Read the following passage.

|  |  |
| --- | --- |
| Plants require phosphate ions that they get from soil. These ions are often in poor supply and this results in poor growth of the plants. Most plants have mycorrhizae that help the plants to obtain nitrates. Mycorrhizal networks can connect the roots of plants growing next to each other. The use of fertilisers containing phosphate and nitrates in farming inhibits the growth of mycorrhizae. As a result, intensively farmed crop plants do not have mycorrhizae.  Plants can defend themselves by producing defensive enzymes that destroy pathogens such as bacteria. Some plants express the genes for defensive enzymes in response to signal proteins secreted by other plants that are being attacked by a pathogen. These signal proteins can be released into the air.  Scientists have discovered that tomato plants increase production of defensive enzymes if plants next to them become infected with a pathogen. These tomato plants were connected by a mycorrhizal network that can carry signal proteins between them. The largest increase in defensive enzyme secretion that the scientists found in a tomato plant in response to the signal protein was by 122.6 per cent. | 5      10      15 |

Use the information in the passage and your own knowledge to answer the following questions.

(a)     Suggest and explain **two** reasons why a poor supply of phosphate ions results in poor growth of plants (lines 1–2).

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(b)     Suggest how defensive enzymes produced by plants destroy bacteria (lines 8–9).

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**(2)**

(c)     The signal proteins secreted into the air by a plant being attacked by a pathogen act as stimuli leading to the expression of genes for defensive enzymes in other plants (lines 9–12).

Suggest how they lead to the expression of these genes.

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**(3)**

(d)     Suggest and explain **the** advantage to tomato plants of transmitting signal proteins through mycorrhizal networks, rather than releasing them into the air (line 11–12 and lines 14–16).

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**(2)**

(e)     The largest increase in defensive enzyme secretion that the scientists found in a tomato plant in response to the signal protein was by 122.6 percent (lines 16–18).

The rate of secretion of the defensive enzymes before the signal protein was produced was 450 µmol dm−3 g−1 hour−1.

Calculate the rate of secretion **per second** after the response to the signal protein.

Answer = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ µmol dm−3 g−1 second−1

**(2)**

(f)      A student who read this passage concluded that farmers should **not** use fertilisers to increase yields when growing tomato plants.

Evaluate his conclusion.

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**(4)**

**(Total 15 marks)**

**Mark Scheme**

(a)     1.      (Required to) make ATP / glucose phosphate, so less respiration / less energy for growth;

2.      (Required to) make nucleotides, so less DNA / mRNA / tRNA for cell division / production of protein (for growth);

3.      (Required to) make RuBP / NADP, so less CO2 fixed / reduced into sugar;

4.      (Required to) make phospholipids for membranes;

**2 max**

(b)     1.      Hydrolyse;

*Accept digest*

2.      murein / glycoprotein (in cell wall);

**2**

(c)     1.      Bind to receptor (on target plant);

2.      Acts as / leads to production of a transcription factor;

3.      (Which) binds to promoter

**OR**

stimulates transcription of genes

**OR**

production of mRNA (for defensive enzymes);

**3**

(d)     1.      Direct plant-to-plant transmission;

2.      (So) localised response

**OR**

faster response

**OR**

no dilution of signal protein;

**2**

(e)     0.278;

*Accept 1 mark for 1001.7 or*

* × 100*

*= 122.6*

**2**

(f)      Should not use:

1.      Fertilisers prevent development of mycorrhizae;

2.      Mycorrhizae help plants to defend themselves (causing an increase in crop yield);

3.      Mycorrhizae help plants to take up nitrates / phosphates (causing an increase in crop yield);

Should use:

4.      Fertilisers containing phosphate and nitrate increase gross primary production so increase yield;

5.      Most soil is poor in phosphate so without fertiliser (tomato) plant might not get enough phosphate;

**4 max**

**[15]**