Genetically modified organisms in agriculture

Question Paper 1

Level	International A Level
Subject	Biology
Exam Board	CIE
Topic	Genetic Technology
Sub Topic	Genetically modified organisms in agriculture
Booklet	Theory
Paper Type	Question Paper 1

Time Allowed : **63 minutes**

Score : **/ 52**

Percentage : **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 The filamentous fungus, *Fusarium venenatum*, is grown in continuous culture in large fermenters to provide mycoprotein for human consumption.

(a) Explain what is meant by the term *continuous culture*.

.....

.....

.....

..... [2]

(b) In an investigation into the growth of the fungus in culture, several factors were varied including:

- temperature
- concentration of the carbon source
- concentration of the nitrogen source.

Some of the results are shown in Table 3.1.

Table 3.1

temperature / °C	concentration of carbon source / g dm^{-3}	concentration of nitrogen source / g dm^{-3}	dry mass of fungus / g dm^{-3}
25	7.0	2.9	3.1
25	14.0	3.5	4.3
30	7.0	3.5	4.8
30	14.0	2.9	4.2

(i) Describe the effect of temperature on the growth of the fungus at the different concentrations of the carbon source.

.....

.....

.....

.....

.....

..... [3]

(ii) Explain why the fungus needs sources of carbon and nitrogen.

carbon .....

.....

.....

nitrogen .....

.....

..... [3]

[Total: 8]

2 Golden Rice™ is a genetically modified form of rice that produces relatively large amounts of β carotene in the endosperm. β carotene is metabolised in the human body to produce vitamin A.

(a) Explain why rice has been genetically modified to produce extra β carotene.

.....

.....

.....

..... [2]

(b) The first types of Golden Rice™ produced only a very low mass of β carotene per gram of rice. Research continued to try to increase this.

Fig. 4.1 shows the metabolic pathway by which β carotene is synthesised in plants, and the enzymes that catalyse each step of the pathway.

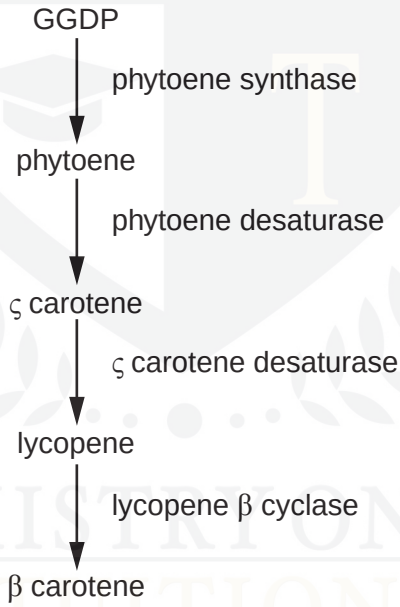

Fig. 4.1

The first types of Golden Rice™ contained a phytoene synthase gene, *psy*, from daffodils and a gene *crtI*, which produced the two desaturase enzymes, from the bacterium *Erwinia uredovora.*

Measurements of the quantities of intermediates in this metabolic pathway in rice endosperm showed that there was always a large amount of GGDP present, and that no phytoene accumulated in the tissues.

Explain how this suggests it was **not** the enzymes produced by the *crtI* gene that were limiting the production of β carotene.

.....

.....

.....

.....[2]

(c) Investigations were carried out to see if *psy* genes taken from species other than daffodils would enable rice endosperm to produce greater quantities of β carotene than the first types of Golden Rice™.

- *Psy* genes were isolated from the DNA of maize, tomatoes, peppers and daffodils. The genes were inserted into different plasmids.
- The promoter *Ubi* 1, and *crtI* genes from *E. uredovora*, were also inserted into all of the plasmids.
- The four types of genetically modified plasmids were then inserted into different cultures of rice cells.
- The quantity of β carotene produced by these rice cells was measured.

The results are shown in Table 4.1.

Table 4.1

source of *psy* gene	**total β carotene content of rice cells / arbitrary units**
maize	14
pepper	4
tomato	6
daffodil	1

(i) Name the type of enzyme that would have been used to cut the *psy* gene out of the DNA of the plant cells.

.....[1]

(ii) Explain why a promoter was inserted into the plasmids.

.....

.....

.....

.....[2]

(iii) Explain whether or not these results support the hypothesis that the *psy* gene, not the *crtI* gene, was limiting the production of β carotene in genetically modified rice.

.....

.....

.....

.....[2]

(d) The original choice of a *psy* gene from daffodils was made because daffodils produce large amounts of β carotene in their yellow petals, and because they are monocotyledonous plants, like rice.

Suggest explanations for the much lower production of β carotene in rice containing the *psy* gene from daffodils than in rice containing the *psy* gene from maize.

.....

.....

.....

.....[2]

(e) Describe the possible disadvantages of growing Golden Rice™.

.....

.....

.....

.....

.....

.....[3]

[Total: 14]

3 In the USA, about 35% of all maize that is grown has been genetically modified to produce a toxin, called Bt toxin, derived from the bacterium *Bacillus thuringiensis.* The genetically modified plants are known as Bt maize.

(a) Explain the advantages of growing Bt maize.

.....

.....

.....

..... [2]

(b) An investigation was carried out into the potential effects of dead leaves from Bt maize on organisms living in streams that flow through areas where the maize is grown.

The researchers conducted a laboratory-based experiment in which larvae of one species of aquatic caddis fly, *Lepidostoma liba*, were fed on non-Bt maize leaves, or on leaves from Bt maize. The growth rates of the larvae were measured.

The results are summarised in Fig. 5.1.

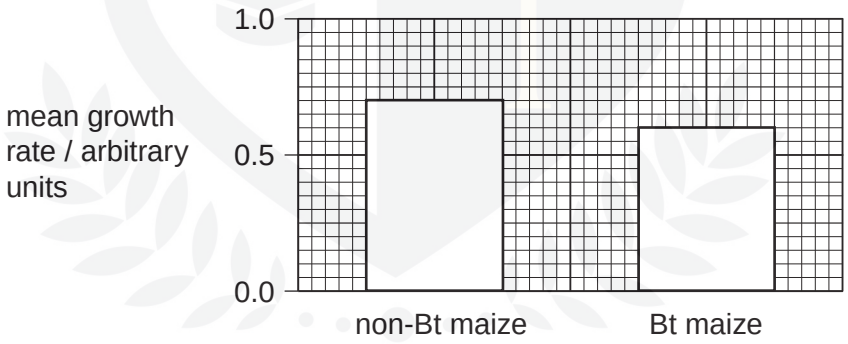

Fig. 5.1

Describe the effect of eating leaves from Bt maize on the growth rate of *L. liba* larvae.

.....

.....

.....

..... [2]

(c) In a second laboratory-based experiment, three groups of larvae of a different species of caddis fly, *Helicopsyche borealis*, were fed on pollen containing:

A no Bt toxin

B Bt toxin at concentrations found in streams in maize-growing areas

C Bt toxin at concentrations twice as high as found in those streams.

The researchers measured the mortality rates of the caddis fly larvae.

Their results are summarised in Table 5.1.

Table 5.1

groups compared	**difference in mortality rate**
groups **A** and **B**	no significant difference
groups **A** and **C**	significantly greater mortality in **C** than in **A**

The researchers were careful to state that their results showed the '**potential** ecological effects' on the caddis fly larvae of growing Bt maize.

Suggest **two** reasons why 'potential ecological effects' is a suitable description of any conclusions that could be drawn from the results of this experiment.

.....

.....

.....

.....[2]

(d) When the results of the experiments described in **(b)** and **(c)** were published, many other scientists criticised the research very strongly.

Suggest why some scientists might wish to suppress results such as these, even if there is no fault with the investigation itself.

.....

.....[1]

[Total: 7]

4 Gene technology has many uses including the production of substances such as insulin.

(a) **(i)** Outline what is meant by *gene technology*.

.....

.....

.....

..... [2]

(ii) Explain why genes for enzymes that produce fluorescent substances are used as makers in gene technology.

.....

.....

.....

..... [2]

(b) There is much controversy throughout the world regarding the use of genetically modified (GM) crops.

(i) Suggest **two** advantages of growing GM rice with an enhanced vitamin A content.

.....

.....

.....

..... [2]

(ii) Suggest **two** disadvantages of growing GM crops.

.....

.....

.....

..... [2]

[Total: 8]

5 **(a)** Fig. 3.1 shows the male and female flowers of maize.

Fig. 3.1

(i) With reference to Fig. 3.1, describe how the flowering habit of maize encourages wind-pollination.

.....

.....

.....

.....

.....[3]

(ii) In a maize plant, the anthers normally ripen before the stigmas are mature and ready to receive pollen. This encourages cross-pollination.

Explain the potential advantages of cross-pollination to a plant species.

.....

.....

.....

.....[3]

(b) Cultivated maize is related to a wild Mexican grass, teosinte. Teosinte looks very different from maize. In particular, teosinte has a very hard layer surrounding the fruit, making it impossible to use as an edible grain.

Archaeological excavations have found that maize in its edible form dates back at least 4000 years. It has been argued that the structural differences between teosinte and maize grains are so great that it is unlikely that maize could have been bred from teosinte so long ago.

Investigations have been carried out into the genetic differences between teosinte and maize. A gene on chromosome 4, *tga 1*, containing 1042 base pairs, was found to be responsible for all of the structural differences between teosinte and maize.

Fig. 3.2 shows the DNA base sequence of the only part of *tga 1* that always differs between teosinte and maize.

teosinte	GAT	TGG	GAT	CTC	AAG	GCG	GCG	GGC	GCG	TGG
maize	GAT	TGG	GAT	CTC	AAC	GCG	GCG	GGC	GCG	TGG

Fig. 3.2

(i) Outline the principles of electrophoresis as used in sequencing this DNA.

.....

.....

.....

.....

.....

.....

..... [4]

(ii) Suggest how the difference in the base sequence of the *tga 1* gene shown in Fig. 3.2 could cause large differences in phenotype between teosinte and maize.

.....

.....

.....[2]

(iii) With reference to Fig. 3.2, explain how these results support the suggestion that it would have been relatively easy for early farmers in Mexico to have bred maize from teosinte.

.....

.....

.....

.....

.....[3]

[Total: 15]