Read the following extract and study the results of a scientific investigation provided below. Answer the questions that follow.

ALIEN CACTI INVADING FARMLAND

The spread of invasive alien cacti across South Africa has proved disastrous for wool, livestock and game farmers.

Cactus infestations threaten bio-diversity as they compete with and replace indigenous species and have a negative impact on farming. These invasive cacti reduce available land for grazing and thus lowers the carrying capacity. The thorns restrict movement of animals, become entangled in wool and cause injuries. All these factors combine to cause the drastic devaluation of wool, skins and agricultural land.

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A cactus branch covered in scale insects

Biological control agents, e.g. scale insects, have been used effectively against invasive species. These insects are imported from their indigenous habitat where they control populations of invasive alien plants. They are tested under quarantine (in isolation) before being released into the new habitat.

The prickly pear cactus (*Opuntia stricta*) is an invasive alien cactus in South Africa. Scientists performed an investigation to test the effectiveness of two different biological control agents, scale insects (*Dactylopius opuntiae*) and cactus moths (*Cactoblastis cactorum*), on controlling the growth of the prickly pear cactus.

Scale insects pierce the cactus to consume its juices while the cactus moth lays its eggs on the cactus; upon hatching the larvae bore into the cactus and consume the cactus.

Scientists performed the following procedure in two test areas (**A** and **B**) with prickly pear cactus populations:

- they released 100 scale insects into the test area **A**
- they released 100 cactus moths into the test area **B**
- both test areas were observed over a period of 12 years:
  - the biomass* of the prickly pear cactus populations was measured every two years
  - the number of each biological control agent was measured every two years

Note: biomass refers to the total quantity of living organisms in a given area

The results are shown in the table on the next page.

Time (years)	Test area A		Test area B	
	Biomass of prickly pear cactus population (mg/ha^{-1})	Numbers of scale insects	Biomass of prickly pear cactus population (mg/ha^{-1})	Numbers of cactus moths
0	16	100	18	100
2	14	90	16	80
4	10	180	16	90
6	8	340	15	80
8	5	580	17	95
10	4	620	16	100
12	2	220	18	120

1.1 Define an *invasive alien*. (2)

1.2 List any TWO negative impacts of invasive alien cactus infestations as mentioned in the extract. (2)

1.3 Explain ONE negative economic impact of cactus infestations on farming. (2)

1.4 Explain how invasive alien cacti could reduce food security. (2)

1.5 List TWO other methods of controlling invasive alien populations. (2)

1.6 Give ONE reason why a biological control agent would be tested under quarantine before it is released into a new environment. (1)

1.7 State the aim of the investigation. (2)

1.8 Identify the independent variable. (1)

1.9 Explain how the effectiveness of the biological control agents was determined. (2)

1.10 State any THREE factors that the scientists kept constant over the course of their investigation. (3)

1.11 State any ONE factor regarding the test areas **A** and **B** that should have been kept constant. (1)

1.12 Explain the importance of conducting the investigation over a period of 12 years and not 2 years. (3)

1.13 Calculate the percentage decrease in the prickly pear cactus population in test area **A** between the 2nd and 6th year. Show ALL calculations. (3)

1.14 Draw a line graph to compare the change in biomass of the prickly pear cacti in both test areas over the 12-year period. (8)

1.15 Which biological control agent was more successful in controlling the prickly pear cactus populations? (1)

1.16 Suggest a reason for the dramatic decrease in the number of scale insects between year 10 and 12. (2)

(37)

MEMORANDUM

1.1 a species that does not belong to an area✓ and which outcompetes the indigenous species✓ of that area (2)

1.2 - reduce/threaten/outcompete indigenous species/biodiversity✓
- reduce available land for grazing✓
- reduce carrying capacity of land
- cause injuries to livestock
- devaluation in wool/skins/land (*only first TWO will be marked*) (2)

1.3 - entangled thorns decreases market value of wool✓/ must be removed at great cost to the farmer / thorns damage skin
- farmer makes less profit✓ from selling wool/skins
OR
- farmer cannot keep as much livestock✓ due to reduced grazing land/carrying capacity
- less meat✓/skins to sell
OR
- agricultural land is less desirable✓ if infested with invasive species
- land value decreases✓ (*any 1* x 2) (2)

1.4 - less grazing land✓ for livestock / severe injuries to livestock
- fewer livestock✓ kept / more livestock die
- less meat✓/food produced/available / food prices increase (*any 1* x 2) (2)

1.5 - mechanical control✓
- chemical control✓ (*only first TWO will be marked*) (2)

1.6 - to ensure that it is effective against the invasive species✓
- to ensure that it does not become a pest species itself
- to ensure that it is suited to the new habitat conditions
- to give the biological control agent time to acclimatise
- to ensure that the biological control agent does not bring in unwanted diseases/pests/parasites
- to ensure that it does not endanger indigenous species/crops/people
(*only first ONE will be marked*) (1)

1.7 to test the effectiveness of **two different biological control agents** / scale insects (*D. opuntiae*) and cactus moths (*C. cactorum*) on controlling the **growth of the prickly pear cactus**✓✓ (2)

1.8 the two types of biological control agents✓ (1)

1.9 by measuring/observing the reduction✓ in biomass✓ of the prickly pear cactus populations✓ after 12 years (2)

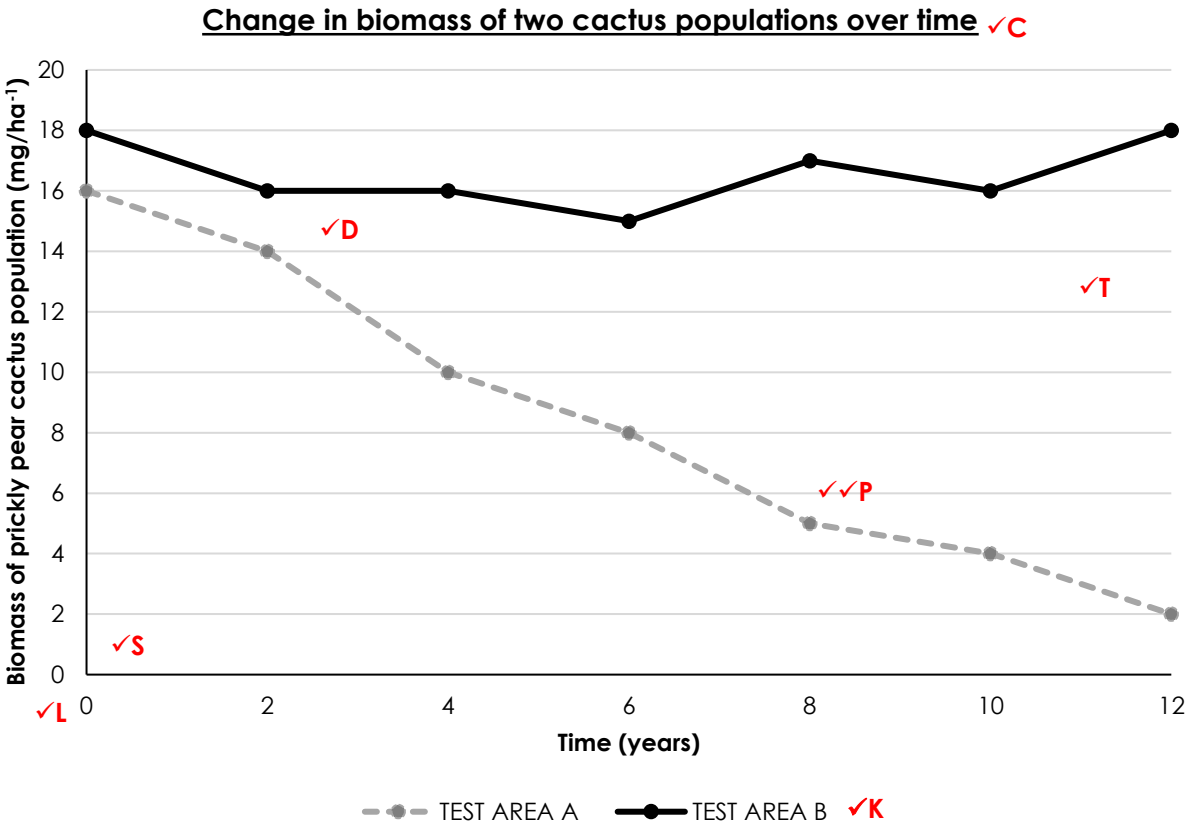
1.10 - the same species of cactus in both test areas✓
- the same number/100 of each biological control agent✓ released initially
- the same total time frame / 12 years✓
- the same interval for measurements / 2 years (*only first THREE will be marked*) (3)

1.11 - the same size/number of hectares✓
- the same weather conditions/climate
- biological control agents must be released at the same time in each test area
(*only first ONE will be marked*) (1)

1.12 - it increases the validity✓ of the investigation
- it prevents any short-term factors✓/weather/drought/fires
- from affecting the results✓ of the investigation (3)

1.13 $\left(\frac{8-14}{14}\right)$✓ x 100✓ = – 42,86%/– 43%✓/ decrease by 42,86/43% (3)

1.14



CRITERIA	ELABORATION	MARK
Correct type of graph **(T)**	Line graph drawn	1
Double line graph **(D)**	Two lines drawn on same set of axes	1
Key included **(K)**	Clear key to distinguish different line graphs	1
Caption of graph **(C)**	Both variables included	1
Axes labels **(L)**	Correct labels and units on x- and y-axis	1
Scale of x- and y-axis **(S)**	Equal spacing between intervals on each axis	1
Plotting of points **(P)**	1 to 8 points plotted correctly All points plotted correctly	1 2

(8)

1.15 scale insect / *D. opuntiae*✓ (1)

1.16 - the biomass of the cacti is very low✓ / few cacti remain
- very little food✓ left for the scale insect to consume (2)
(37)