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What is a greenhouse

For the backyard gardening enthusiast, the health conscious or the believer in garden-fresh produce, the joy of being able to produce quality crop, personally tended, irrespective of the vagaries of weather would surely be a dream come true.

A greenhouse is a perfect solution to your desires to sink your teeth into freshly plucked veggies at a time of the year when foods labeled as ‘fresh’ also have attached tags of ‘frozen’ or ‘shipped directly from…’ (some far away place full of sunshine!). If you believe in the goodness of organically grown food or practically year-round availability of certain fresh grown foods, this greenhouse guide is for you. Not only can you think of edible things, you can also grow flowers when outside weather conditions do not permit a single blossom to show up above the soil. Imagine its happy colorful face nodding at you!

A greenhouse in your backyard or one on your farm would add a new dimension to your lifestyle, not to mention your health. Your greenhouse is not an oppressive or stifling heated room, rather it is your own personal garden paradise that allows you to grow vegetables, fruits and flowers even when the external environment is inhospitable to plant cultivation. It also gives you an edge when you prepare seedlings and plantlets that can be readily transplanted as soon as spring arrives.

A greenhouse is a structure, primarily of glass or translucent poly-film, polycarbonate or polyethylene sheets that allow sunlight through and in which microclimate can be controlled to grow crops largely independently of climatic and seasonal changes. Controlled microclimate means you can control the humidity, ventilation and temperature, thereby maintaining a conducive environment required by your crops. Here, plants grow well because they grow under protected and controlled conditions.

Science behind the greenhouse

Most plants require warmth and humidity to thrive. Both glass and plastic film are good at allowing sunlight to pass through into the greenhouse, but being poor conductors they do not allow the heat to escape back to the outside. This trapped heat is used to warm up the air and soil inside the greenhouse. Under ambient temperature conditions along with regulation of other factors, yield, vigor and nutrient value of crops increases several-fold.
Types of Greenhouses

A variety of greenhouse designs are available to suit individual requirements and individual budgets. From tiny window units to reasonably large free-standing structures in the backyard, you have plenty to choose from. If larger space is available, you can scale-up the free-standing variety to any extent you like. A home greenhouse can either be an attached structure which has a common wall with some part of the external wall of the house, or a freestanding structure situated a few meters from the home.

Greenhouses can be of several styles determined by the roofline, the presence or absence of sidewalls and finally the foundation. A bird’s eye view of the types of greenhouse would help you make the correct decision about what best fulfils your needs. Greenhouses are categorized into three basic types: attached, ridge or furrow greenhouses and detached.

Attached Greenhouses

Lean-to

When space is limited, a half-greenhouse is a good option. A lean-to’s ridge line is attached to the side of the house or garage and ideally has a doorway leading into the building. As they abut the main structure of the home, lean-to greenhouses have easy access to electricity, water and heat.

The height of the lean-to would obviously be limited by the supporting wall it abuts. Also, the supporting wall may hinder sunlight. You have to be vigilant that during winters snow or ice do not slide off the main structure of the house onto the lean-to.

Accessibility, lower cost and easy heating are the main plus points of the lean-to greenhouses. These greenhouses come with straight eave or curved eave designs.

Ridge or Furrow Greenhouses

These are attached by a common gutter only at the lower edges or eaves of the roof. In order to increase efficiency and maintain continuity by increasing the area under the greenhouse canopy, there is no division of the structure by inner walls. The roofs of these greenhouses can either be curved or gabled. The curved arches are preferred where flexible and lighter materials such as polyethylene or polycarbonates are to be used. The gabled roof generally uses heavier materials like glass or fiberglass.
**Even-span Greenhouses.**
An even-span greenhouse is a graceful structure that can be installed as an attached structure or a free-standing one. In the attached variety, it has one gable end attached to the wall of another building. It is usually the largest of the garden greenhouses and can be lengthened as desired. This is of value if you start with a fixed budget and decide to up-scale the project later. It has the capacity to accommodate two to three benches for crop production and beats the lean-to in availability of usable space and better shape and size to maintain optimum temperature and ventilation. An efficient even-span greenhouse would have dimensions of 6 feet by 12 feet in width and length respectively.

**Window mounted Greenhouses.**
These are the smallest of all the greenhouse enclosures available and are great for hobbyists. They are window mounted and contain two or three shelves that can accommodate a few choice plants. These are relatively low cost and require very little time and effort on your part.

**Detached Greenhouses**
Detached greenhouses are stand-alone or independent structures. These do not share any common wall with your house. The advantage a detached greenhouse offers is that its size can be comparatively larger than that of the attached varieties, and it depends on your ability to manage your greenhouse that determines its size. Not being encumbered by shadows of an abutting wall, they receive more sunlight. A word of caution is in order here; being larger, these greenhouses may need greater investment with regard to electricity, ventilation, irrigation and heating as well as personal time.

**Quonset Greenhouse**
Quonset greenhouses are an inexpensive option for the garden enthusiast. Their cost is limited due to use of polycarbonate or polyethylene coverings stretched over a hoop that looks like an inverted ‘U’. These are the least expensive of all greenhouses. Being arched, Quonset greenhouse is low and restricts storage as well as headroom.

**Gothic Arch Greenhouse**
Gothic arch greenhouses are similar to the Quonset. They are made up of two separate curved pieces that meet at the ridge line of the roof. Their walls show a less pronounced curvature. As a result, compared with the Quonset, these offer better space and headroom along the walls and the design lends itself to more efficient ventilation. The Gothic arch style is preferred for its aesthetic appeal by many greenhouse owners.

**Classic A-Frame Greenhouses**
These are so called because of their shape that looks like the alphabet A. They are very simple in design and can be assembled on the ground in sections before being lifted up to be erected. They have slanting panels that meet at the top in the center ridge. The advantage is that the sloping walls are good for dealing with snow, but this design compromises on usable space. They also consume more energy for heating due to their high ceiling.
Modified A-Frame Greenhouses
Shaped like a typical house, these greenhouses have straight high walls with wide A-shaped roof whose slope is much less steep as compared to the classical A-Frame. These have gabled roofs without eaves. They are less expensive to heat than the A-Frame because the slope of the roof is not so steep. The straight walls increase usable space and provide headroom.

Barn Style Greenhouses
This has upright walls and with an eave at the roof’s edge that connects the roof to a sidewall. It has more headroom as the peaked roof slants to meet the eaves. The straight walls also provide more choice for placing vents appropriately. Barn style greenhouses may be straight or slant sided. The slant sided barn style offers a wider sunny span.

Dome Greenhouses
These are detached greenhouses that are semi-circular in design. They have the advantage of offering minimum wind resistance and allowing maximum light transmission.

Cool, Warm and Hot Greenhouses
Greenhouses may also be classified specifically keeping temperature that you wish to maintain in mind. There are several types that include the cool, warm and hot greenhouses. Each of these may have various types of designs and equipment for temperature maintenance.

In a cool greenhouse temperature never falls below 40 degrees F or 4 degrees C. An advantage is that you can propagate seeds, cuttings and seedlings in the cold greenhouse for early planting outdoors or within the greenhouse itself. You can also bring in susceptible plants to tide over extreme winter. The cool greenhouse is convenient and relatively inexpensive as heating costs are drastically cut. Just a basic greenhouse structure with insulation meets the requirement. These greenhouses need good ventilation and free air flow. During winters the plants should be sparingly watered or wetness may result in botrytis fungal infections.

A disadvantage is that it does not allow the same scope as a warmer greenhouse. This restriction can be overcome by picking the right kind of plants that are suitable for this type of greenhouse i.e those that do not need consistently high temperatures.

The warm greenhouses are those that have a temperature range of around 50 degrees F. These are good to grow certain perennials even through winter. Equipment for heating may be needed in extreme winter to keep the temperature at the designated level.

The temperature in a hot greenhouse should not fall below around 60-65 degrees F. These may require installation of equipment for heating and lighting. They are good if you are looking at growing exotic or tropical plant varieties that need consistently warm temperatures.
Solar Greenhouses
Though all greenhouses are designed to collect and use solar energy, solar greenhouses are specifically designed to trap and store thermal energy from the sun. This stored energy can be used later at night or when it is cloudy outside. Solar greenhouses can be in the form of gabled or arched structures, cold frames or even subterranean pits. Large scale solar greenhouses are usually freestanding, while backyard solar greenhouses are attached.

Solar greenhouses may be of two types: active or passive.

Passive Solar Greenhouses
Passive solar greenhouses work by absorbing solar radiation through glazing, converting it into heat and limiting its leakage back to the outside. Much of the sun’s energy is absorbed by plants which then radiate it back into their surroundings. This radiated heat is absorbed by surfaces such as soil, water, rock and other inexpensive materials. When temperature falls, these materials passively allow heat flow to the greenhouse environment to keep it suitably warm. No external energy is needed to maintain an ambient temperature in this type of greenhouse except in extremely cold conditions when electric or gas heating may be needed to supplement solar heating.

Active Solar Greenhouses
Active solar greenhouses also collect, store and deliver energy like the passive ones except that they need supplemental energy to direct the thermal energy from storage areas to the greenhouse environment. Of the two types of solar greenhouses, the passive ones are less costly.

Sun-pit Greenhouse
It is advantageous to think of using the natural warmth of the soil if you are looking at a greenhouse that does not place a major drain on your monetary resources. A few inches below the surface, the soil maintains a relatively stable temperature of around 50 degrees F. If you were to construct a pit greenhouse that is sunk into the ground to retain warmth, you would find that they stay up to 10 degrees warmer that a greenhouse built on the surface. The pit greenhouse may be freestanding or attached.

Sun pit greenhouses may also be made by planting the crop at ground level and building a 3 feet sunk walkway around and between the beds. You would need to line the walls of the walkways with ply.

Handy tip...
Maintaining your greenhouse requires a thorough annual clean-up operation. Autumn is a good time. Remove pots from a selected area, clean by brushing away dirt, scraping away stubborn debris, wash shelving with warm water and disinfectant. Be sure to get at all the cracks and crevices. Leave disinfectant for a while and then clean up by giving the hardware a good scrub with a brush and wash off with plain water.
Cold Frame Greenhouse
A really simple greenhouse for your garden would be the cold frame variety suited to the backyard. Cold frames, sun boxes and hotbeds are relatively inexpensive options. They are good when you want to grow cool weather crops in early spring, fall and even into the winter months. They work well for early planting of summer annuals and seeds, faster rooting of cuttings, starting perennials from seeds in summers, and protecting delicate plants in winters. The advantage of cold frames and sun boxes is that being solar greenhouses they do not need supplemental energy to heat them. You would need to ensure ventilation on hot days to keep plants from overheating. The design of cold frames has a south orientation with an opaque and insulating north-reflecting wall, and removable glazing. Cold frames work by trapping the sun’s heat during the day and also retain heat radiated by the soil during the cooler night.

Modern designs of cold frames increase efficiency by including excellent insulation as well as movable insulation. The latter is folded up during the day, but is pulled down at night or in cold weather. Other ideas for heat retention are the use of water-filled barrels painted black that are good absorbers of heat from the sun. They passively radiate heat back into the greenhouse environment at night due to the temperature differential.

Handy tip...

Follow a set routine to monitor your vegetables in the greenhouse:

- Visit your greenhouse at regular intervals during the day as far as possible; say each morning and early evening or whatever schedule suits you best.
- Keep a check on the temperature, especially mid-morning.
- Water the plants in the evening, but do not over-water.
- Make adequate arrangements to keep the greenhouse warm when it begins to turn cold in the evenings.

Handy tip...

Stack bales of straw or sacks filled with leaves against the top and walls of the cold frame during sudden cold spells to keep the temperature from falling to levels that could damage your plants.
Hot Beds

These greenhouses are heated from beneath by several methods. You could use fibrous manure buried under the roots of plants, steam-carrying pipes or electric cables laid in the soil.

Warming the soil is a good idea when you plan to give your plants an early start. It is more cost effective to warm the soil in such a case. With a warm soil, your plants will be better able to withstand low air temperatures thereby mitigating the adverse effects of cold weather.

In order to prepare plantlets for early sowing or keeping your more delicate plants, you can prepare warm propagating beds. Steam-carrying pipes are an expensive option as you need to lay down an array of pipes and also install a pump for the heated water to be circulated. With a boiler in the basement to heat water, it might be possible for you to consider this option, otherwise it is not advisable. Instead, you can go in for readymade plastic propagating trays or kits that you can plug into a standard wall socket. These trays have built-in soil warming cables laid into their floor and come with thermostat option that is of great value in maintaining temperature as desired.

Building a propagator that suits your needs according to the space available and the quantity of seeds you wish to propagate is not a difficult task. For the construction, buy standard equipment that is certified for quality. You will need wood, plastic sheeting, polythene covered with polystyrene, coarse sand, warming cables and a thermostat. Make a container of suitable size with a base and sides. The sides should be about 4 inches or 10 cm high. Spread a sheet of plastic sheeting to cover the base and the sides of the tray you have prepared to prevent damage by water. Next, lay down a sheet of polystyrene covered polythene over the plastic sheet. Follow it up by laying the warming cables leaving the portion to be plugged into the electric supply easily accessible. Complete the assembly by covering the contents of the tray with about 4 cm of coarse sand and installing a thermostat. You can place your pots and trays directly on the sand to keep them warm. Take safety precautions when you work in this area as remember you are working with electricity in a moist environment.

There is a huge variety of greenhouses that one may choose from. The basic principle to remember is that all greenhouses work on the principle of providing a protected, warm and controlled environment for growth of planes. Your individual choice of the type of greenhouse you wish to set up would largely depend on several obvious factors. Budget, recurrent expenditure, personal time you can give, purpose of your greenhouse, types of plants you want to grow, general climate, your location, water availability, and available space are a few factors that you would want to think about while choosing. Type of greenhouse and its design is largely a matter of personal preference.
Setting-Up - Material, Equipment and Accessories

The variety of greenhouses and greenhouse material, equipment and accessories are astounding. However, there are certain basic materials that are needed.

**Structural framing materials** include low maintenance non-heat conducting timber; strong and durable galvanized steel; or light, low-maintenance and sturdy aluminum alloys. Though plastic pipe frames are usable, they are not very strong to withstand snow load or wind sheering forces. What you choose as the framing material would be determined by the material you wish to use as glazing, your budget and the permanence of the structure you desire.

Aluminium is a popular material for greenhouse framework because it is relatively lightweight, rustproof, affordable and easy to assemble. The downside is that it is not a good insulating material and in very cold weather, heat loss from the metal frame could inflate your heating bill. Also, you would need to look for sturdy frames if your greenhouse is located in an area that experiences high winds. Condensation could also occur on an aluminium frame.

Wooden structural frameworks for garden greenhouses are also a popular choice for its aesthetic value, natural feel and the ‘warmth’ it exudes. It is an easy material to work with especially if you are not using a greenhouse kit for building. Some greenhouse owners would settle for nothing else as they believe it is the only material that complements the natural beauty of plants inside the greenhouse! Wood is a good insulating material so it will not allow heat loss in cold weather. Reinforced wood has superior strength and has an excellent load bearing capacity. Being a natural material, it has the potential to develop mildew or disease and offer a haven to tiny pests. So, when you choose wood to build the framework of your greenhouse, be sure that you pick a high quality hardy wood such as redwood, cypress or cedar. Also, treat wood with non-hazardous chemicals so that your plants are not adversely affected. The preservatives used for wooden greenhouse frames should be pressure treated, salt type or copper naphthenate. Copper naphthenate is a general use preservative used for pressure treating utility poles and timber. It is known to be very effective in preventing mold, mildew and dry rot. It works very well against wood-damaging fungi and insect pests. Pentachlorophenol is a restricted use wood preservative and is toxic to plants and humans. It is not available to the general public and poles or timber treated with it are not suitable for use in a greenhouse.

PVC pipe can also be used as support for small greenhouses that are to be covered with polyethylene, but PVC requires additional support to withstand strong winds. Being flexible, PVC can be used particularly well in hoop houses. Though it has the advantage of offering insulation and, if UV treated, are long-lasting, they are not good at bearing the load of hanging baskets and shelving to any appreciable degree. PVC that is treated to be resistant to ultraviolet radiation is also known as UPVC.

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**Handy tip...**

*Roof pitch of a glass greenhouse should be 27 degrees as this is ideal to prevent condensation that forms inside from dripping on plants. A 27 degree pitch translates to a six-inch rise per foot. Greenhouses covered with plastic glazing need a steeper pitch of 7 to 8.5 inch rise per foot to prevent dripping.*
Another option for greenhouse framing is Solexx. These greenhouse frames have excellent structural strength being made of combination composite tubing, steel and PVC. The advantage of using these is that while composite tubing and steel provide amazing strength, PVC provides insulation and minimizes condensation on the frame. The Solexx greenhouses have no trouble with harsh winds or weather. In addition, they are also easy to clean.

**Handy tip...**

*Treat with safe preservatives all wood including redwood and cedar wood that you plan to use. Copper or zinc based preservatives are generally considered safest.*

Covering materials or glazing material you pick must be durable, low-maintenance, allowing for best light transmission and least heat loss. You need to keep these factors in mind over and above aesthetic appeal. Covering options use glass or plastic of various types. You have a choice of polycarbonate panels, polyethylene sheets, rigid fiberglass, or plastic films – each with its unique advantage or disadvantage. You would need to match the framing material with your choice of covering. Generally, double glazing gives a good result with heat retention.

During winters when natural light is reduced, there is a direct analogous reduction in plant growth. So, a covering material that has good transmission properties is a desirable choice. Common glazing materials transmit about 80-90 per cent of the light that is incident on them. Materials such as glass allow for direct transmission of light while other materials allow diffuse light transmission. The diffuse light creates a more even distribution of light than does direct light which is characterized by sharp areas of illumination and shadow.

**Glass** is the traditional covering material for greenhouses. Glass used for greenhouses today is tempered to augment its strength. Glass is great for direct light transmission and durability. The tinted varieties reduce transmission of light significantly, though they correspondingly reduce heat loss as well. Glass may prove to be an economical choice in the long run, but initial installation costs are significant. Also, though tempered glass is strong, it is not completely hail-proof and there is a risk of shattering.

Glass is traditionally used in greenhouses for its excellent light transmission and though it allows about 94 per cent light to go through, being a bad heat conductor it retains heat and can cause rapid heating of the internal environment. This is good news in very cold winters, but it could ruin your plants in hot summers. So, ventilation and temperature control become critical factors in this regard. In addition, glass is a lot heavier than some of the other glazing materials available and so, you would need a correspondingly sturdy framework to hold it up securely. Generally, heavy frameworks translate into heavy investments too. You have to be extra careful in transporting glass as it is fragile in this regard. This is not to discourage you completely from opting for glass, it does have its advantages. Its light transmission in excellent, no other glazing is as durable and glass in the long run, and if you
can avoid breakage, there is hardly any maintenance needed. As it comes as panels of convenient sizes, you would need to replace only the individual damaged panels without any effect to the rest of the glazing. Plus, the aesthetic value of glass is incomparable. Your greenhouse would look as beautiful from outside as inside!

**Polycarbonate** is an increasingly popular choice for greenhouse coverings due to its many desirable features. It is very strong with high impact value, hail-proof, clear to allow excellent transmission of light, reasonably flexible so that it can be bent, and is less flammable than other plastic materials. It comes as single, double or triple-wall structured sheet. The single wall polycarbonate sheets are available as corrugated sheets in matte and clear varieties. The polycarbonate rolls available for greenhouses already come with a coating of material that reduces dripping of moisture. Polycarbonates tend to expand or contract with temperature changes and installation must be accordingly done to allow for this feature. Single sheet variety can be installed with screws and rubber gaskets, while the multiple-layered sheets can be secured to the frame with aluminium extrusions. Aluminium tape is used to seal the top and bottom of the sheet to prevent entry of dust, insects or algae. Polycarbonate sheets score over plastic films in their estimated life span which is around 15 years or more as compared to plastic films for which it is around 4 years. Glass, of course, outlives both at a life span of about 25 years.

**Plastic films** are good options especially for hoop houses as they are very flexible. They are available in varying grades of quality. Plastic films are low cost, flexible and lightweight. If you opt for these films, your overall structural costs go down because you need lighter frames to support these. Woven polyethylene films are extremely resistant to tears. Sheets designed especially for use as coverings of greenhouses are UV stabilized, have light transmission comparable to glass and last for about 4 years. Once properly attached to the frame they can withstand a good deal of the shearing force of the wind as well as heavy snow or hail. Another attractive feature is their additional ability to reduce heat loss due to the presence of infrared inhibitors that keep heat inside. The plastic films are made with anti-drip surfaces that prevent condensation of moisture on the film. The 6mm UV stabilized film is standard for greenhouse use, though you will find films of various thicknesses in the market. Polyethylene is the most inexpensive covering for a greenhouse.

The plastic films include polyethylene films, PVC or polyvinyl chloride sheets and copolymers. Polyethylene lasts much less than the PVC or copolymers which last up to five years. These usually cost much more than polyethylene. UPVC is a rigid plastic material that was first used in the construction industry. UPVC has the potential to be used as glazing as well. It comes as standard units of double glazing, as custom made prefabricated panels that are brought to the site ready to be simply bolted together.
Ordinary utility polyethylene that is not UV stabilized can be used as glazing too, but if you are going to build a greenhouse glazing is not one of the areas you should be economizing on. Utility polyethylene would last you about a year. Glazing is critical to the performance of a greenhouse, so you should opt for one that is specifically designed for use in greenhouses. Earlier, polyethylene sheets were too fragile, prone to easy tearing and damage by the rays of the sun. Not only this, they also allowed condensation to occur on the inside walls of the greenhouse which attracted dirt, grime and resulted in diseases breaking out in the greenhouse. The polyethylene available for greenhouses addresses all these issues, but it is still the glazing that requires most frequent changing. Being the cheapest option in glazing, polyethylene is an attractive choice, but do study other glazing materials before you zero in on this one.

Other than the coverings discussed above, fiberglass and acrylic coverings are also available, though these are losing popularity and are being increasingly replaced by polycarbonates or plastic films. fiberglass is treated to have a coating of plastic resin over glass to create fiberglass reinforced plastic or FRP. This coating tends to erode with the passage of time – in about seven to ten years - leaving the underlying glass exposed to dirt, grime and dust. Accumulation of these significantly affects light transmission. You could get the covering recoated, but that would involve the laborious process of washing and cleaning the discolored sheet and then overlaying it with a single layer of plastic resin by painting.

Acrylic sheets that are double-layered and used as coverings are longer lasting than polycarbonates. However, they tend to yellow with age thereby reducing light transmission. Some disadvantage with these is that they are flammable, cost more than polycarbonate sheets and are not hail-proof. Acrylic sheets lose to polycarbonates in other areas too – they are easily scratched and gather grime and dust more easily. In addition, these sheets are not as flexible as polycarbonates and therefore are generally used on flat straight surfaces; the method of securing them being quite the same as in case of the polycarbonate sheets. They too need to be secured allowing scope for expansion.

Insulation is an important consideration for those who build their greenhouses in areas with severe winters. Double or triple glazing is very useful in improving insulation. Up to 30% heat loss can be reduced by choosing double glazing over single one. A triple glazing would reduce the heat loss by 50%. This is initially expensive, but evens out and is in fact advantageous in the long run if you need to heat your greenhouse throughout the winter. Polyurethane and polystyrene insulation boards are very effective when placed on the side and end walls up to the height of the benches. A cheaper option for the winters is to place bags of heat retaining material straw and dry leaves along the outside of the greenhouse. Thermal blankets are also available which are hung up like curtains that are to be drawn during the night.

Thermal systems and heating equipment, control systems such as thermostats or sensors, shading material have to be chosen according to the plants you want to grow, the size and shape of the greenhouse, the covering material, and the climate. Heating systems in a home greenhouse work either by heating through hot water or by directly heating the air. While heating systems may be based on electricity, gas, wood or oil, it would be a good idea to install an air circulation system so that uniform temperature is maintained throughout the greenhouse. In absence of air circulation the lighter warm air tends to rise to the top and cooler air settles nearer the ground. It would be advisable
to invest in automated control systems, especially if your area is prone to weather fluctuations. Manual monitoring if possible is fine, but requires you to be on your toes all the time.

Heating by electric heaters works well where climate is mild and there are few cool nights to face. If you are in a region that faces severe winters, the cost of the electric heaters becomes prohibitive for a larger greenhouse. If an electric heater is the suitable option for you, look for one with an in-built thermostat and fan.

Kerosene heaters need to be vented to the outside to allow the fumes to escape. Though usable, these are no longer preferred.

If you are building an attached greenhouse, extending the home heating system to the greenhouse might be worth exploring. If you have a boiler based system, it would need to be checked out for capacity. Also, several add-ons would be necessary to make the system work. You would need to install piping, pump, thermostat and radiators.

Gas heaters are cost effective floor mounted units that come with a thermostat, a safety shut-off valve and an integral fan. Units with mechanical thermostats are also available which do not need electricity to run.

**Lighting systems** would also depend largely on the type of plants you want to grow and your location. Lighting for plants is not merely about being able to view them or to substitute daylight hours on overcast or cold winter days when the sun is supposed to be out. Light plays a critical role in plant growth, budding and flowering. The type or wavelength of light, its intensity and its duration are critical to plant health. So, your choice of grow lighting systems for your greenhouse plants is something you must take very seriously. Spend some time finding out about light requirements of different plant types. Study and compare the lighting systems available and weigh the pros and cons before you settle for a particular type.

A variety of horticulture lighting systems can be found in the market. Their basic function is to provide your greenhouse plants with light that is the equivalent of sunlight when sunlight is not available. The purpose of supplementing sunlight is to extend the growing season, to start plants early, or to induce flowering. If you plan to maintain a regular supply of your favorite vegetables, herbs or flowers throughout the year, you would need to explore the light requirement of your plants and supplement it with artificial grow lights when necessary.

Horticulture lighting systems are of three types. These include the High Intensity Discharge or HID systems which comprise Metal-Halide or MH lights that produce light mainly in the blue spectrum, and the High Pressure Sodium lights or HPS lights that produce light predominantly in the red-orange region. The MH lights give out white light while the HPS lamps give out a yellow colored light. Light in
the blue spectrum region promotes vegetative plant growth meaning it is good for foliage development and keeps the plant compact by allowing proportionate overall growth. The orange-red area of the visible spectrum is critical for inducing budding and flowering. The HID lights are energy efficient and give good results.

Another type of lighting system available is the Fluorescent lighting system. Fluorescent lights emit more of the usable light for plants. They are relatively ‘cool’ lights because they do not generate nearly as much heat as either the incandescent lights or the HID lights. As a result, you can place these lights a lot closer to the plants because they will not damage foliage by scorching it. These are good for herbs and vegetables, as well as for starting seedlings and cuttings.

The third type of grow-lights available are the incandescent varieties. Though they are the most inexpensive option you can find, they are also the least effective for plant growth and are inefficient in terms of electricity consumption. Incandescent lamps are completely avoidable in your hobby greenhouse if you have better choice available to you.

A new type of lighting system that is being explored now-a-days is the LED system. Touted by manufacturers to be the most efficient in performance and least damaging due to being a ‘cool’ lighting system, these however, have not yet shown any significant advantage over the fluorescent lights which are a lot cheaper at the moment.

Your choice of lighting system would not just be based on the needs of your plants, but also on their performance output in terms of the wavelength of light they make available to plants, the light intensity or brightness which is measured in a unit called lumens, and the best use of electricity. You don’t want be shocked with the electricity bill at the end of the month! Wattage and efficiency of the various types of lighting systems are compared and elaborated in a subsequent section.

Fastening materials to hold the covering in place and also to put together the structural frame-work consist of clamps, screws, fasteners, and adhesive tapes. You can know more about fastening glazing to the framework under the heading ‘Building a suitable greenhouse’.

Ventilation is an essential part of plant cultivation inside the greenhouse. It is simply the practice of replenishing and replacing air inside the greenhouse with the air outside. Ventilation has multiple purposes. It is an important way of controlling temperature, humidity and maintaining levels of carbon dioxide in the greenhouse environment. Ventilation requirements vary with season and weather. You could opt for a natural ventilation system where vents are located on the roof along the ridge line. Side vents or louvers allow cross-flow by allowing lighter warm air to escape through the roof vents and pull in fresh air from outside through the side vents. Mechanical ventilation makes use of exhaust fans to throw out inside air which is replaced with fresh air channeled through inlet louvers on the opposite walls. The choice of the size of exhaust fans could be a critical factor for larger greenhouses; the thumb rule being that they should have the capacity to exchange total air volume inside the greenhouse every minute.
Cooling may need to be done where summers are hot as ventilation may not be sufficient. Excessive heat build-up may cause wilting of plants and cause scorching. To prevent this, evaporative cooling, screening, shading, and ventilation are viable options. You may also need to use screening and shading to limit light intensity on very hot days.

Shade cloth is a good choice to invest in as they are cost effective and light-weight. They are generally woven of polypropylene, polyethylene or polyester. You can choose from those that cut light transmission from 5 to 95 per cent. If you are not sure about how much shading is suitable for your greenhouse, go for a shade cloth that provides 40 to 60 per cent shading and covers the entire roof area. Be sure to purchase shade cloth that has grommets for easy attachment. Be sure to avoid covering roof vents when you install the shade cloth. Secure the shading material by using nylon cord or tie-downs.

External shading can also be done by use of blinds that can be retracted on cloudy days. You have several options for blinds; aluminium, bamboo or wooden slats will all work well. Another option for shading is to spray on, paint, or roll shade compounds available in the market. Begin in late spring with a single layer and add another layer as it gets hotter in the summer. These materials wear away by themselves as the summer wanes. Any remnants can be removed using clearing compounds available for the purpose.

The fact that evaporation of water causes cooling is used in cooling systems that work on the principle of evaporative cooling. Evaporation depends on relative humidity and air temperature. Water takes up heat from air to evaporate thereby bringing down overall temperature in the greenhouse. An associated benefit is that humidity rises in the greenhouse. Evaporative cooling is known to be most effective when the relative humidity is around 60 per cent. Several methods are available for evaporative cooling. Popular among these are misting, fogging and fan and pad systems.

Fogging systems are effective because of their ability to cool the greenhouse environment uniformly while correspondingly increasing the relative humidity. The foggers installed in the greenhouse above the plant canopy release tiny droplets of water, no more than 10 to 20 microns in size, which are suspended in the air. These are so tiny that they pick up heat from the air and evaporate before hitting the leaf canopy. The pressure at which the droplets are released needs to be monitored. You do not want water droplets coating the leaf canopy as this would lead to increased incidence of pests and disease. Fogging systems must be properly maintained and periodically checked.

Misting works in much the same way as fogging except that the droplet size is much larger being in the range of 100 to 200 microns. Misting is used when weather conditions are too hot or too dry so that frequent spraying becomes mandatory to lower temperature and increase humidity inside the greenhouse. As the droplet size is much larger as compared to fogging, being heavier, these droplets do not completely evaporate before hitting the leaf canopy. You will find a coat of wetness and moisture on the leaf canopy as a result. This is potentially risky as it could promote incidence of disease among the crop. In order to avoid this, you have to carefully monitor frequency of misting in your greenhouse.
Another method to cool the greenhouse consists of installing exhaust fans on one end of the greenhouse with porous pads that are constantly being wetted installed at the opposite end. As the exhaust fans continuously pull out air from inside of the greenhouse and expel it outside, a corresponding inflow of air is maintained through the wet pads at the opposite end. As external air passes over the pads, it cools down and carries moisture into the greenhouse thereby cooling it. Though the fan and pad systems are effective, they are on the expensive side and are difficult to maintain. Associated disadvantage of this method is that it does not ensure uniform cooling due to the setting up of a temperature and humidity gradient across the greenhouse, the coolest area being near the pad end and the warmest at the fan end. The constant draught created due to the air movement may further compromise crop quality.

**Watering Systems** available are again of various types depending on requirement. You can always hand water your crops provided you are available for watering. However, automatic watering systems are a good investment if frequent watering is needed over short periods of time. Watering systems are also used to deliver fertilizers or pesticides as required. Timers and mechanical evaporation sensors can monitor and control timely watering. Misting, spraying, drip irrigation or simple watering kits are all options you can explore. Drip irrigation systems are excellent for delivering the right amount of water directly to plant roots as also to minimize water wastage. For regions where water restrictions are a chronic phenomenon, this system may serve you well though it needs more investment to install.

It is ideal to have a water source close to your greenhouse. If this is not possible, invest in a good hose with a suitable nozzle if you plan to opt for hand watering. If your greenhouse is not too large, you can opt for a watering can of reasonable size. Make sure it is large enough not to require too frequent refills and is not too unwieldy for you to lug around your greenhouse.

You have another choice of using capillary mats that work on the simple principle of conducting water from a reservoir to the plants through the bottom of the troughs, trays or pots. It is a good way to keep seedlings appropriately moist.

**Foundations** of your greenhouse have to be chosen based on your location, the type of greenhouse you plan to build and the materials to be used for construction. The important thing is that the foundation should anchor the greenhouse firmly to the ground and should provide a level patch to

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**Handy tip...**

*Cooling the greenhouse involves striking a balance between shading, ventilation and humidity. All three factors need to be controlled to the right degree for effective cooling.*
keep the structure strong. If you live in an area that sees severe winter and frost, or if your soil is too loose to provide a solid base, concrete foundations are a good choice. Alternately, your greenhouse may rest on piers and posts that reach below the frost line. A poured or slab concrete foundation provides flooring as well as structural support to freestanding greenhouses that are built in regions with very cold winters. For milder climates, a foundation of concrete blocks and piers is suitable. Wooden foundations that are easy to install and are inexpensive are available for small greenhouse (less than 12 ft x 20 ft). You may need to provide additional strength to this foundation with help of anchor stakes in windy regions.

**Flooring** is already done when you opt for a concrete slab foundation. If you plan to use your greenhouse mainly for starting seeds, the clean environment provided by concrete walkway or flooring is a plus as it reduces chances of infection that could be spread from open soil areas. In addition, once this type of flooring is in place, maintenance is reduced to periodic cleaning. The concrete flooring has the ability to absorb heat and radiate it back to the greenhouse environment when temperature differential comes into play.

In absence of a poured concrete slab or walkway, flooring can be made of brick, flagstones or raised slats. For a brick walkway, layering the walkway with landscape fabric is done to prevent growth of weeds. This is followed by layering with lumber, crushed rock, sand and finally bricks to give easy access to plants. Gravel can be use to cover over any additional floor area. Laying a flooring of rock works well too, if you also add gravel to drain off excess water. It should be kept in mind that whichever option you choose for flooring, be sure that the material has sufficiently rough texture to prevent slippage while you walk. Also, all flooring should be laid such that water does not accumulate on the walkway.

**Greenhouse accessories** other than all those mentioned above include benches, shelves, work platforms, tools, pots and containers, plant supports and sundry other things that make the greenhouse a workable unit.

Benches are the largest structures you will put in your greenhouse. Their placement, size and design will greatly determine the overall output of the greenhouse. Benches you put in your greenhouse must be practically chosen so that your plants get maximum light, sufficient growing room and best display area. Bench design or placement should not obstruct air flow or sunlight. They should be designed to stand to a comfortable height for you to work upon and their width should be suited to your reach. The standard height is around 30 inches with a width of 2 to 3 feet. The slats are usually cut to 4 inch width and a space of one inch is left between slats. The benches should comply with simple safety standards so that you are not injured by projections, jagged areas or sharp edges. Bench strength is an important criterion while choosing and be sure to zero in on those that are sturdy with good load bearing capacity. They should not sag when loaded. The benches you choose must be resistant to damage by water, rust and general wear and tear.

Benches for greenhouses can be purchased from the market and you have the choice of wood, plastic or metal. If you wish to customize the benches to your unique requirement of space and style, you can build them yourself with the right kind of material. Redwood that is pressure treated works well and
has a long life. If you plan to use capillary matting in your greenhouse, aluminium would be a more appropriate choice because it is resistant to water damage as compared to wood. Special aluminium capillary matting benches are also available in the market designed specifically for placing capillary matting on their surfaces.

Optimize space in your greenhouse by planning an effective and efficient layout for the benches. Arrangement of benches is usually done in a north-south direction as this ensures sunlight to all the plants as the sun moves from east to west. If this is not possible, go for an arrangement that allows maximum uniform exposure to sunlight in the greenhouse. Two common layout plans in hobby greenhouses are the aisle or the peninsula arrangements. In the aisle layout, benches are arranged along the walls of the greenhouse with a central aisle. In the peninsula arrangement benches are arranges at right angles to the side walls with very narrow walkways between them and a central wider aisle. Both layouts work well depending on whichever you feel is more convenient for you personally.

You do not strictly have to opt for one or the other layout. Your choice of benches and their layout can be as individualistic as you like. You can plan for short benches or tall ones depending on what you plan to display on them. You can opt for a traditional material like wood or a modern material like plastic. You could go in for any readymade bench that suits your needs including racks of different types. You could make a style statement with ornate wrought iron benches or build customized benches of galvanized or plastic pipes if you want durable benches that shed water and soil easily, though they feel cold to the touch in winters. Aluminium shelving and benches are becoming more popular because, unlike wooden benches, they are long lasting, low maintenance, waterproof, lightweight and portable. However, they may not score very highly in the looks department when compared with wood. For conventional free-standing bench of slatted wood, you will need to build a wooden frame and top it with wooden slats. You would need galvanized nails, wood screws, paint and basic carpenter’s tools. Make an additional lower shelf where possible so that you have extra space to stow away tools, equipment or knick-knacks conveniently.

The area closer to the roof of your greenhouse remains warmer than the lower parts. It is an excellent space for sun-loving and heat tolerant plants. There are several ways you can use this space. It is easiest to attach hooks to the roof framework or roof support bars and simply hang up baskets. Securing shelves, rails or pipes to the greenhouse walls with brackets works well to create extra usable space where more plants can be accommodated. Whatever additions you make on the framework of the greenhouse would put additional load on it, so be sure that you do not exceed the safe load bearing capacity of the structure. Another idea to increase space is to use step benches. They make for eye-catching arrangement and display of plants. In any event, you would want your greenhouse to be orderly without being monotonous, so experimenting a little with various ways of displaying your plants without compromising on functionality and efficiency would test your creativity, besides being fun!

To keep your tender plants uniformly watered in dry and hot conditions, you could use benches specially designed to accommodate capillary matting. These special benches have raised edges and
capillary matting is laid out on the surface with a portion of it going over the bench into a trough of water. The way the capillary matting works is that its design allows its dipped portion to soak up water from the water trough and conduct it to spread out evenly throughout the matting. Pots placed on the damp matting in turn soak up water from it and provide it to the potted plant thereby fulfilling its water requirement effectively.

**Handy tip...**
Add soluble fertilizer to the water trough when you are away for a few days and have to leave your plants untended.

For tall plants making beds on the greenhouse floor works well. You could prepare beds by simply digging the floor soil and supplementing it with soil prepared for greenhouse plants. It would pay to think about avoiding water logging and finding ways to allow good drainage. A wooden frame with a plastic lining is also a convenient option. You can fill it with appropriate soil mix. While making floor beds, ensure that their width is so restricted that you are able to reach the furthest section without discomfort.

Supports for tall plants with slender stems and climbers with weak stems need to be provided. Wooden stakes and bunches of bamboo canes are easy choices for this purpose. You can also have horizontal or vertical supports attached to the greenhouse framework where necessary.

Pots, tubs, troughs and an assortment of containers are needed in your greenhouse. There are a number of choices for potting material. Clay pots are the traditional choice of potting container. They are stable, porous and therefore less likely to cause water logging. However, old pots that cannot be cleaned even with a hard brush to remove surface deposits, moss or other growth should be discarded as they are not only unsightly, but also a disease hazard. Plastic pots are less liable to breakage and need less watering. Tubs are good for a bunch of plants grown together or for shrubs. A layer of gravel at the bottom helps drainage. Be sure that drainage holes are present when you buy the tubs. Raised beds work well where soils are not well drained. Polythene sleeves are low-cost options and are easy to store. Peat pots are used to start plants before transferring them to soil. They can be buried into the bed directly as they are biodegradable. Plastic bags called growing bags with drainage holes or slits on the sides are filled with soilless medium for planting.
Building a suitable greenhouse –
size, material and other requirements

A plant lover would immediately understand the benefit a greenhouse represents. Whether you wish to grow vegetables and herbs all year round, prepare seedlings for early spring planting, bring your winter sensitive plants indoors to tide over extreme cold, or grow flowers for a regular personal or market supply, the greenhouse in your backyard offers you hours of quiet leisure. You could use it as a place to unwind with friends during cold winter months – the enveloping warmth and delightful greenery would do wonders to your mental health. Pottering around in the greenhouse ensures you get enough regular exercise too provided you do all the work yourself. Some people play music as they work in the greenhouse and would tell you that plants in their greenhouse grow with more vigor as a result!

Your greenhouse is your personal space and planning to build one requires thorough research and careful consideration. Building it need not be an expensive proposition. On the other hand, you could have a reasonably elaborate set-up. You could choose to have just a tiny window unit or a large structure in your backyard. You could plan to grow exotic tropical plants or off-season flowers and vegetables. In short, unless you are clear about several things, you will end up making the wrong choices! To be a successful green house owner and user, you need to keep in mind among other things the space available, choice of site, costs, permits needed, personal time you can dedicate, your home architecture and purpose of your greenhouse at the planning stage itself.

Making a checklist to address these concerns and think things through will really be valuable. Your checklist should include the following:

1. What should be the size of your greenhouse?

The size of your greenhouse would automatically be limited by the space available for you to construct upon. You should have sufficient space to accommodate all the plants you want and then some! There should be enough space for walkways and benches with some flexibility for scaling-up the operation. To maximize space utilization go in for hanging rods to accommodate hanging baskets. Ensure there is structural facility installed for putting up grow lamps and sidewall shelves. Choose a structure that allows you the flexibility to add-on to the original structure if you are a serious grower and feel that you would need more growing room later.

2. What is your purpose in setting up a greenhouse?

This is extremely pertinent because why you want a greenhouse and what you wish to grow in it will be important considerations with regard to kind of structure, foundation, framework and covering material you choose. You could desire to grow houseplants, prepare seedlings from bulbs or seeds for
early sowing, or perhaps grow flowers and vegetables all year round. In all cases, you have to identify the plants to be grown. Based on their requirements, the greenhouse style and design can be worked out. For example, for year-round flowers and vegetables, a greenhouse that allows high transmission of light with provision for warming would be advisable. On the other hand, houseplants do not need very strict parameters for light transmission. If your aim is to start seedlings for your external garden, you do not need an elaborate structure at all; a simple, relatively small and inexpensive set-up would serve the purpose as long as you have a covered structure that meets the basic requirement of warmth and humidity.

If you think you want a multipurpose greenhouse that allows you the choice of growing your favorite plants anytime, you would have to assess the needs of each category and incorporate the necessary features while planning the greenhouse. Once you are aware of what is needed, explore what works best to fulfill the needs. Features you would look at would also include ventilation, temperature control and irrigation systems other than the ones mentioned above. It would be best that your greenhouse is such that it can be adapted to your changing needs. It should allow you to adjust it and customize it as per your requirements so that you may grow a wide variety of plants in the same greenhouse.

3. How much time will you be able to spare on a regular basis?
A greenhouse requires you to spend time in it on a regular basis. Of course, there is some flexibility, but you do have to make room in your schedule to potter around your greenhouse frequently. When you set out to build a greenhouse, be truthful and realistic about how much time you will be able to dedicate to the greenhouse. Making grandiose plans that do not work out will cost you heavily.

4. Are there any local guidelines and laws that you should be aware of before you begin construction?
Generally, your area will have its own set of laws and guidelines for building and construction. You may need to obtain permits and show compliance with construction guidelines, especially if your greenhouse is classified as a permanent structure. It would be a good idea to confirm whether construction of a greenhouse on your property would make you liable to pay additional taxes. Approach the responsible local authorities to find out what clearances you need before you start construction of any kind.
5. What additional heads should you consider apart from the construction costs while planning the budget?

Plan for costs of heating, irrigation and ventilation systems. If you are in a cold area, think about the cost of electrically heating the greenhouse. Can you afford it or would you need to cut down the size of your greenhouse so that electricity costs are not prohibitive? The covering material choice needs due consideration with regard to monetary investment as well as suitability. Factor in any additional taxes you may have to pay such as property tax. If you find that electrically heating the greenhouses over long periods is not feasible, consider alternatives such as solar heating.

6. What materials should you opt for?

To get best value for money, opt for materials that are strong and durable. Go for easy-to-maintain frames as far as possible. Though metal frames of galvanized steel and lightweight aluminium are good choices for durability, being metallic, they are good conductors of heat and can allow substantial heat loss from your greenhouse when there is a large temperature differential between the internal greenhouse environment and the outside.

Plastic frames have the advantage of being non-conducting, lightweight and low maintenance, but lose out on strength and load-bearing capacity. If are planning for a glass or fiberglass covering, these frames will not work. They will work with lightweight polyethylene or polycarbonate films. You should avoid using them if your area is prone to strong winds, heavy snow or storms as they do not provide as much structural strength as metal frames.

Timber is potentially a good choice for its non-conduction of heat. These frames do not cause heat loss during winters and instead retain heat. In summers they remain cool, not soaking up heat from the surroundings. These frames are sturdy and hardy with very good structural strength. Hardwoods such as red or cedar wood that is pressure treated is long lasting. A big plus for timber is that it gives you the freedom of putting up secure temporary or permanent additional shelving, supports, work platforms or counters, hooks or rails that can be used to hang up plants, create storage space for accessories, and tack up screens for shading in summers or insulating materials in winters.

Apart from the framework, the glazing material is also a critical choice. Whatever material you pick, it should be scratch-proof, reasonably durable and should have high impact value. Storms, snow, hail and extreme weather are not the only things that can damage the glazing, you don’t want damaged glazing because kids in the neighborhood were playing ball! Be sure your greenhouse is safe from damage by regular daily activities that go on in your neighborhood.

Glazing is the material you put over the framework in your greenhouse to form an enclosed space. Materials for glazing have already been thoroughly discussed in a previous section above. So, here we will just add a few more pointers while choosing glazing. Polycarbonates are by far the most popular choice from the standpoint of durability, strength, value for money and ease of use. Double wall polycarbonates are preferred and they score well by meeting all the critical parameters of a good covering material. They are lightweight, allow for excellent light transmission, flexible, easy to use and
transport, shatterproof, warmth retaining and do not catch fire easily. Choose polycarbonate sheets that have been treated to have a UV inhibitor coating on the exposed surface.

If you are going in for glass, be sure to research whether you would need to put up shading during summers and insulation during winter. Glass comes in panes of various sizes. Larger panels allow greater light transmission as structural supports cast fewer shadows. However, smaller panels do not significantly inhibit light transmission, so you can take your pick according what you feel works for you.

Covering materials that diffuse light are considered more effective because they ensure a more uniform distribution of light. Triple layered polycarbonates seem to be garnering the most votes as covering choice. They are stronger than either glass or plastics, have high impact resistance and are flexible which makes them less prone to damage.

7. What would you need to attach the glazing to the framework?

Glass glazing can be secured to the frame by using an underlying plastic strip under the glass and securing the two with metal clips at regular intervals. You may have to use bar-capping consisting of a continuous strip of metal to secure glass glazing in places that are subject to strong winds.

Poly films can be attached to arched frames using poly channel locks. Poly channels consist of silver colored rails that can be bent and secured to the arched frame. A wavy metal strip also called the insertion clip is used to secure the poly film to the channel which is already attached to the frame of the greenhouse. The poly film is secured in such a way that when replacing of film becomes necessary, you just have to remove the insertion clip, replace the film and replace clip by inserting it into the poly channel lock.

Usually, when you buy the framing and covering material for your greenhouse, the accessories to secure the glazing to the frame would be included in the package. However, it pays to know about the terminology and uses of covering accessories.

Tube lock systems are easy to install and are used to secure poly films to the greenhouse frame. It consists of tube lock bases and extruded aluminium tube lock clips that come in varying lengths. You can pick a length that you find convenient. Poly film is placed on the installed tube lock base and then the tube lock clip is inserted into the base sandwiching the film in between. Tek screws are used to clamp down the base and clip combo.

A spring lock base and clip section is an economical fastening system. The spring lock which is a wavy piece with slight flexibility goes on top and neatly holds down the poly film to the base of the fastening system. The top spring lock comes in varying lengths and you can pick between PVC and galvanized spring tops. For wooden frames, a polypropylene adhesive tape is available to attach poly film in conjunction with a tacker.

When polycarbonate sheets are used as glazing, no-drip spacers are inserted between the multi-layered polycarbonate panel and the building structure at the roof level. The insertions raise the
panels above the roof purlins to avoid condensate drip. The washers or spacers are made of neoprene which is a synthetic rubber resistant to abrasion and chemicals. It is waterproof and slightly stretchable making it ideal as no-drip spacers. You can use lap fasteners with screws to fasten overlapping polycarbonate panels. The fasteners come in an assembly made of lap fasteners and a self-tapping screw. You do not need sealants with lap fastener assemblies. To fasten polycarbonate panels to wood, you have a choice of wood screws of various sizes. Purchase wood screws that come with neoprene washers. If you are looking at attaching polycarbonate sheets to steel frame, you would need Tek screws with neoprene washers. Tek screws are multi-purpose screws custom designed for use as fasteners for different purposes.

Horizontal grooved, vertical or corrugated foam closures are useful to seal polycarbonate sheets along horizontal attachments, vertical attachments or corrugated horizontal attachments respectively. Top sealing aluminium foil tape is used to keep out dirt and moisture by sealing the top sections of the twin-wall polycarbonate panels, while another anti-dust tape seals the bottom portion of the panels. To join two polycarbonate panels that are side by side, you can use an assembly of aluminium glazing bar and cap.

Putting up shading would need grommet clips or snap hooks.

Other than the covering accessories mentioned above, a variety of clamps, hooks and clips can be found in the market suited to different covering materials and various frame types.

8. What other materials should I be aware of?

More fundamental to good growth than ambient temperature and optimum moisture is the growing medium you provide to your greenhouse plants. Potting mixtures and soils available in nurseries and gardening stores come in huge varieties, each with its own claim to excellence! In general, any soil or potting mix you use should have some basic features with regard to texture, moisture retention, aeration and nutrient composition. The soil should have good moisture retaining capacity without getting water-logged, it should drain well, should not compact tightly, have a good mix of macro and micronutrients as well as organic manure and should be completely pest and disease free.

Growing media available for plants are of three basic types. Additions of other components can be made on a need basis.

- Garden soil dug up directly from the garden may contain pests and weeds. It may not have the best texture, water retention ability or nutrient composition. It is advisable to mix garden soil with peat in a 4 to 1 ratio to promote drainage.

- Soilless compost does not rely on presence of loamy soil. Loam may itself show variable quality and a good quality loam is not easily available. As a result, gardeners go in for composts based on peat or a mixture of peat and sand.

- Soil based compost is rich in fertilizers as loam soil free of pests, disease and weeds is blended with sand and peat to enhance texture, water retention and fertility.
Humus is a component of soil that is made of decayed and decomposed organic matter from biological source such as leaves, weeds and grass. Humus has a texture that allows a good deal of aeration to the roots and helps retain an optimum amount of moisture in soil. It is a stable component because it has reached complete breakdown stage. It is crumbly and has the capacity to hold and release water and nutrients as needed. Though it has some amount of trace elements, it is almost completely deficient in Nitrogen and Phosphorus, both of which are macronutrients for plant life. The value of humus is therefore more for its stabilizing of soil structure and enhancing soil texture than anything else. For this reason, you need not go overboard trying to get humus for your plants under the misconception that your plants just cannot do without it. In fact, what exactly is the composition of packaged humus that you can buy in gardening supply stores is rather debatable as it may come from different sources and means different things to different people – a soil scientist’s definition is not the same as a gardener’s. Humus practically has no value as a nutrient source for plants.

When gardeners talk of adding humus to the soil mix they generally refer to organic matter such as leaf mold or compost. The term altogether excludes the mineral requirements of plants. Humus can very well be replaced by more easily available substitutes such as peat moss. Other components are added to reach a mixture that is best suited for plant growth.

The requirement of soil mix ultimately is as varied as is plant variety! You can only try to achieve a mix that fulfils the fundamental conditions of good drainage, water and nutrient retention capacity, aeration and texture. You often have to vary the components of the soil mix according to the needs of specific plant types. Some plants may need more sandy soils, while others would thrive in a particular pH range, and yet others may need a great deal of specific macro or micronutrients.

In addition, your choice of planting container also impacts your soil mix. For example, using terracotta pots as against plastic containers could affect the moisture available in soil.

The soil mix to be prepared then appears to be complicated affair and you are probably wondering how to go about it! Fortunately, guidelines are available that work well for a large variety of plants on an overall basis. A basic mixture that works with almost all plants can be made using organic matter such as peat moss or humus mixed with sand, perlite or vermiculite in a ratio of 3 to 1. For rooting of cuttings of most common plants, one part vermiculite or sand is mixed with two parts organic matter.
Plants that need a lower pH in the acidic range can be potted using one part vermiculite or sand and four parts organic matter. A mixture of organic matter and vermiculite or sand is good for rooting cuttings of acidophilic plants.

Plants that require good drainage such as succulents and most type of cacti do well with a mixture of two parts vermiculite or sand and three parts organic matter.

Orchids and tropical cacti need a mixture of three parts bark chips in addition to one part organic matter and one part vermiculite or sand.

Bone meal, cow dung, leaf mold and loam are variously added to meet specific requirements of plants.

Using the right potting mix for the right purpose and customized to the category of the plant, you can have the deeply felt satisfaction that your plants are getting the best they can. The difference will show up in the vigor of the plant, its foliage and number and size of blossoms or other produce.

**Handy tip...**

*Perlite is a silica based volcanic rock that has much the same features as vermiculite as far as agricultural and gardening applications are concerned. So, you can use perlite and vermiculite interchangeably in potting mixes depending on which is more readily available.*

**9. Which of the horticultural lighting systems would suit me?**

HID or High Intensity Discharge lights are extremely efficient and cost effective for the greenhouse owner. The Metal-Halide lights are good as a primary light source in absence of sunlight. An MH bulb would perform well for a duration of about ten thousand hours after which its efficiency would decline. You should change it at this point even if it has not burnt out. MH lights are nearly three times as efficient in converting electricity to appropriate brightness (measured in a unit called lumens) as compared with fluorescent lights. While standard fluorescent lights would give 39 lumens of brightness per watt of electricity consumed, MH lights would produce 125 lumens. Incandescent lights would produce 18 lumens for one watt of electric energy consumed. The HID lights come in low, medium and high wattage. The wattage determines the area illuminated by the light. The low wattage lights have a rating of 100 to 250 watts, the medium lights are between 300 and 600 watts, while the high wattage HIDs are up to 1000 watts and above. For the hobby greenhouse a 400 watt rating is usually enough with a primary illumination area of 5 feet by 5 feet.

**Handy tip...**

*Low wattage HID lights should be hung at a height of 2-3 feet from the top of the plants, medium wattage lights at about 4 feet, and high wattage at about 4-6 feet.*
The HPS or High Pressure Sodium lights are greatly suited for greenhouses because they are very effective as flowering lights when sunlight is absent or reduced. These have twice the lifespan of MH lights, but will begin to be less effective and will drain more energy as per wattage rating after about eighteen thousand hours of use. Their lumen rating also makes them a preferred choice. They produce 140 lumens of light per watt of electricity consumed. The only downside with the HPS is that it is deficient in blue light and causes vertical elongation of the stems of seedlings without proportionate foliage development. The stems are lanky and weak and you have to trim the plant back to the original size before the elongation spurt. To overcome this handicap, HPS lights can be used in conjunction with MH lights so that the plants get both the blue and the red portions of the spectrum in required amounts. Sunlight as primary source of light and MH or HPS as supplementary sources work well in sunlight deficient periods.

CFLs and T5 fluorescent lights are ‘cool’ full spectrum lights that have the advantage of providing the plants with the blue as well as the red components of visible light. They produce between 75 and 90 lumens of light per watt. They are cost effective and efficient and can be placed closer to the plants thereby more effectively delivering the light to the plant with negligible lumen loss. These lights are preferred for growing plants with low light requirements. They are also good for starting seedlings.

### Handy tip...

*Calculate the cost of running a lighting system in your greenhouse by using the following formula for running cost per hour:*

\[
\text{(Combined light wattage output/1000) x cost of electricity per kilowatt hour}
\]

*By multiplying the operating cost per hour with the number of hours the lights are used per month, you can get an idea of the running cost per month.*

### 10. How are foundations for greenhouses laid?

In order to make a foundation for your greenhouse, you must first know the dimensions of the external side of the base of the structure. As mentioned earlier, you can make foundations of wood, concrete slab, or concrete block.

For small greenhouses a wood foundation of cedar, cypress or redwood works well. These are naturally resistant to decay due to presence of certain naturally occurring chemicals in them. Another option that is available is pressure treated wood. It is sturdy, but is corrosive to aluminium. If you are working with aluminium shelving in apposition with pressure treated wood, use polyethylene, vinyl or plastic sheets as barriers. A 10 mil thick barrier sufficiently protects aluminium.

To make a concrete slab foundation, you must first decide whether your greenhouse would be an attached variety or the free standing type. If your greenhouse is going to an attached type, the finished
floor should be level with or a step or two below the floor of your house. In case you are going to build a free standing a greenhouse, the finished floor should stand a few inches above the ground level outside.

A floor that is three inches thick is sufficient for a home greenhouse. Having the outside edges a little thicker would provide support and strength to the superstructure. The concrete base should be laid so that it is larger by one inch on all sides as compared with the outer dimensions of the greenhouse.

For proper drainage, make a drain at the center of the slab that ends in a gravel pit or leads to the outside. As in the wood foundation, a base of gravel at least four inches deep should be laid and then covered with a moisture barrier to keep the foundation dry.

Before pouring the concrete, place lumber around the perimeter. The top should be level with the planned height of the finished floor. To increase the strength of the slab, you can add reinforcing wire or rebar and wire mesh if needed. Leave the concrete to set for twenty four hours after which you can remove the lumber. Placing insulating boards around the external portion of the foundation will help in retaining heat during winters. The insulation boards should be pushed in to a depth of one to two feet. To prevent heat escaping from the line where the foundation meets the greenhouse frame, it is advisable to use 2” x 4” wooden slabs of cedar, redwood, cypress or plastic composite lumber to act as insulating materials. (see picture below)

Now, the final step is to anchor the base of the greenhouse frame to the concrete foundation by using anchor bolts specially designed for the purpose. For proper anchoring, first bolt the structure at all four corners within one foot of each corner. Now, set additional bolts at a distance of four feet each and go all the way around the structure till it is completely anchored.

The concrete wall foundation is more suited to support heavier structures such as greenhouses with glass glazing. The concrete wall is set on a concrete footing or platform below the frost line. To build the concrete wall foundation, you would first need to excavate earth by digging a trench below the frost line, then place wooden bars to mark the boundaries of the platform, and finally pour a concrete platform. The footing should be twice as wide as the wall and equally as thick.

Let the base platform or footing harden before you place the wooden forms on top to pour the walls. The height of the walls should be at least six inches above the external ground level. Make drainage possible by digging drains around the perimeter. To improve heat retention, you could attach insulation board to either the inside or the outside surface of the walls. Now, fill soil to complete the foundation. Just as in case of the concrete slab foundation, making a wooden sill to act as insulation at the point where concrete joins the greenhouse frame, is advisable. Attach the greenhouse base with anchor bolts in the same way as for the concrete slab foundation.

A sidewall measuring 2 to 3 feet can be useful in providing additional support to the greenhouse. Though you can use concrete blocks for the sidewalls, stone or brick are more popular choices for their aesthetic appeal. If these clash with the look of your home, you can use any other structural material.
that works for you. People have used clapboard as well for the purpose, but it would be wise to stick to materials which are more structurally recommended for use in the greenhouse.
What can be planted – how to choose the crop

What you can grow in your greenhouse and in which part of the year will depend on your location and the prevalent season.

The purpose of your greenhouse is to create the perfect growing environment for the selected crops throughout the year. The greenhouse does not do this all by itself, of course! You, the gardener, have to make the adjustments for ambient temperature, ventilation, humidity, heating or cooling and then monitor each of these parameters for success in growing the plants you want to. With a little effort, you can grow vegetables in your greenhouse throughout the year.

Your greenhouse gives you the opportunity to grow different types of vegetables, herbs and fruit among food crops. You can use pots, planters, prepared beds, grow bags and even hydroponics to achieve amazing results. All food plants need consistent care, ample sunlight and ventilation, optimum soil moisture and feed in the form of fertilizers, constant watching for pests and disease, and finally, support to keep them from trailing on the floor. As most vegetables grow best at moderate temperatures, they can be mixed with a number of greenhouse plants.

You can grow food plants in containers as well as in beds. Both work well, but have different requirements as far as care is concerned. It is easier to manage and care for food plants if you use containers for perennial herbs and fruit plants, but a greenhouse bed for annual vegetables, herbs and bedded fruits like strawberries. Clay pots are ideal for perennial herbs because their roots prefer relatively drier root zones with minimum fertilizer input. You can use separate pots for different varieties, but it is possible to plant several of your favorites together.

Vegetables: When preparing beds for the vegetables and annual herbs, ensure proper drainage on a concrete floor by laying down slatted base under the beds or making a drainage pipe to channel away excess water. Cover these with aluminium screening to keep in the soil mix. Create more space by attaching trellises for tomatoes and cucumbers, and filling up the spaces between these as they grow by planting other salad plants below.

If you wish to do away with the mess created while preparing beds and growing mixes, you can simply buy grow bags that contain an ideal growing mix for vegetables and annual herbs. These are effective for a season, but get depleted thereafter. Also, the bags restrict room for root growth and the growing mix may get rapidly heated up on warm days. It needs more effort to keep the grow bags adequately watered individually.

The temperatures rise through the spring and into the summer. For the summer vegetables, a temperature beyond 95 degrees F can delay fruiting. Maintain temperature in your greenhouse with proper ventilation and cooling strategies. You need to be alert to pests at this time so, check your...
plants for incidence of infection or disease every few days. Immediately remove any infected plant from the greenhouse.

You can set out readying early crops by planting seeds as autumn progresses into winter. Plan your crops at this time so that you have them ready in early spring. Lettuce sown in late autumn or early winter will be ready in early spring to delight you in a fresh salad. Many herbs will do well in your greenhouse in the winter providing fresh flavoring ingredients in your cooking adventures!

**Handy tip…**

In a warm greenhouse, keeping the temperature from falling below 55 degrees F in winters is as important as it is to keep it from rising beyond 90 degrees F or so in spring and summer. So, you need to have both, cooling as well as heating strategies in place depending on the season. Tomato is a good example to illustrate that going beyond the recommended temperature range affects crops. As temperatures touch and go beyond 90 degrees F, tomatoes stop growing.

Most vegetables do well at temperatures between 55 and 90 degrees F. Starting time of seeds varies according to the vegetables being grown and the type of greenhouse you have. In warm greenhouses, you can start tomatoes as early as when winter just begins to lose its bite. Alternately, you can start out vegetables such as tomatoes, cucumbers, eggplants and peppers in early spring. It would be pertinent to remember that seasons vary according to your geographical location on the globe, so grow plants according to your local climate. The thumb rule is to ensure adequate heating in autumn and winter, and adequate cooling in spring and summer wherever you are located according to the requirements of your plants.

Sweet and chilli peppers can be grown in the greenhouse by starting seeds in spring and transplanting the seedlings into pots as they grow larger. It is delightful to watch the ripening sweet peppers turn from green to yellow, orange or red. Allow each variety to ripen before picking them. Beans, melons and squash can also be grown quite successfully in your greenhouse. Root crops like carrots, radish and beet can be grown throughout the year along with green onions. These are not heavy feeders and do not need much fertilizers. Salad greens such as lettuce can be grown in unheated greenhouses except in the peak winter months. These are heavy feeders and need regular fertilizers. It is advisable to look for seeds that are specially prepared for greenhouse production.

Aubergines or eggplants are warmth loving plants that can be started along with tomatoes and peppers. You should soak the seeds in warm water for a day before planting to stimulate germination. Seedlings are transplanted when they are around four inches in height. To make the plant bushier, you have to pinch off growing tips to curb apical growth and induce lateral shoots to develop. The plants have tender stems and need support as they grow.
Tomatoes are a greenhouse favorite! From tiny juicy berries to king size firm salad must-haves you can grow them to get a high yield as they are excellent as a greenhouse crop. When choosing the varieties for your greenhouse, go in for ones which are more upright and climb as they grow rather than varieties that go sprawling over the floor. Seeds are sown in early spring so that the seedlings are ready for transplantation by the summer. Use larger pots than eggplants; twelve-inch pots serve the purpose well. Tomatoes require regular high potassium input. As with eggplants, tomatoes too have weak stems, and especially when laden with fruit, need support in the form of bamboo stakes, cane or any other suitable support that would keep the plant from trailing on the ground and damaging foliage and fruit. Initial care requires you to pinch off any side shoots that begin to come up between the leaf-bases and stem. Help pollination along by tapping the support canes gently to release pollen when flowers petals are fully open and curved outwards. Later, when fruit begins to appear in quantity, pinching off the main stem will help promote fruit growth.

Cucumber is started right alongside tomatoes in early spring. When seedlings are large enough transplant them into larger pots with cane support to climb upon. When the seedling reaches the six leaf stage, pinch off the growing shoot.

Fruit trees and plants: Growing smaller fruit trees in the greenhouse is another challenge that the greenhouse gardeners greatly enjoy and dwarf varieties do very well. Many of the fruit plants need only moderate temperatures for appropriate growth, but citrus fruit trees prefer somewhat warmer environment than others. Citrus fruits are a particular favorite, not just for their fruit, but also for their fragrant blossoms. The seeds germinate at around 55 degrees F and can tide over the winter comfortably if the surrounding temperature remains in the range of 40 degrees F. Growing trees from seeds can be a long process and you may have to wait several years before you taste any fruits. For quicker yield, plant healthy cuttings.

Peaches and nectarines grown in the greenhouse require more frequent watering because their root systems tend to be compact. These trees can be grown in unheated or cool greenhouses and usually need your help with pollination which has to be done diligently all through the flowering season. Prune the trees to provide ample room for fruits to form and to make picking easy. Thinning of fruit is done when the fruits are as big as walnuts. Leave about two fruits to develop per foot.
Grapes are also good candidates for the greenhouse. You can choose from varieties that are specifically made for the heated greenhouse or for cooler conditions. Grapes need well-drained soils and waterlogging can harm the plant greatly. As these are vines, they need support as they grow. Vines produce flowers and fruits on each year’s new growth, so pruning of the previous summer’s side shoots should be pruned in the winter. Appropriate watering, fertilizer application and thinning of fruit at the right time will ensure your success with grapes.

You can carry your stone fruit trees out into the garden for the summer, so plant pears, peaches, apples and loquats in pots. Strawberries and grapes need to be planted in beds inside the greenhouse. Pollination is a very important consideration while choosing seeds or plantlets. Investing in self-pollinating varieties or trees which are suitably grafted would be valuable because the closed greenhouse environment provides little opportunity for pollination to occur naturally. You can also learn to hand pollinate the flowers when they are mature, but this is a skill you would need to work on. It is not difficult to master, but requires diligence as the needs of each individual flower have to be catered to.

Greenhouse hydroponics: Another wonderful option you can exercise in your greenhouse is the science of hydroponics. Hydroponics, also known by other names such as hydroculture, aquaculture or nutriculture, is the science of growing plants in a completely soilless medium, so you can grow your vegetables without digging any beds or carting in soil and dirt into your greenhouse. If you get the art right, you will be rewarded by faster plant growth with distinctly more lush foliage. Hydroponics is great for conserving water and fertilizer and maximizes the use of greenhouse space. You can work with active or passive hydroponics systems, but a fundamental requirement is to regularly replenish the fertilizer or nutrient mix in the growth solution.

Hydroponically grown plants have roots dipped directly into a nutrient solution and are therefore able to fulfill their nutritional requirements without developing extensive root systems. Instead, they are able to channel much of their energy into the growth of the shoot system accounting for more lush foliage and faster growth. You can use porous growing media that allows the passage of water and nutrients to the root, or simply allow plants to float in a water stream to absorb all the required nutrients from there.

Herbs in the greenhouse: Herbs are traditionally grown out in the open in suitable weather in the appropriate seasons. When grown out in the open, herbs are generally harvested in the spring and summer. Growing herbs in greenhouses has the obvious advantage of extending the growing season so that many herbs are available almost year-round. Growing methods for herbs are quite similar to growing vegetables in the greenhouse. Irrigation and fertilizer application are two aspects that need to be managed a bit differently as they are plant specific. Negative results with excessive fertilizers and irrigation show up in various ways. Slow growing seedlings and cuttings do not establish themselves well under such circumstances, while those that are naturally rapid growers tend to show excessive growth. Essential oil content may show a decline and you would not have the expected aroma or flavor.
You can use your greenhouse to start a variety of herbs early and prepare them for planting outside. Annual and biennials are generally raised from seeds while the perennials are better propagated through cuttings. Seeds require good quality seed compost for best results. When the seedlings are large enough, they should be removed to larger pots. Harden off the cuttings and seedlings before planting them out.

Another use of your greenhouse could be for over-wintering your herbs even if you are not planning on harvesting them through the winter. Herbs in your garden can be removed to pots and brought into the greenhouse as winter sets in. You can allow the leaves to drop before covering them in bubble wrap for protection. Your herbs will get off to a great start when the new growing season arrives. Be sure to acclimatize your plants to external environment and harden them off before planting them out in the new growing season. Herbs such as aniseed and cumin may be brought inside as winter sets in and days start getting shorter.

Most herbs reach usable size within six to ten weeks of planting. Parsley, sage, rosemary and thyme may be started nearly a month in advance as compared with anise, basil, chives, dill, coriander and fennel. Each fresh-cut herb has its own unique requirement for harvest. Mint, for example, is best grown in raised bed and snipped uniformly section by section, while rosemary sprigs are harvested individually.

You can enjoy coriander, parsley and chervil throughout the winter in the frost-free environment of a greenhouse if you start these in late summer or early autumn. Even herbaceous perennials such as mint, chives and tarragon that are warmth loving can be maintained in a greenhouse by lifting and dividing mature plants in late summer or early autumn and replanting the them in loamy potting compost. The herbs will put routinely put out new shoots you can use throughout winter.

Decorative plants for the greenhouse: Exotic decorative plants that do well in the heated greenhouse include the arresting Bromeliads. This is a large category that needs moderate or warm temperatures and diffused light for best growth. The varieties come in various shapes; you can have tall plants or short spirals with their spiky foliage and showy flowers. Varieties to try out in the greenhouse are Billbergia, Tillandsia and Guzmania. Billbergia nutans with its serrated thirty-inch leaves is a commonly grown variety. It requires watering weekly and the water is to be filled in the flower cup which is the plant centre where the rosette of leaves meet. Fertilizers are applied directly to the soil and not in the cup. Another beautiful bromeliad that needs similar care is Billbergia fasciata.

Other plants to be grown are Gloriosa and Gardenia. With temperatures maintained at 50 to 60 degrees F, you can grow begonias, poinsettias and cyclamens too. You can grow showy tropicales, insectivores such as pitcher plant, orchids, all kinds of flowering plants and even aquatic plants like water lilies. There is something for every greenhouse enthusiast to grow; each individual choice reflecting individual interests and preferences.

Exotic plants need not necessarily be grown in warm greenhouses. There are several candidates for the cool greenhouses too. A favorite is the striking Hedychiums with their amazing fragrant flowers. A
number of varieties are available that grow and flower readily in the greenhouse. These are propagated in early summer by division and replanting of rhizomes or through seeds that germinate in around six weeks.

Other decorative displays can be created in a cool greenhouse with plants like Gloxinia and Camellias.
Pests in the greenhouse

Common pests in the greenhouse are aphids, whiteflies, spider mites, fungus gnats, mealybugs, scales and other bugs. Effective pest control and management depends primarily on identification of pest. Integrated pest management requires prevention, monitoring and identification and use of the most suitable and least toxic pesticides.

The best management strategy is to keep pests from getting inside the greenhouse in the first place. For this, always inspect new plants or cuttings you buy and then keep them away from other plants for a month before adding them to the mix of other plants in your greenhouse. Also, starting from seeds would reduce incidence of pests because pests are mostly introduced into the greenhouse through new plants that you add to your collection from the outside. Install insect screens on air intakes and vents. Another important precaution to be taken is to clean your footwear before entering the greenhouse, especially if you have been working outdoors in your garden. Use non-toxic insecticides that are available in the market in the form of sprays, aerosols, fogs or smokes.

It would be a rare person who would not respond to the beauty of nature in all its colorful and vibrant glory! Greenhouses are a wonderful way to keep in touch with nature and enjoy not only its beauty, but also its other abundant gift of food. Your greenhouse is not only your personal space, but also your personal laboratory where you have all the freedom to experiment, delight in new discoveries or relish the power of not having to succumb to nature!

What strategies can I adopt to manage pests in my greenhouse?

- Discard any infested plant as far as possible.
- Give a weekly wash with a strong spray of water to plants with sturdy foliage to get rid of aphids and spider mites.
- Use insecticidal soap sprays which kill the pests on contact. Some plants such as ferns and nasturtiums are sensitive to these, so first test spray a few leaves. Observe these for a day or so and if they do not show damage, you can spray the rest of the plant.
- Diatomaceous earth is non-toxic powdery natural substance and kills insects by causing them to dry up. It kills all insects, irrespective of whether they are beneficial or harmful. Use this only where you do not have an ecology of beneficial insects such as inside your greenhouse.
- Pyrethrins are active ingredients from pyrethrin daisies that are useful in control of chewing and sucking insects. These substances can be harmful to animals including humans, so take your plant out and spray it to get rid of the insects. Some plants like cyclamens may be sensitive, so test the substance on the plant first.
- Biological control of pests involves use of several species of insects that are commercially reared for use as natural enemies of pests and harmful insects. These are expensive though effective, but you may not like the idea of having bugs, even good ones, inside your greenhouse!

What are the do’s and don’ts that I should follow?

- Keep your greenhouse clean, neat, tidy, organized and in a good state of repair.
- Work at it regularly and give enough time to the greenhouse.
• Educate yourself consciously about growing plants and maintaining your greenhouse.
• Know the plants in your greenhouse; tend each one lovingly and watch them flourish.
• Explore, experiment and most importantly, enjoy your greenhouse!
• Start with plants that are hardy and easier to grow. Take up new challenges as you become more adept at handling and understanding the plants and their needs.
• Your greenhouse is your responsibility!
• Don’t play nursemaid to sick plants by taking them into your greenhouse!
Frequently Asked Questions

Are small greenhouses better?
The smaller your greenhouse, the more rapid the temperature fluctuations it faces.

The air volume inside smaller greenhouses is lower while the exposed area that allows heat exchange; loss or gain, is comparatively large.

As a result, the air temperature changes rapidly and needs to be regulated frequently.

Where should I site my greenhouse?
Choose a direction that precludes cold winter winds and pick a site that complements the light requirement of your crop.

Site your greenhouse close to sources of heat, water and electricity. Make sure that you have easy access to your greenhouse.

Greenhouse site must have good drainage, so choose your location with care.

How can I grow herbs organically?
To grow herbs organically, you need to use certified organic potting mix. Neither wetting agents nor synthetic fertilizers are allowed in organic potting mixes.

Most potting mixes certified for organic growing are based on good quality compost mixed with peat moss, perlite or vermiculite. The mix is supplemented with organic fertilizers such as bone meal or kelp. Finally, you would have to ensure that pH of the prepared mix falls in the range of 6 to 7.

What are the general essential conditions for herb cultivation?
Temperatures suitable for herb production range from 70 to 75 degrees F for the day and around 60 degrees F for the night.

Appropriate light intensity needs to be maintained because low light intensity causes reduction in essential oil production thereby diminishing the culinary value of the herb. Provide maximum light in late winter and early spring.

Herbs are not usually grown in beds, but in soilless media. Most herbs are native to neutral or slightly alkaline soils with a pH range of 6 and 7. However, as the soilless mixes are slightly acidic with a pH of 5 to 6, you would have to add a little lime to the soilless mix.

What are active and passive hydroponics systems?
Active hydroponics systems require larger sized planting media such as perlite, vermiculite or pea gravel if you are not directly floating the plants in a water-nutrient solution. A nutrient solution is actively passed over the roots of the plants using pumps. There are several categories of active hydroponic systems depending on how they make nutrient solution available to the plants. Some of
these are the trickler system, the ebb-and-flow system, drip irrigation system, aquaponics and NFT or Nutrient Film Technique.

A passive hydroponics system works through a capillary or wick system that passively absorbs and delivers nutrient solution to the root system by drawing it up from a reservoir. It can be set up easily, involves no moving parts like pumps, and uses mainly sawdust, sand or peat moss as growing media.

The passive system is easier to set up in a hobby greenhouse as it is cost effective and independent of electricity.

**What use are the cold, cool, warm and hot greenhouses?**

The terminology refers to the nighttime temperatures that are maintained in the greenhouse using heating or cooling methods as appropriate.

A cold greenhouse is only sun-heated in winter and usually the temperature does not fall below 28 degrees F. This temperature is too low for plants to grow successfully. However, you can over-winter plants that are not frost sensitive.

Cooler greenhouses are heated by various means to maintain a minimum temperature of 45 degrees F. At this temperature, you can over-winter frost sensitive plants. Very little plant growth will occur here.

It is the warm greenhouse that is the star attraction to a gardening enthusiast! At a minimum temperature of 55 degree F, a wide variety of plants, including vegetables, can be successfully grown during winter.

Hot greenhouses can be used to grow exotic varieties of plants which need consistently high temperatures. This is an expensive proposition in places with long winters as the cost of heating could burn a big hole in your pocket!

**How does climate affect my greenhouse design?**

The kind of weather cycle you face through the year has a bearing on your choice of style of your greenhouse structure.

- If you face cold winters, go for a design with steeply sloping roof and sturdy sidewalls to which insulation may be attached when needed.
- For snowy or cold windy regions, solar greenhouses would provide great insulation and heat in the most economical way. Solar heating is an excellent choice to limit cost of heating using electricity.
- A windy region demands additional strengthening of the structure to withstand force of wind. Think of attached greenhouses as they provide structural strength and shelter against wind.
- If torrential rains and heavy leaf fall plague your region, steep A-Frame greenhouse without side walls would work for you.
- Rainy areas with low light intensity would be ideal for attached greenhouse structures. You would have ready access to electricity to provide artificial lighting. You will have no trouble
accessing the greenhouse from an internal doorway thereby avoiding getting soaked and trailing mud into your greenhouse.

- For warm regions vents placed close to the floor will greatly help regulate temperature and keep the greenhouse ventilated.
- If you are in a hot region, build a greenhouse that is structurally amenable to putting up screens and shades to control light intensity as well as excessive build up of heat.

**How can I make a wood foundation for my greenhouse?**

A step-wise approach to building your greenhouse foundation would have your greenhouse set up in no time!

- Level the site where the greenhouse will stand. Remove any lumps, rocks or clods of soil that could make the foundation uneven.
- Cut 4” X 4” or 4” x 6” timbers to fit the greenhouse base using standard carpenter’s tools.
- Place the cut timber pieces on the site in the orientation that you expect the greenhouse to stand.
- Use a level of the kind used by carpenters to ensure that each of the timber slabs forming the greenhouse base is perfectly level to the ground.
- Secure the leveled base of timber together at the corners with lag screws that are about 3 inches longer than the board it is screwed through so that the next board that is attached is tightly held in place.
- Now, lay the ground cover under the frame and cut the excess fabric at the edges to size. Choose a ground cover specially approved for greenhouses as it keeps out weeds, while allowing water to drain through the material of the fabric. If you use a material like black plastic sheet or tarp, the draining process will be hindered and your plants will suffer all kinds of problems as a result.
- The next step is to square off the foundation by making diagonal measurements and adjusting the base till both measurements are same.
- Fill in sand or gravel to a depth of 2 or 3 inches inside the base you have made so as to completely cover the underlying ground cover fabric.
- Use 2 inch galvanized screws with washers to fasten the panels of the greenhouse frame to the wooden base. Use a sealant where the aluminum ridge meets the wooden base.

**Can I grow anything anytime?**

Your greenhouse is a sophisticated laboratory of sorts in which you can grow all kinds of plants; those that are native to your region or those that belong to far off places with very different climes.

However, simply providing warmth or protection from cold is no guarantee for success when you bring in an eclectic mix of non-native plants. You have to learn about all their requirements in as much detail as possible which means you have to play the scientist to the hilt!

Some plants may prefer extremely hot and humid environment, while others flourish only in mild or moderate conditions. Yet others may need a relatively cool environment with little humidity.
Remember that you can grow only what you successfully cater for. So, choose your mix of plants to reflect the conditions you will create in the greenhouse – or vice versa. Make informed and sensible choices!

What this means is that selection of plants is not just based on what you fancy, but also on the fact that plants you pick must fall within an acceptable and similar range of climatic requirements when you plant to grow them together.

**How do I decide what kind of shading would be effective for my greenhouse?**

Awareness about the following would help you in deciding the shading material and density your greenhouse would require:

- Install shading outside the greenhouse for an improved efficiency of up to 40%.
- Use reflective shading if you want to put up shading inside the greenhouse, otherwise the temperature inside your greenhouse will rise as a result of heat retention.
- You can use fiberglass shade screens or panels which have a reasonably long life.
- Knitted plastic shades are lightweight and easy to use, while polypropylene is a good choice for its longevity.
- For very hot and sunny areas, reflective shading is recommended. Its life span is shorter than that of any of the other shading materials, but it is highly effective for the purpose for which it is recommended.
- Shading paint is used by commercial growers. It is applied in early summer and followed up by an additional coat if needed. It automatically wears away as the season progresses. Any remnants can later be removed with recommended clearing agents. Shading paint can look unsightly and most hobby greenhouse owners do not prefer them for aesthetic reasons.
- 40-60% shading is generally effective in the temperate zone, while 70-80% may be needed in hotter areas.
- Use a high density shade that blocks out more light on the roof and a lower density shade on the walls of the greenhouse.

**How can I use my cold frame greenhouse effectively?**

Your cold frame can be used in every season for a specific purpose.

**Early spring:** it is very useful to harden seedlings started in the greenhouse for transplantation to the outside by allowing gradual adjustment to the more stressful external environment. You can also start cool weather crops early in the cold frame and transplant them at the appropriate time.

**Spring and summer:** it is an excellent time to focus on plant propagation. Rooting of cuttings can be done effectively during this period by replacing a portion of the cold frame soil with a suitable growing medium like peat moss. You can continue with acclimatizing your seedlings for transplantation to the outside.

**Fall:** it is a good time to start some cool weather crops. With proper heating, adequate moisture and fertilizers, you can have a supply of herbs, vegetables and root crops throughout the winter too.
On clear, hot and sunny days in late winter, early spring and early fall, you would need to be alert to the need of ventilating your cold frame to prevent build-up of high temperatures inside it.

Shading your cold frame using knitted shades, bamboo blinds or lath also helps control high temperature build-up in the summers.

Water your plants early so that excess moisture is dried off the foliage before dark. This prevents onset of disease due to wetness.

**What kind of electric heater should I select for my greenhouse?**

For a medium size greenhouse, an electric greenhouse heater is a viable option.

- A 2 kW or 3 kW electric air heater with built-in thermostat is suitable. Larger wattage heaters may damage your plants by drying out the plants closest to the heater.
- Pick a heater that has adjustable fan strengths such as low, medium or high. Take one that has an additional feature of blowing unheated air.
- For safety reasons, select air heaters specially designed for greenhouses.
- Place the heater or heaters so as to avoid cold spots in the greenhouse.

**What more should I know about how light impacts plant growth before I choose a particular lighting system?**

Visible light that we know is made of the seven colours of the spectrum falls into a wavelength range of about 380 nm and 750 nm where nm stands for nanometer and is a tiny unit for measuring length.

The wavelength of visible light, both in the blue and in the red ranges, that falls on plants is the key to promote photosynthetic activity that keeps the plant alive and allows growth and flowering.

The shorter wavelengths of visible light fall in the violet, blue and green portions of the spectrum. These are crucial for leafy growth or vegetative growth of the plants.

The longer wavelengths of visible light fall in the orange and red portions of the spectrum and are responsible for release of chemicals that induce budding and flowering.

Light intensity drives photosynthesis and if the intensity is below a certain level, plants would not be able to use it to drive photosynthetic activity.

Duration of light is crucial to flowering. You can divide plants into short day plants which need about 10-13 hours of light, long day plants that need 13-18 hours, and day neutral plants that need between 12 and 18 hours of sunlight.

Short day plants include Gardenias, Chrysanthemums and Poinsettias; some long day plants are Dahlias, Nasturtiums, China Asters and Annuals; day neutral plants are Roses, Geraniums, carnations, Coleus and Begonias.
How can I calculate the optimum exhaust fan rating for ventilation of my greenhouse?

You can calculate the CFM rating (cubic feet per minute) of the exhaust fan to be used for ventilation in your greenhouse in the following way:

For effective ventilation, you need a fan that can exchange the entire air volume in the greenhouse with external air in about one minute. To calculate the air volume exchange capacity or CFM rating, you need to know the length, width and height of your greenhouse measured in feet. Now, use the following formula to get the CFM rating:

\[
\text{Length} \times \text{width} (\text{height} \times 1.2) = \text{fan CFM rating}
\]

The size of the inlet vents should be determined to complement the CFM rating of the exhaust fan. If inflow of air does not match the outflow, the motor of the fan would be under strain. This would wear the motor out quickly.

What options are available for watering of my plants if I am away for a while?

- Capillary matting for seedlings can work if you are away for a couple of days.
- Automatic watering systems that work on batteries are easy if you are away for a month or more. They do not need electricity, are adjustable and can water two dozen or more plants depending on capacity. Tubing, reservoir and dripers come in the kit.
- Request a responsible and dependable person to water your plants for a few days if it is critical!

What kind of potting containers could I have in my greenhouse?

- Clay pots
- Plastic pots
- wood, fiberglass or plastic tubs
- raised beds
- polyethylene sleeve pots
- Biodegradable peat pots
- Growing bags

What materials can I add to enhance the quality of the potting mix?

Soil mixes are custom blended to suit specific plant categories. The blends include the following:

- Coarse sand is added for better drainage.
- Peat moss increase water retaining ability.
- Vermiculite or Perlite also enhances water retaining properties. It is added to enhance soil texture by making soil light, airy and promote drainage.
- Manure promotes soil fertility.
What advantage will I have if I use vermiculite or perlite?

Vermiculite is a naturally occurring mineral mixture of aluminium, magnesium and iron silicate. It is mined for use in industry, construction and agriculture. The properties that have made it a preferred choice of gardeners the world over are:

- It is inorganic, non-irritant, non-abrasive, nontoxic.
- It is sterile; disease, pest and weed free.
- It has high water retention and air holding capacity.
- It absorbs excess nutrients and releases them when needed.
- It insulates soil by minimizing temperature fluctuations.
- It facilitates rewetting.
- It can be stored in dry condition without deterioration.

Vermiculite is used mixed with peat moss compost for rooting of plants. The mixture stimulates growth of roots, providing anchorage and facilitating nutrient uptake.

Vermiculite can be used alone for seed germination because its non-irritant, non-toxic, non-abrasive properties make it suitable for direct contact with seeds. Its properties of good water retention and aeration make it suitable for seed germination. As the seeds contain stored nutrients for germination to occur, you should only start adding fertilizers before transplanting when the first true leaves appear.

In potting mixes, vermiculite, in addition to its other properties, allows rewetting thereby increasing the time duration between successive watering. Its property of absorbing and storing excess nutrients and releasing them slowly as needed is a big bonus when it is used in potting mixes.

Vermiculite and peat moss used in a 50-50 proportion is good for greenhouse pots.
<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Dimensions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass Pane</td>
<td>5-6</td>
<td>2440 x 1000, 1220</td>
</tr>
<tr>
<td>Rims</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Supports</td>
<td>4</td>
<td>490 x 300, 320</td>
</tr>
</tbody>
</table>

**Material List**
Montana (1175)

(1) Attach a hook to the corner of the door panel.

(3) Cut the supports as shown below and set aside for assembly later. You will need 4 of these supports.

These supports should be cut to prevent water intrusion and rotting.

(2) Push in the glass panel flush with the bottom panel.

(4) If you have all the glass panels and supports, the assembly is pretty easy with a little planning!
Once the shelves are completed, you may mount as you wish.

(to environmental) Design to prevent water intrusion. It will get a crack of polyurethane.

We recommend at least a crack of polyurethane.

Once the supports are cut, we recommend at minimum, adding a layer of polyurethane (or equivalent) sealant to prevent water intrusion and rotting.

4 of these supports.

(1) To begin, cut 2x6 support posts as shown below and set aside for assembly later. You will need experience using a router with a guide so all of the windows will be confirmed. The router will be the frame as shown in 2x6 (4590mm) frames. We recommend using

2.4.2 (600)

5.3.1 (1350)

1.7.1 (430)

4.5.2 (1192)

6.1.2 (1552)

The skill greenhouse is not complicated to complete, but it is recommended. The plan has some...
Build the frame without screws, glue or other attachments around the glass panel to ensure the frame pieces will come together and fit snugly.

Shifting while assembling:

1. DO NOT recommend soaking or soaking all the pieces and assembling the panels all at once. It will be very hard to keep the frame pieces separate unless you are very careful and seal and separate all frame pieces into different pieces. Either way, I recommend waiting on one panel at a time to avoid any confusion.

2. Shifting along the edge:
   - Whether using a drill or a nail gun, ALWAYS leave any clamps in place to prevent the frame from shifting. Whether glueing edges and corners or dry glue blocks before gluing corners. Always strengthen the frame panel edges and frame pieces come together. Use a bead of sealant with the glue. Give the ends of the glass panes and frame pieces some time to come together.

3. Frame pieces will come together and fit snugly.

4. Assemble the frame without screws, glue or other attachments around the glass panel to ensure the frame pieces will come together and fit snugly.

5. Repeat the same process for the side panels. Construction is exactly the same. Dimensions are slightly different.
GREENHOUSE

Note to customer:

1. Make sure the small flask will not cause your hand negative pressure or suction, which may lead to the soil and water suction and result in the plant suffering. For this reason, please make sure that your hand never touches the soil or water suction. It is recommended to use a large plastic glove to handle the soil or water suction.

2. For those who wish to grow in nutrient water, please follow these steps:

- **Prepare the water solution:**
  - Measure the size of the pots and prepare the nutrient solution accordingly.
  - Adjust the pH level to the recommended range of 6.0-7.0 for your specific plant.

- **Plant the seedling:**
  - Make sure the seedling is secure and stable in the pot.
  - Add water to the pot until it is slightly above the soil line.

- **Maintain the nutrient solution:**
  - Regularly check the nutrient levels and adjust as needed.
  - Ensure the nutrient solution is not allowed to dry out or become excessively diluted.

3. You can also use small containers (5-10cm) for individual plants, which can be easily placed in the soil or water.

- **Growing tips:**
  - Keep the soil or water solution well-drained to prevent root rot.
  - Provide adequate light and water according to the specific needs of the plant.

4. For those who wish to grow in soil, please follow these steps:

- **Prepare the soil:**
  - Ensure the soil is well-drained and nutrient-rich.
  - Add water to the pot until it is slightly above the soil line.

- **Plant the seedling:**
  - Make sure the seedling is secure and stable in the pot.
  - Add water to the pot until it is slightly above the soil line.

- **Maintain the soil:**
  - Regularly check the soil moisture and adjust as needed.
  - Ensure the soil is not allowed to dry out or become excessively moist.

5. **Additional tips:**

- **Watering:**
  - Water the plant thoroughly and allow the excess water to drain through the drainage holes.
  - Avoid overwatering, which can lead to root rot.

- **Fertilizing:**
  - Add a balanced fertilizer according to the specific needs of the plant.
  - Avoid overfertilizing, which can burn the roots.

6. **Troubleshooting:**

- If the leaves are wilting:
  - Check the soil moisture and adjust as needed.
  - Ensure the plant is not suffering from a lack of water.

- If the leaves are yellow:
  - Check the soil pH and adjust as needed.
  - Ensure the plant is not suffering from a nutrient deficiency.

7. **General care:**

- **Temperature:**
  - Maintain the ideal temperature range for the specific plant.
  - Avoid extreme temperatures, which can stress the plant.

- **Lighting:**
  - Provide adequate light for the specific plant.
  - Avoid placing the plant in direct sunlight, which can burn the leaves.

8. **Precautions:**

- Ensure the plant is not exposed to direct sunlight, which can burn the leaves.
- Avoid placing the plant in areas with high humidity, which can lead to root rot.

9. **Conclusion:**

- Follow these guidelines to ensure the healthy growth and development of your plant. Regular maintenance and care will lead to a thriving and beautiful plant.

---

**Diagram:**

- Illustration showing the steps for growing in nutrient water and soil, including pot placement, soil and water addition, and maintenance.

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**Recommendations and Notes:**

- For more detailed information, please refer to the user guide or contact the customer support team.
- Regular maintenance and care are essential for the healthy growth and development of the plant.
- Always follow the recommended guidelines provided by the manufacturer.
The greenhouse is intended to expand the warmer growing seasons only. This is NOT intended for cold-climate growing. If the builder would like to make this coop cold-resistant, a weather-resistant, opaque greenhouse film is recommended. Follow all safety and manufacturer directions when using a heat source.

2) Cover material is up to builder’s choice to insulate the greenhouse. Methods such as double pane, rigid foam, etc. may be necessary.

3) The builder may choose to saw or drill the plastic sheathing to the PVC pipe, but adhesive is REQUIRED for weather resistance. I would recommend both methods if you live in a region with high wind velocities. Be sure to use a plastic water-proof, or two-lb. weight for safety.

4) These pipes are intended for use with moisture. Always check the readability of label before purchasing pipe. If the pipe is too rigid, it may break when plu under pressure. If the pipe is too soft, it could break before purchased. If the pipe is too rigid, it may break when plu under pressure. If the pipe is too soft, it could break before purchased. If the pipe is too rigid, it may break when plu under pressure.

5) Construction methods vary. I recommend both methods, but use at your own discretion. I would recommend both methods if you live in a region with high wind velocities. Be sure to use a plastic water-proof, or two-lb. weight for safety.

6) Cover material is up to builder’s choice to insulate the greenhouse. Methods such as double pane, rigid foam, etc. may be necessary.

7) The builder may choose to saw or drill the plastic sheathing to the PVC pipe, but adhesive is REQUIRED for weather resistance. I would recommend both methods if you live in a region with high wind velocities. Be sure to use a plastic water-proof, or two-lb. weight for safety.

Always read these instructions carefully and...
1. For vertical sheeting, start by giving the piece sheeting over the PVC pipes like a gasket in the base boards. You should have something similar to the diagram below.

2. Lay the sheets over one another, overlapping the edges. Do NOT give the second sheet a cut. Make sure to overlap the base board to form a tight seam.

3. Continue giving the middle piece, making sure they are level with each other. Round the opposite edges and glue the ends set with the first end.

4. Leave enough space for the PVC pipe to pass through. Ensure the gasket is secure and tight. Measure the diameter of the pipe and cut the PVC sheet accordingly.

5. For horizontal sheeting, make sure the gasket is secure and tight. You can purchase additional plastic gaskets if necessary.
<table>
<thead>
<tr>
<th>Material List</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Quantity</td>
</tr>
<tr>
<td>Screen</td>
<td>1</td>
</tr>
<tr>
<td>Door</td>
<td>1</td>
</tr>
<tr>
<td>Frame</td>
<td>4</td>
</tr>
<tr>
<td>Fitting</td>
<td>4</td>
</tr>
<tr>
<td>Screws</td>
<td>4</td>
</tr>
<tr>
<td>Door Screen</td>
<td>1</td>
</tr>
<tr>
<td>Frame Screen</td>
<td>1</td>
</tr>
</tbody>
</table>

1. Image shows with built-in constructed doors. We recommend the
   approval-pre-constructed option.
2. We do not accept responsibility for any mistakes or errors in this
   construction. Always refer to your manufacturer's instructions
   before construction. (ON/OFF) refer to assembly.
1. Begin by cutting plans as shown in the diagram below. Make all the corners at a 45° angle. Mark all the square and edges are flush. Use pressure treated lumber to prevent moisture intrusion.

2. In this guide, we are going to assemble the lower side wall first. Cut all three side boards and mitre the ends at 15°. These will act as supports for the sill.

3. Construct the longer wall as shown below. It is exact the same as the side wall.

4. Construct the rear wall as shown below. Remember to make the correct plans of the board.

5. Ensure all the corners are square, edges are flush. Use pressure treated lumber to prevent moisture intrusion.
1) Carefully attach the front wall frame onto the side walls. Make sure all legs are flush with each other. Check the corners are square, yes, some boards are long and you will see why.

2) Now, go ahead and attach the sill pieces as shown. Two on the ends and center.

3) Walls are square, so the gaps is Flush (a) the side against the building. The middle piece over the door header. Make sure the sill piece on top of the long edge.

4) For the front wall, measure, cut and assemble pieces as shown below. We recommend filling the gaps and laying out the pieces before assembly so you can be sure the wall will fit between the studs.

5) Assemble the two side walls and the rear wall as shown below. Make sure the edges are square and the corners are square. Attach the walls to the base through the top of the wall base plate with #30X2 (50mm) torque (557N) head screws.
<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x 6 pine</td>
<td>2400mm</td>
<td>4</td>
</tr>
<tr>
<td>1 x 4 pine</td>
<td>2400mm</td>
<td>4</td>
</tr>
<tr>
<td>1 x 2 pine</td>
<td>2400mm</td>
<td>4</td>
</tr>
<tr>
<td>2 x 4 pine</td>
<td>2400mm</td>
<td>4</td>
</tr>
<tr>
<td>2 x 6 pine</td>
<td>2400mm</td>
<td>2</td>
</tr>
<tr>
<td>2 x 6 pine</td>
<td>3000mm</td>
<td>1</td>
</tr>
<tr>
<td>2 x 8 pine</td>
<td>2400mm</td>
<td>2</td>
</tr>
<tr>
<td>2 x 8 pine</td>
<td>3000mm</td>
<td>1</td>
</tr>
</tbody>
</table>

*Note: Dimensions may vary depending on the specific design requirements. See the attached diagram for detailed measurements.*

**Material List:**

1. 1 x 6 pine: 2400mm x 4
2. 1 x 4 pine: 2400mm x 4
3. 1 x 2 pine: 2400mm x 4
4. 2 x 4 pine: 2400mm x 4
5. 2 x 6 pine: 2400mm x 2, 3000mm x 1
6. 2 x 8 pine: 2400mm x 2, 3000mm x 1

**Diagram:**

The diagram shows the frame structure of the greenhouse, including the use of 2 x 4, 2 x 6, and 2 x 8 pine for the framework. The dimensions are approximate and should be verified with the actual project requirements.

**Warning:**

Projects and products that are not built to plans may be dangerous. Use caution when working with power tools and sharp objects. Always wear protective gear when necessary. The materials listed above are standard for greenhouse construction.
Greenhouse
Building Plans

1. Frame is attached below and attach with #3DG (7.5m) or (6.0m) screws. Leave the frame on table and install it to the screws. After the frames are installed, the top bar is attached. Adjust the frames to fit the

2. For our purposes, we have decided the mean at 2.5 (6.0m) centers. To cut

3. Do not interfere with the slope of the roof. Through the frame as designed. Don’t forget to cutouts the door head, so they
can be installed. The door head is least 6 (15m) long to connect the crown. Then, the door head is least 6 (15m) long to connect the crown. Then, cutout the door head is least 6 (15m) long to connect the crown. Then, cutout the door head is least 6 (15m) long to connect the crown. Then, cutout the door head is least 6 (15m) long to connect the crown. Then, cutout the door head is least 6 (15m) long to connect the crown. Then, cutout the door head is least 6 (15m) long to connect the crown. Then,

4. For the frame, cut all angles as shown below. Use a carpenter square and layout

5. At this point, go ahead and assemble the walls to form a box. Remember to make

6. For added stability and to support the roof rafters, cut a sill plate as shown below.

7. Sill plates are flush and corners are squared.
1. To start, use a circular saw or jigsaw (both with a guide) to cut a piece of wood to the size shown below:

![Diagram]

2. For the screen, cut a piece slightly larger than the frame. Shape the mesh around.

3. For the window, cut a piece of plastic to fit the outside rim of the window. Seal.

4. We recommend attaching side posts to the corners of the window and to the house itself. Be sure to drill the plastic sheet over the frame and clamp until the adhesive bonds.

5. After all the pieces are glued, it is simply a matter of lining the window of and putting it back into place in the house.
Instructions for the door on the door will need to be adjusted to fit the door.

4) Should you wish to repeat the steps for the window and screen and install a screen

The door will be easily assembled when compared to everything else.