Plant factories

Introduction
The global population is increasing exponentially and the demand for food is rising at an unprecedented rate[1]. Vertical farming is a crop production system for the future, which may offer the solution to providing food for the expanding population predicted to increase by a further 3bn by 2050[2].

Vertical farming is a technique for growing plants on a series of levels in a vertical space, where all parameters essential for plant growth, such as light, temperature, water, nutrients and carbon dioxide, are provided at a continuous, optimum level. In theory, this combination of inputs provides the best environment for crop growth, yet it also can create issues with electrical power consumption, labour requirements and the complexities of plant science.

Using controlled environments, crops can be cultivated that may otherwise be unsuited to the UK climate, reducing reliance on overseas supply chains[2]. To meet the increasing demand for high quality herbs, controlled environment agriculture is an alternative to conventional cultivation and can provide a supplement to field production[3].

Paul Challinor of Jones Food Company describes a new high-care, multi-layer, hydroponic plant production facility in the UK.

Another factor in the provision of high quality, fresh produce is the control of microbiological contamination throughout the production process, particularly where the final product is presented in a ready-to-eat format.

Designing an intensive plant production system
The Jones Food Company instigated a project to design, build and operate a commercial, high-care, intensive plant production unit. The facility is now up and running, having produced its first harvest of culinary herbs and leafy greens during the Autumn of 2018.

The construction method needed to be both modular and scalable to enable subsequent units to be efficiently assembled in any area where food production is required, including urban spaces. The production system design incorporates the latest knowledge and research on hydroponics, LED lighting and environmental control systems. Initial water filtration, precision irrigation and recirculation of drainwater (irrigation solution not used by the plants) are key factors in the overall water-use strategy. Additional filtration and the use of ultra-violet light treatments ensure that the water quality is maintained throughout the unit (Figure 1).

The building itself was originally constructed as a cold storage facility (Figure 2) and is very suitable as a controlled, multi-level, growing environment. It is well insulated and twelve metres in height. This has allowed the construction of five main growing racks, each containing seventeen crop production levels. The actual crop production area is, therefore, over 5,000 m².

The original metal storage racking was removed, strength tested, cleaned and treated with white, anti-microbial paint. This recycled metalwork was then incorporated into the new growing structure, which supports the growing trays and crop produce.
The unit is divided into separate zones for seed sowing, germination, crop growing, harvesting, tray cleaning and despatch. All main areas have independent environmental controls and the unit is sealed to prevent pest ingress from the outside. As a result, the pest and disease risk is lowered and, therefore, there is no need to use pesticides in the unit.

A separate consideration was to automate the crop production and harvesting processes as far as possible, to further reduce the risk of contamination. The use of automation at every stage throughout the production and harvesting processes reduces the requirement for handling of the food products, resulting in a lower microbiological contamination risk. Another positive benefit of this system is less waste product.

The unit layout was designed to allow the operation of an autonomous forklift vehicle from the seeding area into a separate germination chamber and, subsequently, to the growing room and harvesting zone.

A purpose-designed quality management system has also been compiled to match and evolve with specific customer requirements.
LED lighting and cropping

The LED lighting profile uses Current by GE ‘Arize Lynx’ lights (Figure 3), which were firstly tested on a small growing rig. After extensive trials involving many plant types, a balanced light spectrum was selected to allow efficient plant growth and optimum product quality. Important considerations for final selection of the lights included the LED efficiency (conversion of energy to light, rather than heat), spectrum, longevity of the luminaires and ease of installation.

Light is one of the most important environmental factors influencing herb quality, phytonutrient content and growth and development. The recent adoption of light-emitting diodes provides opportunities for targeted regulation of growth and phytonutrient accumulation by herbs to optimise productivity and quality under controlled environments[3].

This facility is currently growing culinary herbs and leafy greens (Figure 4), but the unit is capable of growing most plant types and may be adapted to accommodate larger plants by adjusting the number of growing levels per rack in order to create additional height per growing tray.

Studies growing lettuce under LEDs have demonstrated that growth and nutritional values can be enhanced in indoor plant production facilities[4]. Further plant growth and varietal testing are planned; a range of crop plants may be cultured under the GE LED lights by manipulating the photoperiod.

Treatment of growing materials entering the high-care unit

All materials destined to enter the growing and harvesting areas are treated with UV-C light. Both the growing substrate and the cropping trays enter the high-care areas via an enclosed tunnel, which allows 360° exposure to the UV-C light. In addition, all seed is tested before use to monitor microbiological levels and is treated with UV-C in a separate machine, before delivery into the high-care unit. The seed treatment mechanism involves the use of a vibration belt, which causes the seed to somersault, allowing all surfaces of the seed coat to be exposed to the UV-C light.

Clean liquid feed, at a known pH level and electrical conductivity (EC), is irradiated into the growing trays, which hold the growing substrate and support the growth of the crops. Drainwater is captured from each growing rack and returned to the water management area. From the drainwater tank, the liquid feed is transferred back to a clean storage tank, via a separate UV-C treatment unit. This allows a combination of fresh liquid feed and treated drainwater to be irrigated back to the growing crop on a continuous basis.

In terms of labour, all crop operatives complete a sequence of hand washing, use of protective cleanroom suits, hoods and boots, final hand washing and hand sanitising, prior to entering the high-care area. The final step before entering is via a pharmaceutical air-shower unit, to remove any extraneous dust particles (Figure 5).

Intensive hydroponics system

Hydroponics is the culture of plant crops in soilless water-
It is possible to exercise precise control over the internal temperature, humidity, carbon dioxide concentration and lighting regime to provide the consistent conditions for plant growth in every twenty-four hour period.

References and article available online at fstjournal.org/features/33-1/intensive-farming

Dr Paul Challinor  Chief Technical Officer, Jones Food Company Ltd

Email paul@jonesfoodcompany.co.uk

Web maybarnconsultancy.co.uk