2022/65832

Government of **Western Australia**
School Curriculum and Standards Authority

PLANT PRODUCTION SYSTEMS

ATAR course examination 2022

Marking key

Marking keys are an explicit statement about what the examining panel expect of candidates when they respond to particular examination items. They help ensure a consistent interpretation of the criteria that guide the awarding of marks.

Section One: Multiple-choice **20% (20 Marks)**

Question	Answer
1	d
2	b
3	a
4	c
5	b
6	a
7	d
8	a
9	c
10	b
11	c
12	d
13	a
14	c
15	d
16	b
17	d
18	b
19	c
20	a

Section Two: Short answer **50% (99 Marks)**

Question 21 **(17 marks)**

(a) State the type of hormone used in the citrus producer's experiment. (1 mark)

Description	Marks
States gibberellic acid.	1
Total	**1**

(b) State the hypothesis that the citrus producer was testing. (2 marks)

Description	Marks
States a hypothesis using both the dependant and independent variable that considers both crops/saleable fruit.	2
States a hypothesis using either the dependant or independent variable or only mentions one crop.	1
Total	**2**
Answers could include: Saleable fruit yield will increase with rate of gibberellic acid for both crops.	
Accept other relevant answers.	

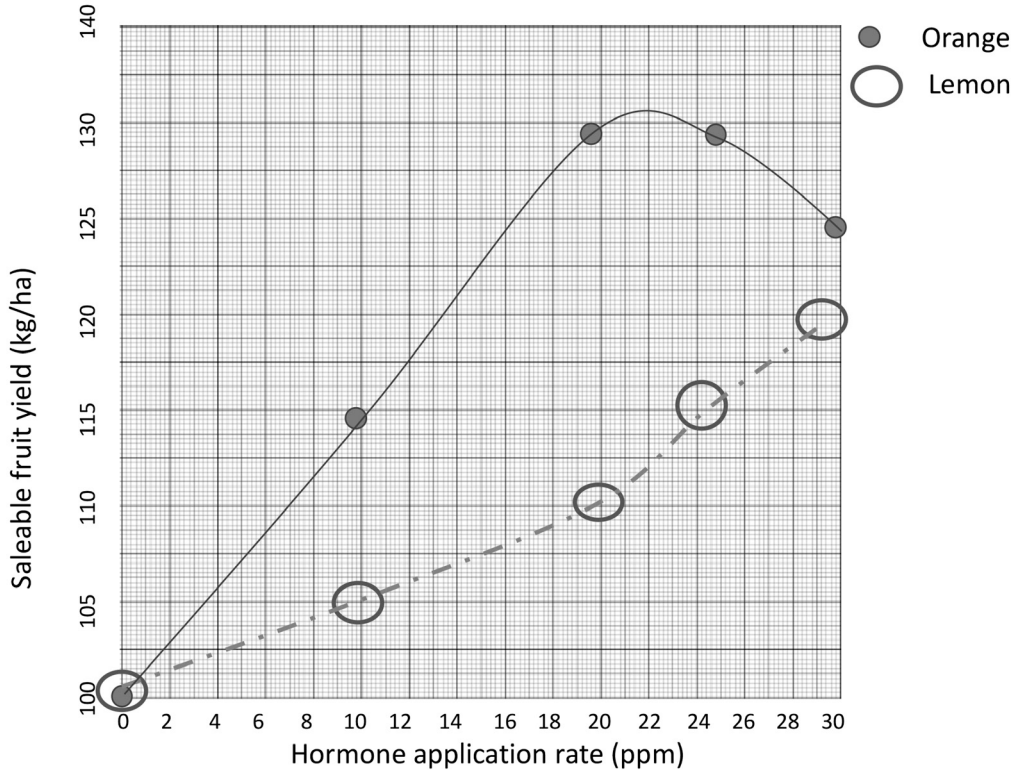
Question 21 (continued)

(c) Using the grid below, graph the data from the producer's experiment. (6 marks)

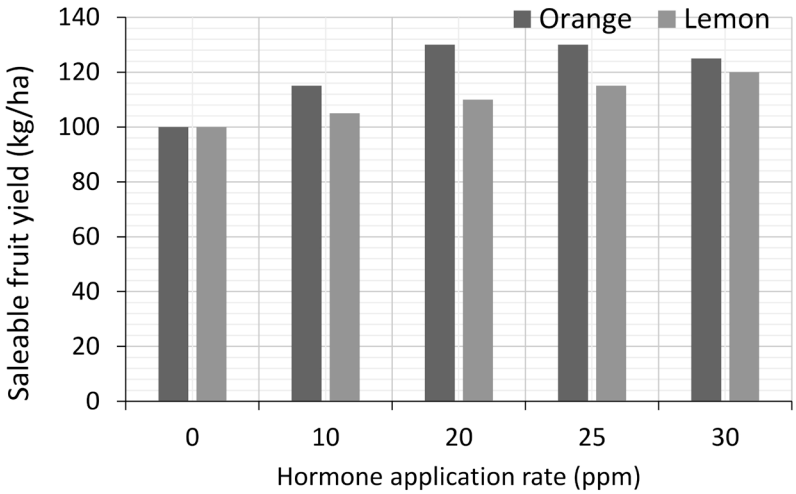
Description	Marks
Title accurately reflects the content of the data.	1
Both axis correctly scaled with number placed correctly.	1
Data points correctly placed on graph.	1
Each axis labelled with both the correct title and units.	1
Data graphed as a continuous line or paired columns.	1
The lines/columns for oranges and lemons are distinct and there is a key.	1
Total	**6**

Answers could include:

The effect of hormone rate on saleable fruit yield of lemons and oranges



The effect of hormone rate on saleable fruit yield of lemons and oranges



(d) Outline **one** conclusion from the graphed data about the impact of a hormone treatment on the saleable fruit yield. (2 marks)

Description	Marks
Outlines one conclusion.	2
States one conclusion.	1
Total	**2**
Answers could include: • the impact of hormone application on saleable fruit yield differs between lemons and oranges • hormone application has less impact on saleable fruit yield for lemons than oranges • the maximum yield response to hormone application occurs at a lower rate for lemons than oranges.	
Accept other relevant answers.	

(e) Discuss how randomisation could be applied in a future experiment to ensure the results of the experiment were valid. (4 marks)

Description	Marks
Discusses how randomisation could be used to ensure the results of the experiment were valid.	4
Describes how randomisation could be used to ensure the results of the experiment were valid.	3
Outlines how randomisation could be used.	2
Makes a relevant statement about randomisation.	1
Total	**4**
Answers could include: Trees from within the orchard should be chosen randomly and the hormone treatment levels applied randomly to these trees to ensure that the trees are representative of all the trees in the orchard and that the treatment impacts are not confused with other impacts, e.g. the experiment should not involve only edge trees or only trees on one of two soil types and the level of hormone should not increase inwards from the edge such that higher rates are always in the middle.	
Accept other relevant answers.	

(f) Propose a question for a future investigation that could make the results from the grower's experiment more relevant to the citrus producer. (2 marks)

Description	Marks
Proposes a question that is relevant to the producer.	2
Proposes a question that is only somewhat relevant to the producer.	1
Total	**2**
Answers could include: • What rate of hormone application will the saleable yield of lemons be maximised? • What level of the saleable yield do oranges increase to between 22 and 25 ppm of hormone application? • Are the results repeatable across the orchard and/or across years? • What is the level of hormone application which maximises financial return?	
Accept other relevant answers.	

Question 22 **(15 marks)**

(a) (i) Outline the **main** reason for the management activities marked on the graph. (2 marks)

Description	Marks
Outlines the main reason by referring to the graph.	2
Makes a relevant statement about the main reason.	1
Total	**2**

Answers could include:

As the population of insects moves past the economic threshold control measures need to be put in place to prevent the pest reaching economic injury level, the point where the cost of control exceeds the additional income the reduction would achieve.

(ii) Describe how the producer could use the information provided in the graph to manage the number of insects. (3 marks)

Description	Marks
Describes how the producer could use the information provided in the graph to manage the number of insects.	3
Outlines how the producer could use the information provided in the graph to manage the number of insects.	2
Makes a relevant statement about managing the number of insects.	1
Total	**3**

Answers could include:

- monitors insect levels on the plant and surrounding areas in the paddock in the early morning
- record micro weather conditions, particularly wind direction. This will give the direction of the insect movement across the paddock
- monitor the build-up of insect population
- seek advice on specific insect behaviour
- check the stage of the crop and its vulnerability to numbers
- check numbers of predator insects and numbers of natural biological control
- avoid careless spraying; seek advice.

Accept other relevant answers.

(b) Explain why the gap between the economic threshold and economic injury level may vary. (4 marks)

Description	Marks
Explains why the gap between economic threshold and economic injury level may vary.	4
Describes why the gap between economic threshold and economic injury level may vary.	3
Outlines why the gap between economic threshold and economic injury level may vary.	2
Makes a relevant statement about the gap between economic threshold and economic injury level.	1
Total	**4**

Answers could include:

- the number of insects – the reproduction rate of the insect's population may be very slow and so it may take a while before the insect levels reach the economic levels
- stage of plant growth
- variation in weather conditions – the environment (cool and wet) will play a part in the insect built up in the environment and in the spread of the insects across the paddock. Heavy rains may destroy insect eggs and delay population build up
- value of the crop/plants – stage of growth of the plants also plays a part as the insects may attack a part of the plant not valued or harvested
- yield levels of the crop – heavy, high yielding crops have a higher value
- percentage area of the crop affected by insects – damage may only be on the edges of the crop due to the movement of the insect.

Accept other relevant answers.

(c) Describe **two** strategies a producer could use to slow the progress of resistance if the management activity shown in the graph was applying a contact insecticide. (6 marks)

Description	Marks
For each of the strategies (2 x 3 marks)	
Describes a relevant strategy about slowing resistance to a contact insecticide.	3
Outlines a relevant strategy about slowing resistance to a contact insecticide.	2
States a relevant strategy about slowing resistance to a contact insecticide.	1
Total	**6**

Answers could include:

- rotate the mode of action of contact insecticides
- follow application instructions carefully, particularly the mixing rate, nozzle size, climatic conditions during spraying and the target insect's stage of life
- calibrate spray equipment to ensure accurate and even coverage (wetting pattern)
- use chemical adjuvants/wetters to help insecticides stick to target
- check to make sure targeted insect is present and in sufficient numbers to warrant a chemical application (threshold levels).

Accept other relevant answers.

Question 23 **(16 marks)**

(a) Match up the following cause and effect statements relating to plant product quality by writing the correct numbers in the spaces provided. (5 marks)

Description				Marks
Caused by		**Effect on quality**		
1	Plant variety	**3**	Growth deficiency	1
2	Weather conditions (frost)	**1**	Disease susceptibility	1
3	Soil nutrients	**5**	Mouldy fruit	1
4	Product handling (harvesting)	**2**	Wilted leaves	1
5	Product transport	**4**	Cracked grain	1
			Total	**5**

(b) Select **one** of the matched statements in part (a) and recommend an adaptation to the plant production system to improve the product quality. (3 marks)

Description	Marks
Recommends a relevant adaptation that highlights improved product quality.	3
Outlines a relevant adaptation that mentions improved product quality.	2
States a relevant adaptation.	1
Total	**3**

Answers could include:

- plant variety/disease resistance – find a variety where the crop has demonstrated resistance to diseases that are prevalent in the cropping system, select a variety of another crop species that does not provide the disease with a host or that demonstrates resistance through breeding
- weather conditions/frost – find out when frosts are most likely to happen and plant crops so that they flower outside of these times
- soil nutrients/growth deficiency – soil test/tissue test to ensure the crop has the right nutrients at the start and identify any deficiencies that occur during the growth phase
- product handling/cracked grain – adjust the grain header drum to reduce cracking, increase amount of stem that is harvested with the grain to cushion the grain during threshing
- product transport/mouldy fruit – maintain low temperatures during transport to reduce mould. Make sure transport is clean, sterile environment before placing product inside.

Accept other relevant answers.

(c) (i) Explain, using a relevant example, how productivity can be improved by developing cultivars for a specific environment. (4 marks)

Description	Marks
Explains, using a relevant example, how a cultivar can improve productivity for an environment that is clearly specified.	4
Describes, using a relevant example, how a cultivar can improve productivity for a specific environment.	3
States a relevant example of a cultivar for an environment AND makes a relevant statement about developing a cultivar for a specific environment.	2
States a relevant example of a cultivar for an environment OR makes a relevant statement about developing a cultivar for a specific environment.	1
Total	**4**

Answers could include:

- growing Roundup Ready Canola in paddocks where there are problems controlling weeds due to resistance to selective herbicides. Using this during the growth phase means the producer can control yield reducing weeds in crop while not affecting the productivity of the crop
- planting barley in paddocks that have salinity issues. While there is some effect on yields the barley will out-perform other cereals and be productive
- alkaline soils and low rainfall do not support clover pasture, and a choice of a more suitable pasture such as Medics can be a better option. Medic pasture density can respond positively to the sowing of re-inoculation medic pasture seed. This results in higher grazing potential and more productivity on the farm.

Accept other relevant answers.

(ii) Explain, using a relevant example, how profitability can be improved by developing cultivars for a specific market. (4 marks)

Description	Marks
Explains, using a relevant example, how a cultivar can improve profitability for a market that is clearly specified.	4
Describes, using a relevant example, how a cultivar can improve profitability for a specific market.	3
States a relevant example of a cultivar for a market AND makes a relevant statement about developing a cultivar for a market.	2
States a relevant example of a cultivar for a market OR makes a relevant statement about developing a cultivar for a market.	1
Total	**4**

Answers could include:

- noodle wheat markets of Japan and Korea require varieties such as Ninja, Kinsei and Zen that have a consistent level of protein to manufacture udon noodles
- bass barley required for the export brewing market, which requires a protein level of 9% and attracts a premium price above feed barley
- Australia Prime Hard (APH): 5-10% of the Australian wheat crop is APH and has a very high protein level of 13%, APH has exceptional milling quality and is in high market demand. APH produces high quality dough for bread and white noodles.

Accept other relevant answers.

Question 24 **(15 marks)**

(a) Clarify the role of tariffs as a strategy to protect Australia's domestic market. (3 marks)

Description	Marks
Clarifies the role of tariffs as a strategy.	3
Outlines the role of tariffs as a strategy.	2
Makes a general statement or identifies a tariff.	1
Total	**3**
Answers could include: Tariffs are imposed on goods being imported into Australia so that the local product is cheaper to buy. Tariffs also prevent importers from flooding the Australian market with cheaper products and a tariff may be put in place to protect a new/fledgling industry until it develops its market.	
Accept other relevant answers.	

(b) (i) Name a quality assurance program used in a plant production system with which you are familiar. (1 mark)

Description	Marks
States a relevant quality assurance program.	1
Total	**1**
Answers could include: • Grain Care • Fresh Care • Ausveg • HACCP • Haycare • Avowest	
Accept other relevant answers.	

(ii) Outline **three** strategies used in the quality assurance program named in part (b)(i) that support best practice quarantine standards. (6 marks)

Description	Marks
For each of the strategies (3 x 2 marks)	
Outlines a relevant strategy that could be used that supports quarantine standards.	2
States a relevant strategy that could be used that supports quarantine standards.	1
Total	**6**
Answers could include: • regularly monitor crops for signs of pests and diseases and recognise those that are endemic, reporting those that are not • all visitors to the site sign in at a designated point • visitor vehicles have restricted access and park in designated area • farm vehicles undergo wash down when they go off farm • contractors' machinery undergoes wash down before entering the farm • any purchased inputs are from a reputable outlet and have a commodity vendor declaration supplied with the goods • equipment for cleaning and disinfecting footwear or fit-for-purpose footwear is provided • storage of produce in areas that are monitored, sampled and fumigated to eliminate contamination.	
Accept other relevant answers.	

(c) (i) Outline the importance of the global economy to Australia's plant production industry. (2 marks)

Description	Marks
Outlines the importance of the global economy to Australia's plant production industry.	2
Makes a relevant statement about the importance of the global economy to Australia's plant production industry.	1
Total	**2**
Answers could include: • Australia is a net exporter of plant products, with about 70% of production exported • as global demand for food rises the Australian plant production industries will need to increase production through innovation while maintaining its clean, green reputation • Australia has a comparative advantage due to its climate, soils and production systems that attract global buyers that are unable to grow certain crops.	
Accept other relevant answers.	

(ii) Describe how quarantine standards can assist Australian plant producers maintain their global competitiveness. (3 marks)

Description	Marks
Describes how quarantine can assist Australian plant producers maintain their global competitiveness.	3
Outlines how quarantine can assist Australian plant producers maintain their global competitiveness.	2
Makes a relevant statement about how quarantine can assist Australian plant producers maintain their global competitiveness.	1
Total	**3**
Answers could include: Global competitiveness can be maintained by having a strong national border to keep unwanted pests and diseases out, a well-resourced state body to manage any outbreaks and farmers committed to maintaining best practice quarantine on their farms.	
Accept other relevant answers.	

Question 25 **(16 marks)**

(a) (i) State which treatment is the control in this experiment. (1 mark)

Description	Marks
Nil	1
Total	**1**

(ii) State the variable in this experiment. (1 mark)

Description	Marks
Herbicide	1
Total	**1**

(iii) Draw a conclusion on the basis of the information provided in both graphs. (2 marks)

Description	Marks
Makes a relevant conclusion that links the changes in weed biomass to the changes in grain yield.	2
Makes a relevant statement about the graph and changes in weed biomass or grain yield.	1
Total	**2**
Answers could include: • crop yield was lower when weed biomass was higher • weed biomass was higher when no herbicide was applied and this resulted in lower crop yields • the type of herbicide applied impacted crop yield because the herbicides differed in their efficacy in controlling weed growth.	
Accept other relevant answers.	

(iv) The graphs show the mean and standard error for each treatment. Outline a key conclusion which can be drawn from the standard errors. (2 marks)

Description	Marks
Outlines a key conclusion.	2
Makes a relevant statement.	1
Total	**2**

Answers could include:

Weed biomass and crop yield varied more among replicates/paddocks for the control (nil) than for herbicide 1 or herbicide 2.

(v) Clarify **one** reason why the standard error for weed biomass is largest in the 'Nil' treatment. (2 marks)

Description	Marks
Clarifies one reason.	2
Makes a relevant statement.	1
Total	**2**

Answers could include:

High variability in the Nil treatment likely reflects different numbers of weeds present in replicates/paddocks (due to a different soil weed seedbank size) as a result of differences in factors such as:

- paddock management history
- position in the landscape
- soil type
- rainfall.

Accept other relevant answers.

(vi) Clarify why 'herbicide type' could differ in its impact on weed biomass if the experiment were to be repeated on a different farm. (2 marks)

Description	Marks
Clarifies why the impact of herbicide type could differ on a different farm.	2
States one reason the impact of herbicide type could differ on a different farm.	1
Total	**2**

Answers could include:

- another farm could have a different population of weed species (or herbicide-resistant weeds) and hence one or both herbicides may be more or less effective
- another farm could have a different environment resulting in crops being more or less stressed and hence one or both herbicides may be more or less effective (e.g. water stress, waterlogged)
- another farm could have more uniform paddocks and hence there would be less variation among paddocks and thus smaller standard errors
- another farm could have weed seed banks so low (or so high) that herbicide type effects would not be visible.

Accept other relevant answers.

Question 25 (continued)

(b) (i) State **one** new digital weed control technology. (1 mark)

Description	Marks
States a new digital weed control technology.	1
Total	**1**
Answers could include: • drones • precision herbicide application • weedBots.	
Accept other relevant answers.	

(ii) Outline how the technology stated in part (b)(i) benefits weed control. (2 marks)

Description	Marks
Outlines how a new technology benefits weed control.	2
States a relevant fact about a new technology that benefits weed control.	1
Total	**2**
Answers could include: • weedBots – target individual weeds using infra-red cameras, lasers and mechanical arms to remove weeds, minimising crop disturbance and the use of pesticides • drones – can identify the areas of weed occurrence and their types from the air, downloading that information to a spray rig which can then target those areas in the crop that are infested, reducing overall herbicide use and crop disturbance • weedseeker – targets individual weeds, not bare ground, minimises pesticide use, reduces costs and any harmful effects on the crop.	
Accept other relevant answers.	

(iii) Consider how the technology stated in part (b)(i) makes production more sustainable. (3 marks)

Description	Marks
Considers how the new technology aids with optimising production.	3
Outlines how the new technology can aid with optimising production.	2
States a relevant fact about how the new technology can aid with optimising production.	1
Total	**3**
Answers could include: • targeted application may lead to less herbicide applied and therefore reduces costs, reduces environment of herbicides on soil, less chance of herbicide runoff into waterways and natural vegetation • precision application rates can lead to reduced chance of herbicide resistance arising • lower use of herbicides reduces fossil fuel use for manufacture of herbicides and fuel for application • reduced costs enable the activity to be more viable and therefore more sustainable.	
Accept other relevant answers.	

Question 26 **(20 marks)**

(a) (i) Complete the table to calculate which stocking rate would be the **most** profitable if urea is the only input. Urea costs $1/kg and each 0.5 stocking rate/ha earns $50 income. (3 marks)

Description	Marks
Income/ha correctly filled in.	1
Cost/ha correctly filled in.	1
Profit/ha correctly filled in.	1
Total	**3**

Urea				
Stocking rate/ha	**Income/ha**	**Kilograms/ha**	**Cost/ha**	**Profit/ha**
1.0	100	45	45	55
1.5	150	60	60	90
2.0	200	80	80	120
2.5	250	100	100	150
3.0	300	225	225	75

(ii) State the **most** profitable stocking rate/ha. (1 mark)

Description	Marks
States a stocking rate of 2.5/ha.	1
Total	**1**

(iii) State how a producer might utilise these production records. (1 mark)

Description	Marks
Makes a relevant statement.	1
Total	**1**
Answers could include: Demonstrates how to maximise income using the correct fertiliser rate.	
Accept other relevant answers.	

Question 26 (continued)

(iv) Outline **two** strategies a producer could use to mitigate the potential negative effects of urea fertiliser on the environment. (4 marks)

Description	Marks
For each of the strategies (2 x 2 marks)	
Outlines a relevant strategy to mitigate the negative effect of urea on the environment.	2
States a relevant strategy without referring to the effect on the environment.	1
Total	**4**

Answers could include:

- do not apply in wet, windy weather to reduce drift and run-off into waterways
- use split applications so that the plant can make best use of small amounts, thus reducing wastage from volatilisation into the atmosphere
- apply to cool, dry soil prior to a rain event to minimise volatilisation
- apply urea in a band below the soil prior to the seeding operation to reduce denitrification
- apply urea as a side-band into the soil for crops such as vegetables to minimise leaching into the ground water.

Accept other relevant answers.

(b) (i) Complete the budget outline to compare urea and ammonium sulfate. Assume that double the ammonium sulfate will produce the same pasture growth as urea and that ammonium sulfate costs 40c/kg. (4 marks)

Description	Marks
Income/ha for ammonium sulfate calculated for each stocking rate.	1
Kilograms ammonium sulfate/ha calculated for each stocking rate.	1
Cost of ammonium sulfate/ha calculated for each stocking rate.	1
Profit/ha for ammonium sulfate calculated for each stocking rate.	1
Total	**4**

AMMONIUM SULFATE				
Stocking rate/ha	**Income/ha**	**Kilograms /ha**	**Cost/ha**	**Profit/ha**
1.0	100	90	36	64
1.5	150	120	48	102
2.0	200	160	64	136
2.5	250	200	80	170
3.0	300	450	180	120

Note: Budget outline should show a clear comparison of the Profit/ha for both fertilisers.

(ii) State which fertiliser type **and** rate is **most** profitable. (1 mark)

Description	Marks
Ammonium sulfate at a rate of 200 kgs/ha.	1
Total	**1**

(iii) Outline **one** advantage and **one** disadvantage of swapping from urea to ammonium sulfate. (4 marks)

Description	Marks
Advantage	
Outlines a relevant advantage.	2
States a relevant advantage.	1
Subtotal	**2**
Disadvantage	
Outlines a relevant disadvantage.	2
States a relevant disadvantage.	1
Subtotal	**2**
Total	**4**
Answers could include: Advantages • the profit/ha for ammonium sulfate is higher • good source of sulphur. Disadvantages • ammonium sulfate requires twice as much fertiliser to provide the same amount of nitrogen • this will mean increased freight costs and more time spreading, increasing labour costs and machinery hours.	
Accept other relevant answers [does not have to be financial].	

(c) Outline **one** alternative plant production strategy, apart from using a different nitrogen fertiliser, that could improve the profitability of the grazing enterprise. (2 marks)

Description	Marks
Outlines an alternative strategy that could affect profitability.	2
States a relevant alternative strategy.	1
Total	**2**
Answers could include: • introduce legumes into the pasture by reseeding or overseeding, to increase the natural fixing of nitrogen in the soil and reduce the reliance of the grasses on nitrogen fertiliser • soil/tissue testing to check nutrient levels in soil, making sure plants are getting what they need for maximum production.	
Accept other relevant answers.	

Section Three: Extended answer **30% (40 Marks)**

Question 27 **(20 marks)**

(a) Compare the rate of matter recycling in the natural ecosystem with that of the plant production system you have identified. (6 marks)

Description	Marks
Compares, using similarities and differences, the rate of matter recycling in the two systems identified.	6
Explains, using similarities and/or differences, the rate of matter recycling in the two systems identified.	5
Describes the rate of matter recycling in the two systems identified.	4
Outlines the rate of recycling matter in the systems identified.	3
States the rate of the recycling of matter in the systems identified.	2
States the rate of the recycling of matter in a system.	1
Total	**6**

Answers could include:

- Natural ecosystems – swamp, river, winter creek, remnant vegetation area
- Plant production system – cropping paddocks, pasture, orchard, tree plantation

Similarities:
- both systems rely on plants to provide organic matter for recycling.

Differences:
- the amount of matter for recycling is in balance in a natural ecosystem, whereas in a plant production system there are periods of boom and bust. Agricultural plants deplete the soil of nutrients at a rate faster than can be provided by the recycling of matter so artificial fertilisers are used to compensate. This creates a cycle of decreasing pH levels and a reduction in soil biota
- when detritus organism populations fall there is reduced recycling of matter and during a boom period, for example, harvested crop stubble, there is not enough recycling so farmers need to manage the stubble when going into their next crop
- soil surface temperature is lower in a natural system and has less of an impact on the number and type of soil borne organisms that break down organic matter.

Accept other relevant answers.

(b) Explain a strategy that would improve the level of matter recycling in the plant production system you have identified. (4 marks)

Description	Marks
Explains a relevant strategy that would improve the level of recycling.	4
Describes a relevant strategy that would improve the level of recycling.	3
Outlines a relevant strategy that would improve the level of recycling.	2
States a relevant strategy that would improve the level of recycling.	1
Total	**4**

Answers could include:

- reduce cultivation – plant matter retained on the surface, acting as protection from erosion and summer heat. Root systems providing organic matter for variety of soil organisms, from earthworms to microbes. Less soil disturbance, encouraging a more stable soil structure which leads to better water infiltration and retention
- use pasture rotations in cropping programs – adopt grazing strategies that minimise soil and plant degradation, encourage greater root mass by maintaining enough leaf growth for quick regeneration of the pasture
- grow high biomass crops – increases the amount of organic matter that can be broken down. Green manuring is a technique where the crop is sacrificed while it is still green, back into the soil, to feed soil organisms
- use organic and manure/compost fertilisers – easy for soil organisms to break down, doesn't add chemicals to the soil that can alter the nutrient balance of the soil, either through altering the pH or by tying up nutrients
- application of gypsum to improve soil structure and texture, allows moisture to penetrate the soil deeper

Accept other relevant answers.

Question 27 (continued)

(c) Explain **one** adaptation to the plant production system you have identified that could have a positive short-term effect on production caused by one of the following circumstances:

- lower average winter rainfall, or
- higher average summer temperatures. (4 marks)

Description	Marks
Explains a relevant adaptation that would have a positive short-term effect.	4
Describes a relevant adaptation that would have a positive short-term effect.	3
Outlines a relevant adaptation that would have a positive short-term effect.	2
States a relevant adaptation that would have a positive short-term effect.	1
Total	**4**

Answers could include:

Lower average winter rainfall
Increase:

- plants' ability to access stored soil water – dry seed to allow plants to germinate with first rain and develop roots that can access stored moisture, usually from summer rainfall events.

Improve:

- soil water holding capacity
- water harvesting by creating furrows and contour banks to retain water where it falls
- maintain trash cover to reduce evaporation, control summer weeds that use stored water
- use adapted crop species/cultivars – grow low rainfall crops such as millet, and select low rainfall varieties of grain crops, usually bred for their short length of growing season, less tillers, shorter stems
- optimise sowing dates – dry seeding to optimise growing season
- manage plant density – reduce seeding rate to decrease plants/square metre, increase width of rows to reduce plant numbers.

Higher average summer temperatures

- maintain soil cover – to reduce excessive evaporation of stored moisture. Restrict grazing to maintain 1000 kgs/ha dry matter
- targeted control of summer weeds – to reduce stored moisture loss

Accept other relevant answers.

(d) Propose a strategy that could assist with the conservation of biodiversity in a natural ecosystem **and** the plant production system you have identified. (6 marks)

Description	Marks
For each system (2 x 3 marks)	
Proposes a relevant strategy.	3
Outlines a relevant strategy.	2
States a relevant strategy.	1
Total	**6**

Answers could include:

Natural ecosystem:
- fence out remnant vegetation/creeks/swamps/lakes/wetlands to prevent grazing
- create riparian zones along natural waterways to filter nutrient flow from paddocks
- leave fallen trees/branches to provide refuge
- install artificial nesting boxes
- control feral predators
- monitor/control weed infestations
- maintain a diversity of trees and understory, with regular replanting
- set up contour banks to redirect excess water flow into the natural area
- spot graze to remove weeds and grass infestation and avoid chemicals.

Plant production system:
- establish plants for pollinators
- adopt Integrated Pest Management practices
- maintain genetic diversity in crops
- reduce reliance on chemical products by utilising organic substitutes
- establish green corridors
- introduce beneficial insects
- grow legumes in rotation
- rotational grazing rather than set stocking.

Accept other relevant answers.

Question 28 **(20 marks)**

(a) Explain **two** adaptations a producer could make to their plant production practices in response to climate change, in order to remain sustainable. Discuss how these adaptations could have long-term effects on the improvement of farm resources.

(11 marks)

Description	Marks
For each adaptation (2 x 3 marks)	
Explains an adaptation a producer could make in response to climate change, while remaining sustainable.	3
Outlines an adaptation a producer could make in response to climate change, while remaining sustainable.	2
States an adaptation a producer could make in response to climate change.	1
Subtotal	**6**
Long-term effects on farm resources	
Discusses the long-term effects these adaptations could have on the improvement of farm resources.	5
Explains the long-term effects these adaptations could have on the improvement of farm resources.	4
Outlines the effects these adaptations could have on farm resources.	3
States the effects an adaptation could have on farm resources.	2
States an effect an adaptation could have on farm resources.	1
Subtotal	**5**
Total	**11**

Answers could include:

Adaptations in response to climate change while remaining sustainable:

Breeding/GMO/Cultivars/Varieties
- using plant breeding to collect and select varieties that can cope with climate change factors such as drought, frost, salinity, acidity, increased temperature, water availability
- genetic modification – shorter growing season to make use of limited water and changing temperature and seasons
- cultivars/varieties that can tolerate saline conditions, use less water, and are responsive to organic fertilisers.

Water
- more efficient and higher capacity water storage facilities
- more efficient irrigation (micro spray, drip feeding)
- wetting agents for better absorption
- conservation methods
- plant varieties bred for less water consumption or need.

Cultivation
- cultivation methods such as minimum tillage, direct drill/seeding, deep ripping
- liming and claying for increases in production
- mulching
- alternative cropping methods such as enclosed shade areas
- weed management.

Rotation
- resting and rotation of crops (broadacre and horticulture) and pastures
- smaller paddocks, strips or lots to enable rotation and to introduce pasture or soil regeneration.

Technology
- monitoring of weather patterns and climate predictions to inform production decisions
- weed mapping, GPS or use of drone technology to improve application and avoid overlay.

Interaction of environments
- consider the natural environment, biodiversity and measures that can be taken to increase the benefit of one on the other
- soil sampling and water testing of soil water reserves to make decisions regarding crop variety and/or type, timing and yield projection.

Government
- development of policy to combat climate change and the increase in occurrence of natural disasters
- research into trends and forecasts of weather patterns and predictability
- funding of agronomy research and extension of knowledge and findings to producers
- development of funds reserve to educate farmers in the adaptations and adoptions necessary to combat changing conditions to production.

Long term effects that adaptations can have on the improvement of farm resources:
- a more sustainable cropping option (broadacre or horticulture) that makes better use of water availability or is more robust in changing environmental factors such as increased temperatures
- water storage for the future
- wetting agents for soil water absorption
- irrigation methods ensure less water consumption
- mulching mitigates evaporation from soil, traps moisture, enables carbon and nitrogen cycle to occur, and means less wind and water erosion
- a more balanced ecosystem using the interaction of the natural and agricultural systems
- less chemical and/or fertiliser use through technology avoiding overlap or application where not needed
- cultivars and breeding technology will enable producers to plant climate and environment specific species
- more natural applications of fertilisers through liming and claying reduces need for manufactured fertilisers which leads to less negative impacts. Can also mention nitrogen fixing through legume crops and pastures.

Accept other relevant answers.

Question 28 (continued)

(b) Select **one** of the adaptations, identified in part (a), and explain how the conflicting demands of the triple bottom line could be managed by the producer. (9 marks)

Description	Marks
For each part of the triple bottom line (3 x 3 marks)	
Selects one adaptation and explains how the conflicting demands of the triple bottom line can be managed.	3
Selects one adaptation and describes how the conflicting demands of the triple bottom line can be managed.	2
States an adaptation with reference to the triple bottom line.	1
Total	**9**

Answers could include:

Selects one of the adaptations in part (a) and identifies the triple bottom line – economic, social and environmental factors can be managed.

Economic:
- rising costs will be offset through gains (more efficient use of resources) through technology – GPS guidance, yield mapping, computer programming for whole production plans and strategies
- budgeting and use of short-term loans for cash flow
- futures forecasting, locking in prices to guarantee an income
- diversification of production to spread risk
- identifying trends and cycles in markets to maximise profit and minimise loss
- long term market predictions to use risk matrix to apply strategies to production to mitigate risk.

Social:
- utilisation of services such as mental health support and financial planning
- maintaining employment and family support
- agronomists and consultants
- join focus groups to be abreast of latest developments, research and discoveries
- upskilling of knowledge through attendance at forums, field days, research groups – online information.

Environmental:
- less soil compaction, soil erosion and degradation through use of minimum tillage methods
- use of water harvesting, catchment and retention techniques to build up soil water reserves
- better use of natural resources through crop selection
- crop selection is dependent on weather forecasting and climate patterns
- long range forecasting and weather patterns can be factored into the business plan
- more sustainable use of water through irrigation methods and water storage options
- increasing yield through the use of cultivars and plant breeding methods.

Accept other relevant answers.

Question 29 **(20 marks)**

(a) Compare the complexity of the breeding method for genetically modified organisms (GMO) and a conventional plant breeding method. (10 marks)

Description	Marks
Compares, using similarities and differences, the complexity of the breeding method for GMOs and a conventional plant breeding method.	9–10
Explains, using similarities and/or differences, the complexity of the breeding method for GMOs and a conventional plant breeding method.	7–8
Describes the complexity of the breeding method for GMOs and a conventional plant breeding method.	5–6
Outlines the breeding method for GMOs and/or a conventional plant breeding method.	3–4
States a breeding method.	1–2
Total	**10**

Answers could include:

Conventional breeding should include one of the following:

- crossbreeding – deliberate crossing of related individuals with desirable characteristics to produce a new variety
- backcrossing – a single trait is identified and crossed with a related variety that needs the trait, crossing back to the original parent and selecting for the new trait
- hybrid breeding – two different inbred varieties are crossed to produce an offspring with stable characteristics and hybrid vigour, where the offspring is more productive than the parents of the hybrid
- mass selection – seed is collected from desirable appearing individuals in a population, the next generation is sown, and seed is retained by subjectively assessing individual plants
- GMO – allows individual genes with desired traits to be inserted directly from one organism into the living DNA of another. This insertion does not occur in nature and requires a chemical or electrical treatment to undertake the insertion of the desired gene into the chromosome of the host plant
- conventional breeding – by crossing together plants with relevant characteristics, and selecting the offspring with the desired combination of characteristics, particular combinations of genes are inherited from the two parents. Even in controlled environments this process takes years
- both conventional plant breeding and GMO deliver genetic crop improvement
- many genes have been identified that could contribute to improving sustainable food production. In some cases conventional breeding will be the best way to transfer them and in others GMO might be easier/faster or indeed the only way they can be transferred.

There are two main reasons why GMO might be preferable:

- the gene of interest might not exist in a species that can be successfully crossed with the crop. The gene might come from an entirely different kingdom, such as a bacterium, or it might come from a different plant species
- today's high yield crop lines have carefully honed combinations of genes. Crossing the high yield line with the wild relative will result in mixing together the genomes of the two parents, destroying the carefully selected combination of genes in the high yield line and will take multiple generations to reassemble the required gene combinations. This can be avoided by introducing the gene directly into the high yield crop by genetic modification.

Accept other relevant answers.

Question 29 (continued)

(b) Explain the effect the **two** breeding methods, identified in part (a) could have on farm sustainability by applying the triple bottom line framework. (10 marks)

Description	Marks
Explains the effect the two breeding methods could have on farm sustainability by applying the triple bottom line framework.	9–10
Describes the effect the two breeding methods could have on farm sustainability by applying the triple bottom line framework.	7–8
Outlines the effect the two breeding methods could have on farm sustainability by applying the triple bottom line framework.	5–6
States the effect one or two breeding methods could have on farm sustainability by applying the triple bottom line framework.	3–4
States the effect a breeding method could have on farm sustainability.	1–2
Total	**10**

Answers could include:

Economic aspect of triple bottom line framework:
- cross-bred varieties can be bulked up on-farm, providing seed for future plantings at a low cost
- cross-breeding takes a long time to produce a superior variety, the cost of which is passed onto the producer in Plant Variety Rights (PVR) levies
- GMO will potentially give higher yields, increasing producers' income
- GMO seed needs to be purchased each season; cost is controlled by plant breeding companies
- GMO crop produce does not have full access to markets. The EU, for example, will not import GMO grains
- GMO developed to have greater drought resistance and lower production costs.

Environmental aspect of triple bottom line framework:
- cross-bred varieties select for genes that enhance production under certain conditions, not resilience to a variety of environmental conditions
- cross-bred varieties can cross-breed with other varieties, diluting the characteristics it was bred for and reducing its ability to perform in the environment it was bred for
- GMO crops may accelerate the damaging effects of farming due to higher yields that require more fertiliser and targeted pest control
- GMO crops may enable gene transfer into wild relatives or conventional crops, creating unwanted plant populations that are difficult to control
- GMO crops may see a change in agricultural practices, such as pesticide and herbicide use, which would be beneficial to biodiversity.

Social aspect of triple bottom line framework: • concerns around the unknown health effects of GMO on humans • GMO varieties producing greater yields to alleviate poverty in developing countries • GMO contamination of neighbouring farms non-GMO production causing friction between neighbours, leading to disputes, legal proceedings and social divide • GMO enables producers to produce crops in areas which have been unsuitable in the past, due to low rainfall, mineral composition of the soil (high aluminium), salinity • cross-bred varieties give producers choice to maintain a diversified cropping program that employs locals, provides revenue for regional economies, and supports regional services.
Accept other relevant answers.

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Question 29(a)

Dot point 3 adapted from: Nerkar, G., Devarumath, S., Purankar, M., et al. (2022, July). Advances in Crop Breeding Through Precision Genome Editing. *Frontiers in Genetics*. Retrieved October, 2022, from https://www.frontiersin.org/articles/10.3389/fgene.2022.880195/full
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Dot points 6–10 adapted from: The Royal Society. (2016). *GM Plants Questions and Answers: Question 3 how Does GM Differ From Conventional Plant Breeding*. Retrieved October, 2022, from https://wascsa.turnitin.com/viewer/submissions/oid:6359:25276117?locale=en
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