Example Biology Higher Level Internal Assessment

This IA had a significant amount of background information, however it is important to remember that this is **not** necessary to receive full marks. This IA is not perfect and should not be used as a formula for increasing your marks.

Will increasing the salinity of the substrate adversely affect the rate of broad bean seed germination?

Background Research

Before a seed germinates, it goes through a resting period, or dormancy. The germination of the seed is when the embryo resumes growth, bursting through its encasing (The Seed Biology Place 2009). This coat acts to protect the internal embryo from the elements, parasites and mechanical injury while it is still dormant (Washington State University 1999). Germination can only take place under particular circumstances, involving suitable temperature, oxygen supply, water and sunlight (RCN 2004). The time it takes for a seed to germinate varies between species, although this can be sped up by forcing germination through various methods. Germination begins once the seed is exposed to moisture, but the embryo will die if it withdrawn (Moore 1982).

Dormancy is caused by a number of factors, including incomplete seed development, the presence of a growth regulator, an impervious seed coat, or a requirement for pre-chilling. All these things would be typically overcome in the seed's natural environment. Thus, it is important to maintain water, oxygen and temperature and optimum levels for germination (Clegg 2007).

Temperature is important, as it often affects the presence of germination inhibitors (RCN 2004). When the temperature in not ideal, these chemicals continue to prevent the continuation of growth of the embryo, to ensure that the seed germinates under favourable conditions for continued growth and metabolism. The favoured temperature for germination varies greatly between plant species, depending on their environment. Temperature fluctuation as found in nature can also be a factor (RTBG 2009).

If there is insufficient supply of oxygen, germination may not take place (Aggie Horticulture 2009). Oxygen is a requirement for respiration, meaning that a lack thereof will cause the plant to die soon after germination. Not all plant species require oxygen for the initial germination; however all show a need afterwards (RTBG 2009).

Before the embryo leaves its casing, there is a large uptake of water, causing the embryo to expand and consequently burst through its casing (Washington State University 1999). The metabolism of the plant is vigorous when it first emerges, requiring a plentiful supply of water to support this (RCN 2004). Sometimes, it can also act to remove the germination inhibitor, allowing for germination to take place (ABC 2006). In all these respects, water is essential for the germination of seeds.

Light is also a factor for some plants, as plants require it for photosynthesis to occur. When buried too deeply, the plants dies soon after germination when it runs out of food supply, which it could not replenish (Aggie Horticulture 2009). It is not always a requirement for germination itself, but some seeds are sensitive to its availability (RTBG 2009).

All these factors are necessary, as they aid the seed to germinate when conditions are the most favourable for its long term growth and survival (ABC 2009). When all these things are

present at the right level, germination will occur. Germination is generally agreed to be the point at which the embryo pushes out of the seed encasing (RTBG 2009). From there, the plant will continue to develop and grow according to its species, producing food through photosynthesis.

Mineral nutrients are crucial for the growth and development of all plants. Legumes, such as broad beans are very efficient nitrogen fixers, adding nutrients to the soil (Moore 1982).

Plants have a tolerance level for the salinity of their substrate, within which they will germinate. Soil and water both have small concentrations of salt naturally present, which plants have developed to tolerate (ABC 2006). Farming in many areas with non-native plants which have shallow roots have raised groundwater, causing salt to rise to the surface.

Broad beans, *Vicia faba*, have been cultivated in Europe for over 4000 years (Blazey 1999). They are frost-hardy annuals, hence they tend to be grown in autumn and winter. Since they are adapted to survive heavy frost, they will usually be sown in autumn for flowering before temperatures rise above 20°C (Blazey 1999). For the Australian climate, this is best done from March to May, as they have a germinating temperature of 5-20°C (Moore 1982).

Question

Will increasing the salinity of the substrate adversely affect the rate of broad bean seed germination?

Variables

Table 1.0 – Table to show independent and dependent variables in the experiment

Independent Variable	Salinity of Soil****. Five trials will be done with the following concentrations of solution:** 1. **0.00%** 2. **0.25%** 3. **0.50%** 4. **0.75%** 5. **1.00%**
Dependent Variable	Number of days for seeds to germinate.

**Concentrations of salt do not include any naturally occurring salt in the substrate or water

Controls

<u>*Amount of Water*</u> – All the seeds will be given 100mL of water at planting, and then were not given any more. They will all be receiving the same amount of water. Water is retained by laying clear plastic wrap over the containers to prevent water evaporating off.

<u>*Salt*</u> – '*Saxa*' iodised table salt (Manufactured by '*Cheetham Salt Ltd*' for '*Salpak Pty Ltd*') will be used in all soils that are being treated with salt.

<u>*Seeds*</u> – '*Yates*' broad bean *Vicia faba* seeds will be used throughout the entire experiment.

<u>*Water*</u> – The water used on the seeds will be sourced from the same tap for the entire experiment. This is to reduce any variation in levels of chlorine and other substances, which may affect them. The water will also be of the same temperature as it will be collected from the same source.

<u>*Sunlight*</u> – All the seeds will receive the same amount of exposure to sunlight. They will remain in the same area at all times, meaning that there will be no variation between groups. The amount they receive cannot be measured, but as it is constant, it will not be a factor in any difference between the results of each test.

<u>*Temperature*</u> – The temperature of the seeds' environment will be controlled by keeping the seeds in the same area. This will mean that there is no variation in temperature between them. This in turn will keep the temperature of the water constant.

Substrate – The soil used for the experiment was the same for all the trials. All other substrates, such as soil, would naturally have a low salt concentration, altering the concentration the seeds would be exposed to.

Materials

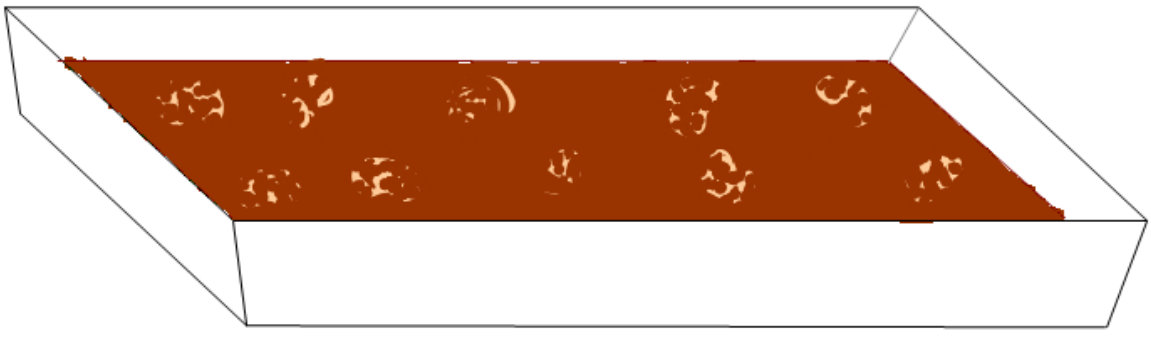
- 50 x broad bean *Vicia faba* seeds
- 5 x take-away containers – 11x16cm
- 5 litres tap water
- *Saxa* iodised table salt
- *Pyrex* 1 litre measuring jug
- *Pyrex* 500mL measuring jug
- Electronic balance
- Black permanent marker pen
- Metal stirring rod
- Clear plastic *Home Brand* cling wrap
- *Yates GroPlus* Multi Purpose Potting Mix

Table 1.1 – Table to show the uncertainty for the equipment used in the experiment

Equipment	**Uncertainty**
Pyrex 1 litre measuring jug	±25mL
Pyrex 500mL measuring jug	±10mL
Electronic balance	±0.01g

Setting Up

Figure 1.2 – Figure to show setting up for experiment with seeds in plastic container, partially covered by substrate. See Appendix A for photograph.



Method

1. The side of each take-away container was marked with the number 1 to 5 with the marker pen, to indicate which concentration it contained.
2. Each container was filled with potting mix to a depth of 2cm.
3. Ten broad bean seeds were placed in each container, pressed into the soil so that they were partially covered by the potting mix.
4. Washed 1 litre measuring jug then filled with 1 litre tap water, taking care that no parallax error was made in reading.
5. For the first solution, no salt was added, so 100mL of the water was measured in the 500mL measuring jug, then poured over the substrate in container marked 1.
6. Washed the measuring jug, and then filled with 1 litre of tap water from the same source. Exactly 2.60g salt was measured on the electronic balance and added to the water to make a concentration of 0.25%, and then stirred with the rod until the salt dissolved.
7. 100mL of the salt solution was measured into the 500mL measuring jug, then poured over the substrate in container 2.
8. This procedure was repeated 3 more times, washing the measuring jug to remove and residual salt. 5.00g, 7.60g and 10.20g of salt were added in turn for concentrations of 0.50%, 0.75% and 1.00% respectively.
9. Once all the samples had been watered, they were placed in an outdoor area. During the day, they received direct sunlight. They were not exposed to any additional artificial light.
10. Clear plastic film was placed over the containers to prevent water evaporating. Air flow was still allowed.
11. The samples were examined daily to see if any of the seeds had germinated. This was indicated by the rupture of the encasing and a visible plant root. The total number of germinated seeds was recorded each day for 10 days.

Results

Table 2.0 – Table to record the cumulative number of seeds germinated for each day of the trial. See appendix 1 for original recordings

Day		1	2	3	4	5	6	7	8	9	10
Total Number of Seeds Germinated	Sample 1 0.00%	0	0	0	5	8	9	9	10	10	10
	Sample 2 0.25%	0	0	0	6	9	10	10	10	10	10
	Sample 3 0.50%	0	0	0	6	8	9	9	9	9	9
	Sample 4 0.75%	0	0	0	1	6	7	7	7	7	7
	Sample 5 1.00%	0	0	0	0	2	2	2	2	3	5

Observations

Evaporated water formed droplets on the plastic film. For the first few days, there was no visible change in the seeds. After day four, many of the seeds began to germinate, with the tip of the root becoming visible. In sample 3, concentration 0.50%, one of the seeds split open and did not germinate. The reason for this is unclear, as the seed coat was not damaged before planting.

After germination, the broad beans plant continued to grow. The roots were not able to grow down because the substrate was too shallow, so they remained visible. The substrate remained quite moist due to the presence of the plastic film.

Processed Data

Table 3.0 – Table to show the number of seeds that germinated each day

Day	1	2	3	4	5	6	7	8	9	10
0.00%	0	0	0	5	3	1	0	1	0	0
0.25%	0	0	0	6	3	1	0	0	0	0
0.50%	0	0	0	6	2	1	0	0	0	0
0.75%	0	0	0	1	5	1	0	0	0	0
1.00%	0	0	0	0	2	0	0	0	1	2

Table 3.1 – Table to show the percentage of seeds that germinated, the average number of days the seeds took to germinate and the standard deviation

Group	Percent Germinated	Average Days to Germinate	Standard Deviation
0.00% salt	100%	4.90	1.22
0.25% salt	100%	4.50	0.71
0.50% salt	90%	4.44	0.73
0.75% salt	70%	5.00	0.58
1.00% salt	50%	7.80	2.59

Figure 3.2 – Example calculation of the average and standard deviation

f	***x***	***f(x)***
1	0	0
2	0	0
3	0	0
4	5	20
5	3	15
6	1	6
7	0	0
8	1	8
9	0	0
10	0	0
	Sum	49
	n	10
	Mean	4.9

Where *f = number of days to germinate* **and** *x = number of seeds which took that amount of time*

Since:

$$\bar{x} = \frac{\sum x}{n}$$

Each *x* value was multiplied by *f*

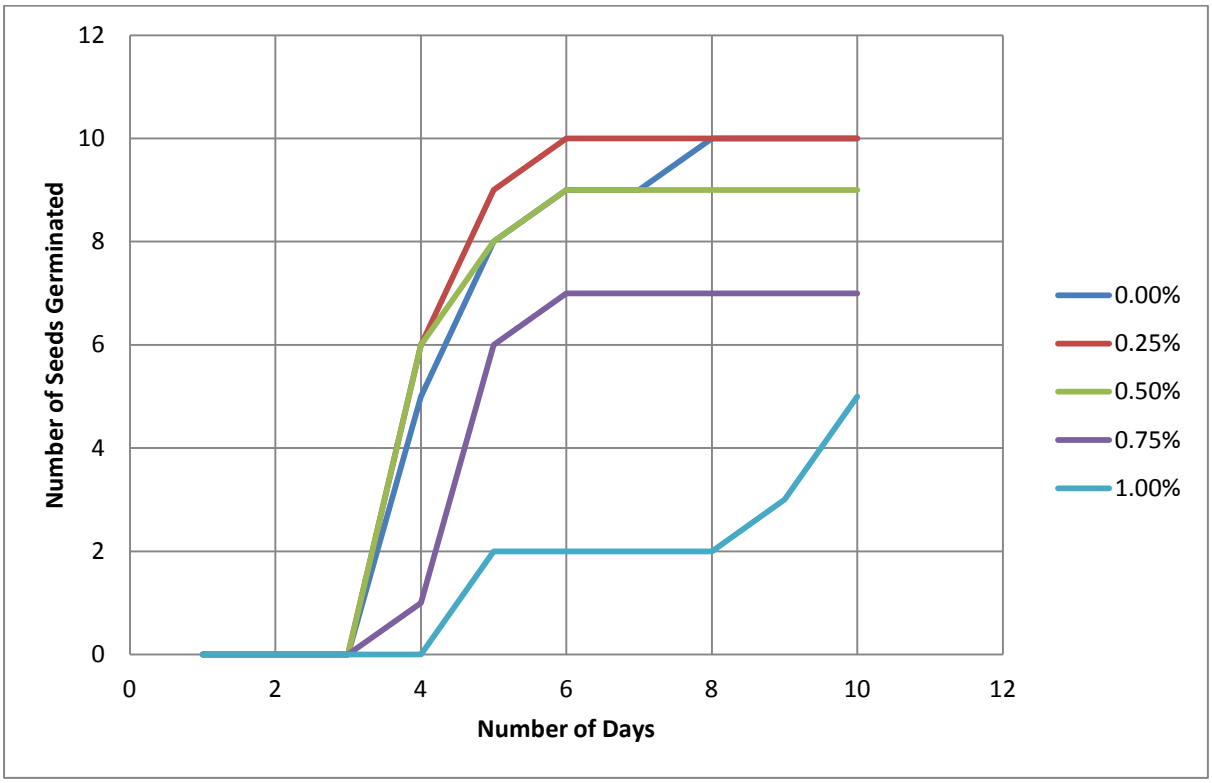
This is because *x* number of seeds took *f* days to germinate

x	$\bar{x}$	$(x - \bar{x})$	$(x - \bar{x})^2$
4	4.9	-0.9	0.81
4		-0.9	0.81
4		-0.9	0.81
4		-0.9	0.81
4		-0.9	0.81
5		0.1	0.01
5		0.1	0.01
5		0.1	0.01
6		1.1	1.21
8		3.1	9.61
		$\sum(x - \bar{x})^2$	14.9

$$SD = \sqrt{\frac{\sum(x - \bar{x})^2}{n}}$$

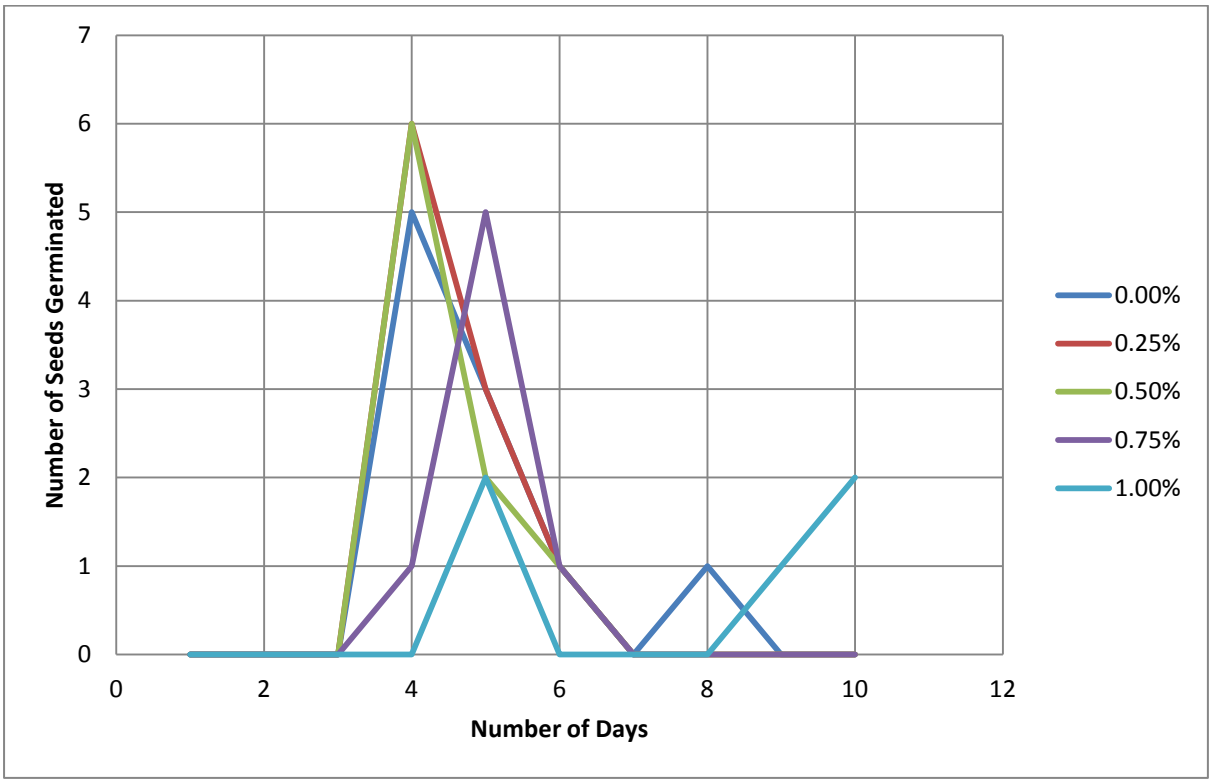
$$= \sqrt{\frac{14.9}{10}} = \sqrt{1.49} = 1.22$$

Graph 3.3 – Graph to show cumulative number of germinated broad bean seeds, as shown in table 2.0



The graph above makes is fairly clear which salt concentrations best promoted germination. The seeds with 1.00% salt were clearly the slowest to germinate. The ones with the 0.75% salt solution were also much slower to germinate. The other three concentrations (0.50%, 0.25% and 0.00%) remained fairly close together, having similar germination rates. However, the seeds with the 0.25% salt solution germinated the fastest, with the 0.00% ones following close behind. With the split seed among the 0.50% seeds, it is uncertain whether all of these seeds would have germinated if this one had been healthy.

Graph 3.4 – Graph to show the number of seeds that germinated on each day, as seen in table 3.0



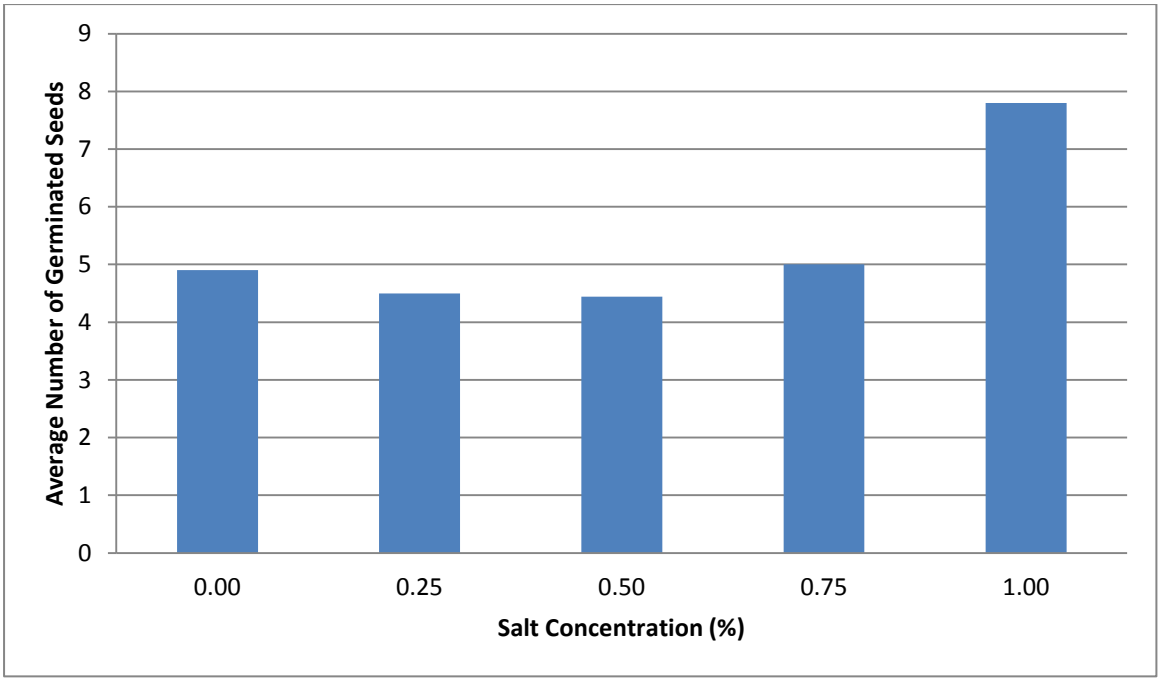
These figures demonstrate that 0.25% and 0.50% both spiked to six germinations on the fourth, and had all of their seeds germinated by the sixth day [excluding the split one in the 0.50% group]. This rapid germination again suggests that these concentrations provide better conditions for the germination of the germination of the broad bean seeds. Out of the two, however, 0.25% had the greatest number of germinations, and they occurred faster, with 3 germinations on the fifth day, compared to 2 from the 0.50% group.

The 0.00% group also had the highest spike on the fourth day, however it was of a smaller magnitude. This group only had 5 germinations, gradually reaching 10 germinations after eight days. While the rate of germination was comparable to the 0.20% and 0.50% groups, it took much longer for all the germinations to happen.

The group planted with the 0.75% salt solution spiked on the fifth day with five germinations. Considering that only seven of the seeds in this group actually germinated, it suggests that these conditions are not as ideal for germination. While germination still occurred, it took longer, and the success rate was not as high.

The 1.00% group were the least successful, with a small spike of two germinations after five days, eventually having 5 germinations after the tenth day. The rate of germination was significantly slower than any of the other groups.

Graph 3.5 – Graph to compare the average number of days it took for the seeds to germinate in the different substrate concentrations.



The trend in this graph clearly shows that the lower salt concentrations in the substrate promoted an earlier germination. However, although 0.50% concentration had the lowest average, it is important to bear in mind that not all of these seeds germinated.

Conclusion

In conclusion, the results of this experiment indicate that the optimum concentration of salt in the substrate to promote germination of broad bean seeds is 0.25%. While all the lower concentrations had good average germination times, 0.25% had 100% germination of its seeds, and had a lower standard deviation that 0.00%. This shows that the seeds all germinated within a very close time period, and suggests that this data is more reliable. Also, in graph 3.3, it can be seen that 0.25% was the first group to have all of ots seeds germinated on day six.

On the other hand, 1.00% yielded very poor results, with only 50% of the seeds germinating and an average germination time of 7.8 days. This shows that the higher salt concentration prevented germination of the seeds.

These results support the hypothesis, showing that a higher salt concentration did in fact adversely affect the rate of germination, based both on how long the seeds took to germinate, and the percentage of seeds which actually germinated. Having a small concentration of salt in the substrate causes faster germination than a zero one, but increasing the concentration further inhibits growth.

The results are further supported by research done by James J. Camberato, Ph.D., S. Bruce Martin and Amy V. Turner in their study of the effect of higher salinity on Rough Bluegrass, *Poa trivialis*. Their results showed that higher salinity slows the rate of germination (Camberato 2000).

Therefore, increasing the salinity of the substrate does have a negative effect on broad bean germination.

Evaluation

Weakness	Significance	Improvements
Uncertainty on Measuring Equipment	Referring back to table 1.1, it can be seen that some of the measuring equipment had a very high uncertainty. While this may not have had a significant effect on the experiment, it could have slightly altered the actual concentration of each solution.	Use more precise equipment which has a smaller error value, especially for the measuring jug. The smallest unit of measurement should be smaller than on the one used here.
Trapping Water	Although a clear plastic film was placed over the seeds to prevent the water from evaporating off, a better system could be used to further stop this. This would maintain the original volume of water and sustain the same water levels for the whole experiment, thus keeping the concentration the same.	Seal off the containers completely with a clear lid or similar device to prevent any water evaporating. This is to maintain a consistent concentration in the soil.
Number of Repeats	Given more time, it could be possible to repeat the experiment in order to collect more data. Only one trial was done here, and an additional one may have allowed for more accurate data.	Perform an additional trial to collect more data. This would confirm the trends and verify the conclusions drawn from this.
Manipulation of Other Variables	Variables including exposure to sunlight, wind and temperature were not controlled, but the seeds were simply exposed to the same conditions throughout the experiment.	Directly control these variables by using artificial light for a set time period, and placing under controlled temperature conditions, it order to prevent major fluctuations in these variables.

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