Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

* 3 9 9 7 4 9 8 7 1 6 *

BIOLOGY **9700/52**

Paper 5 Planning, Analysis and Evaluation **February/March 2023**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **20** pages. Any blank pages are indicated.

DC (CE/SG) 315536/4

1 Potatoes are underground organs made by the potato plant, *Solanum tuberosum*.

Fig. 1.1 shows a potato plant.

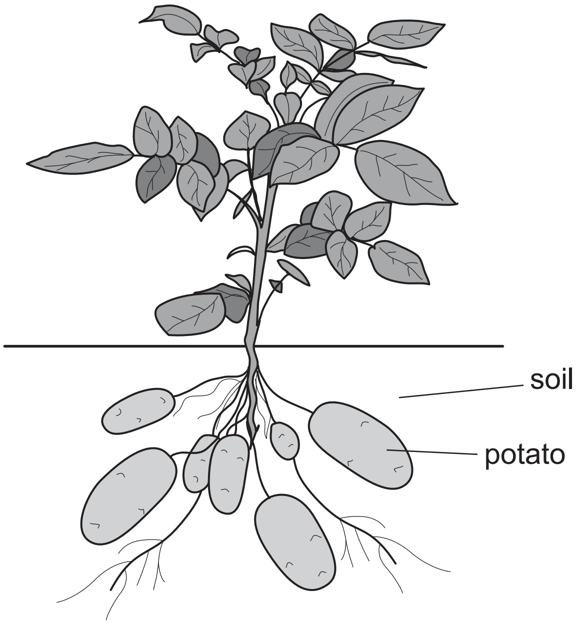

Fig. 1.1

Potatoes contain high quantities of starch and are a popular food. After harvesting, potatoes are stored. During storage, the starch content of potatoes gradually decreases due to the breakdown of starch molecules into glucose.

A glucose assay using a Benedict's test and a colorimeter can be used to determine the concentration of glucose in potatoes.

The glucose assay uses these steps:

- The outer skin is removed from a potato.
- The potato is cut into small pieces that are then ground into a pulp using a mortar and pestle.
- The potato pulp is filtered to remove most of the solids and obtain potato juice.
- Excess Benedict's solution is added to the potato juice.
- The mixture is heated in a water-bath at 90 °C for five minutes. During this five-minute period, copper ions (Cu^{2+}) in the Benedict's solution react with glucose in the potato juice to form an insoluble precipitate.
- The mixture is filtered to remove the precipitate. The filtrate, which is blue, contains copper ions that did not react with the glucose in the potato juice while the mixture was being heated.
- A sample of the blue filtrate is transferred to a colorimeter tube (cuvette).
- A colorimeter is used to measure the absorbance of the blue filtrate.
- A calibration curve is used to determine the glucose concentration of the potato juice from the measurement of absorbance.

Fig. 1.2 shows one type of colorimeter.

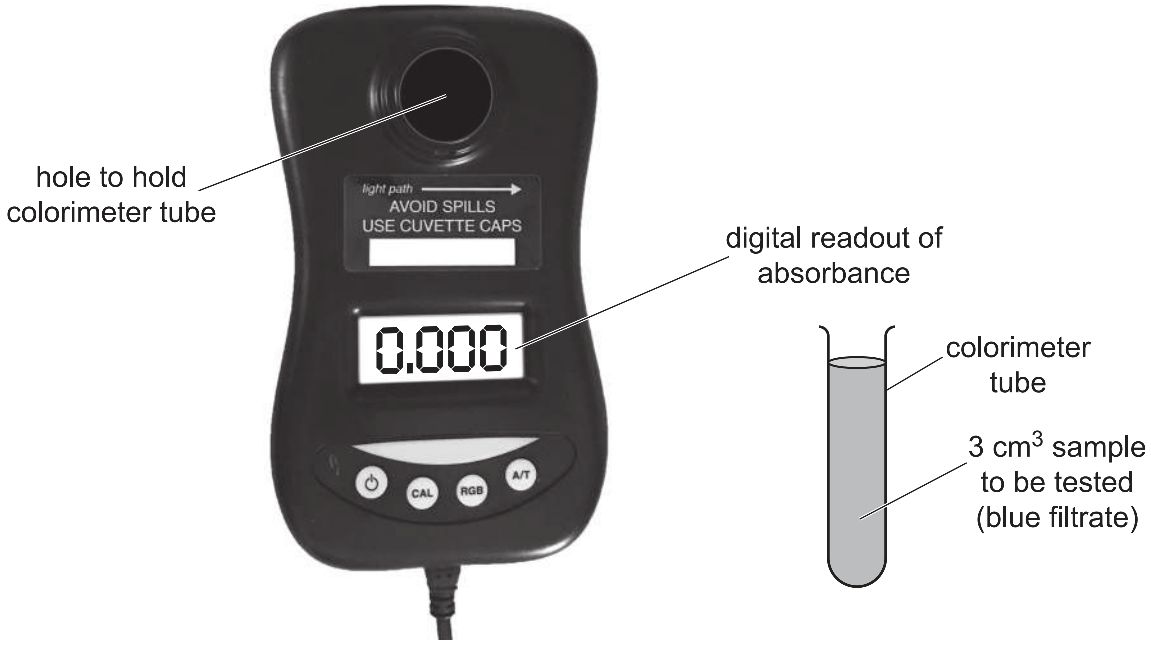

Fig. 1.2

A clean colorimeter tube containing the sample to be tested is placed in the colorimeter. Light is passed through the sample and the absorbance of light by the sample is measured.

(a) **(i)** Outline how colorimeters should be prepared **before** carrying out measurements on samples so that correct absorbance readings in the glucose assay are obtained.

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To determine the concentration of glucose in potato juice using the glucose assay, a calibration curve needs to be produced. This involves using the glucose assay to obtain absorbance readings for standard glucose solutions of known concentrations.

(ii) A student was given a 2.0% stock solution of glucose from which to prepare a range of standard glucose solutions of known concentrations.

State the glucose concentrations the student could use to produce a calibration curve **and** describe how **20 cm^3** of each solution should be prepared by **proportional** dilution of the 2.0% stock solution of glucose.

You may use a table to show your answer.

glucose concentrations to use: ....

how to prepare:

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(iii) Sketch, on Fig. 1.3, a graph of the expected calibration curve that the student would obtain.

Include the axis labels.

Fig. 1.3

[2]

(b) The student decided to investigate the effect of storage time on the glucose concentration of potatoes.

(i) Identify the **dependent** variable in this investigation.

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(ii) The student was provided with freshly harvested potatoes, standard laboratory apparatus and a colorimeter.

Describe a method, using the glucose assay, that the student could use to investigate the effect of **storage time** on the glucose concentration of potatoes.

Your method should be set out in a logical order and be detailed enough to allow another person to follow it.

Details of how to carry out the glucose assay and how to prepare and use the colorimeter should **not** be included.

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Question 1 continues on page 8.

When potatoes are cooked at high temperatures to make potato chips, glucose and amino acids react together. This reaction is known as the Maillard reaction and is responsible for the orange-brown colour of potato chips.

When glucose reacts with the amino acid asparagine, acrylamide is made.

This reaction is shown in Fig. 1.4.

$$\text{asparagine} + \text{glucose} \xrightarrow[]{\substack{\text{high temperature} \\ \text{cooking} > 120\,^{\circ}\text{C}}} \text{acrylamide}$$

Fig. 1.4

Low concentrations of acrylamide are produced when potatoes are cooked at high temperatures to make potato chips. High concentrations of acrylamide are toxic to humans and can increase the risk of certain cancers developing.

Exposing raw potatoes to gamma radiation decreases the acrylamide concentration of potato chips.

Some scientists investigated the effect of gamma radiation on the composition of raw potatoes.

- Four bags of one variety of potato were each exposed to a different dose of gamma radiation: $0\,\text{J}\,\text{kg}^{-1}$, $50\,\text{J}\,\text{kg}^{-1}$, $100\,\text{J}\,\text{kg}^{-1}$ and $150\,\text{J}\,\text{kg}^{-1}$.
- Three samples of raw potatoes from each bag were then analysed chemically to determine the concentrations of glucose, protein and volatile nitrogen compounds as a percentage of dry mass. Volatile nitrogen compounds are present in potatoes due to the breakdown of some proteins and amino acids, such as asparagine.
- Statistical tests were carried out on the data to assess whether the gamma radiation dose affected the concentrations of glucose, protein and volatile nitrogen compounds in the raw potatoes.

Data from the chemical analysis and the statistical tests are shown in Table 1.1.

Table 1.1

gamma radiation dose / $J\,kg^{-1}$	**mean composition of the raw potato sample as a percentage of dry mass**		
	glucose	**protein**	**volatile nitrogen compounds**
0	0.83	10.92	1.14×10^{-2}
50	0.86	11.04	0.75×10^{-2}
100	0.83	10.08	0.68×10^{-2}
150	0.88	10.96	0.40×10^{-2}
statistical significance of differences between raw potato samples exposed to different doses of gamma radiation	not significant at $p < 0.05$	not significant at $p < 0.05$	significant at $p < 0.05$

(c) The scientists suggested that gamma radiation reduces the acrylamide content of potato chips by affecting asparagine.

Explain how the information provided **and** the data in Table 1.1 support this view.

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(d) In a further study, the scientists investigated whether gamma radiation **and** a hot water treatment reduce the acrylamide concentration of potato chips.

- Four bags of one variety of potato were each exposed to a different dose of gamma radiation: 0 $J\,kg^{-1}$, 50 $J\,kg^{-1}$, 100 $J\,kg^{-1}$ or 150 $J\,kg^{-1}$.
- After exposure to gamma radiation, the potatoes from each bag were cut into 1 cm × 1 cm × 5 cm blocks.
- Potato blocks from each bag were given two different treatments.

treatment 1: 100 g of potato blocks were cooked in 1 dm^3 of sunflower oil at 170 °C for five minutes.

treatment 2: 100 g of potato blocks were heated in 500 cm^3 water at 85 °C for five minutes, removed from the water and then cooked in 1 dm^3 of sunflower oil at 170 °C for five minutes.

The scientists measured the acrylamide concentration of the potato chips after these treatments.

This procedure was repeated a further five times to allow statistical tests to be carried out on the results.

The results of the investigation are summarised in Table 1.2.

Table 1.2

gamma radiation dose / $J\,kg^{-1}$	**mean acrylamide concentration of potato blocks / $\mu g\,kg^{-1}$**	
	treatment 1	**treatment 2**
0	4551	1768
50	3629	1487
100	3310	1339
150	2073	1010

(i) Using the data in Table 1.2, calculate the percentage decrease in the mean acrylamide concentration of potato blocks given treatment 2 compared to potato blocks given treatment 1, for a gamma radiation dose of 0 $J\,kg^{-1}$.

Show your working.

percentage decrease = ...
[2]

The results in Table 1.2 are shown as a graph in Fig. 1.5. Error bars have been added to show 95% confidence intervals (95% CI).

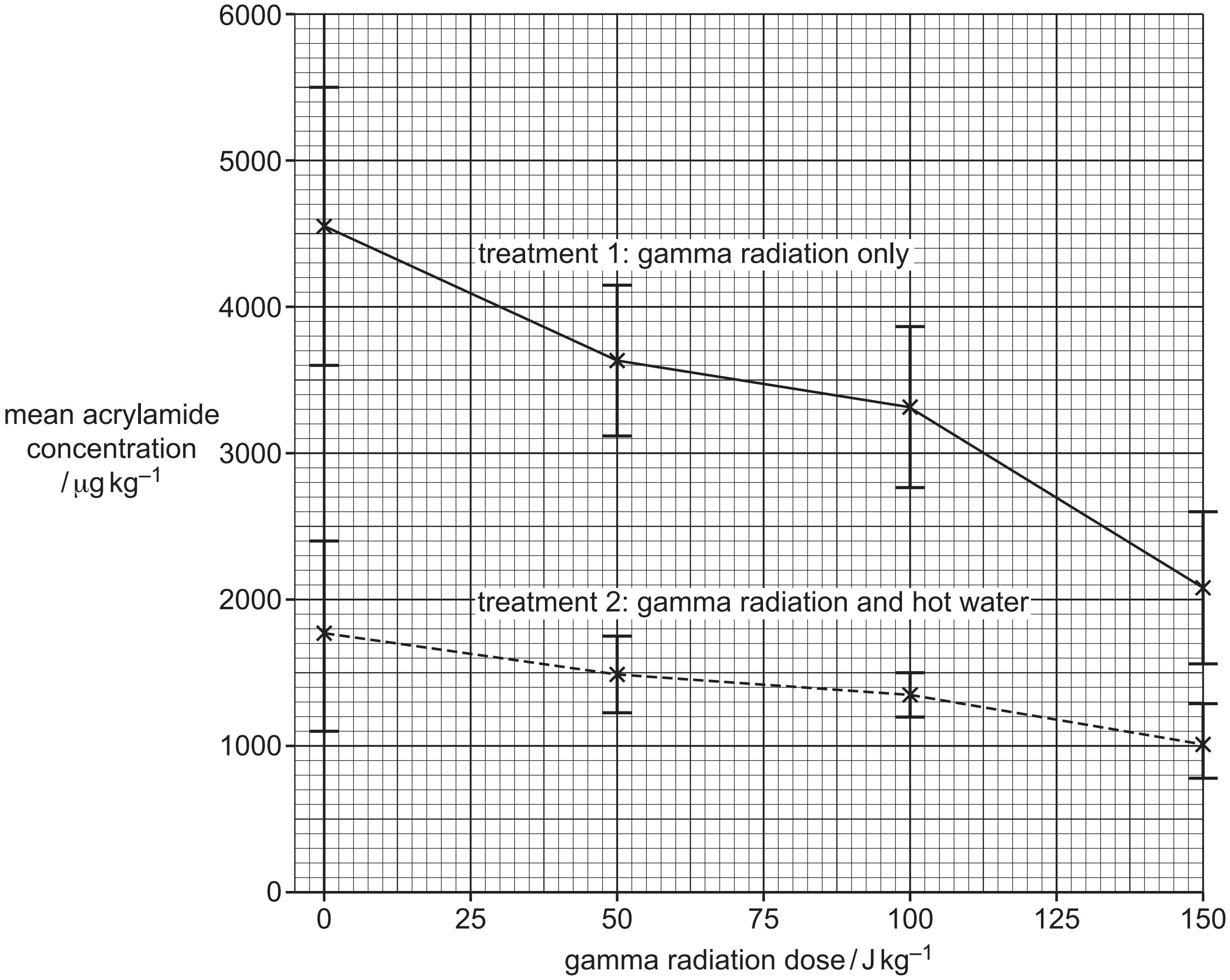

Fig. 1.5

The scientists concluded that a combination of gamma radiation **and** hot water treatment is the most effective way to reduce the acrylamide concentration of potato chips.

(ii) Explain how the information shown in Table 1.2 and Fig. 1.5 supports, or does **not** support, this conclusion.

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[Total: 20]

2 Rice, *Oryza sativa*, is an important food crop. Rice plants are wind pollinated. Pollen containing the male gamete is transferred by the wind to female reproductive organs of rice plants. Fertilisation and grain formation then occur.

Weedy rice is a wild form of rice that grows in fields of cultivated rice. Weedy rice competes with cultivated rice for resources. Weedy rice plants are taller than cultivated rice plants and produce a low yield of rice grains.

Several genetically modified (GM) varieties of cultivated rice have been developed.

One concern about the use of GM rice is gene flow from GM rice plants to weedy rice. Gene flow occurs when the wind carries pollen from GM rice plants to weedy rice plants.

Some scientists investigated gene flow from herbicide-resistant GM rice plants to weedy rice plants. The GM rice plants had a gene for herbicide resistance. Weedy rice plants do not have the gene for herbicide resistance.

The scientists wanted to test the hypothesis that:

> Gene flow from GM rice to weedy rice decreases as the distance between the GM rice crop and weedy rice increases.

The scientists planted GM rice and weedy rice in a field, as shown in Fig. 2.1.

Fig. 2.1 also shows that the wind normally blows in a north–west (NW) direction.

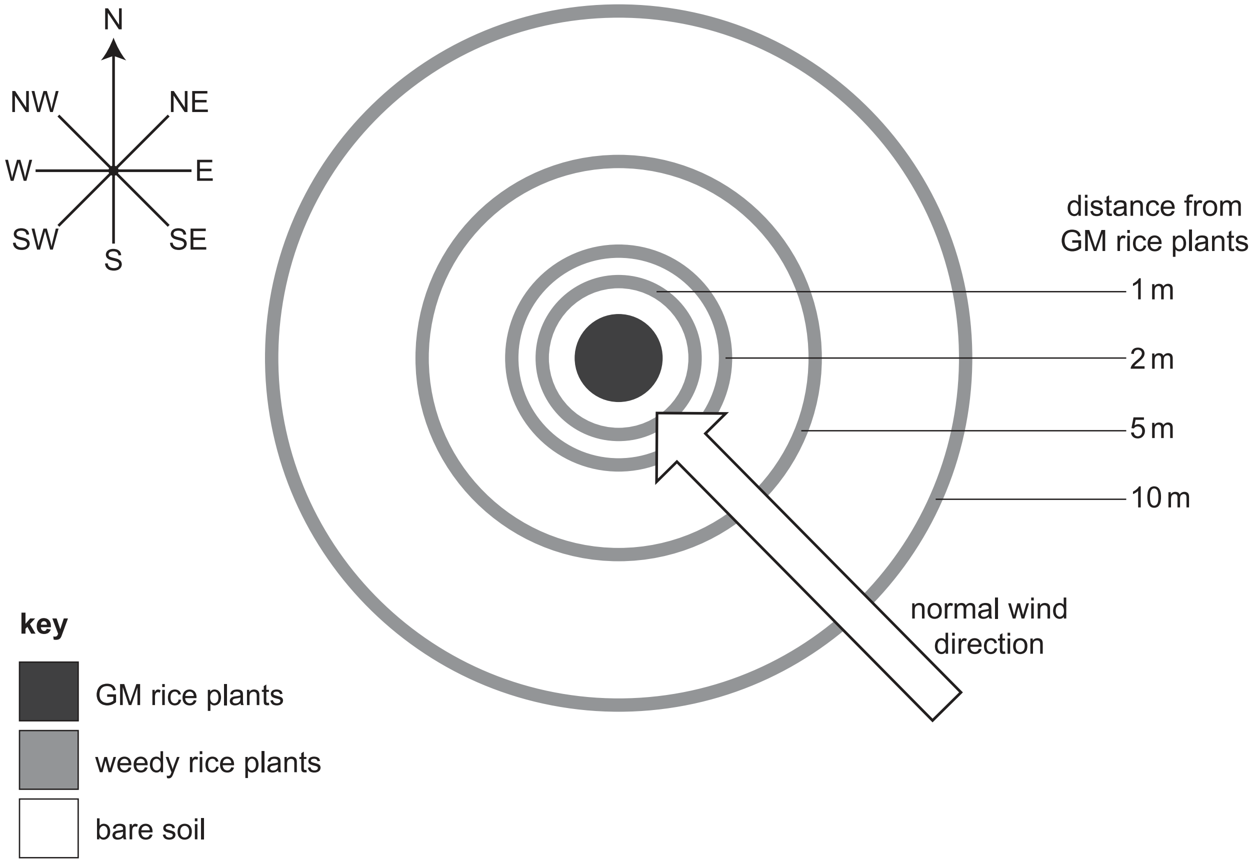

Fig. 2.1

After the plants had been pollinated and the rice grains had developed, the grains were collected from the **weedy** rice plants **only**.

- Grains were collected from all weedy rice plants growing 1 m from the GM rice plants in the directions N, NE, E, SE, S, SW, W and NW.
- Grains were also collected in the same directions from the GM rice plants at distances of 2 m, 5 m and 10 m.
- Approximately 1000 grains from each collection point were planted and germinated in controlled conditions in a glasshouse.
- The plants were grown for three weeks and then tested to determine whether they had the gene for herbicide resistance.

Fig. 2.2 shows young rice plants three weeks after germination.

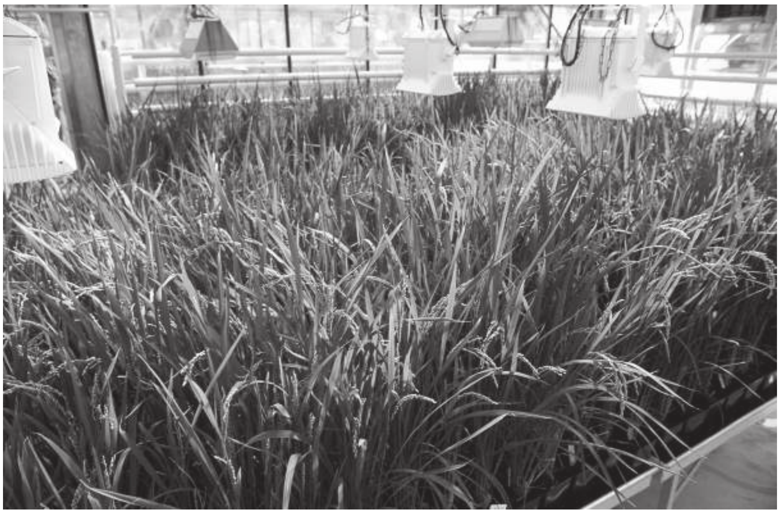

Fig. 2.2

(a) **(i)** Identify the **two** independent variables in this investigation.

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.... [1]

(ii) Some of the young weedy rice plants had the gene for herbicide resistance. This gene had been carried to the parents of these plants in pollen from the GM rice plants.

Outline a method the scientists could use in the glasshouse to determine how many of the young weedy rice plants had the gene for herbicide resistance.

Your method should **not** require the extraction of nucleic acids.

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.... [2]

(iii) The scientists calculated the percentage of young weedy rice plants that had the gene for herbicide resistance. This percentage was used as a measure of gene flow.

The percentage gene flow recorded at each NW collection point is shown in Fig. 2.3.

Fig. 2.3 also shows the percentage gene flow recorded at each distance from the GM rice plants at all the other collection points combined.

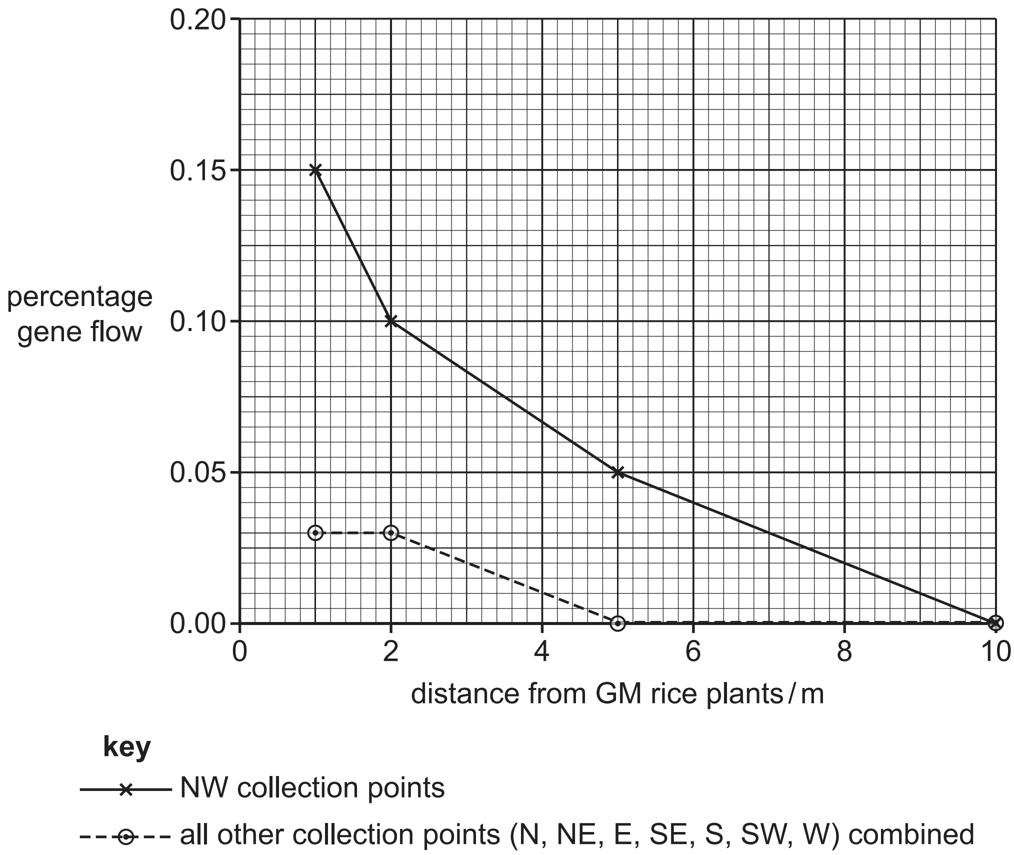

Fig. 2.3

State **two** conclusions that can be made from the data shown in Fig. 2.3.

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(b) Weedy rice plants have a gene that results in increased height. GM rice plants do **not** have this gene. This gene allows gene flow from weedy rice plants to GM rice plants to be investigated.

In a second study, the scientists investigated gene flow from herbicide-resistant GM rice plants to weedy rice plants **and** gene flow from weedy rice plants to herbicide-resistant GM rice plants.

The scientists planted GM rice and weedy rice in areas next to each other in a field.

After the plants had been pollinated and the rice grains had developed, 1000 grains were collected from weedy rice plants at each of eight sampling sites **and** 1000 grains were collected from GM rice plants at each of eight sampling sites.

Plants were grown from the grains that had been collected and tested to determine the percentage gene flow between the weedy rice plants and the GM rice plants at each site.

Table 2.1 shows the results of the investigation.

Table 2.1

	percentage gene flow from GM rice plants to weedy rice plants	percentage gene flow from weedy rice plants to GM rice plants
	0.044	0.136
	0.013	0.136
	0.025	0.273
	0.019	0.235
	0.044	0.239
	0.025	0.242
	0.063	0.244
	0.057	0.273
mean:	....	0.222

(i) Complete Table 2.1 by calculating the mean percentage gene flow from GM rice plants to weedy rice plants.

[1]

(ii) The scientists decided to carry out a *t*-test to compare the percentage gene flow from GM rice plants to weedy rice plants with the percentage gene flow from weedy rice plants to GM rice plants.

The scientists stated the null hypothesis:

> There is no difference between the percentage gene flow from GM rice plants to weedy rice plants and the percentage gene flow from weedy rice plants to GM rice plants.

The scientists calculated the value of *t* as **9.043**.

Table 2.2 shows the probability table for the *t*-test.

Table 2.2

degrees of freedom	**critical values**	
	***p* = 0.05 (5%)**	***p* = 0.01 (1%)**
12	2.179	3.055
13	2.160	3.012
14	2.145	2.977
15	2.131	2.947
16	2.120	2.921
17	2.110	2.898
18	2.101	2.878

Explain, with reference to Table 2.2, what can be concluded from the analysis of the data collected by the scientists.

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(iii) The results of this investigation were published in a scientific paper.

A student who read the paper concluded that the results showed there were no reasons to be concerned about gene flow from GM plants to wild plants.

Suggest **one** reason why the results of this investigation should **not** be interpreted in this way.

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[Total: 10]

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