A plant growing unit (10) comprising a growing chamber (11), within which is provided a plurality of plant holding means (12) supporting a plurality of plants and supplying a fluid nutrient mix to such plants, said growing chamber being provided with illumination means (10), temperature control means, and means for supplying said fluid nutrient mix to said plurality of plant holding means (12).

Figure 1
This invention relates to a plant growing unit for growing plants in an enclosed space.

Normal farming practice in soil is very seasonal as light conditions and climate conditions vary and are often insufficient or unsuitable to support plant growth. The need for fertilizers, herbicides and pesticides causes environmental problems and health concerns for human consumers of the produce. Weeds and other unwanted plants can ruin a crop and the plants are at risk from animals, insects and a host of other pests including bacteria, pathogens and viruses.

One solution to mitigate the problems of variable climatic effects on plant growth is to use a greenhouse to enhance the collection of solar energy for plant growth and to protect plants from the climatic variations. However, large commercial greenhouses are capital intensive in terms of the cost of the greenhouse, purchasing land, land preparation, climate control, pest control, water storage, water treatment, irrigation systems, nutrient mixing systems, power systems and standby systems.

A lot of space is wasted in a large greenhouse, mainly due to light considerations. Therefore a lot of energy may be needed to control the climate within the greenhouse. The use of artificial lighting may be an option, but requires high energy consumption resulting in high energy bills leading to high production costs. Plant production in greenhouses is also very labour intensive.

Typically agricultural produce is cultivated in rural areas while the majority of consumers are concentrated in urban areas. Thus there is a high cost in transporting such agricultural produce to the market, which could take days.

Hydroponics is a technology for growing plants in a nutrient solutions [water] with or without the use of artificial medium to provide mechanical support. Hydroponics techniques may be further categorised as open, where after the nutrient solution has been delivered to the plant roots it is not reused, or closed, where surplus solution is recovered, replenished and recycled.

Known hydroponics systems in temperate regions of the world comprise enclosed in greenhouse-type structures to provide temperature control, reduce evaporative water loss, and to reduce disease and pest infestations.

The principal advantages of hydroponics controlled environment agriculture (CEA) include high-density maximum crop yield, crop production where no suitable soil exists, a virtual indifference to ambient temperature and seasonality, more efficient use of water and fertilizers, minimal use of land area, and suitability for mechanisation, disease and pest control.
The major advantage of hydroponics CEA compared to field grown produce is the isolation of the crop from the soil, which often has problems of diseases, pests, salinity, poor structure and drainage. However, traditional hydroponics systems require high initial capital costs.

There is not a shortage of food in the world it is the logistics of getting fresh healthy food to the people effectively and economically. Once a vegetable is harvested it starts to deteriorate, vitamin and mineral content decreases thus the need to produce food locally.

According to the present invention there is provided a plant growing unit comprising a growing chamber, within which is provided a plurality of plant holding means supporting a plurality of plants and supplying a fluid nutrient mix to such plants, said growing chamber being provided with illumination means, temperature control means, and means for supplying said fluid nutrient mix to said plurality of plant holding means.

In a preferred embodiment said chamber comprises a refrigerated shipping container. The temperature control means may comprise a refrigeration unit or heat pump provided on the refrigerated shipping container. The refrigeration unit or heat pump of the unit may be powered by a diesel engine.

Preferably said chamber includes climate control means. Preferably said climate control means is adapted to control one or more of the temperature, humidity and gas composition within the chamber. Water collected by the climate control means may be used by the nutrient mix supply means.

Preferably the apparatus includes a control system for controlling the illumination means, heating means, nutrient mix supply means and, where provided, the climate control means, to ensure optimum growing conditions within the chamber. Said control system may include a programmable logic controller.

Preferably the illumination means comprises a plurality of LEDs.

Preferably the apparatus is powered by a 12v dc power supply, preferably from one or more batteries. The batteries may be charged by a diesel motor of the refrigeration unit or heat pump.

Preferably said plurality of plant holding means is mounted on vertically arranged racks. Said racks may be mounted on trolleys within the chamber. Alternatively the racks may be suspended within the chamber.

An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which :-
Figure 1 is a side view of a plant growing unit in accordance with an embodiment of the present invention;  
Figure 2 is a plan view of the plant growing unit of Figure 1;  
Figure 3 is an end view of the plant growing unit of Figure 1;  
Figure 4 is a side view of the plant growing unit of Figure 1 showing the air flow through the unit;  
Figure 5 is a side view of the plant growing unit of Figure 1 showing the irrigation/nutrient solution flow through the unit;  
Figure 6 is a perspective view of a plant growing trough of the plant growing unit of Figure 1; and  
Figure 7 is a sectional view through the plant growing trough of Figure 6.

A plant growing unit in accordance with an embodiment of the present invention makes use of a refrigerated shipping container or trailer comprising a thermally insulated chamber having a diesel/electric refrigeration unit to define a growing chamber within which plants may be grown.

Such containers are cheap and easily available. They can be stacked on top of each other, thus using a small footprint, are easily transported, completely self contained and secure. Being portable the plant growing units can be placed anywhere, for example on top of buildings, in communities, car parks, shopping centres, churches, hospitals, schools or anywhere. This enables the plant growing units to be located close to consumers and in city centre locations.

Climate control within the growing chamber can be easily achieved as the growing chamber is thermally insulated and the air volume within the chamber is relatively small, thus making air temperature, humidity and CO₂ levels relatively easy to manage compared to prior art systems.

A plurality of plant holding means are provided within the growing chamber for supporting a plurality of plants and for supplying a nutrient solution to the plants to provide water and nutrients required for plant growth. The plant holding means may be arranged on vertically extending racks, as shown in Figures 1 and 2.

Soil may be used in the plant holding means as a medium for plant support and to retain moisture and for holding the nutrients for plant growth supplied in the nutrient solution. Other plant support mediums may be used which are far cleaner, as long as they are pH neutral.

An ammonia absorption refrigerator, which uses propane as the energy source, may be used for cooling the air and/or the nutrient solution through heat exchange. A gas fired water heater may be provided for heating the chamber and/or nutrient solution through heat exchange.

An air recirculation system is provided for controlling the air temperature, humidity and gas composition of the air within the growing chamber. The air recirculation system includes fans for circulating and moving air through the growing chamber, as shown in Figure 4 and a controlled exhaust and intake means may be provided for bringing fresh air into the growing chamber and
exhausting air from the growing chamber as required. The humidity of the air within the growing chamber may be controlled by air heating and cooling heat exchangers. Water collected in the humidity control system may be used for growing by addition to the nutrient solution. If moisture is needed to increase the air humidity, ultrasonic sensors may be used to create very small water particles, increasing humidity. Hydrogen peroxide in a low concentration may be used in the air recirculation system as a disinfectant and to kill bacteria.

Burning propane produces C02 gas, which is required by plants to grow. Therefore such C02 gas may be collected and used to control the gas composition of the air within the chamber. In both the cooling and heating systems there are no moving parts making them less susceptible to break downs.

Because the growing chamber is a sealed unit, pests and diseases are easily controlled and, with added protection, the unit according to the present invention can eliminate chances of contamination.

Air in the recirculation system will pass through an ozone generator and an ultra-violet light to kill any spores or bacteria in the air, also eliminating odours.

Fresh water supplied to the system may pass through a filter and then a reverse osmosis unit to remove all salts and impurities. The fresh water may be stored in an inbuilt reservoir, as will be described in more detail below, and supplied to the nutrient solution as required. The nutrient solution is preferably recycled where the water is re-used several times, the nutrient mix being mixed with fresh water and nutrients before being returned to the plants. UV sterilisers and ozone generators may be used to control bacteria in the nutrient mix.

The composition and volume of the nutrient solution supplied to the plants may be controlled by a system controller connected to a plurality of sensors to measure pH, EC and temperature, the system controller adjusting these parameters automatically to predetermined desired levels, depending on the crop grown and stage of growth.

Artificial lighting is provided by LEDs (Light Emitting Diodes) 18. These LEDs 18 emit only certain wavelengths of light and have a long lifespan (around 50,000 hours), making them the perfect solution to efficient plant growth. The reason why LED growing is not common place is because it has been difficult to find LED lights powerful enough to sustain good plant growth. Technology has rapidly advanced in this field, allowing LEDs to offer sufficiently high output for plant growth while consuming 75% less power than other lighting sources. Switching banks or groups of these LEDs at high speed cuts power requirement to a very low value making it very efficient and cost effective.

Due to the very low heat produced by LEDs, shelf growing of plants on vertically arranged racks 12 is possible, where other light sources would generate too much heat and radiation. LED illumination enables plants can be grown in a very high density due to the wavelength of light produced and due
to the very small amount of heat generated by the LEDs. Thus the light source can be positioned close to the plant without affecting its growth or structure.

A system controller 20 is provided for controlling the operation of the growing unit, the system controller comprising of a programmable logic controller (pic), which is an industrial computer. A touch screen interface 22 may be provided so data can be displayed and new parameters entered. The system controller 20 may be remotely controlled, to enable remote monitoring and assistance with trouble shooting and fault finding. When an alarm is generated the system controller may communicate with a mobile phone or cell phone. The system controller controls all aspects of the unit to ensure optimum growing conditions within the growing chamber.

The whole system may be powered by a 12 volt dc electrical power supply. This facilitates the use of solar panels or wind generators to provide electrical power for the unit and enables the use of cheaply and readily available 12v electrical systems and batteries. The unit is based upon a refrigerated container which is powered by a diesel engine. Thus the engine can be used to charge the batteries as well this unit does not run continuously only when required thus making it very efficient. The only other source of energy required is propane, used for the heater.

Instead of using one large pump for irrigation, two or more smaller pumps may be used. Similarly two or more small fans may be used within the air recirculation system so that, when one pump or fan malfunctions, the process is still operable in a fail safe mode. The whole system has been designed to eliminate as many problems as possible.

The earth has a natural frequency of proximally 8 Hz’s. It has been found that, by passing a small current though a plant and plant root system at a certain frequency, plant growth and yield can be increased considerably. The same principle may be applied to the lighting system so that, at a certain frequency, plant growth is increased. Such techniques can be applied to the plant growing system of the present invention.

With the growing chamber of the present invention it is possible to provide certain crops with 24 hours a day illumination. However, it may be preferred to provide 18 hours light and 6 hours rest to optimise plant growth.

For certain crops, the system may be adapted to enable multi rooting, wherein one plant has more than one root system and is thus able to take up more nutrients, increasing plant growth and yield. The growing unit comprises a reticulating nutrient system, thus enabling multi ph irrigations to take place because the plant absorbs minerals at different ph levels, thus eliminating a lot of problems with growing.
There is no need for a highly trained operator as the growing cycle is all controlled by the system controller 20. All the operator is responsible for is that the system is operational, for harvesting, packaging of produce and the sowing of new seeds.

The growing chamber 11, and the plant holding means 12 provided therein, may be laid out in such a way that very little time is needed to harvest and sow new seeds thus making labour cost low.

The plant growing unit 10 in accordance with the present invention may also be adapted for farming fish. Aquaponics, which is production of fish, may be incorporated into the unit in addition to the growing of plants using hydroponics. The fish may supply the nutrients for growing of plants and the plants may remove toxins from the water for the fish to survive in, providing a true eco system and a sustainable food source for the human population.

The method of hydroponically growing in a enclosed container is very different from other methods of hydroponics new techniques have to be employed to ensure efficient and a quality product is produced with very little energy used.

It is the combination of all these techniques that ensure the best results in producing a very high quality product in a very short period of time saving costs on labour and energy.

The present invention makes use of a refrigerated shipping container or trailer which has a diesel/electric refrigerated unit and that the container is insulated. Utilizing standard hydroponics principles slightly modified and new techniques to grow a variety of crops. This is the main advantage of the plant growing unit of the present invention is that it is small; sealed and insulated thus making it very easy to control.

The main objective of the present invention is to compete with a standard green house 39.01 metres (128 feet) long by 9.14 metres (30 feet) wide in producing the same amount of produce quicker and more efficiently consuming a lot less energy.

The component parts of the plant growing unit in accordance with a preferred embodiment of the present invention will now be described in more detail.

**Illumination System**

Growers are primarily interested in that light which is responsible for photosynthesis. The portion of the light band most responsible for photosynthesis measures 400-700 nanometres. This band is often termed the Photo synthetically Active Radiation (PAR). Within this range, intensity is the most critical factor along with light period.

- 3000k - 3500k  sunrise / sunset
- 5000k - 6500k  sunny daylight around noon
9000k - 12000k blue sky
For vegetative growth 425nm 450nm 475nm
For flowering 625nm 650nm 675nm
High Intensity Discharge lamps are the ones mostly used. HID lamps come in 3 basic types: High Pressure Sodium (HPS), Metal Halide (MH) and Mercury Vapour. All of these generate a lot of heat and radiation thus they cannot be used close to plants. They also consume a lot of energy which a lot is wasted because they are not close to the plants.

LED lighting has only come about in the last couple of years where the intensity is sufficient for growing. These are very efficient lights consuming very little energy for the amount of light they produce and do not produce a lot of heat so they can be placed close to the plants. Most led grow lights on the market make use of only the red or blue only spectrum then the mixing of the two colours only so they are not very productive in all crops. Led's have a very narrow band width.

The use of artificial lighting has a lot of benefits in that a longer grow period can be given thus the plant is more productive. The illumination system of the plant growing unit in accordance with the present invention makes use of LED lights 18 having a very wide light spectrum of light emission. For vegetative growth predominately blue light would be used with the full spectrum of light in the range of 400 to 700 nm at the same time. When flowering, predominately red light would be used with the full spectrum of light in the range of 400 to 700 nm at the same time. This keeps the Intenodal length of a plant in balance and gives the plants maximum benefits.

In nature the sun rises in the east and sets in the west so the plant tip always follows the light source this helps in promoting stem size. In the plant growing unit in accordance with the present invention, the LED lights are arranged in rows, normally 3 rows, along the length of the growing chamber. When lighting is required, row 1 is turned on. Then 45 minutes later row 2 is turned on. 45 minutes later row 3 may be turned on. At the end of the light period row 1 is turns off then 45 minutes later row 2 is turn off 45 minutes later row 3 is turn off thus simulating the sun. These time periods are adjustable.

When using High Intensity Discharge lamps they are actually turning on and off because they work off alternating current and then have a ballast to generate a high voltage and frequency. Led's are different in that they are always on. It has then been found that if you use a frequency of 126 Hz’s 16 times the earth's frequency you increase plant growth. So the LEDs used are switch at a 126 Hz. The system controller provides this frequency which in turn controls a dc to dc converter which powers a constant current source which supplies the correct power to each led in the system ensuring maximum life and power for the led.

LEDs can be placed close to plants without affecting them there is very little heat and radiation.

Plants can be placed close together because led's can be placed close to them thus giving light to all areas. There is no shading from other plants.
Plant Holding Means

The plant holding means 12 of the growing unit 10 may comprise trays, gutters and/or PVC pipes depending on what crops are grown. The plant holding means 12 may be suspended from racks and/or supported on shelves.

Hydroponics methods of ebb and flow (flood and drain) and/or N.F.T.(Nutrient film technique) may be used.

In one embodiment, illustrated in Figures 6 and 7, the plant holding means 12 comprise elongate gutters 50 formed from lengths of extruded PVC defining an upwardly open channel within which a nutrient solution may be held. Each gutter 50 is provided with an elongate lid 52, the lid 52 being provided with apertures 54 through which the plants can be inserted.

Humidity within the growing unit 10 may be controlled by maintaining a relatively high air temperature within the unit to maintain the air temperature above the dew point and controlling the temperature of the nutrient solution (cooling the nutrient solution) to control the temperature of the plants. Cooling of the nutrient solution is easy achieve via heat exchanges and does not require a large system as the nutrient solution is not a large amount. When irrigating the gutter 50 in which the nutrient solution flows irrigating the plants is cooled thus give a temperature difference where dew point will be reached. This results in the formation of condensation on the outside of the gutters 50. A condensation catchment tray 56 is provided beneath each gutter 50 for collecting condensation formed on the gutter 50 for reuse, for example to be added into the nutrient solution. The condensation catchment tray 56 may be mounted to slope towards one end to drain condensed water from the tray. Standard hydroponic grow trays can also be used by either placing the grow gutter into a slightly larger gutter and slopping the gutter to collect the condensation or by just using a plastic sheet under the grow gutters and sloping it to collect the condensation for reuse.

A channel 58 may be formed between the gutter 50 and condensation catchment tray 56 defining an air duct through which air may be supplied to the plants.
Because of the lighting techniques used, plants may be grown very densely and close together. This permits a shelf system and is formed as racks all available space is used for growing.

When using trays, gutters or PVC pipes a unique feature is used. Two pieces of stainless steel wire are provided, running down either side of the tray or gutter along its full length. This is for root simulation and increases plant growth. A frequency of 4 Hz's (1/2 the earth frequency) derived from the system controller passes a small current thought the root system. When using PVC pipe it is difficult to keep the wires separated so stainless steel locating bolts may be used.

Some plant will allow multi rooting this is where a plant has more than one root system and is best with each root system having a separate grow area. Either PVC pipes or a gutter system is used. A plant is then able to take up more nutrients thus promoting growth. With this system multi ph works extremely well giving real good results. Not only can root simulation be used but current is passed though the plant as well (plant simulation).

The growing racks arranged are in such a manner so as to ensure maximum grow area and to provide maximum air flow throughout growing chamber. The racks may be hung from above using a turn buckle (in case unit is not level), and may be provided on a trolley system so they can moved to provide access to both sides of the growing rack and to provide space to work.

**Fresh water tank**

This is used for the storage of fresh water needed for topping up a nutrient solution storage tank. The fresh water storage tank may be is located in the top of the unit so gravity is used for filling of tanks.

**Fertilizers and ph tanks**

Three tanks are provided two for storing nutrients and to store an acid or alkaline solution for adjusting the ph of the nutrient solution. These further tanks may just above a nutrient solution storage tank.

**The nutrient solution storage tank**

This is where nutrients are mixed with fresh water and the ph of the nutrient solution is adjusted. The nutrient solution is re-circulated from the plant holding means and returned to the nutrient solution storage tank.

**Reverse osmosis unit and water filters**

These are used for cleaning and purification of water, removing most of the natural salts and providing a constant quality supply of water which will not affect the nutrients.

**Battery storage unit**

The battery storage unit 24 (see Figure 3) houses four 120 ah 12 volt batteries for powering the electronic systems of the unit. The battery storage unit may be vented outside.

**Ammonia absorption chiller**
This is used for cooling the nutrient solution and to control the temperature and humidity of the air within the chamber. The ammonia absorption chiller 14 can operate on a varied source of energy, either 12v dc 220v ac or propane. Preferably the absorption chiller is powered by the combustion of propane to generate C02 which may be used in the chamber for plant growth. Its main benefit is the cooling of the nutrients used for irrigation of crops though heat exchanges it is also used in the air system to control humidity and temperature of the grow area though a fan assisted heat exchanger.

Gas fired boiler
This is used for producing C02 for the grow area and for use in the air system to control the humidity and temperature of the air within the chamber though a fan assisted heat exchanger. When growing in an enclosed unit, humidity is the most critical factor as this will produce condensation. Humidity is caused by the amount of water in the system which is needed for irrigations and from air exchanges also the plants transpire giving off water. Plants do not like to have water dripping on the leaves. Condensation will also lead to mold and fungus which in turn can bring diseases.

Twin coil clarifier
This is used for storing hot water. One coil may be used by the gas fired boiler for heating and a second coil may be used by the diesel engine supplied by the main refrigerated unit and has a 220vac heating element making this unit very versatile.

Fan assisted heat exchanger used either for cooling or heating of the air in the chamber.

Battery charger - used in emergency or when the system is operated off electricity.

Ozone generator
This may be used to supply oxygen to the water and nutrient tanks, disinfecting such fluids at the same time to prevent bacteria and pathogens in the nutrient solution.

Submersible UV lights may be used for disinfecting the nutrient solution, preventing bacteria and pathogens.

Circulating pumps are used to keep the water and nutrient tanks from going stale and to ensure the fertilizer is well mixed. Ozone is drawn into the solution by the use of a venturi - no need for air compressors or blowers. The circulating pumps may serve to mix and maintain the nutrient solution at a constant temperature ready for use.

Dosing pumps used for the addition of fertilizers and ph adjust fluid to the nutrient solution, very accurately.

Exhaust and air intake controlled by the system controller to enable air exchange between the chamber and the ambient air when needed.
Ultra sonic humidifier used to increase humidity in the grow area.

Sensors
A number of sensors are used, for the grow area temperature; humidity and C02, for outside grow container temperature; humidity and C02, for the nutrient solution PH; temperature; EC and hydrogen peroxide used for disinfecting.

Propane detector safety device

Insect zapper for killing any insects that may gain access to the unit.

Air system
Air movement is extremely important to keep conditions constant and the required criteria in balance.

Plants will tend to form little climatic pockets due to shading and the plant is transpiring in turn effecting temperature and humidity around the plant. Generally plants do not like air blown directly on them, although some growers do to increase stem size. The main disadvantage is that the leaves are moving thus disabling its full potential to produces sugars needed for growth from the light source.

Most green houses use a vented system which are windows in the roof or on the sides and are opened fully or partially depending on wind direction normally windows that are facing the wind are opened fully allowing air to blow in and air is vented on the leeward side having the windows partially opened. The main disadvantage of having windows is pest; airborne spores; bacteria and pathogens thus the need for insect nets this then restricts the air flow in the region of 40% because the size of mesh required.

The present invention is very different from normal practices as all the available space in the growing chamber is used for growing, thus restricting air flow. Three systems are used to control air flow throughout the growing chamber and have multiple uses.

System one is the main unit supplied with the refrigerated container and is used when there is a large temperature difference or when the batteries need charging. This unit has a very large blower enabling it to move a large volume of air very quickly.

This unit only runs depending on temperature and battery voltage it starts automatically. As this unit charges the batteries which runs the system. Expected usage is 4 hours over a 24 hour period. A 120 litres of fuel should last 78 hours from the manufacture so it is very efficient.
Second system is located in the system control unit and is used to distribute hot/cold air; C02; moisture for humidity evenly throughout the growing chamber. Whatever conditions are required. This unit also does air exchange in that it will bring in fresh clean air from outside and exhaust the air.
from the growing chamber. When fresh air is bought into the growing chamber or when CO2 is not required it is mixed with ozone to kill airborne spores; bacteria and pathogens. When the system is exhausting air this is mixed into the vents from the water storage tank and nutrient tank which are venting ozone eliminating odours. All air weather it is fresh air or recirculation air it is passed over a UV lamp to kill airborne spores, bacteria and pathogens.

This unit does the air intake and exhaust of air depending on conditions and grow cycle. Air is blown from the top down along the two aisles. When used as a recirculation air system air is drawn in from the bottom. This unit is only to maintain conditions while the main unit is not operational. Third system this is to ensure air and all the criteria needed for plant growth is distributed evenly over all the racks.

This removes any heat generated by the LED lights and keeps air flow along each shelf constant. The other air systems are blowing air along the top of the grow unit these little blowers ensure the air is blown downwards circulating the air evenly. CO2 is distributed evenly by the use of these fans.

Heating and cooling systems
The plant growing unit according to the present invention makes use of a number of temperature control methods, making it very efficient and effective. The grow unit is relatively small and thermally insulated, making it easy to heat / cool or maintain conditions with very little energy consumed. The main refrigerated unit of the grow container is a reverse cycle refrigerated unit, thus providing heating and cooling. This heating/cooling system does not need to run continuously, only when required, thus saving on energy. Also provided are auxiliary units that maintain conditions while the main unit is not in use these are installed in the self contained control unit and have multiple uses thus saving on energy and resources. Cooling is achieved by air exchange thought the intake and exhaust vents, but is only used when condition permit. The ammonia absorption unit is capable of using three possible energy sources 12vdc; 220vac or propane, and the unit cools a coolant which is pumped thought a fan assisted heat exchanger. A further cooling means is the main refrigerated unit.

Heating is achieved by a small gas fired boiler or a diesel fired boiler heating a hot water storage clarifier which has two coils the boiler in turn uses one of these coils the other is used by the diesel engine cooling system so when the engine is running it will pump coolant thought the clarifier heating it. Hot water from the clarifier is then pumped though a fan assisted heat exchanger. Next is the main refrigerated unit which is a reverse cycle unit.

Therefore both cooling and heating can be achieved by a number of energy sources making them very efficient and versatile.

When all working together and controlled by the system controller such heating/cooling systems consume very little energy and add a lot of benefits to the whole system.
Humidity control systems
The plant growing system in accordance with the present invention can make use of a number of the heating/cooling means of the system for controlling the humidity of the air within the chamber, with the addition of a ultra sonic wafer which is used to create a very small water particle consuming very little energy. This water vapour is injected into the system control unit air system dispersing it evenly throughout the growing chamber. Because of the volume of air present in the growing chamber makes this method very efficient and possible.

If possible air exchange is used to control humidity as well.

To remove moisture, a fan assisted heat exchanger in the system control unit is used. The pump pumping coolant for cooling is controlled as that the air temperature is not affected but the heat exchanger is cool enough to remove the moisture. This water collected is then used in the nutrient tank.

C02 control systems
In some areas C02 levels are high enough for good plant growth and therefore just good air exchange is needed. However, C02 may be normally pumped into the growing chamber and released below the plants allowing the C02 to filter up though the plants. A number of ways may be used to produce C02. The control system of the plant growing unit may comprises sensors for measuring the C02 outside the growing chamber. If such external C02 levels are high enough, air exchange may be used to control the C02 content of the air within the growing chamber. Otherwise C02 generated by the burning of propane may be used to control the C02 levels within the growing chamber. The diesel engine of the main refrigerated unit when used on bio diesel or run straight on vegetable oil produces a very clean C02. The distribution of C02 is achieved by the air system ensuring C02 is constantly spread evenly throughout the growing chamber. Bottled C02 can also be used and is controlled by the system controller and injected in the system via the air system. Large volumes of C02 are not required as the unit is sealed and small in volume using a recirculation air system thus making it very efficient and very easy to control.

Power generation
A number of power sources can be used or a combination of energy sources used. Because of physical size of the unit only small pumps consuming low power are needed same with the fans. Using these entire techniques make the unit very energy efficient consuming very little. It is basically a 12vdc system.

Option 1 using the diesel powered refrigerated unit charges the batteries which powers the whole unit; provide heating/cooling and C02, no other energy source is needed.

Option 2 using electricity from a national grid which will operate everything except C02 which propane can be used or bottled C02 implemented.
Option 3 solar or wind generators mainly used in warmer climates and heating is not required or CO2, but if required propane can be used making it very efficient.

When using option 1 the unit will start automatically controlled by the system controller when a certain time has elapsed or if the battery voltage falls below a certain level or if the temperature in the grow area goes out of range. Normally used with propane adding extra benefits.

**Water storage and treatment**

Water quality is one of the most important features of hydroponics as this is what it is based on. There are a number of ways to treat water so a variety of water sources can be used as long as good quality water is produced as the end result.

This is all part of the system control unit thus not requiring any additional space. A number of water sources can be used with this system. First is a particle filter is provided which removes the heavier particles and then the water is passed through an active carbon filter which is used to remove chlorine and other contaminants. Activated carbon is carbon which has a slight electro-positive charge added to it, making it even more attractive to chemicals and impurities. As the water passes over the positively charged carbon surface, the negative ions of the contaminants are drawn to the surface of the carbon granules. A booster pump then feeds a reverse osmosis unit removing most the salts and producing a good quality water supply. The system controller controls the reverse osmosis unit in that it does all the back washes keeping the membrane clean on a regular basis. Rain water may also be collected and passed thought the filter system and feed to the storage tank or diverted to a outside tank.

Storage of water does not have to be large as a recirculation hydroponics system is used. Two tanks achieve all that is needed they are black and sealed to prevent contamination and light, preventing alga from growing vented into the exhaust of the main control unit.

One tank is the fresh water tank and is used for topping up of the nutrient tank and is large enough to replace the water in the nutrient tank, in case something goes wrong either contamination or loss of water thought a leak.

Second is the nutrient tank which is large enough to supply the amount of water needed for irrigation of the crops.

Both units may make use of UV lights to sterilise and in addition they have circulating pumps connected to a venturi which may suck in ozone which may be mixed thought a static mixer thus sterilizing and oxygenating the water. This method of oxygenating is very efficient and saves energy. Circulating the water keeps it fresh and keeps the salts in the nutrient tank diluted and stops crystallization.
Nutrient control and supply systems

Measurement of the amount of fertilizer is normally measured by EC (electrical conductivity) and varies depending on the crop and size of plants. Various methods are used for injecting fertilizers and pH adjust into the nutrient solution. The simplest method is to have the fertilizer tanks above a mixing vessel and have solenoid valves that opens for a predetermined time then shuts off. The fertilizer is gravity fed so care must be taken to have even flow by keep levels the same in the fertilizer tanks or by using flow controllers. This is repeated over and over again until the require amount (set point) has been reached.

The next method is using pumps to pump fertilizer into a mixing tank and controlling solenoid valves. Best is the use of dosing pumps that pump a set volume at a set rate so online dosing can be done or a vessel mixing process can be achieved by controlling the speed of the pumps which changes the rate it pumps a very accurate method but very expensive.

Online dosing can be achieved by using a venturi to suck the fertilizers in and the use of flow control valves so a set flow is achieved and controlled by solenoid valves the pump is then used as the mixer. Difficult to set up and control.

The nutrient tank may be used as a mixing vessel and the circulating pump may serve as a mixer. Generally most plants prefer a lower temperature nutrient solution so a heat exchanger may be used to cool the nutrient solution. The system controller controls the temperature and is very efficient as the heat exchanger is connected to the circulation pump and temperature is maintained there is not a sudden temperature difference. When growing salad greens this is a must.

Peristaltic pumps may be used to dispense the fertilisers into the nutrient solution and adjust the pH of the nutrient solution. Such pumps may pump a predetermined volume at a set rate and act as a valve when not in use. The system controller controls these pumps by running them for a set time then stops and allows the circulation pumps to mix the solution. There are two time periods used. One is used when the process value is far out. The other is used as the process value comes closer to the set point giving a very good result accurately.

The sensors are mounted onto a floating system thus level does not interfere with them. Level control is automatic controlled by level sensors and the system controller. During irrigations fertilizers are not added only when the system is idle.

Some plants do better with a standard pH of 6.5 but most will benefit from multiple pH irrigations. The reason for this is that plants absorb minerals at different pH levels. Then with use of other growing techniques it works extremely well see section on growing systems.

The fresh water is always kept at a low pH, irrigations are then done in 3 stages without topping up of the nutrient tank until the 3 stages are completed unless levels drop below a certain level.
The first irrigations will be with a very low ph, closer to 5.5 but never below this. The second irrigation will be with a standard 6.5 ph by adding ph adjust solution. The third irrigation depends on the amount of nutrient solution left in the tank this is done to make sure that when fresh water is added that the ph will be dropped below 6.5 other wise ph is adjusted but never above 7.5.

The cycle is then repeated over and over.

The nutrient solution not used by the plants is collected and used again thus using very little water. Care has to be taken that there is no build up of any one mineral.

Typical nutrient requirements for growing plants are as follows :-

The macro elements are those required in "high" concentrations: Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Sulphur (S), and Magnesium (Mg). Carbon must be supplied to the plant as carbon dioxide gas (CO2). Hydrogen is available in sufficient quantities from the atmosphere and Oxygen is supplied from well-aerated nutrient solutions.

The micro elements are also essential for growth, but required in smaller concentrations. Generally the micro elements are thought to be: Iron (Fe), Chlorine (Cl), Manganese (Mn), Boron (B), Zinc (Zn), Copper (Cu), and Molybdenum (Mo). Certain plant species may need others for good growth: Silica (Si), Aluminium (Al), Cobalt (Co), Vanadium (V), and Selenium (Se).

System controller (pic)

A system controller is used to control and monitor the complete system including climate; environment; lighting; irrigations; CO2; nutrient and ph mixing everything need for optimum growth. There are a number of ways to achieve control of a hydroponics system. The simplest method is the use of timers and manual control of climate, environment and nutrient criteria. The next is an OEM system using either a microprocessor or a programmable logic controller (pic) these are normally limited in what they control and have a set number of inputs and outputs. Manual intervention is still required. Most high end commercial green houses use a embedded system such as PRIVA which is a computer controlled system and is capable of controlling everything needed. It is a large system and is very expensive.

The present invention makes use of a programmable logic controller (pic) connected to a touch screen for data monitoring and entering of data by the operator. It is also connected to a SMS modem thus enabling remote monitoring and receiving of alarms.

Software is provided for controlling everything that is require for the unit and is very versatile that it is capable of using a number of different techniques to achieve a result, such as CO2 can either be generated by the system (burning of propane) or bottled CO2 can be used.
Any function or technique can be selected or deselected by the setup screen which is password protected. Each set of lights on each rack and shelf of the plant holding means can be controlled individually. Each rack and shelf irrigation can be controlled individually. The controller monitors and adjusts parameters that are set in the setup screen automatically and reporting items that go out of range. If it is critical an alarm is generated. If the system was to fail everything can be controlled manually by switches.

Possible markets:

1] Schools
2] Food chain outlets
3] Hospitals
4] Military bases
5] Municipalities for communities
6] Communities
7] Churches
8] Charity organizations
9] Charity organizations giving aid to 3rd world countries
10] Government organizations giving aid to 3rd world countries
11] Prisons
12] Private individuals wishing to supply the hotel and restaurant business
13] Greenhouse suppliers
14] Hydroponics suppliers
15] Corporations
16] Nurseries
17] Farmers

The invention is not limited to the embodiment(s) described herein but can be amended or modified without departing from the scope of the present invention.
Claims

1. A plant growing unit comprising a growing chamber, within which is provided a plurality of plant holding means supporting a plurality of plants and supplying a fluid nutrient mix to such plants, said growing chamber being provided with illumination means, temperature control means, and means for supplying said fluid nutrient mix to said plurality of plant holding means.

2. A plant growing unit as claimed in claim 1, wherein said chamber comprises a refrigerated shipping container.

3. A plant growing unit as claimed in claim 2, wherein the temperature control means comprises a refrigeration unit or heat pump provided on the refrigerated shipping container.

4. A plant growing unit as claimed in claim 3, wherein the refrigeration unit or heat pump of the unit is powered by a diesel engine.

5. A plant growing unit as claimed in any preceding claim, wherein said chamber includes climate control means.

6. A plant growing unit as claimed in claim 6, wherein said climate control means is adapted to control one or more of the temperature, humidity and gas composition within the chamber.

7. A plant growing unit as claimed in claim 6, wherein water collected by the climate control means is used by the nutrient mix supply means.

8. A plant growing unit as claimed in any preceding claim, comprising a control system for controlling the illumination means, heating means, nutrient mix supply means and, where provided, the climate control means, to ensure optimum growing conditions within the chamber.

9. A plant growing unit as claimed in claim 8, wherein said control system includes a programmable logic controller.

10. A plant growing unit as claimed in any preceding claim, wherein the illumination means comprises a plurality of LEDs.

11. A plant growing unit as claimed in any preceding claim, comprising a 12v dc power supply.

12. A plant growing unit as claimed in claim 11, wherein said power supply comprises one or more batteries.
13. A plant growing unit as claimed in claim 11, wherein a motor, in particular a diesel motor of a refrigeration unit or heat pump, is provided for charging the one or more batteries.

14. A plant growing unit as claimed in any preceding claim, wherein said plurality of plant holding means is mounted on vertically arranged racks.

15. A plant growing unit as claimed in claim 14, wherein said racks are mounted on trolleys within the chamber.

16. A plant growing unit as claimed in claim 14, wherein said racks are suspended within the chamber.

17. A plant growing unit as claimed in any of claims 14 to 16, wherein said plant holding means comprise elongate gutters or channels within which a nutrient solution may be held.

18. A plant growing unit as claimed in claim 17, wherein an elongate cover member is provided over said elongate gutter, said cover member having apertures therein within which plants may be mounted.

19. A plant growing unit as claimed in claim 17 or claim 18, wherein a condensate collection channel is provided beneath said elongate gutter for collecting condensation which may form on the outside of the gutter.

20. A plant growing unit as claimed in any one of claims 17 to 19, wherein an air duct is formed on a lower side of the gutter for supplying air to plants located in the gutter.
**INTERNATIONAL SEARCH REPORT**

**INTERNATIONAL APPLICATION**

**PCT/EP2011/006111**

**A. CLASSIFICATION OF SUBJECT MATTER**

**INVENTIONS**

A01G31/02  A01G31/06  B65D88/74

**ADD.**

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

A01G  B65D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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Further documents are listed in the continuation of Box C.

*Special categories of cited documents:

*A* document defining the general state of the art which is not considered to be of particular relevance

*E* earlier application or patent but published on or after the international filing date

*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

*O* document referring to an oral disclosure, use, exhibition or other means

*P* document published prior to the international filing date but later than the priority date claimed

**DATE OF THE ACTUAL COMPLETION OF THE INTERNATIONAL SEARCH**

27 April 2012

**DATE OF MAILING OF THE INTERNATIONAL SEARCH REPORT**

09/05/2012

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016

Authorized officer

Forjaz, Alexandra
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