Which colour of light is best for growing plants?

Lesson overview:

In this lesson, children investigate growing pea plants using different colours of light. It is a good investigation for them to practise identifying variables and manipulating or controlling them.

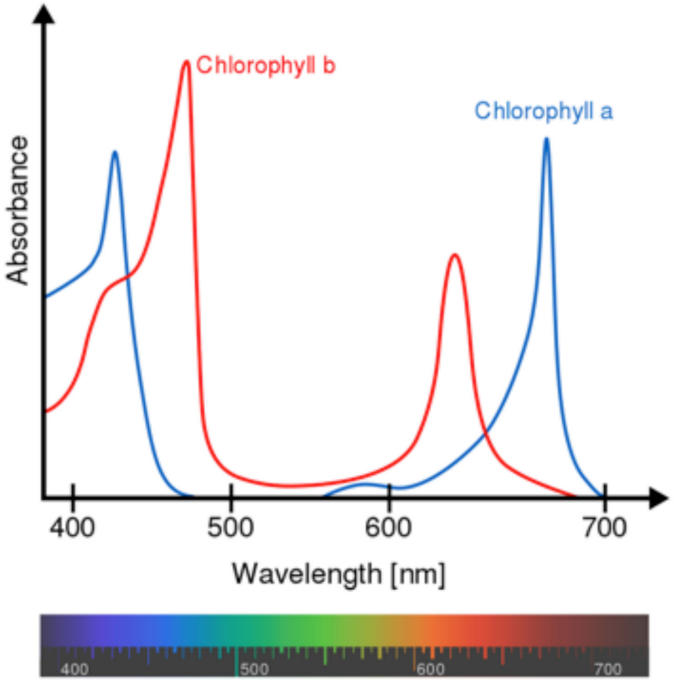
The context for the investigation is helping farmers to grow crops in greenhouses all year round. Increasing crop production is vitally important as the world population increases. Food production in greenhouses contribute to improved food security in the UK and the rest of the world. Typically, the inside of a greenhouse will be several degrees warmer than outside which extends the growing season for plants. However, during the winter months, days are short, and the light intensity is much lower than spring, summer or autumn. Artificial light boosts low natural light intensity and extends the length of growing day.

The PowerPoint presentation suggests a basic method for investigating the effectiveness of different colours of light on pea plant growth. There are slightly different ways in which the investigation can be carried out. For example, instead of using different coloured filters, coloured LED lamps could be used. Ideally, the light intensity in each box should be controlled although in practice, this can be difficult to achieve. One possible method is to change the area of the filter by masking, to limit the amount of light that enters the box. An alternative is to change the intensity of the lamp although in practice, this may be harder to achieve.

Please be aware of the following information without disclosing it to children:

- Red, green and blue (primary) light filters tend to absorb more light than cyan, magenta and yellow (secondary) light filters. This leads to lower light intensity transmitted by primary than secondary light filters.
- Secondary filters tend to absorb one primary light colour, rather than transmit a single colour of colour. For example, a yellow filter will absorb blue light but transmit all other colours of the spectrum including yellow.
- Filters are not perfect; a blue filter is unlikely to absorb all blue light and is likely to filter out some green and violet light.
- The most important colour of light for plants is generally considered to be blue which is readily absorbed by chlorophyll for photosynthesis. However, red light also seems to be important but only in combination with blue light. It appears to contribute to flower development and may lead to stronger growth. Although green and yellow are the least important colours for photosynthesis, a little green and yellow light seems to be important for processes other than photosynthesis.

- The sketch graph below shows the absorption spectrum of chlorophyll a and the chlorophyll b pigments. All photosynthetic plants contain chlorophyll a, and many also contain chlorophyll b.



Reference: https://en.wikipedia.org/wiki/Chlorophyll
Picture credit: Daniele Pugliesi reproduced under CC BY-SA 3.0

Equipment needed:

- Pea seeds (preferably pre-soaked and starting to germinate)
- Potting compost
- Seed trays, plant pots or cream pots
- Several similar boxes with removeable lids e.g. photocopier-paper boxes
- Different coloured filters (red, green, blue, yellow, cyan magenta and colourless are suggested) or different coloured LED bulbs
- Measuring cylinders / beakers
- 30 cm rulers
- Balance (to 0.1 g or 0.01 g precision)

Safety information:

Standard safety procedures should be followed. Spills should be cleared up immediately and children should wash their hands after handing compost. Lamps will become hot and children should take care to avoid burns. Water should be kept away from sources of electricity.

Presentation guidance:

Slide 2:	Explain that the global population is rising quickly and so the need to increase global food production is essential. Explain there are many places in the world where land is not currently used for agriculture because temperatures are low or there is poor light. Greenhouses offer a good solution for extending the growing season by providing plants with a warmer environment, sheltered from the wind and with better light from artificial sources. Artificial lighting may also extend the length of the growing day to 24 hours. Ask children for their ideas about the most important colour(s) of light are for growing plants. A common misconception is that green light is the most important colour for plants because leaves are green. In fact, green light is the least important colour – leaves are green because they reflect green light rather than absorbing it. Avoid giving children answers at this stage.
Slide 3:	Set the context for the investigation. Explain that UK farmers need advice and guidance about the best colour of light for growing plants in their greenhouses.
Slide 4:	Explain the basic experimental set up using this slide.
Slide 5:	Help children to identify the independent and dependent variables in the investigation. They should identify the colour of light / filter as the independent variable and the height / mass of pea plant as the dependent variable.

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Slide 6:	Ask the children about the variables they need to control. They are likely to come up with some basic variables such as the size of box and the type / number of plants. Encourage them to consider other variables they should control or monitor. For example, the type of compost, the amount of water given to the plants, the temperature inside the box and the light intensity / brightness. If children do not come up with light intensity as a variable, show them some different coloured filters and hold them up to the window. Ask them what they observe. (They seem to let different amounts of light through.) Ask children how they could **measure** light intensity. (Data logger and light sensor or light meter). Challenge them to thinks of ways in which they could change the light intensity at the place where the plant is growing. (Change the area of filter letting light through; change the intensity of the lamp; change the distance of the lamp from the filter, or the distance of the plant from the filter.)
Slide 7:	Children now plan the investigation. Ideally, children will work in small groups to agree the equipment they need, the procedure they will use and how they will record their results. Encourage them to identify ways in which they will obtain accurate and precise data from the investigation and identify possible sources of random and systematic error. (Accuracy: measuring mass increase of the plants will give more accurate and precise measurements than measuring plant height) Random errors may be introduced by differences in plant growth and variation of temperature, water and light intensity. Systematic errors may be caused by zero errors of the balance or light meter). Accuracy and precision may be improved, and random error reduced by growing several pea plants in each box. Children should make a risk assessment as part of their plan. Children then carry out the investigation.
Slide 8:	Children now write a scientific report which, at this level, is essentially an experimental write up. However, an important part of their conclusion will be their recommendation to UK farmers based on evidence about the best colour of light for growing plants in a greenhouse.
Slide 9:	Children can create a science research poster on A3 or A2 paper to explain their investigation and report their findings. Slide 10 may be used to model the features of science research poster.

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Slide 10:	Explain that a science research poster would be used to share a summary of research findings at a science fair or research convention. They usually have lots of diagrams, photos, tables, charts and graphs to break up the text. Draw children's' attention to the following features: **Title of research** and researchers' names. **Introduction:** This section gives background information about the area of research and outlines its importance. It may include text, data, diagrams and pictures. **Method:** This section explains what the research team did to collect their data. It should include some diagrams and / or pictures to show how the investigation was conducted. **Findings:** This section should include data from the research including tables, charts, graphs and text. It should explain the results including any anomalies and mathematical calculations such as calculating means. **Conclusions:** This section should highlight the importance of the findings and what show. It should include recommendations for others (such as farmers) as well as ideas for further research. It may contain diagrams, pictures, charts and text. **Acknowledgements:** People other than those in the research group who have contributed should be included here. For example, the research findings of others that may have contributed ideas for this research, or others who have helped directly.

Key Stage 3 Curriculum Links

Subject	Topic	Objective
Science	Working Scientifically (Experimental skills and investigations)	Make predictions using scientific knowledge and understanding. Select, plan and carry out the most appropriate types of scientific enquiries to test predictions, including identifying independent, dependent and control variables, where appropriate. Use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety. Make and record observations and measurements using a range of methods for different investigations; and evaluate the reliability of methods and suggest possible improvements.
Science	Working Scientifically (Analysis and evaluation)	Present observations and data using appropriate methods, including tables and graphs. Interpret observations and data, including identifying patterns and using observations, measurements and data to draw conclusions. Present reasoned explanations, including explaining data in relation to predictions and hypotheses. Evaluate data, showing awareness of potential sources of random and systematic error.
Science (biology)	Cells and organisation	The functions of the cell wall, cell membrane, cytoplasm, nucleus, vacuole, mitochondria and chloroplasts.
Science (biology)	Nutrition and digestion	Plants making carbohydrates in their leaves by photosynthesis and gaining mineral nutrients and water from the soil via their roots.
Science (biology)	Photosynthesis	The reactants in, and products of, photosynthesis, and a word summary for photosynthesis.

Science (physics)	Light waves	The transmission of light through materials: absorption, diffuse scattering and specular reflection at a surface. Light transferring energy from source to absorber leading to chemical and electrical effects; photo-sensitive material in the retina and in cameras. Colours and the different frequencies of light, white light and prisms (qualitative only); differential colour effects in absorption and diffuse reflection.
Language and literacy	Reading and writing	Pupils should develop the stamina and skills to write at length, with accurate spelling and punctuation. The writing they do should include narratives, explanations, descriptions, comparisons, summaries and evaluations.