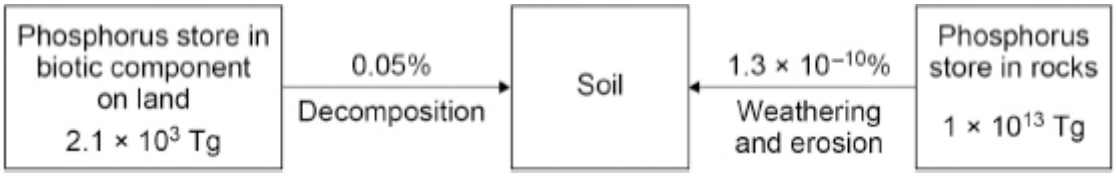
Q1.

Figure 1 shows part of a phosphorus cycle, including the mass of phosphorus in two stores.

Figure 1



One teragram (Tg) is 1×10^{12} grams.

The supply of phosphorus to the soil is shown as a percentage of the total phosphorus mass of each store.

(a) Calculate in teragrams the difference in the supply of phosphorus to the soil from the two stores shown in **Figure 1**.

Show your working.

Answer _____ Tg

(2)

Water shortage can inhibit crop production. Scientists investigated the effect of the mycorrhizal species *Glomus intraradices* on the growth of tomato plants under conditions of water shortage and **no** water shortage.

- The scientists planted tomato seeds into a large number of pots containing sterilised soil.
- They added a culture of *G. intraradices* to 50% of the pots and 50% were left untreated.
- After the seeds had developed into seedlings (young plants), the seedlings from the untreated and treated pots were planted into four separate large greenhouses (glasshouses).
- A very limited supply of water (water shortage) was provided to two of the greenhouses. A sufficient supply of water (**no** water shortage) was provided to the other two greenhouses.
- After 60 days, the scientists determined the mean mass of tomatoes (kg m^{-2}) from each greenhouse.

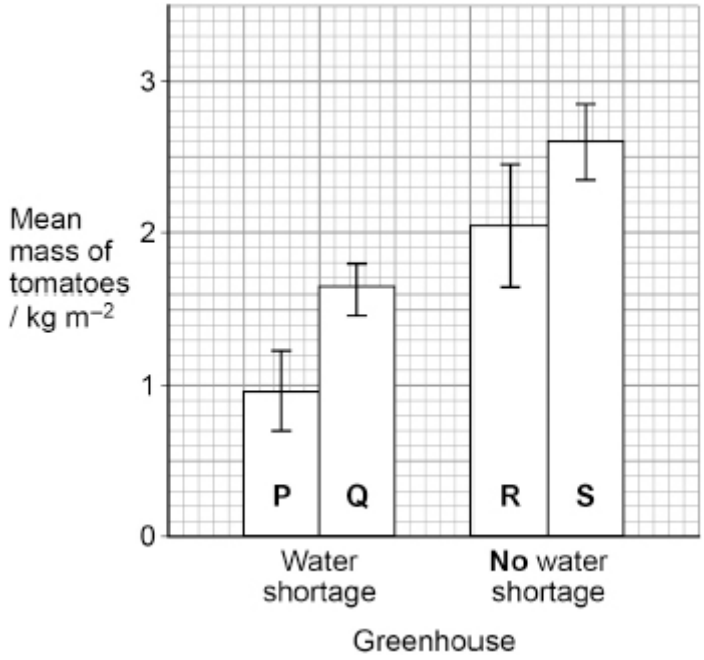
Greenhouse **P** – untreated seedlings with water shortage
Greenhouse **Q** – treated seedlings with water shortage
Greenhouse **R** – untreated seedlings with **no** water shortage
Greenhouse **S** – treated seedlings with **no** water shortage

Treated seedlings are plants grown with *G. intraradices*.

Figure 2 shows the scientists' results.

The error bars represent ± 2 standard deviations from the mean, which includes over 95% of the data.

Figure 2



(b) Using all the information, evaluate the effectiveness of using mycorrhizae to increase crop production under conditions of water shortage and **no** water shortage.

(5)

(c) The tomato seeds were planted into sterilised soil.

Suggest **two** reasons why the soil was sterilised.

1 _____

_____

2 _____

_____

(2)

(d) The soil used in this investigation had the recommended concentration of fertiliser.

Suggest **two** reasons why the soil contained the recommended concentration of fertiliser.

1 _____

_____

2 _____

_____

(2)

(Total 11 marks)

Q2.

Nitrogen-fixing bacteria such as *Azotobacter chroococcum* use the enzyme nitrogenase to produce ammonia from nitrogen gas in the air. *A. chroococcum* can use ammonium chloride as a direct source of ammonia. When a source of ammonia is not available this bacterium uses nitrogen fixation.

A scientist investigated the effect of an increase in the concentration of ammonium chloride on the activity of nitrogenase in this bacterium. He prepared several liquid medium cultures of the bacterium. Each liquid culture had the same volume. He grew each culture in a different concentration of ammonium chloride.

In each culture:

- he recorded the nitrogenase activity in arbitrary units
- he removed the bacteria and then recorded the concentration of ammonium chloride remaining in each liquid medium.

The table below shows the scientist's results.

Concentration of ammonium chloride / µg cm^{-3}	**Nitrogenase activity / arbitrary units**	**Concentration of ammonium chloride remaining in liquid medium / µg cm^{-3}**
0	45	0
20	30	0
40	17	0
60	7	0
80	0	6
100	0	14
120	0	20

(a) Apart from temperature and pH, give **two** variables the scientist would have controlled when **preparing** the liquid medium cultures.

1 _____

_____

_____

2 _____

_____

_____

(2)

(b) A student concluded that this investigation showed that ammonia inhibits nitrogenase activity in nitrogen-fixing bacteria. Use all the information to evaluate the student's conclusion.

(3)

(c) Nitrogenase catalyses the reduction of nitrogen during nitrogen fixation.
The reaction requires 16 molecules of ATP for each molecule of nitrogen that is reduced.
When ammonia inhibits nitrogenase activity, nitrogen-fixing bacteria may benefit.
Explain how.

(2)

(Total 7 marks)

Q3.

Write an essay on **one** of the topics below.

The importance of cycles in biology.

(Total 25 marks)