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CREATE CHANGE

Design your own sunflower experiment

Sunflower experiments

In addition to growing sunflowers for the competition, you may want to design your own sunflower based experiment. Sunflowers are a good choice for experiments as they are easy to germinate, grow and maintain.

Designing your own an experiment is an excellent way of learning to select appropriate investigation types and data collection. You can make them as simple or as complex as you desire. Even if you only want to grow plants for the competition without any experimental interventions, you can still track the development of your plants via the observations listed below.

An ideal experiment involves an “experimental intervention”. You should include a control group (perhaps the plants you submit for the competition) and another group where you modify a variable and take observations. Below are a list of experimental variables you can play with and a list of things you can observe and what they represent in the plant. But before that, you need to actually design your experiment.

When designing an experiment with your sunflowers (or other plants) you should attempt to follow the same general outline:

1. Decide on an aim
2. Pick one (or more) experimental variables
3. Decide on your observations
4. Assess risk and ethics
5. Set up your experiment
6. Run your experiment
7. Collect data
8. Analyse data
9. Arrive at a conclusion
10. Communicate

Decide on an aim

You need to decide (in advance) what you are going to study and WHY you are studying it.

For example, if you are studying salinity: why did you choose it? What effects do you expect to see in the plant? What relevance does this have to plants in the "real world"? You should spend some time thinking about the aim. A good aim is the foundation to a good experiment. If you have learnt about hypothesis generation, you should determine some hypotheses at this point.

Experimental Variables

If you are growing plants for the competition, you can declare those plants your control group and add extra plants as your experimental group. Many of these variables are quantitative.

Variables	
Substrate	Grow plants in differing substrates, e.g. soil, vermiculite, sand, perlite, potting mix, compost, organic matter, and pine bark. Or find different soil types and plant them in the ground.
Fertiliser	Compare effects of fertiliser. Liquid fertiliser vs solid fertiliser. Foliar application versus broadcast or incorporation. You can compare broad spectrum fertilisers or isolate individual nutrients (e.g. nitrogen, potassium, phosphorus).
Light	Grow plants under differing light conditions, e.g. shade versus non-shade. Grow plants under different light regimes, e.g. 24-hour artificial light exposure.
Water	Compare differing water regimes, e.g. drought versus replete versus waterlogged. Use different water sources e.g. grey water versus tank water.
Salinity	Grow plants in different levels of saline soil/substrate.
Heavy metal contamination	Grow plants in substrate amended with heavy metals. Copper and aluminium are common examples. Be careful though, many heavy metals are toxic to people as well as plants.
Pathogens	An experiment with pathogens is challenging. A simpler method is to "imitate" pathogen injury. For example, you can stab holes through a leaf with pins to simulate fungal damage. You can then observe the reaction of the plant (see next entry).
Herbivory	Like pathogens, controlled herbivory damage is difficult unless you have access to a controlled environment. Like above, you simulate insect herbivory by trimming or cutting the leaves.
Plant structure & architecture	Wound plant meristem tissue to induce branching. This is a fairly complex topic involving plant hormone signalling and regulation. If you are interested, you should research "apical meristem" and "axillary budding".
Wind	Subject plants to varying windy conditions or physical stress. This can be as simple as setting up a desk fan next to the plants and running it for a few hours a day.
Weather	While not exactly an intervention, if you are growing your plants outdoors, you can always match variables and observations to the local weather conditions. You can measure them yourselves, or alternatively the Australian Government Bureau of Meteorology website (bom.gov.au) has spreadsheets of analysable weather data you can export.

Observations

At this stage, it is important to ensure you are going to collect reliable data. Think very carefully about which observations you choose and why they might be relevant. Avoid picking everything as more data does not equal better data.

Substrate

Analyse the substrate in which the plant is growing.

Variable	Representative of	Best way to measure
Electrical conductivity	Nutrient content, soil structure, water potential, salinity	You will need an EC probe.
pH	Soil quality, nutrient availability	A pH meter or pH strips.
Soil texture	Type of soil/substrate present	If you are growing in soil, you may want to consider the texture and classification of the soil. More information available here: soilquality.org.au/factsheets/soil-texture

Plant physiology

Observation	Representative of	Best way to measure
Height	Plant growth	A ruler or tape measure. You will need to decide before you start what constitutes the "top" of the plant.
Stem circumference	Plant growth	Wrap a piece of string around the stem then lay on a ruler to measure. Ensure you always measure the same spot on the stem.
Number of leaves	Plant growth	Count them. You will need to decide what constitutes "a leaf".
Number of branches	Plant growth	Count them. You may wish to divide them into primary and secondary branches. Also consider the angle of branching (relative to the stem, or primary branch).
Number of flowers	Plant reproductive success	Count them. Same issue as leaves. Do you only count fully emerged flowers?
Bud/flower emergence time	Plant reproductive success	Count days from planting (seed) to emergence of bud or flower.
Yield	Plant reproductive success	There are several ways you could approach yield: • Count individual number of seeds. • Weigh total seeds.
Weight	Plant vigour	You can weigh individual parts of the plant, but in most cases it is easier to cut the stem from the root ball and weigh each separately. Wet weight – Wipe down the stem with paper towels to remove any excess moisture. Rinse the root ball to remove any dirt or growth medium (avoid damaging the roots, although you will lose a few). Dry as well as you can and weigh. This gives you the weight of plant tissue plus the weight of water contained within. Dry Weight – Dry the tissue until no moisture remains. If you have a drying oven this is straightforward. IF you do not, you can dry them in the sun.
Water content	Plant vigour Environmental conditions	If you have measured dry weight and wet weight, simply subtract dry from wet to give you the water content.
Root architecture	Environmental conditions Plant vigour (sometimes)	Root structure can be just as complex as the shoots and leaves. Root number and architecture will change depending on a wide variety of environmental conditions.

Plant anatomy

Refers to the microstructure of the plant. In most cases, looking at plant microstructure and anatomy will require a microscope.

Observation	Representative of	Best way to measure
Stomata	Plant vigor Environmental conditions	Stomatal density. If you have a dissecting microscopy, you can sometimes observe stomata. You can also try a nail-polish slide. Example procedure (biologycorner.com/worksheets/stomata.html)
Leaf anatomy	Plant vigor Environmental conditions	Taking a cross section of a leaf will reveal some of the inner structures of the plant, like chloroplasts and the vascular system. These can both change depending on environmental conditions and the overall health of the plant.
Root anatomy	Plant vigor Environmental conditions	As above, but root cross sections are more difficult than leaf sections.

Assess risk and ethics

Before starting any experiment you need to do a risk assessment and think of any ethical considerations. Risk assessments are important to ensure your safety whilst doing your experiments, this may include risks of lifting large potted plants, touching potting mixtures and getting sunburnt potting plants/taking measurements. Working with plants does not involve the same level of ethical consideration as animals, but that does not mean you should not consider the broader ethical implications. For example, would society view your experiment as ethical?

Setup experiment

All you need to run a plant experiment is some soil, seeds and water. Everything else is a bonus. If you have a glasshouse, that is an ideal place to grow your plants however they will grow happily outside if you provide sufficient water. If not, think carefully about where you are going to put your plants. Will they get enough sunlight throughout the day? Will any buildings be in the way? Are they sheltered from wind and other weather? Have you included replicates in your experiment?

Run experiment

If you have planned everything correctly, running your experiment should be the easiest part. That said, you should always plan for contingencies. Plants are living organisms doing their own thing. Sometimes they will not cooperate with your experiment. That is normal: part of becoming a biological scientist is coping with that uncertainty. Just remember to check your plants as frequently as possible. Once a day is ideal.

Collect Data

Selecting appropriate equipment to allow the recording of systematic, accurate data is important. All tools will introduce some form of error: as long as you plan for it, account for it and note it in your methodology it will not negatively affect your results. Also: always report errors! Always. Even if it was a simple mistake. In science, all data is worthwhile.

Analyse your data

There are many ways of analysing data, and it will depend on what variables you observed and how you collected the data. Usually, the simplest thing you can do is visualise: draw a graph. This will allow you to see trends in the data. If you are at an advanced level, you may consider doing statistical analyses such as regression, ANOVAs, t-tests etc. Robust statistical design and analysis is beyond the scope of this guide, but remember: good analysis should be planned BEFORE an experiment begins and not after. Also beware of multiple comparisons and pseudo replication!

Conclusion

With any conclusion you reach, you should consider it critically. Does this make sense? Does it match up with primary and secondary sources in the published literature and your class textbooks? Are there any other alternative explanations? You should avoid the phrase "more research is needed": more research is ALWAYS needed! Instead, consider ways that you could improve or expand on the experiment.

Communicate

The most important part of doing an experiment is communicating your results to the wider scientific community in a logical and easily understood fashion. In most cases this involves writing a report, but consider the other ways you could communicate your results: posters, diagrams, social media, conferences etc.

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