Intensive crop production systems

Nigel Collins

Much of the food that we eat comes from systems in which large numbers of plants or animals are grown under closely controlled conditions, designed to maximise production. In this article we look at two intensive crop production systems which illustrate key points in your GCSE course.

GCSE key words
Factors affecting plant growth
Photosynthesis
Human impact on the environment

All green plants have certain basic requirements — oxygen, water, a source of mineral nutrients such as nitrate ions, space to grow and reproduce, suitable temperatures and, of course, a supply of carbon dioxide (CO_2) for photosynthesis. All plants compete with each other for these resources and are at risk from pests and diseases and extremes of weather.

When they grow plants as crops farmers intervene in various ways to optimise growth, so that the food is produced as quickly and cheaply as possible.

Temperature and carbon dioxide

Growth is dependent on chemical reactions, catalysed by enzymes. These reactions, which include photosynthesis and respiration, protein synthesis and the synthesis of all sorts of other chemicals, such as cellulose for cell walls or starch and oils stored in seeds, are all faster at higher temperatures. As a result, fruits or underground structures, like potatoes and carrots, develop and grow more quickly.

Plant growth is also often constrained by lack of carbon dioxide. It is difficult to raise carbon dioxide concentration outdoors, but in a greenhouse this is feasible. Carbon dioxide can be generated by burning a fuel — which also raises the temperature.

The combined effects of light intensity, carbon dioxide concentration and temperature on photosynthesis are shown in Figure 1. Initially, light intensity

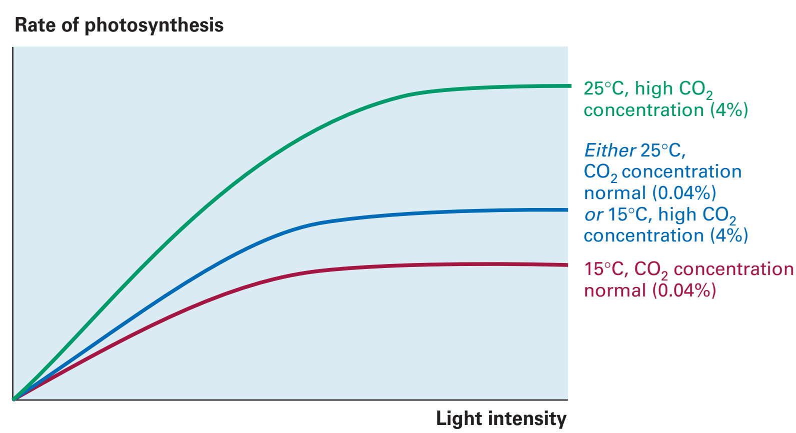

Figure 1 *Light, temperature and carbon dioxide concentration and photosynthesis. Raising* either *the temperature* or *the carbon dioxide concentration increases the maximum rate of photosynthesis possible at higher light intensities. Increasing* both *has the greatest effect*

Holt Studios

Growers planting seedling lettuces in soil blocks in hydroponic channels in a large glasshouse in Hertfordshire

Box 1 Hot beds

Another way to achieve higher temperatures and carbon dioxide concentrations which used to be used in kitchen gardens is to set up a hot bed. This is a deep pit in a glasshouse filled with straw and animal dung – obtained from a stable or a shed for overwintering cattle.

Decomposition sets in as bacteria use the materials in the bed for food. As they respire the bacteria release carbon dioxide which is useful for the plants in the bed. They also release heat, which warms the bed.

When European plant hunters first brought them home, exotic plants such as pineapples were grown in this way.

limits growth, but above a certain light intensity photosynthesis reaches an upper limit and continues at a steady rate. To increase the rate of photosynthesis above this, the *limiting factors*, in this case temperature and/or carbon dioxide concentration, must be increased.

Salad and strawberries

There is concern that in some parts of Britain the introduction of polytunnels covering large areas for up to 6 months of the year is spoiling the countryside.

Lettuces, tomatoes and strawberries can all be grown outdoors in Britain – indeed lettuces and strawberries are often produced in this way for a relatively short season. But growth is slower than if the plants are placed in a glasshouse or protected under polythene. In open soil the plants are also more likely to be eaten by slugs and snails. Under protection the plants can be more isolated from pests and the growing season can be extended significantly.

A farm in Kent has the biggest single area under glass in Europe for growing strawberries across a 6-month season. A combined heat and power (CHP) plant that generates electricity for use on the farm also produces heat and carbon dioxide for accelerating photosynthesis and crop growth. Surplus electricity is fed into the National Grid. Box 1 describes another way to achieve higher temperatures and carbon dioxide concentrations which used to be used in kitchen gardens.

Glasshouses and polythene tunnels (polytunnels) have a further use when growing strawberries. The UK crop has always been vulnerable to devastation by heavy rain, but polythene protects the crop from this risk.

You might expect that supermarket strawberries or salad crops grown in the much hotter climate of southern Spain would be grown outdoors, but in fact they are also grown under polythene. Hectare after hectare of the arid countryside, which has very thin soils, is covered in polythene. The polythene used in Spain is often much less transparent than in Britain, to provide shade in the daytime from the full strength of the Mediterranean sun. This is important because at *very* high light intensities chlorophyll molecules can be damaged, which will affect photosynthesis. The polythene also helps to retain warm air at night, because in the open air temperatures can drop quickly at night under clear skies. Plants here are often grown in 'artificial soil', an inert material such as rock wool, with water and added fertilisers trickling through it. This technique of **hydroponics** will be described in the next issue of CATALYST.

Controlling pests and diseases

Problems with this method of growing crops include the fact that large expanses of a single variety can be vulnerable to infections which may spread quickly and ruin a crop. *Elsanta*, a widely grown strawberry variety, is prone to such infection. One solution is to sterilise the soil using chemicals. In Britain, the industry currently makes use of methyl bromide – an ozone-depleting chemical which other countries have phased out. This chemical is not selective – it kills all soil organisms, rather than just the nematodes and fungi that cause problems for strawberry growers. Methyl bromide use is now being phased out in Britain.

One advantage available to growers of crops under glass is that if there is an infestation by some pests such as mites or small flies, biological control can be used (see CATALYST Vol. 16, No. 1). Predatory insects are released to catch the pests. This is not often a viable proposition with crops grown outdoors.

Mushrooms

Mushrooms are the fruiting bodies of certain fungi. They may be gathered wild or grown under cultivation. The most commonly cultivated mushroom species is *Agaricus bisporus*. The annual worldwide production of this species of mushroom is 2 million tonnes which is worth £3 billion. In the UK we consume more than 100 000 tonnes of mushrooms each year — a significant proportion of which is imported.

How do mushrooms grow?

Mushrooms cannot trap energy from the sun because they do not contain chlorophyll. Instead, mushrooms extract their carbohydrates and proteins from a rich compost of decaying plant matter and manure. They are grown in the dark under carefully controlled conditions of light, heat and moisture.

Preparing the compost

Preparation of the compost is quite complex. The compost is pasteurised to kill harmful organisms by heating it to 60 °C for at least 2 hours. Temperatures are not high enough for complete sterilisation.

A fungal innoculum or 'spawn' is added to the compost in containers or beds and very fine fungal hyphae then grow to form a network of strands (mycelium) which spread through the compost. After 12–15 days a layer of peat or soil (the 'casing') is added.

Harvesting mushrooms

The fruiting bodies begin to appear about 6 weeks after spawning and continue to appear in flushes about 7–10 days apart for the next 6–8 weeks. Mushrooms are harvested over a period of 2–4 days within each 7–10-day period. The cap and a small section of connected stem are usually harvested before the caps are fully expanded.

Box 2 Mushroom fly pests

Small flies found in mushroom houses:

- reduce yield by damaging the compost and feeding on the mycelium
- act as vectors of diseases
- are a nuisance to pickers
- can cause rejection of pre-pack mushrooms at market

Researchers at Warwick HRI are trying to work out whether some fungal strains possess natural resistance to mushroom fly pests.

Mature mushrooms inhibit the growth of more in their vicinity, so when they are picked off another flush can mature. The first three flushes are the most productive.

Ventilation

The amount of fresh air entering the room and temperatures within it are controlled automatically. Carbon dioxide concentration is also monitored. Ventilation rates depend on the amount of mushrooms being grown on the beds and on heat and carbon dioxide production (which increase as respiration speeds up). If stale air with high carbon dioxide levels builds up around the mushrooms, quality suffers.

Under ideal conditions mushrooms can double in size every 24 hours.

Pests and diseases of mushrooms

Various small fly and midge species are pests of mushrooms (see Box 2). Depending on the species, larvae feed on the compost or on fungal mycelium in the compost. They may also tunnel into the fruiting bodies.

A range of mite species may affect the yield and quality of the mushroom crop. Some damage the fruiting bodies directly, others attack the mycelium. Mycelium-eating mites can cause high yield losses. Nematodes cause a loss in yield and brown, watery mushrooms, and, in extreme cases a soggy, smelly compost. Peat added to the casing layer is a common source of nematodes and has to be treated before use.

Even though the mushroom itself is a fungus, it can in turn be affected by a range of fungal pathogens. Managing this is difficult because fungicides cannot be used! Bacteria and a range of viral diseases can also attack mushrooms. The best way for a farmer to counter diseases is to be very strict about hygiene at all stages of production.

- **When you next eat strawberries or tomatoes think of all the applied science involved in their production.**

- **You can read about intensive meat production systems in CATALYST Vol. 12, No. 2.**

***Nigel Collins** teaches biology and is an editor of CATALYST.*