2023

AP® Environmental Science

Sample Student Responses and Scoring Commentary Set 1

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Free-Response Question 1

- ☑ **Scoring Guidelines**
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Question 1: Design an Investigation — 10 points

(a) **Identify** the control group in this experiment. **1 point**

Accept one of the following:

- Plot D
- Unmodified beans

(b) **Identify** the scientific question for the investigation. **1 point**

Accept one of the following:

- Will genetically modified green beans have higher crop yields than unmodified green beans?
- Is there a difference between the crop yields of genetically modified and unmodified green beans?
- Does genetically modifying green beans affect crop yield?

(c) Researchers repeated the experiment modifying the length of time for the spray irrigation to 20 minutes per day. **Explain** how the results of the experiment could be altered with this modification. **1 point**

Accept one of the following:

- With less water, there will be lower crop yield/fewer green beans harvested in all plots.
- The genetically modified beans will remain similar in yield because they are resistant to drought/need less water, but the unmodified beans will decrease in crop yield because they will receive less water.

(d) Based on the data in the table, **identify** the plot with the lowest soil temperature. **1 point**

Accept one of the following:

- Plot D
- The unmodified green beans

(e) **Describe** how sediment runoff and fertilizer runoff compare between the unmodified green beans and the genetically modified green beans. **1 point**

Accept one of the following:

- Both types of runoff/Sediment and fertilizer (phosphorus/nitrogen) runoff are lower with the genetically modified beans.
- Both types of runoff/Sediment and fertilizer (phosphorus/nitrogen) runoff are higher with the unmodified beans.

(f) The Type 2 GMO beans in Plot B were developed to grow more quickly than the unmodified beans in Plot D. Researchers have hypothesized that the Type 2 beans would use fertilizer more completely than the other varieties. Based on the data in the table and the experimental design, **explain** whether the researchers' hypothesis was supported or refuted. **1 point**

Accept one of the following:

- The hypothesis is supported because there is less fertilizer (phosphorus/nitrogen) in the runoff from plot B, so the beans in plot B are absorbing/taking up more fertilizer (phosphorus/nitrogen).
- The hypothesis is supported because there is more fertilizer (phosphorus/nitrogen) in the runoff from plot D, so the beans in plot D are absorbing/taking up less fertilizer (phosphorus/nitrogen).
- The hypothesis is supported because the plants in plot B were able to produce more beans given the same amount of fertilizer.

(g) **Describe** the ecological process that occurred on the plots after the crops were burned. **1 point**

Accept one of the following:

- Fast growing/early successional organisms returned to/colonized the soil after the fire/major disturbance.
- Secondary succession occurred where plants recolonize a habitat after the fields were burned/after a major disturbance.

(h) After each flooding event, the plot with twice the plant diversity returned to its prior level of biodiversity more quickly than the other plots did. **Explain** why a community with more plant diversity will recover more quickly from the flooding. **1 point**

Accept one of the following:

- The plot with higher diversity/richness has more species/organisms, so the floods harm a smaller proportion of the species/organisms.
- The plot with higher diversity/richness has more connections between organisms, so the floods disrupt a smaller percentage of the connections between organisms.
- The plot with higher genetic diversity within species may have more flood tolerant individuals that will survive a flood.

(i) After the last flooding event, a beetle not previously known in the area appeared in one of the plots with less plant diversity. Over a period of a few months, the new beetle population increased, whereas the existing beetle species in the plot had declining populations. **Explain** why the new beetle species could be better able to successfully populate this plot than the existing beetle species could. **1 point**

Accept one of the following:

- The new beetle is a generalist/r-selected species and could more quickly populate the area/outcompete the existing/native beetle species.
- The flooding of the plot caused a natural disruption to the existing community, eliminating species/natural predators and opening niches for the new/invasive beetle.
- Low diversity communities are susceptible to disruption and can't recover allowing the new/nonnative beetle species to invade
- The new beetle is an invasive species that can live outside its normal environment and threaten native species

(j) **Describe** one realistic method to prevent the new beetle from spreading beyond the experimental plot. **1 point**

Accept one of the following:

- Remove beetles by trapping/physical removal to reduce their population size.
- Apply a chemical/pesticide to kill beetles.
- Add a predator/parasite/pathogen/biological control that harms beetles.

Total for question 1 10 points

Important: Completely fill in the circle that corresponds to the question you are answering on this page.

Question 1 ● Question 2 ○ Question 3 ○

Begin your response to each question at the top of a new page. Do not skip lines.

a) The control group is the plot of unmodified beans.

b) Do genetically modified green beans yield a higher amount of beans than unmodified beans in arid regions?

c) The crops would recieve less water, which would help beans that can survive on little water thrive, while the other types wither, changing the results of the experiment.

d) Plot d, the unmodified beans has the lowest temperature.

e) Sediment and fertilizer runoff are greater in the plot of unmodified beans in comparison to the genetically modified green beans.

f) The researchers' hypothesis is supported because the levels of fertilizer runoff were lowest in plot 2, which is seen by the relatively small amount of nitrogen and phosphorous runoff, in comparison with the other varieties.

g) After the crops were burned, their nutrients leeched back into the soil as they decayed, which opened up the plot to pioneer plant species, which began growing. This was the first step in the succession process, and as the habitat was restored and covered by vegetation, this makes the habitat available for animal species to survive there.

h) A community with more plant diversity would recover from the flood quicker, because the diversity in the gene pool would allow ~~them~~ plants with flood-resistant genes to survive, ~~and recover quicker~~ as opposed to a ~~community~~ community with low diversity, where if the dominant gene isn't flood resistant, much more of the community can be wiped out.

Important: Completely fill in the circle that corresponds to the question you are answering on this page.

Question 1 ● Question 2 ○ Question 3 ○

Begin your response to each question at the top of a new page. Do not skip lines.

i) The new beetle species could be a generalist species, so that its sources for food are increased, and it does not need to compete for a specific type of plant species or other food source. This would allow the new beetle type to have more available resources and populate the plot more than the original beetle species could.

j) You could introduce a limited amount of the beetles' predator to the area in order to keep the beetle population low, and not allow it to spread beyond the experimental plot.

Use a pen with black or dark blue ink only. Do NOT write your name. Do NOT write outside the box.

Important: Completely fill in the circle that corresponds to the question you are answering on this page.

Question 1 ● Question 2 ○ Question 3 ○

Begin your response to each question at the top of a new page. Do not skip lines.

a. Plot D with unmodified green beans.

b. How will green beans grown in the same environment be affected by different genetic modifications in terms of crop yields?

c. Shorter irrigation time would mean less water to the plots which could create longer growing time.

d. D (unmodified beans)

e. The unmodified beans have more sediment and fertilizer runoff than the GMO beans.

f. The hypothesis is ~~correct~~ incorrect because the table shows lower amounts of runoff from plot B which indicates there is less waste from the fertilizer.

g. Primary succession occured because of the burning, which led to initial removal of the plants, but led to an increase in biodiversity after the regrowth.

h. A community with higher plant diversity will recover quicker because each plant or species has a higher tolerance to different conditions and can adapt quickly.

i. The introduction of the invasive beetle species caused competition with the other beetle species for food and survival which led to the decline of the native beetle species.

j. One realistic method could be the introduction of a new species that is a predator to the beetle, which will slowly decline the beetle species.

Important: Completely fill in the circle that corresponds to the question you are answering on this page.

Question 1 ● Question 2 ○ Question 3 ○

Begin your response to each question at the top of a new page. Do not skip lines.

The control group in this experiment would be Plot D. The scientific question would be which new variety of green beans produce a higher yield in arid regions. By reducing the time for spray irrigation to 20 minutes this can effect the rate of which the experiment changes. The Plot with the lowest soil temperature would be plot D (unmodifed beans). The sediment runoff ~~compares to~~ and the fertilizer runoff compares to the green beans because it effects the way they grow, The unmodified beans had a higher effect from sediment runoff than the GMO beans. The researchers hypothesis was refuted because the results show that plot D used the fertilizer more completely than plot B. The ecobgical process that occured when burning the crop cause those nutrients to go back into the soil giving the soil a new life and materials to be re newed. A community with more plant diversity will recover more quickly from the flooding because the different plants have different roles helping in a flood. A new beetle species could be better to populate the plot due to ~~apa~~ adapting to a new environments. It's harder for a existing beetle because they are already use to the environment ~~and~~ and everything in it. One method to prevent the new beetle from spreading would be to plant more plants to the beetles liking.

Use a pen with black or dark blue ink only. Do NOT write your name. Do NOT write outside the box.

Question 1

Note: Student samples are quoted verbatim and may contain spelling and grammatical errors.

Overview

The intent of this question was for students to demonstrate an understanding of the broad categories of agriculture, succession, populations, and pest control. Students were presented with an experimental design and data table comparing crop yields from genetically modified green beans with unmodified green beans [Topic 5.3 The Green Revolution].

In parts (a–c) students were asked to describe and identify experimental design components, as well as provide an explanation for how the results of an investigation could be altered by the modification of the experiment by reducing the length of time for irrigation from one hour to 20 minutes [Science Practice 4 Scientific Experiments and Topic 5.5 Irrigation Methods]. Students were expected to analyze and interpret quantitative data represented in a table. This included interpretation of experimental data in relation to a given hypothesis [Science Practice 5 Data Analysis].

Parts (d–f) required students to read and interpret data provided in a table, and to use that data to support or refute a given hypothesis [Science Practice 4 Scientific Experiments, Science Practice 5 Data Analysis, Topic 5.3 The Green Revolution, Topic 5.15 Sustainable Agriculture].

In parts (g–i) students were asked to describe how communities and populations change following disruptions such as burning, floods, and the introduction of a new species [Science Practice 1 Concept Explanation, Topic 2.7 Ecological Succession, Topic 2.1 Introduction to Biodiversity, Topic 3.1 Generalist and Specialist Species, and Topic 3.2 K-Selected r-Selected Species].

In part (j) students were asked to describe a realistic method to prevent the spread of a new beetle [Science Practice 7 Environmental Solutions, Topic 5.6 Pest Control Methods, and Topic 5.14 Integrated Pest Management].

Sample: 1A
Score: 8

One point was earned in part (a) for identifying “unmodified beans” as the control group. One point was earned in part (b) for identifying “Do genetically modified green beans yield a higher amount of beans than unmodified beans” as the scientific question for the investigation. No point was earned in part (c). One point was earned in part (d) for identifying “Plot d” as the plot with the lowest soil temperature. One point was earned in part (e) for describing how “Sediment and fertilizer runoff are greater in the plot of unmodified beans in comparison to the genetically modified green beans.” No point was earned in part (f). One point was earned in part (g) for describing “After the crops were burned … opened up the plot to pioneer plant species, which began growing” as the ecological process that occurred after the crops were burned. One point was earned in part (h) by explaining “diversity in the gene pool would allow plants with flood-resistant genes to survive.” One point was earned in part (i) for explaining “a generalist species … this would allow the new beetle type to … populate the plot more than the original beetle species could.” One point was earned in part (j) for describing “introduce a limited amount of the beetles’ predator … to keep the beetle population low” as a realistic method to prevent spreading of the new beetle species.

Question 1 (continued)

Sample: 1B
Score: 5

One point was earned in part (a) for identifying "Plot D" as the control group. No point was earned in part (b). No point was earned in part (c). One point was earned in part (d) for identifying "D (unmodified beans)" as the plot with the lowest soil temperature. One point was earned in part (e) for describing, "The unmodified beans have more sediment and fertilizer runoff than the GMO beans." No point was earned in part (f). No point was earned in part (g). No point was earned in part (h). One point was earned in part (i) for explaining "the invasive beetle species caused competition with the other beetle species for food and survival which led to the decline of the native beetle species." One point was earned in part (j) for describing "the introduction of a new species that is a predator to the beetle, which will slowly decline the beetle species" as a realistic method to prevent spreading of the new beetle species.

Sample: 1C
Score: 2

One point was earned in part (a) for identifying "Plot D" as the control group. No point was earned in part (b). No point was earned in part (c). One point was earned in part (d) for identifying "plot D" as the plot with the lowest soil temperature. No point was earned in part (e). No point was earned in part (f). No point was earned in part (g). No point was earned in part (h). No point was earned in part (i). No point was earned in part (j).