

Forest Garden Greenhouse update

Background

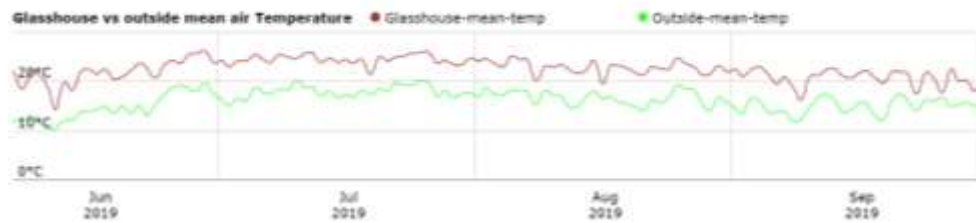
The ART Forest Garden Greenhouse was built in 2016, based on the work of Jerome Osentowski from Colorado USA. It uses a ground heat storage system to store heat from summer and autumn to use in winter, to enable a growing system for subtropical plants.

We used a standard commercial “Venlo” type glasshouse, 22.5m x 19.2m in size, with height of 6.75m to eaves (6.0m to the top of the walls.) This is pretty high for a Venlo structure but the extra height will allow us to grow quite large trees inside.

We used two layers of heat-exchange pipes, at depths of 1.0m and 0.5m in the soil. Fans blow ambient greenhouse air through these to either store heat in the soil (if air temperatures are warm/hot) or release heat into the greenhouse (if air temperatures are cold).

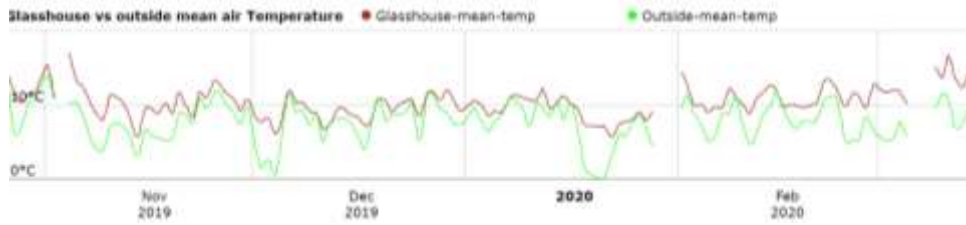
A ‘water wall’ of 50 tonnes of water held in black ibc tanks is sited on the north side, which acts as an extra thermal buffer, storing and releasing heat on a cycle of days/weeks rather than weeks/months like the soil heat storage.

Drip irrigation, using water collected off the roof, is mainly used for watering the plants.



Glasshouse and outside mean air temperatures over summer 2019. The average temperature inside is about +7 degrees compared with outside.

The first plantings were made in spring 2017 – ie 3 years ago. Most of the main canopy-height plants were put in during the first year. Subsequently there have been plantings of shrubs and perennials, and planting is ongoing. Plants sometimes don't make it through the winter, even though it is frost-free inside: the lack of winter light can be fatal to some subtropical and tropical plants, though there is scant information out there about this. So room for plenty of experimentation!



Glasshouse and outside mean air temperatures over winter 2019/2020. This period was excessively cloudy and rainy (the wettest winter for several hundred years in the UK). In mild (cloudy) conditions, glasshouse mean temperatures are only a little above outside values. But in cold spells, when the ground heat store system is triggered to start releasing heat, there is a gain of +4 to +5 degrees inside.



Debregeasia edulis
(*D.orientalis*) 'Elite'

Planted in 2017, this shrub from parts of subtropical Asia is now 1.8m high.

The ball-like flowers are followed by edible red fruits looking like smaller versions of Japanese wineberry.



Aloe vera, planted in 2017, is slow growing and perhaps in too much of a shady spot. Well known for its medicinal properties, the jelly-like leaf sap is used for burns and other skin injuries. It is also taken internally with antiviral properties amongst others.



Soil temperatures 1m and 0.5m deep in the greenhouse, over the last year to April 2020. The speed of increase or decrease in soil temperatures reflects air temperatures in the glasshouse, which themselves reflect the amount of solar radiation – in effect sunlight. The period of October 2019 to mid March 2020 was excessively cloudy, with low sun levels. Hence the long period of soil temperatures hovering around the 10 degree mark. Ideally soil temperatures do not go below 10 degrees for long, as many subtropical/tropical species will be damaged. A long spell of sunny weather from March 2020 led to a rapid rise.



Cajanus cajan (pigeon pea), here planted (in 2019) as a fertility or green manure tree. Some 20 of these were planted in spring 2019, and trimmed down in the autumn as 'chop and drop'.



Tree chilli (*Capsicum pubescens* 'Hidalgo') has done fantastically well. This perennial shrub is now about 1.2m high and more in width, and is likely to get larger.

Native to Bolivia and Peru, this chili pepper is the most important ingredient of the Bolivian sauce llajwa. It is also considered the flagship of Peru and it is consumed fresh, paste, dried, or ground. It is known in Peru and Ecuador as *rocoto*, *locoto* in Bolivia and Argentina and as the *manzano* pepper in Mexico which means 'apple' for its apple-shaped fruit. The species name, *pubescens*, means hairy, which refers to the hairy leaves of this pepper. As they reach a relatively advanced age and the roots lignify quickly, sometimes they are called tree chili. Of all the domesticated species of peppers, this is the least widespread and systematically furthest away from all others. This species has the ability to withstand cooler temperatures than other cultivated pepper plants, although it cannot withstand frost.



An 'Orinoco' banana peeks out from behind a loquat (*Eriobotrya japonica* 'Olivier').

Loquat is an evergreen fruit tree from Asia, cultivated in many regions with Mediterranean climates. It bears orange fruit the size of apricots with a delicious flavour. The tree flowers here in December, with fruits ripening in May or June. We have had problems with grey mold on the flowers and will try and increase airflow near it next winter.



A sea of flowering nasturtiums is clambering half up an avocado 'Hass.

Avocado (*Persea americana*) has great potential in these systems. We have two cultivars, 'Hass' and 'Fuerte' for cross pollination. Planted in 2017, the Hass has flowered but not the Fuerte yet.



Mountain papaya (*Vasconcellea pubescens*, formerly *Carica pubescens*), planted in October 2019. This species originates from high in the Andes (up to 3000 metres) and bears large ribbed fruits which are eaten raw or cooked as a vegetable.



White sapote (*Casimorea edulis* 'Mcdill') is a tree from Central America which bears large fruits with a delicious edible pulp. We had trouble with scale insect on this, eradicating the pest by cutting off all growth and allowing to resprout. The holes of the leaves here are caused by woodlice over the winter. In front/right is an olive.



Pigeon pea (*Cajanus cajan*) grown for seed, planted 2017

This species is widely grown as a staple crop, for example in India where the seeds make Toor dal. It is a leguminous shrub – ours is now 2.5m high and across – bearing pods containing the edible seeds which can be eaten fresh, or harvested dried and used whole or split.



Flowers of pigeon pea (*Cajanus cajan*), April 2020



Lemon verbena (*Aloysia citriodora*) is well known for the aromatic leaves used in commercial herb teas. Originally from South America, the leaves drop near zero degrees but the wood is hardier. Ours is nearing 2m high but we will trim back regularly to encourage new growth.



Lychee (*Litchi chinensis* 'Mauritius') planted in 2017, is growing well and looks healthy all through winter.



Flowers appearing on the babaco (*Vasconcellea x heilbornii*; syn. *Carica pentagona*). Originating from Ecuador, this is the most cold-tolerant species in the family. Planted in 217, it fruited in 2018 and abundantly in 2019, bearing long yellow juicy fruits.



A new banana (*Musa* 'Blue Java') planted in October 2019 has grown steadily through the winter. With the success of our first banana ('Orinoco', planted in 2017, which produced a large head of bananas in 2019) we are confident this will do well. 'Blue Java' is also known as 'Ice Cream banana' referring to vanilla ice cream flavour. Yum!



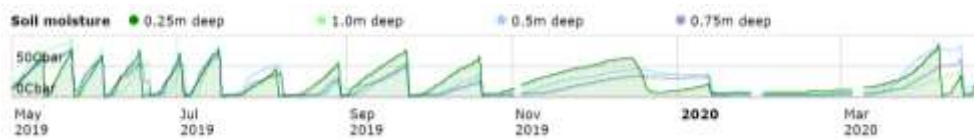
Bulbine (*Bulbine frutescens*) is a small perennial/shrub with fleshy leaves – appearing rush-like – and yellow flowers as you can see here. Originating from South America, the leaves and flowers are edible (raw in salads or cooked), and the leaf sap is used like Aloe sap, for treating burns etc.



Pineapple guava (*Acca sellowiana*) is fairly well known subtropical fruit, grown commercially in the Mediterranean, New Zealand and of course South America from where it originates. To the right and above in the this photo is banana passionfruit (*Passiflora mollissima*) which has flowered but not set fruits for us yet.



Hoja santa, or Mexican pepper leaf (*Piper auritum*) is a hardier member of the true pepper family and is thriving in the greenhouse, suckering vigorously. The leaves have a complex flavour and are much used in Mexican cuisine for wrapping foods for cooking, and in other ways.



Soil moisture levels over the year to April 2020. The graph shows water availability (the higher the measurement in cbar, the lower the availability). The cycles of drying and the wetting through irrigation are very clear. Much less irrigation is required over the winter.



Cardamon (*Elettaria cardamomum*) stays green all winter. This plant, from southern India, is hardier than many in the ginger family (true ginger and turmeric do not overwinter for us, the temperature gets too cool for them).



Another hardy papaya, this is oak-leaved papaya (*Vasconcellea quercifolia*) from South America. Like other members of the family it has large edible fruits. This was planted in October 2019 so we don't know what quality the fruits will be yet!



Pepino (*Solanum muricatum*) is well known subtropical perennial fruit. For us, it suckers each year and puts up shoots that flower, fruit and then usually die afterwards, although a few overwinter in leaf. It is flowering here (April 2020) and you can see a young fruit at the front. These grow to the size of a large lemon, with a flavour of melon and cucumber mixed – excellent.

Solanum species have sometimes been a problem due to their susceptibility to whitefly. Protected cropping systems like this will always get whitefly turning up, and usually it is easy control with things like biocontrols (aphids or encarsia wasps). However, many *Solanums* are so susceptible that they get overwhelmed and the attack is impossible to control. Hence we have removed tamarillo (*Solanum betaceum*) as this just ended up being a reservoir of pests to spread to other plants.

Pepino does get a few whitefly but the predators usually achieve control quite quickly.

One other *Solanum* member we do grow is Dwarf tamarillo (*Solanum abutiloides*) (photo below) . This is an evergreen bush – ours is about 1.5m tall and wide from planting in 2017. The white flowers you see here are followed by small orange edible fruits, which have a slight bitterness that not everyone appreciates. It has not suffered at all from whitefly so far.

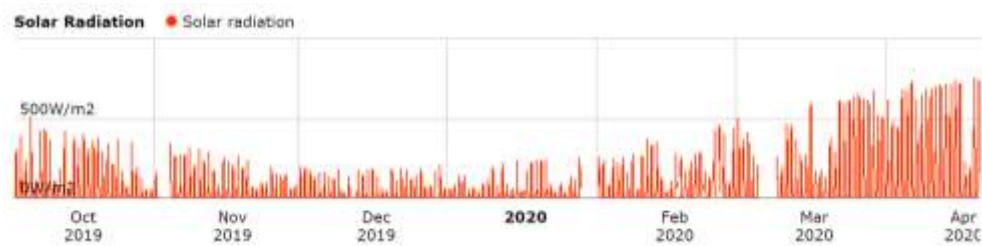


Showing max, min and average temperatures in the glasshouse over the year to April 2020.



One of our favourite leafy edibles from the greenhouse is Okinawa spinach (*Gynura bicolor*). This is an evergreen perennial/shrub for Asia, growing a metre high or so and spreading a bit wider, with leaves green one side and purple the other.

The leaves are eaten cooked or raw in salads with a nice texture and mild flavour. There is some debate about toxicity of leaves (alkaloids similar to those in comfrey have been detected in small amounts).



Solar radiation graph shows just how cloudy it was over the winter



Ginger lemon grass (*Cymbopogon exaltatus* / *C. procerus*) is also known as Australian citronella grass. Like the better known lemon grass, it grows to about 1m high, and is used in exactly the same ways, the leaf bases being used for flavouring. As the name suggests, this is a mixture of lemon and ginger making this a fantastic ingredient. Ours was only planted in 2019 and is already a good size.



Avocado 'Fuerte' was planted in 2019 as a pollination partner for 'Hass'



Indoor and outdoor humidity March and April 2020.

Despite it being an enclosed system, the indoor humidity closely follows the outdoor humidity (which, being England, is usually high!) This is despite it being kept quite dry inside, with irrigation usually sub-surface so the soil surface is dry. This also shows why it important to have some method of keeping airflow inside (we have two destratification fans near the roof which run the whole time).



Pomegranate (*Punica granatum* 'Mollar') is a deciduous small tree or large shrub. Ours is growing strongly, planted in 2017 but is has not flowered yet.



Thai lime (*Citrus hystrix*) is widely grown in warmer regions for the leaves, used for flavouring in Asian and other dishes. It also bears abundant knobby green fruits with a fantastic flavour. This is one of several Citrus we grow and along with lemon has fruited prolifically – enough for us to sell some of the limes at our local market over this winter.



Showing the banana (*Musa* 'Orinoco') planted in 2017, with the loquat to the right. The banana fruited in summer 2019, and flowered again towards the autumn, forming a bunch of immature bananas but unfortunately that stem has partly snapped so we're not sure if they will ripen this year. In the foreground there is atemoya (*Annona x atemoya* 'Geffner') which is growing but not exactly thriving. More nasturtium is flowering on the ground.