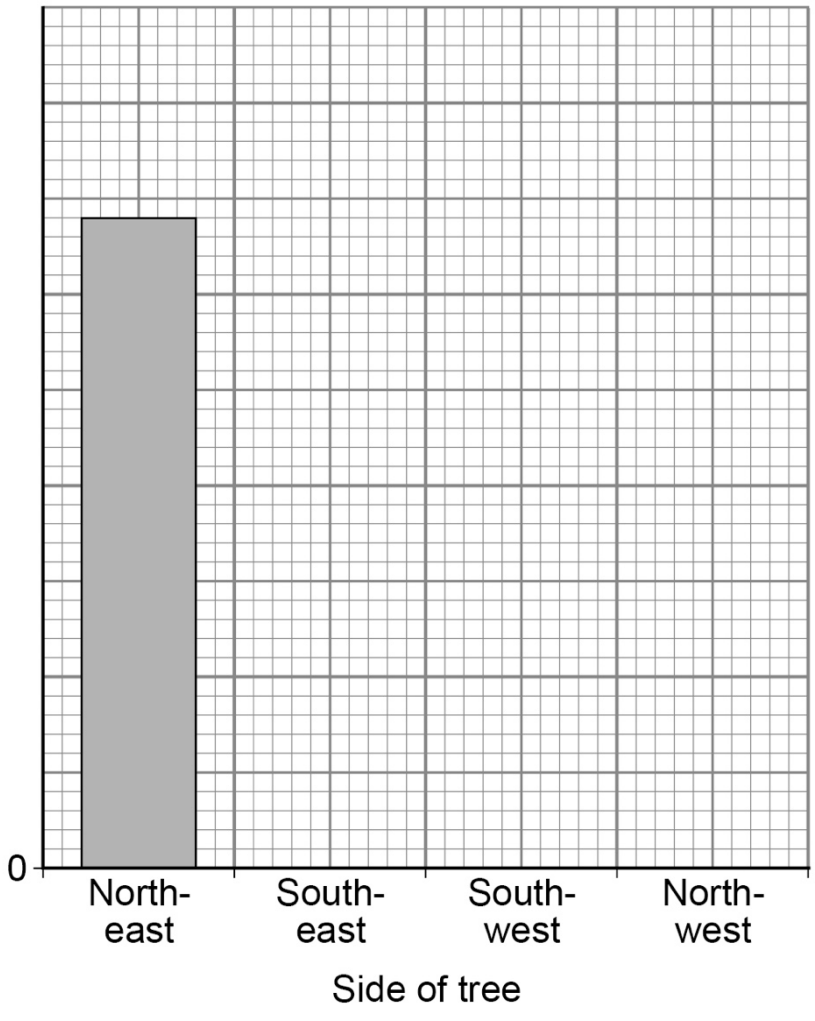
3.3 Complete **Figure 4**.

Use the information from **Table 2**.

- Label the y-axis
- Add a scale to the y-axis
- Plot the bars

[4 marks]

Figure 4



3.4 On which side of the tree were there the most algae growing?

Suggest **one** reason why more algae grew on this side.

[2 marks]

Tick (✓) **one** box.

North side ☐

South side ☐

East side ☐

West side ☐

Reason:

_____

_____

Question 4 [non-manipulative parameter measurement]

A class of students estimated the population of dandelion plants on the school field. The students worked in pairs.

This is the method used.

1. Measure the dimensions of the field.
2. Randomly position a quadrat measuring 0.5m by 0.5m on the field.
3. Count and record all the dandelion plants in the quadrat.
4. Repeat steps 2 and 3 nine more times.

4.1 Suggest how the quadrat could be positioned randomly on the field.

[1 mark]

_____

_____

04.2 Why is it important that the quadrat is positioned randomly?

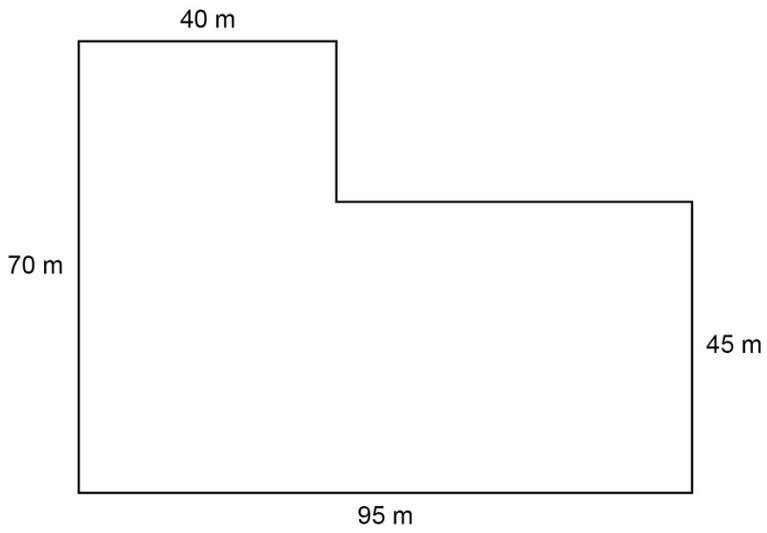
[1 mark]

_____

_____

Figure 5 shows the dimensions of the field.

Figure 5



4.3 Calculate the total area of the field.

[2 marks]

Total area of field = _____ m^2

4.4 Calculate how many quadrats would fit into the total area of the field.

[2 marks]

Number of quadrats = _____

Table 3 shows the results for one pair of students.

Table 3

Quadrat number	Number of dandelion plants
1	2
2	6
3	0
4	8
5	3
6	2
7	5
8	1
9	0
10	2

4.5 Estimate the total number of dandelion plants on the field.

Use your answer to **04.4** and data from **Table 3**.

[2 marks]

_____

_____

_____

Total number of dandelion plants on the field = _____

4.6 This method cannot give an accurate value for the number of dandelion plants on the field.

Suggest why.

[1 mark]

_____

_____

_____

4.7 One student said that they would get a better estimate for the number of dandelion plants on the field if they pooled all their results together.

Why would this give a better estimate?

[1 mark]

_____

_____

Question 5 [combined task]

Read the information about plant growth.

Draw one line from each piece of information to its description.

[4 marks]

Information	**Description**
A student noticed that there were very few grass plants growing under the canopy of large trees.	Conclusion
	Hypothesis
She thought this was because there was very little light under the tree.	Investigation
She measured the light intensity and counted the number of grass plants at different distances from the trunk of a large tree.	Observation
	Result
At a distance of 1 m from the trunk there were 20 grass plants and at 2 m from the trunk there were 80 grass plants.	Prediction

Mark scheme

Question 1

Question	Answers	Extra information	Mark	AO / Spec.
1.1	any one from: • to make sure it was the weed killer that had an effect • to check that water did not have an effect	allow to see if water had an effect allow for comparison with the weed killer allow as a control do **not** allow as a control variable	**1**	AO3/3b 4.7.2.1 WS 2.2, 2.3, 3.8
1.2	any **two** from: • same size areas sampled • same volume of liquid / solution / weed killer used • left for the same length of time		**2**	AO2/2 4.7.2.1 WS 2.2
1.3	$\frac{8}{12} \times 100$ = 67 (%)	an answer of 67 (%) scores 2 marks allow correct rounding of 66.666667 (%) allow **1** mark only for 66 (%)	**1** **1**	AO2/2 4.7.2.1 WS3.3 Ma 1a, 1c, 2a, 3a
1.4	to control for the number of weeds in each square at the start	allow because there were not the same number of weeds in each square	**1**	AO3/3a 4.7.2.1 WS2.2, 2.4

1.5	(no) any **one** from: • the percentage decrease in weeds at a concentration of 50% was less than that at 40% • we don't know what the pattern is above 50% concentration **or** (yes) results from 0% up to 40% concentration show that increasing the concentration increased the number of weeds killed and the percentage killed at 40% and 50% concentration are very similar	the mark is for a correct reason correctly linked to their decision	**1**	AO3/2a 4.7.2.1 WS 3.5, 3.6
1.6	any **two** from: • do repeats at each concentration **and** calculate a mean • (grow weeds in trays) so starting number of weeds are the same • (grow weeds in trays) so same type of weeds are used • extend the range of concentrations used • go up in smaller intervals of concentration	allow example, e.g., every 5% concentration	**2**	AO3/3b 4.7.2.1 WS 2.7, 3.7
Total			**9**	

Question 2

Question	Answers	Mark	AO / Spec.
2.0	**Level 3:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	**5–6**	AO2/2 4.7.2.1
	Level 2: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.	**3–4**	AO1/2
	Level 1: The design/plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	**1–2**	AO1/2
	No relevant content	**0**	WS 2.2, 2.3, 2.4, 2.5, 2.6
	Indicative content • lay a transect line across the path • place a quadrat at regular intervals • on the same side of the transect line each time • use suitable sized quadrats • count number of each species present (in the quadrat) **or** estimate percentage cover of each species • use a key to identify the individual species • repeat another transect line parallel to the original / 5m further along the path • conduct at least three transect lines • calculate the mean for each distance across the path to access level 3 the key ideas of using quadrats with transect lines and counting the number of each species need to be given to produce a valid outcome		

Question 3

Question	Answers	Extra information	Mark	AO / Spec.
3.1	$\frac{11}{25} \times 100$ = 44	an answer of 44(%) scores 2 marks allow 1 mark for evidence of counting 11 squares	1 1	AO2/2 4.7.2.1 WS 1.2, 3.2, 3.3 Ma 1c, 2d, 3a
3.2	(dependent variable): (mean) percentage cover of algae (independent variable): side of tree		1 1	AO2/2 3.7.2.1 WS 2.2,
3.3	Label y-axis: mean percentage cover of algae Add scale: e.g., 1 cm = 10% or 2cm = 20% All three remaining bars correctly plotted		1 1 2	AO2/2 3.7.2.1 WS 3.1, 3.2 Ma 2c, 4a, 4c
3.4	North side Reason: any **one** from: • it is more humid • it is not as hot • there is less pollution	 allow wetter allow colder	1 1	AO3/2b 4.7.2.1 WS 3.5 Ma 2c, 4a
Total			**10**	

Question 4

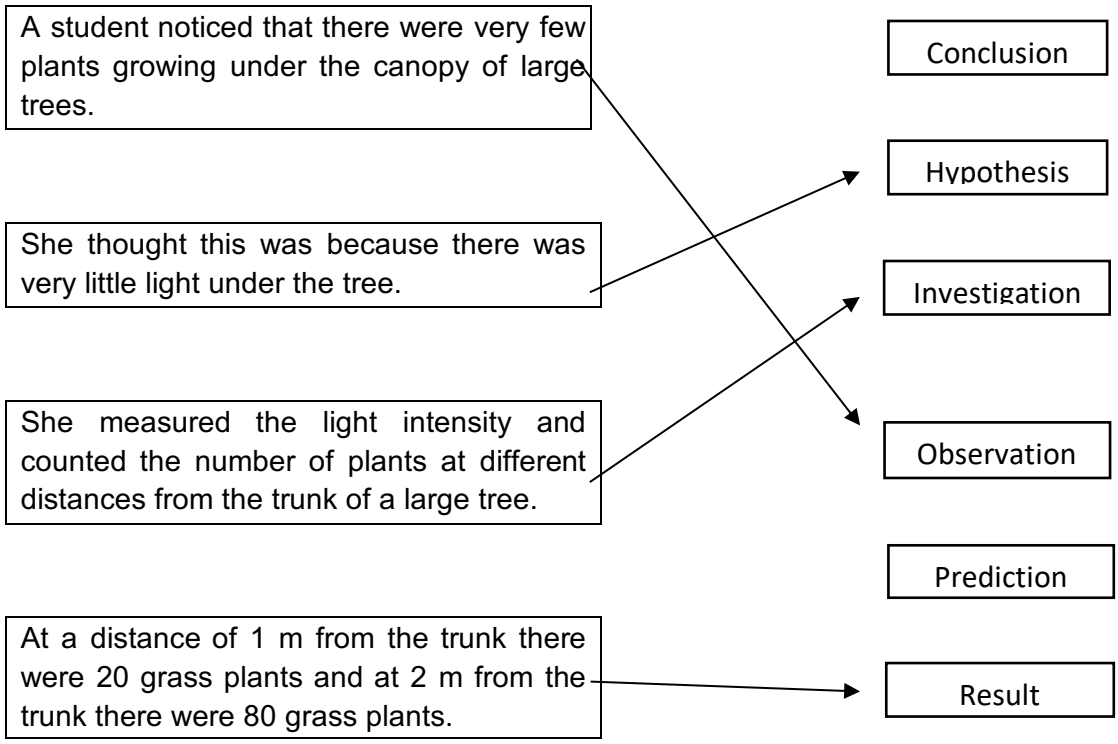
Question	Answers	Extra information	Mark	AO / Spec.
4.1	any **one** from: • use a numbered grid map of area and select numbers from a bucket • use a numbered grid map of area and a random number generator • use a random walk method	Ignore throw it over your shoulder	1	AO2/2 4.7.2.1 WS 2.2, 2.5
4.2	to avoid bias	allow the idea of obtaining a representative sample of the whole area	1	AO3/3a 4.7.2.1 WS2.5
4.3	(40 x 70) + (55 x 45) **or** (95 x 45) + (40 x 25) = 5275 (m^2)	an answer of 5275 scores 2 marks allow 2800 + 2475 allow 4275 + 1000	1 1	AO2/2 4.7.2.1 WS 1.2, 3.2, 3.3 Ma 5c
4.4	(area of one quadrat = 0.5 x 0.50 = 0.25 (m^2) (5275 / 0.25) = 21 100	an answer of 21 100 scores 2 marks allow ecf from 04.3	1 1	AO2/2 4.7.2.1 WS 1.2, 3.3 Ma 1c, 3a, 5c

4.5	[mean number of plants per quadrat = (2+6+0+8+3+2+5+1+0+2) / 10] = 2.9 (total number of plants on field = 2.9 x 21 100 =) 61 190	an answer of 61 190 scores 2 marks allow ecf from 04.4	1 1	AO2/2 4.7.2.1 WS 1.2, 3.3 Ma 2b, 3a, 5c
4.6	any **one** from: • not all the plants are counted • the plants are not distributed evenly over the field • sample size too small for such a large field		1	AO3/2a 4.7.2.1 WS 2.7, 3.7
4.7	bigger sample size will reduce the effect of anomalies	allow idea that there might be many plants in one area and few in another, having more data will help control for these differences	1	AO3/2a 4.7.2.1 WS 2.5
Total			**10**	

Question 5

Mark for each correct line. Extra lines negate that mark.

Total: 4 marks



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