# Investigation 2: The effect of sunlight on biomass
## Moderator comments

| Personal engagement x/2 | Exploration x/6 | Analysis x/6 | Evaluation x/6 | Communication x/4 | Total x/24 |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 2 | 2 | 10 |

## Personal engagement

| Mark | Descriptor |
|---|---|
| 1 | • The justification given for choosing the research question and/or the topic under investigation does not demonstrate **personal significance, interest or curiosity**. 0 <br> • There is little evidence of **personal input and initiative** in the designing, implementation or presentation of the investigation. 1 |
| **Moderator's award** 1 | **Moderator's comment** <br> There is little sign of personal engagement. Though there is some sign of initiative in designing the investigation it is minimal. |

## Exploration

| Mark | Descriptor |
|---|---|
| 1–2 | • The topic of the investigation is identified and a research question of some relevance is **stated but it is not focused**. 2 <br> • The background information provided for the investigation is **superficial** or of limited relevance and does not aid the understanding of the context of the investigation. 2 <br> • The report shows evidence of limited awareness of the significant **safety**, ethical or environmental issues that are **relevant to the methodology of the investigation**. 1 |
| 3–4 | • The methodology of the investigation is mainly appropriate to address the research question but has limitations since it takes into consideration only some of the significant factors that may influence the relevance, reliability and sufficiency of the collected data. |
| **Moderator's award** 2 | **Moderator's comment** <br> The research question is presented though it is not focused. The background presented is relevant but incomplete. There is a method presented that is concise and random sampling is used. There is no consideration of the environmental impact of the investigation and working in the sun could be a safety issue. |

## Analysis

| Mark | Descriptor |
|---|---|
| 1–2 | • The report includes **insufficient relevant** raw data to support a valid conclusion to the research question. 2 <br> • The processed data is incorrectly or insufficiently interpreted so that the conclusion is invalid or very incomplete. 2 |
| 3–4 | • Appropriate and sufficient data processing is carried out that could lead to a broadly valid conclusion but there are significant inaccuracies and inconsistencies in the processing. 3 <br> • The report shows evidence of some consideration of the impact of measurement uncertainty on the analysis. 3 |
| **Moderator's award** 3 | **Moderator's comment** <br> There is barely sufficient data to support a valid conclusion. Appropriate processing is carried out but it is hard to follow thus it is difficult to accept the interpretation. For example, it is not clear where the standard deviations used as error bars in the graph come from. The precision of the masses is hard to believe. The graphical analysis is appropriate. |

## Evaluation

| Mark | Descriptor |
|---|---|
| 1–2 | • Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are **outlined** but are restricted to an **account** of **the practical** or **procedural issues** faced. 1<br>• The student has **outlined** very few realistic and relevant suggestions for the improvement and extension of the investigation. 1 |
| 3–4 | • A conclusion is **described** which is relevant to the research question and supported by the data presented. 3<br>• A conclusion is described which makes some relevant comparison to the accepted scientific context. 3 |
| **Moderator's award** 2 | **Moderator's comment**<br>A conclusion is drawn that is relevant and, as far as can be judged, is supported by the data. There are a lot of other factors that have not been considered (or controlled), making it difficult to accept the conclusion. There is an attempt to set the conclusion in a scientific context. Some other factors that may have influenced the investigation are identified. These could have been controlled by more appropriate site selection. Some important factors were not considered (the only one mentioned is irrigation and there are no details). The improvements remain vague (bigger samples, longer drying time, more precise measuring methods). |

## Communication

| Mark | Descriptor |
|---|---|
| 1–2 | • The report is not well structured and is unclear: the necessary information on focus, process and outcomes is missing or is presented in an incoherent or disorganized way. 1<br>• The understanding of the focus, process and outcomes of the investigation is obscured by the presence of inappropriate or irrelevant information. 2<br>• There are many errors in the use of subject-specific terminology and conventions. 2 |
| **Moderator's award** 2 | **Moderator's comment**<br>The investigation is structured but it is mostly superficial and it is not clear in places; in particular, the processing is difficult to follow. Too many steps are missing. The data are displayed respecting the conventions but the terminology is poorly defined. |

# The effect of sunlight on biomass

## Introduction

Biomass is the weight of living organisms in a given area. Biomass can differ due to a variety of factors, such as exposure to sunlight, proximity to human activity, mineral nutrient levels and water availability. The first, sunlight exposure, will be the subject for this investigation.

Research Question: How does sun exposure affect above ground dry biomass of grass?

In this experiment, the independent variable is sun exposure and the dependent variable is dry biomass, measured in grams (g).

There are other variables that affect the biomass of grass, other than sun exposure. These include the amount of water each area of grass receives, proximity to footpaths and sidewalks, and the amount and mass of water in the grass. To control the last two variables, both areas sampled were the same distance from the main sidewalk and were left to dry before being measured.

## Materials

- 1 meter squared quadrat
- 10 centimeter squared quadrat
- 10 plastic resealable bags
- Scale

## Method

1. Two 1-meter$^2$ grass areas around the school campus were chosen; one exposed to the sun throughout the day and one under the shade of a tree throughout the day. Each meter squared area was 5 meters from the front sidewalk of the school, controlling the variable of proximity to sidewalks.
2. Once the areas were chosen, 1 meter$^2$ quadrat was placed in each area.
3. Each meter$^2$ was divided into 100 quadrats, each being 10cm x 10cm. Once it was divided into 100 quadrats, they were numbered 1-100, left to right, starting from the upper left corner.
4. Using a random number generator, 5 numbers were picked for each site (5 for the meter$^2$ in the sun and 5 for the meter$^2$ in the shade).
5. The numbers generated represented the numbered quadrats. Samples of grass were taken from the quadrat numbers that were randomly generated and placed resealable plastic bags. A standard for collecting the sample was established; the grass was pinched at the stem right above the ground, and then plucked, leaving the roots intact in the soil.
6. Once 5 samples were collected from each square meter, the grass was then left to dry for two days. Drying out the grass allows the dry biomass to be taken. This controls the variable of different amounts of water in the grass.
7. After two days of drying, the mass of each sample of grass was taken.
8. Once the masses were recorded, the t-test was performed to determine the average mass of grass in each area and to determine if the difference in masses were statistically significant, or due to chance.

Ex: Definition limited, here it should be referred to as above ground biomass. Limited scientific context. Research question not focused.

PE: Investigation remains trivial in content. Not much sign of engagement by the candidate.

Ex: Limited explanation of the method. How long? Where?

Comm: Method could be repeated though some details are missing.

Ex: No consideration of safety ethics or environmental impact

Ex: Sample area controlled

Ex: No details of the distance of the tree or what species it is?

Ex: Sampling shows some elements of control.

Ex: OK though cutting with scissors would probably be more consistent.

Ex: The sample size is limited and small. Insufficient data collected.

Ex: This is better than the fresh mass but it ought to have been specified that it is above ground biomass.

An: Appropriate method of analysis chosen.

## Results

1 meter

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
| 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
| 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
| 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |

1 meter (left axis label)

Figure 1: Diagram of 1 meter squared quadrat divided into 100 ten meter squared quadrats. Yellow highlighted quadrats represent location of sun samples and the blue highlighted quadrats represent the location of shade samples

| Additional Observations |
|---|
| • Grass in the shade was more patchy |
| • More dead grass in the sun exposed area |
| • Grass in the sun exposed area was wetter than the grass in the shade |
| • |

Table 3: Observations

| Sun Exposed | |
|---|---|
| Sample & Quadrat number | Mass |
| Sample 1 Quadrat 52 | 8.1 |
| Sample 2 Quadrat 41 | 9.6 |
| Sample 3 Quadrat 74 | 11. |
| Sample 4 Quadrat 5 | 7.7687 |
| Sample 5 Quadrat 34 | 10.2805 |
| Average Mass | 9.5628 |

Table 1: Biomass of grass in the sun

| Shade Area | |
|---|---|
| Sample & Quadrat number | Mass/g ± 0.0001 |
| Sample 1 Quadrat 100 | 8.6943 |
| Sample 2 Quadrat 21 | 3.2373 |
| Sample 3 Quadrat 80 | 5.9215 |
| Sample 4 Quadrat 96 | 9.3583 |
| Sample 5 Quadrat 2 | 5.7696 |
| Average Mass | 6.5962 |

Table 2: Biomass of grass in the shade

An: Insufficient data to support the conclusion fully.

An: Difficult to believe a precision of ±0.mg!

An: Appropriate analysis (averages).

Comm Layout could be improved but not incomprehensible

Comm Notation OK

Comm Conventions OK

An: Qualitative observations made but what about the influence of the tree?

**Average Biomass of Grass**

Statistical analysis

P value: 0.058
P> 0.050
Accept null hypothesis
(difference is due to chance and is
not statistically significant)
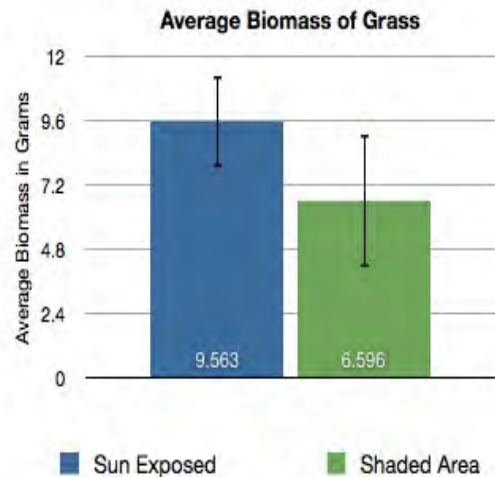
Figure 2: Average biomass of grass in sun and
shaded areas. The error bars represent ± 1
standard deviation

Comm: Graph fairly clear

An: Uncertainties (error bars)
drawn well and explained.

Comm: Conventions appropriate

This is not easy to follow. Is it a t-
test?

An: Methods of analysis seem
appropriate but they are difficult to
confirm because too many
processing steps are missing.

Ev: Uncertainties calculated as
Standard deviations (shown on the
graph) but that's all.

An: Interpretation weakened by
poor presentation of the analysis.

**Conclusion**

The data supports the null hypothesis that there is no difference in biomass of grass
in the sun and in the shade.
A possible explanation is as follows. Grass is a primary producer of biomass because
it can fix inorganic matter (carbon dioxide). Biomass is therefore an indirect
measure of productivity of an area.  Grass in the sun receives more sunlight to use
for photosynthesis. During photosynthesis, light energy is converted into chemical
energy. When there is more light, more light energy is absorbed and used for the
production of more chemical energy. Productivity can then said to be greater in the
area with a greater biomass. In this experiment, the results did not show a
statistically significant difference in biomass. Even though the average biomass of
the grass in the sun was greater than that of the shaded area (table 1 and 2) , it was
not significant. This could be due to the role of other variables, such as amount of
water and limited sample size.

**Comment [PB18]:**
Ev:  conclusion set in  scientific
context

**Comment [PB19]:**
Ev:  Relevant conclusion but difficult
to support from the limited data

**Comment [PB20]:**
Ev:  Consideration of uncertainties is
too vague.

## Limitations

There are other variables that may have affected the biomass of the grass in each area. The amount of water each area receives could not be controlled. Quite often, there are sprinkles watering the grass. The amount of water each area receives can affect the rate of photosynthesis, which will affect grass growth. If the grass in either area received more water, the results could be an over estimation. In my procedure, the sample size was sufficient, however not large enough to show significant results. The data in the shaded area was mare variable than the data in the sun exposed area (Figure 2). The variation could possibly be decreased if the sample sized was increased. Additionally, the 10cm² quadrats were sometimes difficult to determine and measure precisely. The shade sampling area was near a recreational area, where a cement 4-square court is built. The shade area may experience more direct human contact and trampling, resulting in less grass. The grass was patchier. This could result in an under estimation of the biomass of the grass in the shade. Also, due the warm tropical climate and frequent sun, the shade area may be used more than the sun-exposed area for shade to avoid sun exposure.

## Modifications

To be more precise with measurements, I would construct a meter-squared quadrat that is pre-divided into 100 ten centimeter squared quadrats. This would allow much more uniform precision, decreasing human error. When biomass was taken, some grass samples were still moist, and did not dry fully. In order to ensure that water mass was not a factor affecting grass biomass, the grass would have been left longer to dry, if time permitted.
An experiment that controls the amount of water each area receives, as well as human contact, with more precise measuring methods would be ideal and more accurate in determining if there is a difference in biomass of grass in the sun and the shade.

Ev: Not clear. Was the sample size big enough or not? Clearly the evidence suggests that it was not.

Ev: Ought to refer to standard deviations

Ev: Identifies a number of factors that may also influence the outcome.

Ev: The modifications do not concern most of the weaknesses identified.

Ev: Did not consider the impact of management other than irrigation.

Ev: Or use an oven and repeat the measurement of mass until it is constant.

Ev: Too vague. Lacks concrete suggested improvements e.g. put a fence around the areas to keep out humans.