Agricultural Science 2019 v.3

IA2 high-level annotated sample response

October 2022

Student experiment (20%)

This sample has been compiled by the QCAA to assist and support teachers to match evidence in student responses to the characteristics described in the instrument-specific marking guide (ISMG).

Assessment objectives

This assessment instrument is used to determine student achievement in the following objectives:

2. apply understanding of animal production, plant production or agricultural enterprises to modify experimental methodologies and process primary data
3. analyse experimental evidence about animal production, plant production or agricultural enterprises
4. interpret experimental evidence about animal production, plant production or agricultural enterprises
5. investigate phenomena associated with animal production, plant production or agricultural enterprises through an experiment
6. evaluate experimental processes and conclusions about animal production, plant production or agricultural enterprises
7. communicate understandings and experimental findings, arguments and conclusions about animal production, plant production or agricultural enterprises.

Note: Objective 1 is not assessed in this instrument.

Queensland Government | Queensland Curriculum & Assessment Authority

Instrument-specific marking guide (ISMG)

Criterion: Research and planning

Assessment objectives

2. apply understanding of animal production, plant production or agricultural enterprises to modify experimental methodologies and process primary data
5. investigate phenomena associated with animal production, plant production or agricultural enterprises through an experiment

The student work has the following characteristics:	Marks
• informed application of understanding of animal production, plant production or agricultural enterprises to modify experimental methodologies demonstrated by – a considered rationale for the experiment – justified modifications to the methodology • effective and efficient investigation of phenomena associated with animal production, plant production or agricultural enterprises demonstrated by – a specific and relevant research question – a methodology that enables the collection of sufficient, relevant data • considered management of risks and ethical or environmental issues.	5–6
• adequate application of understanding of animal production, plant production or agricultural enterprises to modify experimental methodologies demonstrated by – a reasonable rationale for the experiment – feasible modifications to the methodology • effective investigation of phenomena associated with animal production, plant production or agricultural enterprises demonstrated by – a relevant research question – a methodology that enables the collection of relevant data • management of risks and ethical or environmental issues.	3–4
• rudimentary application of understanding of animal production, plant production or agricultural enterprises to modify experimental methodologies demonstrated by – a vague or irrelevant rationale for the experiment – inappropriate modifications to the methodology • ineffective investigation of phenomena associated with animal production, plant production or agricultural enterprises demonstrated by – an inappropriate research question – a methodology that causes the collection of insufficient and irrelevant data • inadequate management of risks and ethical or environmental issues.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Analysis of evidence

Assessment objectives

2. apply understanding of animal production, plant production or agricultural enterprises to modify experimental methodologies and process primary data
3. analyse experimental evidence about animal production, plant production or agricultural enterprises
5. investigate phenomena associated with animal production, plant production or agricultural enterprises through an experiment

The student work has the following characteristics:	Marks
• appropriate application of algorithms, visual and graphical representations of data about animal production, plant production or agricultural enterprises demonstrated by correct and relevant processing of data • systematic and effective analysis of experimental evidence about animal production, plant production or agricultural enterprises demonstrated by − thorough identification of relevant trends, patterns or relationships − thorough and appropriate identification of the uncertainty and limitations of evidence • effective and efficient investigation of phenomena associated with animal production, plant production or agricultural enterprises demonstrated by the collection of sufficient and relevant raw data.	5–6
• adequate application of algorithms, visual and graphical representations of data about animal production, plant production or agricultural enterprises demonstrated by basic processing of data • effective analysis of experimental evidence about animal production, plant production or agricultural enterprises demonstrated by − identification of obvious trends, patterns or relationships − basic identification of uncertainty and limitations of evidence • effective investigation of phenomena associated with animal production, plant production or agricultural enterprises demonstrated by the collection of relevant raw data.	3–4
• rudimentary application of algorithms, visual and graphical representations of data about animal production, plant production or agricultural enterprises demonstrated by incorrect or irrelevant processing of data • ineffective analysis of experimental evidence about animal production, plant production or agricultural enterprises demonstrated by − identification of incorrect or irrelevant trends, patterns or relationships − incorrect or insufficient identification of uncertainty and limitations of evidence • ineffective investigation of phenomena associated with animal production, plant production or agricultural enterprises demonstrated by the collection of insufficient and irrelevant raw data.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Interpretation and evaluation

Assessment objectives

4. interpret experimental evidence about animal production, plant production or agricultural enterprises
6. evaluate experimental processes and conclusions about animal production, plant production or agricultural enterprises

The student work has the following characteristics:	Marks
• insightful interpretation of experimental evidence about animal production, plant production or agricultural enterprises demonstrated by justified conclusion/s linked to the research question • critical evaluation of experimental processes about animal production, plant production or agricultural enterprises demonstrated by – justified discussion of the reliability and validity of the experimental process – suggested improvements and extensions to the experiment that are logically derived from the analysis of evidence.	5–6
• adequate interpretation of experimental evidence about animal production, plant production or agricultural enterprises demonstrated by reasonable conclusion/s relevant to the research question • basic evaluation of experimental processes about animal production, plant production or agricultural enterprises demonstrated by – reasonable description of the reliability and validity of the experimental process – suggested improvements and extensions to the experiment that are related to the analysis of evidence.	3–4
• invalid interpretation of experimental evidence about animal production, plant production or agricultural enterprises demonstrated by inappropriate or irrelevant conclusion/s • superficial evaluation of experimental processes about animal production, plant production or agricultural enterprises demonstrated by – cursory or simplistic statements about the reliability and validity of the experimental process – ineffective or irrelevant suggestions.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Communication

Assessment objective

7. communicate understandings and experimental findings, arguments and conclusions about animal production, plant production or agricultural enterprises

The student work has the following characteristics:	Marks
• effective communication of understandings and experimental findings, arguments and conclusions about animal production, plant production or agricultural enterprises demonstrated by – fluent and concise use of scientific language and representations – appropriate use of genre conventions – acknowledgment of sources of information through appropriate use of referencing conventions.	2
• adequate communication of understandings and experimental findings, arguments and conclusions about animal production, plant production or agricultural enterprises demonstrated by – competent use of scientific language and representations – use of basic genre conventions – use of basic referencing conventions.	1
• does not satisfy any of the descriptors above.	0

Task

See IA2 sample assessment instrument: Student experiment (20%) (available on the QCAA Portal).

Sample response

Criterion	Marks allocated	Provisional marks
Research and planning Assessment objectives 2, 5	6	6
Analysis of evidence Assessment objectives 2, 3, 5	6	6
Interpretation and evaluation Assessment objectives 4, 6	6	5
Communication **Assessment objective 7**	2	2
Total	**20**	**19**

The annotations show the match to the instrument-specific marking guide (ISMG) performance-level descriptors.

Key: Research and planning Analysis of evidence Interpretation and evaluation Communication

Note: Colour shadings show the characteristics evident in the response for each criterion.

Research and planning [5–6]

a considered rationale for the experiment

The rationale contains evidence of a logical, scientifically informed basis for the experiment.

Rationale

Agricultural producers aim to create a plant product that meets or exceeds the requirements of the relevant market. Understanding plant nutrition is vital to allow optimal plant growth for any crop or pasture species and achieving the maximum yield for the least cost of production. All plants have their own nutritional requirements to allow optimal growth and development. Thirteen soil minerals (nutrients) have been identified as important for plants to grow well (Campbell, 2009). Two nutrients important for the vegetative and reproductive growth stages of plants are nitrogen (N) and phosphorus (P) (Uchida, 2000).

Nitrogen is essential for vegetative growth due to it being part of the chlorophyll molecule and subsequently the process of photosynthesis. It improves the quality and quantity of protein in grain crops. Phosphorus aids in root development, flower initiation, and seed and fruit development (Uchida, 2000).

The response of agricultural crops (e.g. French beans) to different levels of soil nitrogen and phosphorus will depend upon the availability of the nutrients in the soil but is also related to the timing of nutrient application in relation to crop physiology and morphology (Mengel, 1983).

A practical trial was initiated in class to test how different levels of major nutrients affect the growth and development of French beans (*Phaseolus vulgaris* cv. excalibur). The trial was conducted using a control (no fertiliser), diammonium phosphate (DAP) fertiliser, blood and bone or a combination of both fertilisers to test the effect of nutrient management on growth and development. The primary data collected showed the greatest yield of French beans came from the use of both fertilisers. A nutrient analysis of the blood and bone showed the presence of all of the major essential plant nutrients except for magnesium (Yates Australia, n.d.).

The response carefully communicates the purpose and reasons for the experiment.

Sen (2010), conducted an experiment to assess the response of French beans to four different levels of nitrogen (0, 100, 150 and 200 kg/ha) and three different levels of phosphorus (0, 40 and 60 kg/ha). The main finding was a significant response in yield to increased levels of nitrogen and phosphorus up to a certain level before production started to decline.

The rationale explicitly communicates the reasons for modifying the original experiment.

The main purpose of this experiment is to refine Sen's experiment by investigating the effect of six different levels of nitrogen application (0, 40, 80,120,160 and 200 kg/ha) on the yield of a commercial French bean cultivar (Excalibur). It is expected that modifying Sen's experiment by increasing the number of nitrogen application rates will provide information to help identify the most efficient level of nitrogen to apply to French beans for optimal yield. This experiment will also help to redirect Sen's experiment and the class trial by narrowing the investigation to testing the effect of one nutrient (nitrogen) on the yield of French beans. It is expected that by narrowing the investigation and applying side dressings of nitrogen at specific growth stages, (emergence and floral initiation) the relationship between level of nitrogen applied and plant yield can be made clearer. The information gathered from the results could assist vegetable producers make management decisions on choosing the most cost-effective rate of nitrogen to apply during the life cycle of the crop.

Research and planning [5–6]

a specific and relevant research question

The research question is clearly defined to allow the collection of sufficient and relevant data.

The research question is connected to the rationale and the topics covered in the unit.

The research question is clearly defined.

The independent variable and the dependent variable are clearly stated.

Research and planning [5–6]

justified modifications to the methodology

The response gives sound reasons for how the modifications to the methodology will refine, extend or redirect the original experiment.

The research question to be investigated is:

What is the relationship between level of nitrogen available and yield of French beans?

Modification to experiment methodology

The specific modifications to the original experiment (Sen, 2010) and the class experiment are as follows:

Table 1: Modifications to experiment methodology

Modification to Sen's experiment and class experiment	Reason why this modification will refine or extend the original experiment
Increase the number of nitrogen levels investigated from 4 to 6 (e.g. Diagram 1)	A relationship exists between level of available nitrogen and the growth of French beans (Sen, 2010). By using 6 points of data rather than 4, a more precise understanding of the relationship between the level of nitrogen application and yield of French beans can be established which could illustrate the law of diminishing returns (Brown, Hindmarsh, & McGregor, 2015).
Redirecting the experiments to focus on the effect of nitrogen on plant yield and development in French beans.	Sen's experiment found a relationship between the growth of French beans and the level of nitrogen and phosphorus present in the soil. By redirecting the experiment to only look at nitrogen applied at specific growth stages, the aim of this experiment will be to collect more data to establish the nature of the relationship between nitrogen and plant yield (assuming phosphorus is not a limiting factor).

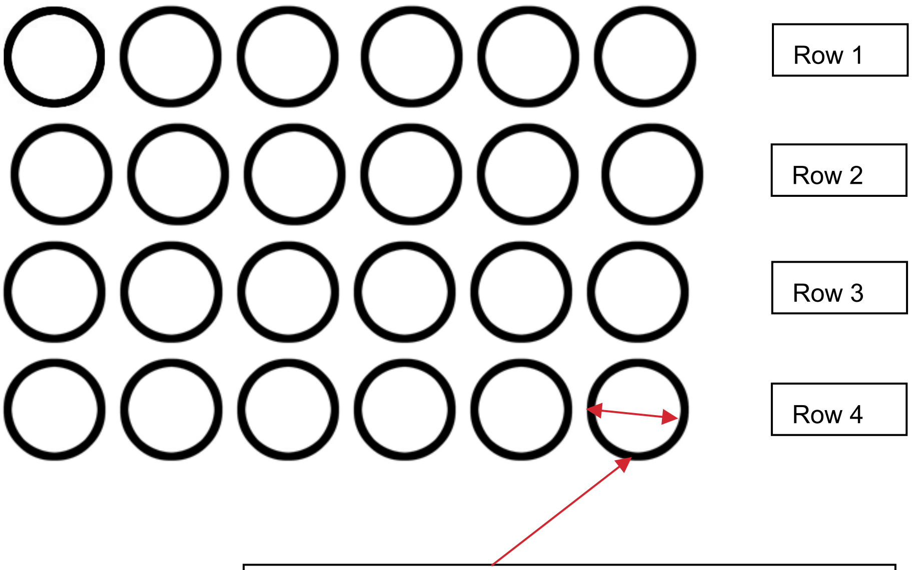
Diagram 1: Experimental set up for a randomised complete block design

(RCBD 6x4 with each of the six treatments (trt) allocated randomly within each of the four rows)

Basal application of 60 kg/ha P as DAP for all pots

Levels of nitrogen applied:
Each level of nitrogen was assigned a treatment (trt) number.

Trt 1: 0 kg/ha Trt 4: 120 kg/ha
Trt 2: 40 kg/ha Trt 5: 160 kg/ha
Trt 3: 80 kg/ha Trt 6: 200 kg/ha



20 cm diameter pots (3 F. Bean seeds planted 3 cm apart in the middle of each pot. One–two seedlings removed after 7 days if all emerge.

Research and planning [5–6]

considered management of risks and ethical or environmental issues

The response shows careful and deliberate identification and planning to handle risks and ethical or environmental issues in the experiment.

Management of risks

Table 2: Management of risks in this experiment

Risk identified	Management strategy
The bags of soil collected for filling pots are heavy and need to be lifted	The correct lifting technique must be used to minimise stress on the lower part of the back.
Urea fertiliser can sting if contact is made with eyes.	Eye protection (safety goggles) and gardening gloves should be worn when measuring out and applying urea fertiliser to each pot.
Water spills on the green house floor (concrete surface)	Rubber-soled footwear will help prevent any slipping.
Use of pesticides to control potential insect pests in experiment.	Use, when possible, a synthetic pyrethroid insecticide and discuss commercial alternatives.

Raw data

Qualitative data

Table 3: Relevant extract of observations from crop diary.

Date (days after planting)	Observations
7.	'Uniform' emergence of all seedlings. Seedlings removed to allow only 1 seedling/pot. 1st application of urea fertiliser.
28.	One pot in the control group did not have the same volume of soil compared to the rest of the pots.
35.	First floral buds developing on plant. 2nd application of urea. A treatment 3 plant appears to be yellowing around the base of the plant. No obvious signs of floral initiation. Teacher has suggested “flushing” the soil in case of urea burning of the base.
66.	Harvest date. Leaves appear to be darker green colour for 120, 160 N levels.

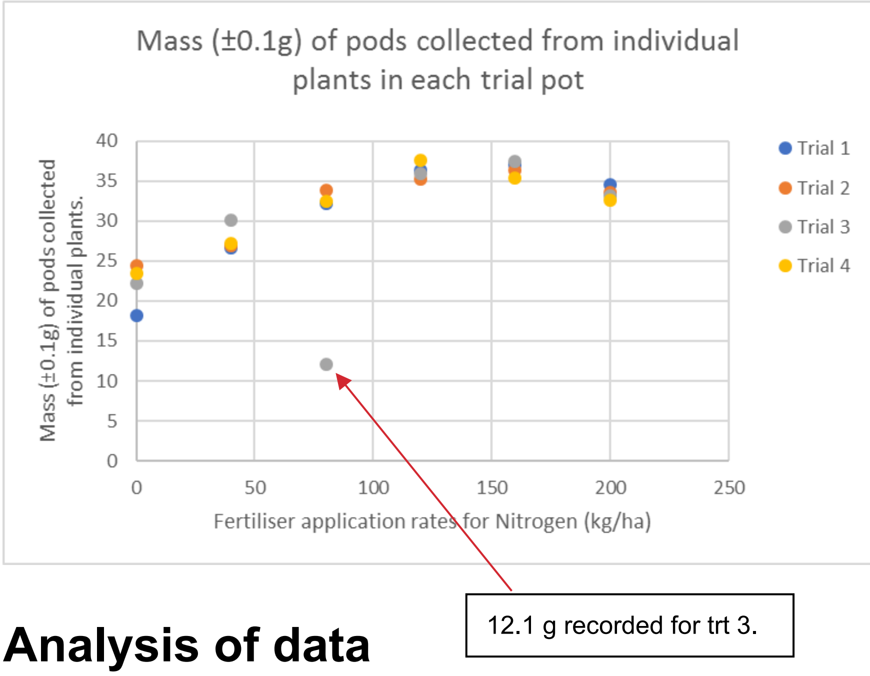
Research and planning [5–6]

a methodology that enables the collection of sufficient, relevant data

The methodology shows careful and deliberate thought. It enables collection of adequate data so an informed conclusion to the research question can be drawn.

Quantitative data (Raw data)

Graph 1: Raw data of mass of bean pods/plant collected across four separate trials with respects to level of nitrogen application (kg/ha).



Analysis of evidence [5–6]

collection of sufficient and relevant raw data

The raw data is adequate for forming a conclusion and has direct bearing upon the research question.

Analysis of data

Table 4: Mean mass (g) of pods/plant (±0.1g) for different levels of nitrogen

Nitrogen application (kg/ha)	Mass(g) of pods collected from each plant (±0.1g)				Mean mass (g) of pods/plant ± (SE)	Mean mass (g) of pods/plant ± (CI)
	Trial 1	Trial 2	Trial 3	Trial 4		
0	18.2	24.4	22.2	23.4	22.1 ± 1.36*	22.1 ± 2.67
40	26.7	26.9	30.1	27.2	27.7 ± 0.80*	27.7 ± 1.56
80	32.2	33.9	12.1	32.4	27.7 ± 5.20**	27.7 ± 10.2**
120	36.4	35.3	35.9	37.6	36.3 ± 0.49*	36.3 ± 0.96
160	37.1	36.3	37.4	35.4	36.6 ± 0.45*	36.6 ± 0.88
200	34.5	33.6	33.1	32.6	33.5 ± 0.41*	33.5 ± 0.79

* Standard Error (SE) was calculated using Excel

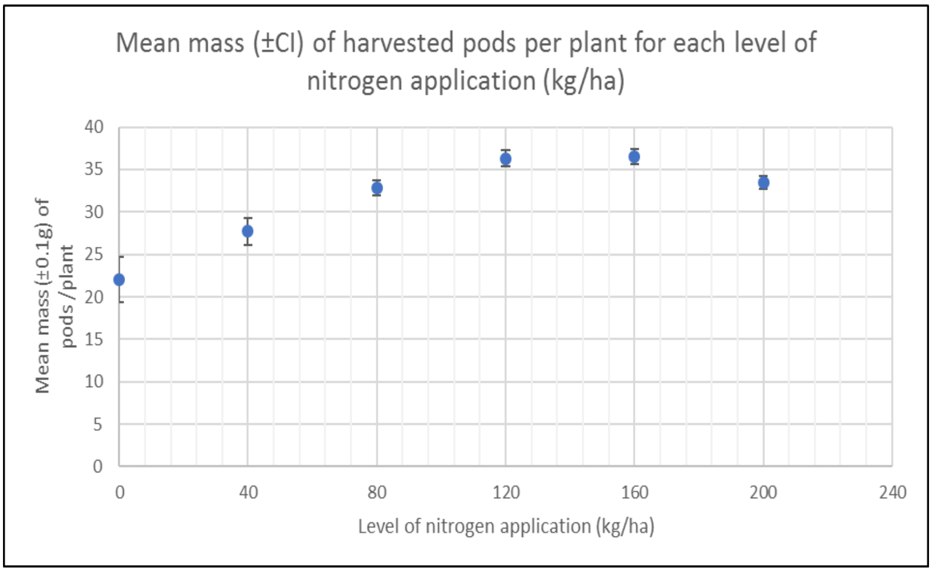
** **Note** significantly larger SE and consequently CI

Communication [2]

appropriate use of genre conventions

The response follows scientific conventions of units and significant figures.

▢ Shaded area represents a potential outlier

Analysis of evidence [5–6] correct and relevant processing of data Raw data is manipulated accurately to provide evidence that is applicable to the research question.	**Analysed data: sample calculations** (including processing of data) **1. Mean** values in **Table 4**. Mean mass of pods/plant for **40 kg/ha** of N: $= \frac{(26.7+26.9+30.1+27.2)}{4}$ = 27.7g **2. Standard Error (SE)** of the mean **SE** = Standard deviation (s) / √n = 0.80 g (where n=number of samples) **3. Calculation of Confidence Interval (CI)** at 95% level **Mean** mass ± **CI** for **40 kg/ha** of N: = 27.7 ± (1.96*SE) = 27.7 ± 1.56 For the purpose of analysis, the outlier (12.1), was removed and the effect on the mean can be seen in graph 2. **Graph 2:** Mean mass of harvested pods/plant for each level of nitrogen (kg/ha) with outlier removed.
Analysis of evidence [5–6] thorough identification of relevant trends, patterns or relationships The identification of trends and patterns is not superficial or partial. The trends and patterns are applicable to the research question.	
Analysis of evidence [5–6] thorough and appropriate identification of the uncertainty and limitations of evidence	Graph 2 indicates a positive relationship or effect between plant yield and increasing levels of nitrogen applied up to 120 kg/ha (i.e. no statistical difference between mean yields for 120 and 160 kg/ha). A greater response in plant yield to increasing levels of nitrogen appears to be between 40–80 kg/ha (i.e. using 'new' mean).The results for mean values in Graph 2 support the law of diminishing returns which states a point is reached when a maximum production occurs and then declines; a tipping point exists where

The response suitably identifies uncertainty and limitations of the data in a way that is not superficial or partial. The response examines the uncertainty to determine if the evidence that will be used to draw a conclusion to the research question is reliable and valid.	the cost of adding additional units of inputs is more that the benefits gained by the increase in outputs (Brown, Hindmarsh & McGregor, 2015), (Sen, 2010). Analysis of the data suggests that there is a larger level of uncertainty about the accuracy and precision of data for the 80 kg/ha nitrogen treatment and the control group. A recorded yield of 12.1g (i.e. trial 3, trt 3) as seen in Graph 1 and Table 4 resulted in a significantly larger standard error (i.e. 5.20), reflecting higher variability of sample data around the mean compared to other standard error values (Table 4). This particular plant appeared to suffer fertiliser burn resulting in poorer growth and ultimately a smaller yield. A more accurate reflection of the mean (Graph 2) was achieved when this outlier value was removed from the calculation of the mean in Table 4 (i.e. new mean 32.83 ± 0.46 g compared to 27.65 ± 5.20 g). The standard error of the mean (i.e. 1.36 g) for the control group indicates the shaded value in table 4 (18.2g) has caused a level of uncertainty about the accuracy of the mean value. The standard error of the mean for the control group is approximately three times greater than the standard errors for the 120, 160 and 200 kg/ha group means (0.49 g, 0.45 g and 0.41 g) respectively. It should be noted that there are limitations of the data due to the small sample size (n = 4) and the methodology of this pot experiment. The limitation of the methodology is due to the data not being collected from a true representation of the environmental conditions that a crop (i.e. population) would normally endure. That is, the plants were grown in pots in a uniformly blended soil mixture and in an area where environmental variables were controlled (i.e. French beans are susceptible to some soil types, levels of soil moisture, high maximum temperatures and frosts).
Interpretation and evaluation [5–6] **justified conclusion/s linked to the research question** The conclusions draw upon scientific understanding and evidence, and directly respond to the research question.	## Interpretation and evaluation Based on the evidence, the results indicate an increase in plant yield with increasing levels of nitrogen up to a nitrogen level of 160 kg/ha. The results would support a management decision by a grower to apply a level of nitrogen of 120 kg/ha for the production of French beans. From Graph 2, there is no significant difference in yield between the 120 and 160 kg/ha application rates as the error bars for these two levels overlap each other (i.e. 36.3 ± 0.49 g vs 36.6 ± 0.45 g respectively). Therefore, it would be of no benefit to a producer to add additional nitrogen fertiliser (i.e.160 kg/ha) to achieve a negligible increase in overall yield. It is also worth noting that the error bars for the mean yield at 200 kg/ha of nitrogen do not overlap either the error bars for the 120 and 160 kg/ha application rates indicating a significant reduction in yield. Further evidence can be seen in Table 3 which would indicate the plants are healthiest at the 120 and 160 kg/ha application rates of nitrogen. These findings are consistent with existing scientific understanding of the effect of increasing nitrogen on plant growth and development as stated in the rationale. To reduce the range of collected results and improve the accuracy and precision of the measurements a number of steps could be taken: • Remove plants from the trial if they have obviously been affected by a random environmental factor (e.g. application of nitrogen fertiliser too close to the base of the plant in the pot).

Interpretation and evaluation [3–4] **suggested improvements and extensions to the experiment that are related to the analysis of evidence** The suggested improvements would improve the validity and reliability of the experiment. However, the response does not use evidence to inform the modifications.	• Increase the number of trials used for each level of nitrogen application. This would decrease the standard error of the mean and reduce the effect of any variation (i.e. random error) of the recorded data on the mean. Calculated confidence intervals would be smaller which would mean that the experiment would be more precise. • Use an automatic irrigation system to deliver the same moisture levels to each pot. This would reduce any variation in the volume of water delivered to plants by hand-watering. Further investigation could look at extending the: • scope of the experiment by planting a field trial • range of the experiment to look at the response of French bean plants to changing levels of phosphorus or other major nutrients to investigate any limitation on the effect that the experimental nitrogen levels had on plant yield.
Interpretation and evaluation [5–6] **justified discussion of the reliability and validity of the experimental process** The discussion uses evidence from the identification of uncertainties to determine the reliability and validity of the experimental process.	The reliability of the experimental process can be improved once outliers are removed from the raw data. For example, when an outlier (12.1 g) was removed, the standard error value for treatment 3 was significantly reduced from ± 5.20 g to ± 0.46 g. This caused a significant reduction in the confidence interval (Graph 2), allowing greater certainty in establishing the sample mean. The experimental method used is only valid when applied to a pot trial which is conducted under the following conditions: • soil used was not subject to any prior fertiliser application which could have influenced the effect of increasing nitrogen levels • plants have access to most nitrogen and phosphorus supplied as there would be minimal leaching due to excessive rainfall • soil type that commercial producers use is not the same type as that used during the experiment • fluctuations in air temperature are less allowing more optimal growing conditions (e.g. decreasing the incidence of frosts or added moisture stress caused by higher air temperatures).
Interpretation and evaluation [5–6] **justified conclusion/s linked to the research question** The conclusions draw upon scientific understanding and evidence, and directly respond to the research question.	The results from this experiment help to conditionally answer the research question and support earlier work by Sen (2010). It would appear that levels of nitrogen application between 120–160 kg/ha will give the optimal yield as long as other nutrients are not limiting.
Communication [2] **fluent and concise use of scientific language and representations** The response is easily understood, avoids unnecessary repetition and meets the required length.	Word count: 1991

Communication [2] **acknowledgment of sources of information through appropriate use of referencing conventions** The sources of information are acknowledged using a referencing style that is suitable for the purpose of the scientific report.	# References

Brown, L., Hindmarsh, R. & McGregor, R. (2015). *Dynamic agriculture: Years 11–12*, Cengage Learning Australia.

Campbell, C. (Host). (2009). Plant nutrition [segment transcript]. In *Gardening Australia,* ABC. http://www.abc.net.au/gardening/stories/s2589149.htm

Mengel, K. (1983). 'Responses of various crop species and cultivars to fertilizer application'. *Plant and Soil*, 72, 305–319, https://doi.org/10.1007/BF02181970.

Sen, R., Rahman, M.A., Hoque, A.K.M.S., Zaman, S., and Noor, S. (2010)**.** Response of Different Levels of Nitrogen and Phosphorus on The Growth and Yield of French Bean. *Bangladesh J. Sci. Ind. Res.* **45(2)**, 169-172.

Uchida, R. (2000). Essential nutrients for plant growth: Nutrient functions and deficiency symptoms. In J.A. Silva and R. Uchida (Eds), *Plant Nutrient Management in Hawaii's Soils, Approaches for Tropical and Subtropical Agriculture* (pp. 31–55). College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa.

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