

Study of Climbing Plant Species for Application of Vertical Greening in DSD Facilities

**Drainage Services Department
Research and Development Forum 2012
Charles K Kao Auditorium
Hong Kong Science Park, Shatin
27 November 2012**

**C.Y. Jim
Department of Geography
The University of Hong Kong
hragjcy@hku.hk
geog.hku.hk/staff_FT_jim.html**

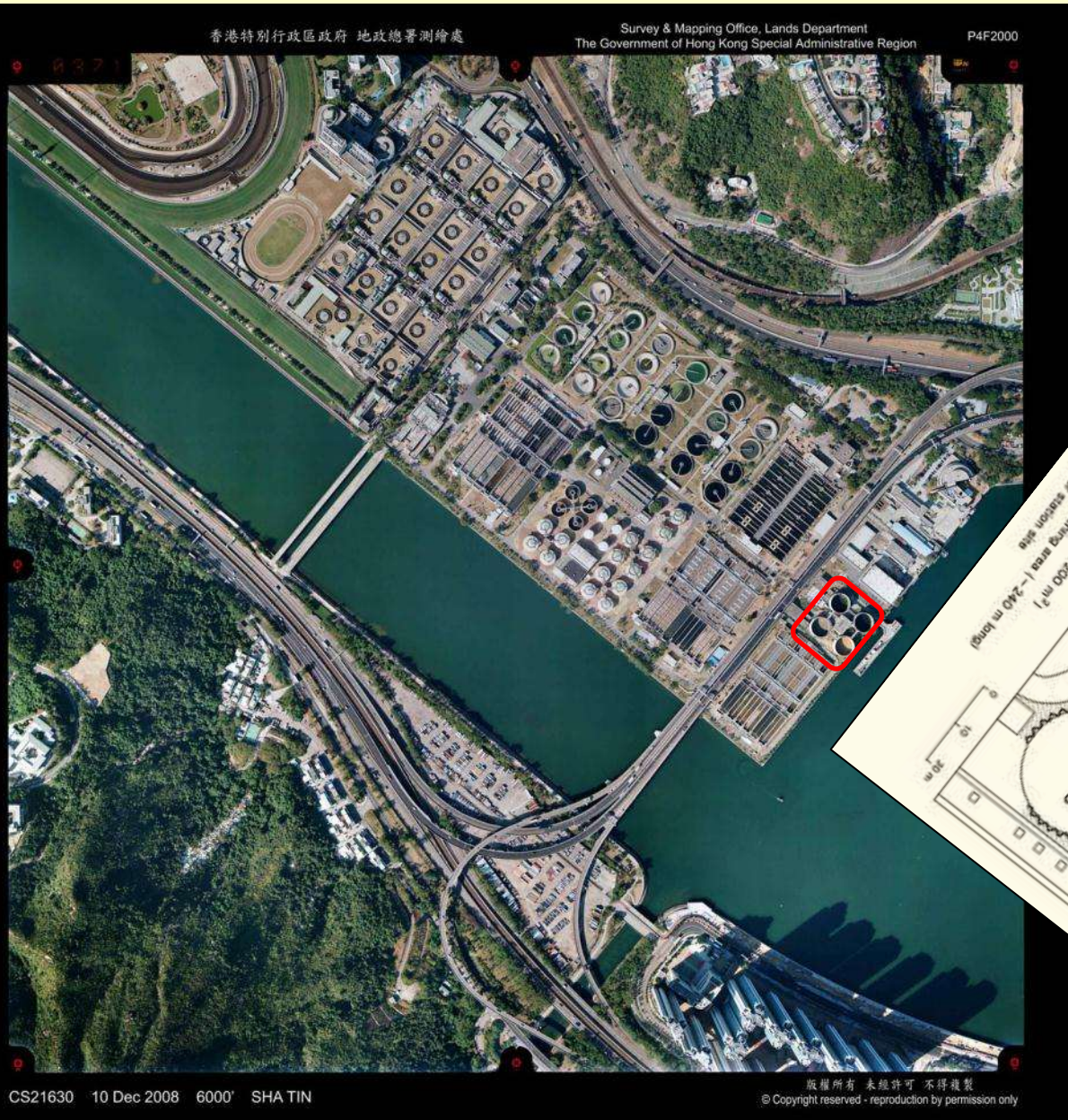
DSD Vertical Greening Study

- 1. Introduction**
- 2. Experimental design**
- 3. Results: Experiment I**
- 4. Results: Experiment II**
- 5. Results: Experiment III**

Landmark project dates

- Commencement of the 28-month Agreement on 14 July 2009
- Installation of the climber mesh frames and irrigation system, and replacement and improvement of soil by the contractor in the early part of 2010
- Planting of the climbers by the contractor in March–May 2010
- Installation of environmental monitoring sensors and data loggers in March–April 2010
- Commencement of live data collection and climber growth assessment from 01 June 2010
- First interim report in February 2011
- Second interim report in August 2011
- Presentation of interim results to DSD in February 2012
- Original end of two-year monitoring in November 2012
- One-year project extension to December 2012

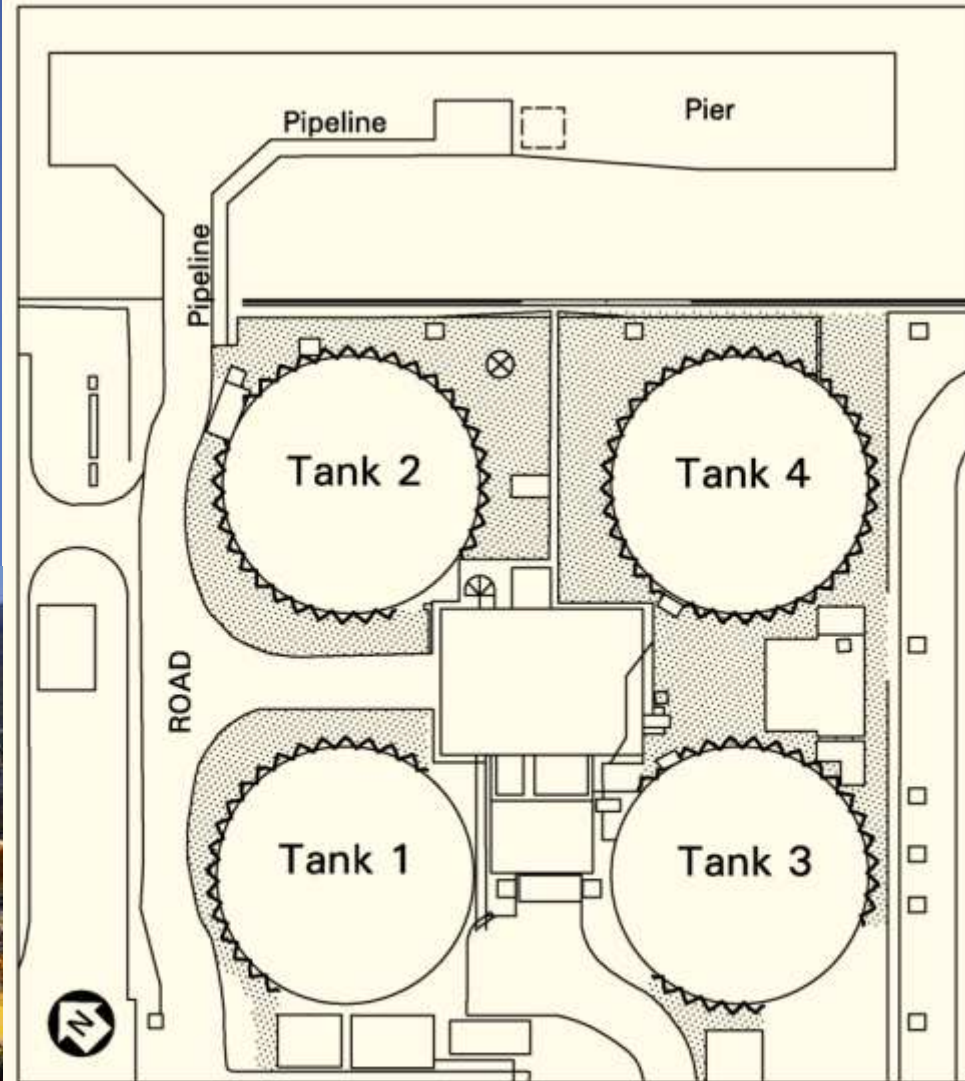
Experimental site and tanks






13.3 m tall
27.2 m diameter
1136.5 m² total surface area
341.8 m total circumference
240 m total plantable
circumference
1200 m² total exposed soil area



Experimental site and tanks



Legends:

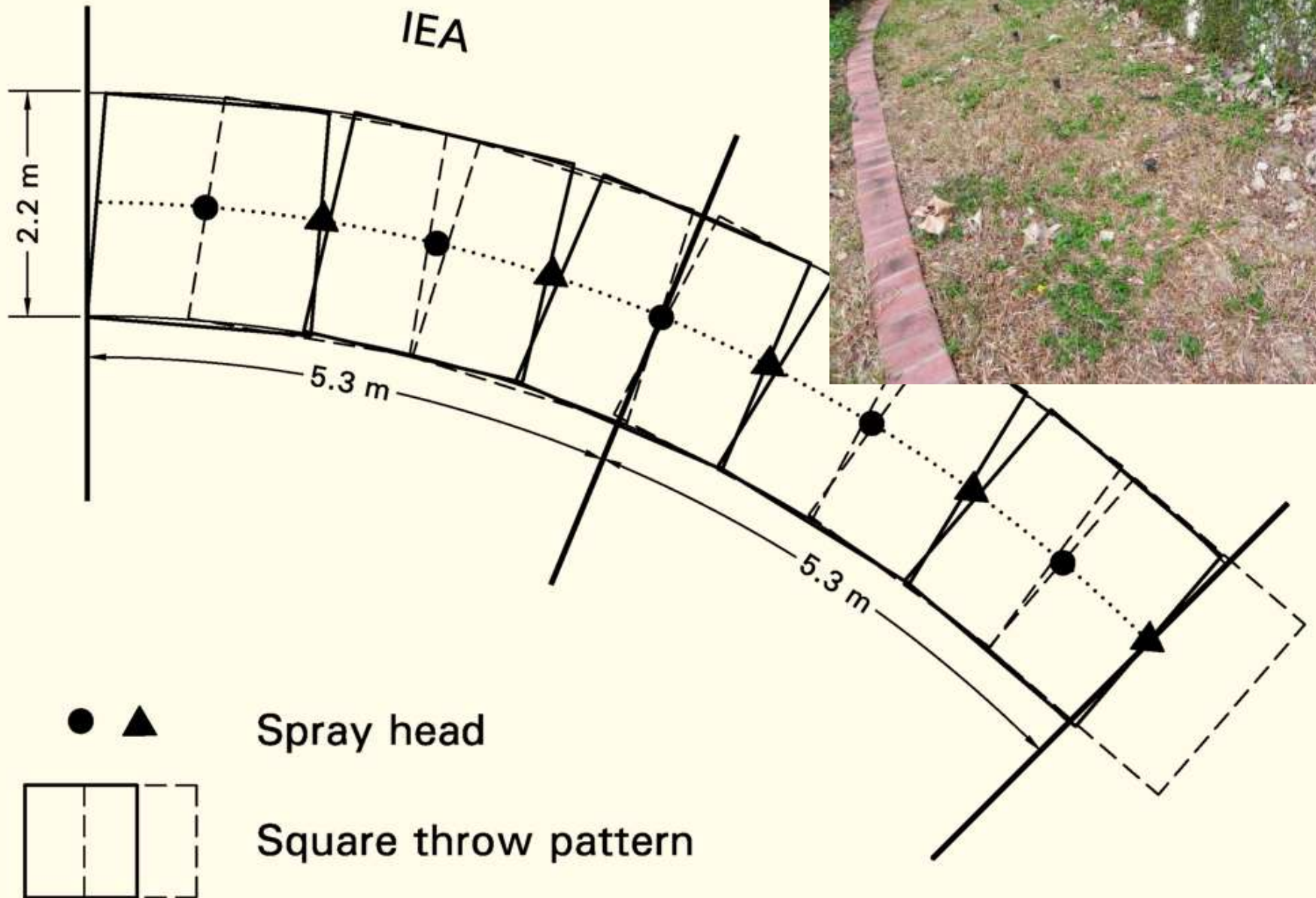
-  Exposed soil ($\sim 1200 \text{ m}^2$)
-  Vertical greening area ($\sim 240 \text{ m}$ long)
-  Weather station site

0 10 20 m

Experimental site and tanks



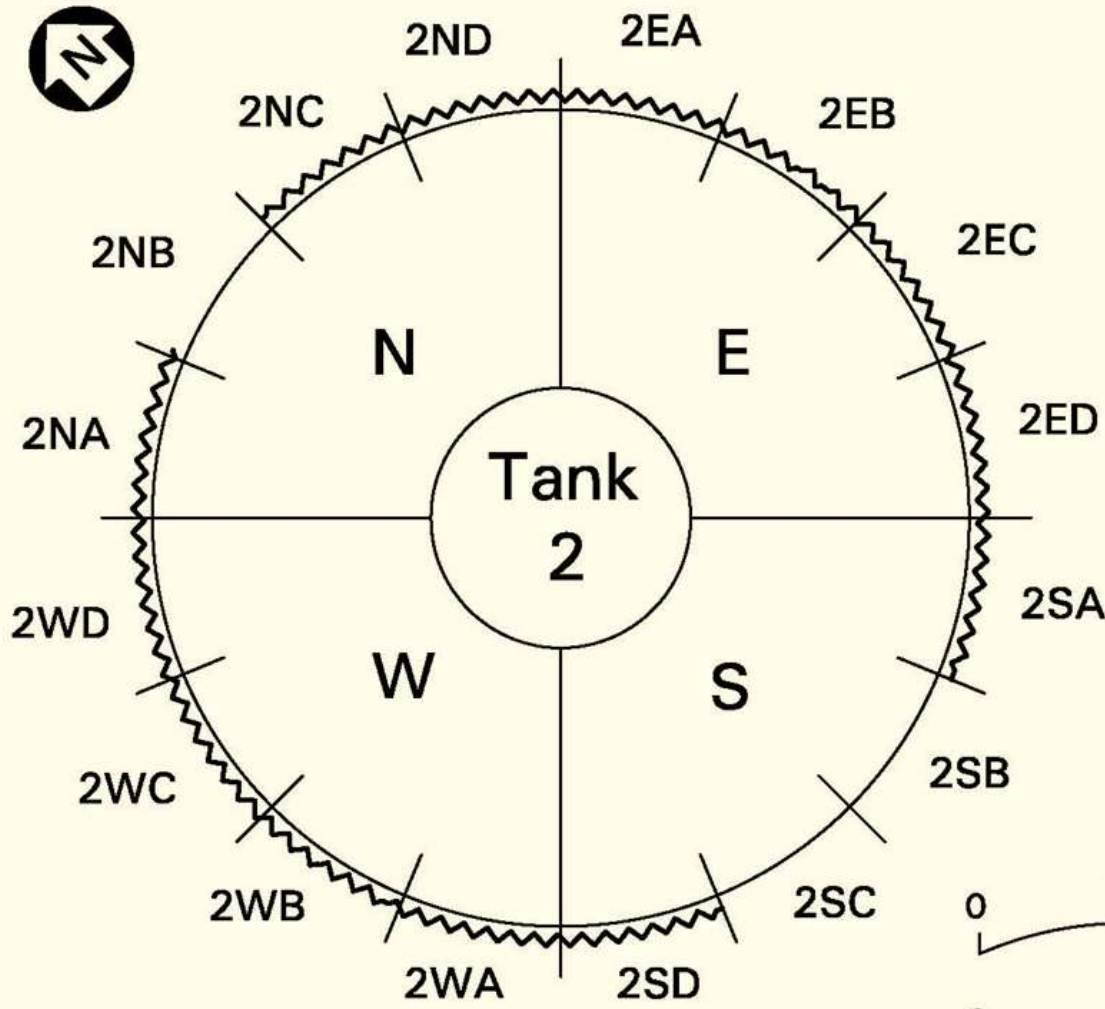
Experimental site and tanks



DSD Vertical Greening Study

1. Introduction
2. Experimental design
3. Results: Experiment I
4. Results: Experiment II
5. Results: Experiment III

Demarcation of tank surface into experimental plots



Each tank: 4 quarters: N, S, E, W
Each quarter: 4 sectors: A, B, C, D
= Experimental plots
5 m arc length
13.3 m tall
66.5 m² area
Total 45 plots (ideal 64 plots)

Concrete

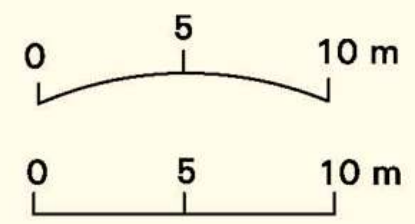
A: *Campsis grandiflora*

C: *Ficus pumila*

Mesh

B: *Bauhinia corymbosa*

D: *Pyrostegia venusta*



Experiment I: Tanks 2 & 4: Site factor effect

Test site factors

➤ Orientation

- 4 quarters = four cardinal compass directions

➤ Climbing mode & species

- Sectors A & C: Concrete

- *Campsis grandiflora* & *Ficus pumila*

- Sectors B & D: Mesh

- *Bauhinia corymbosa* & *Pyrostegia venusta*

➤ Soil quality

- Original soil: Tank 2

- New soil mix: Tank 4

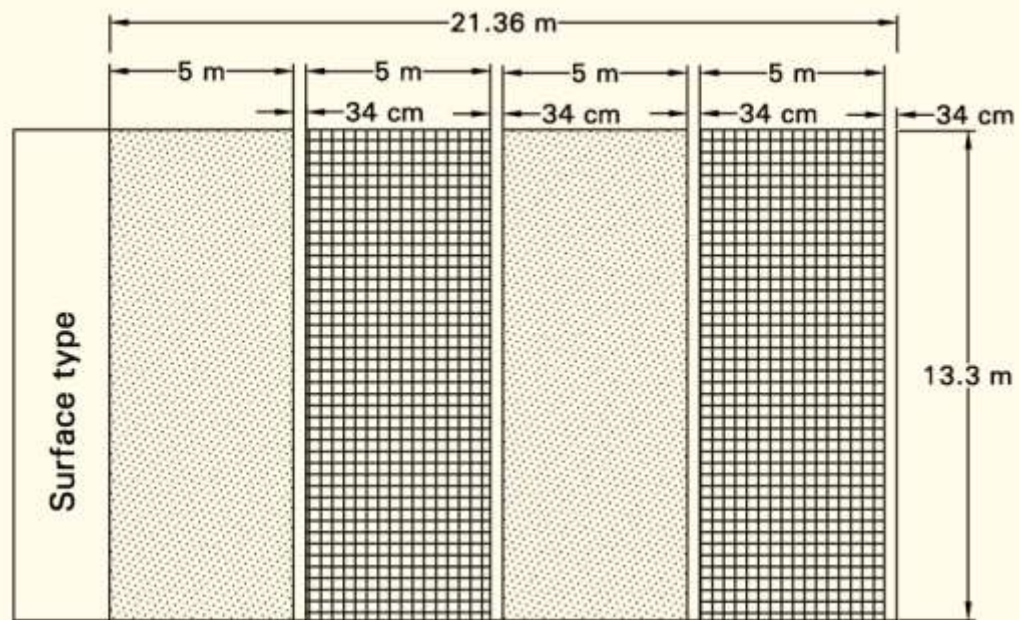
- Replaced soil strip 2 m wide and 0.6 m deep

- Both soil types treated with fertilizer in top 30 cm

Experiment I: Tanks 2 & 4: Site factor effect



Experiment I: Tanks 2 & 4: Site factor effect



Surface type	21.36 m				
	5 m	5 m	5 m	5 m	
		34 cm	34 cm	34 cm	
				34 cm	
					13.3 m
Plot	A	B	C	D	
Climber attachment	Concrete (painted)	Mesh (75 mm square)	Concrete (painted)	Mesh (75 mm square)	
Species	<i>Campsis grandiflora</i> (Chinese Trumpet Creeper)	<i>Bauhinia glauca</i> (Climbing Bauhinia)	<i>Ficus pumila</i> (Creeping Fig)	<i>Pyrostegia venusta</i> (Firecracker Vine)	

Experiment I: Tanks 2 & 4: Site factor effect



Campsis grandiflora
Chinese Trumpet Creeper
凌霄
紫葳科
Bignoniaceae

凌霄原產於中國。花冠為漏斗狀，外呈橙紅色，內呈鮮紅色，極具觀賞價值。凌霄花有藥效，可行血去瘀。



花期：5至8月
果期：10月



Bauhinia corymbosa
Camel's Foot
首冠藤
蘇木科
Caesalpinaceae

首冠藤為本地原生品種。白色花瓣帶粉紅色脈紋，具芳香。長圓形果實，紅艷可愛，是理想的攀援和垂直綠化植物。



花期：4至6月
果期：9至12月



Ficus pumila
Creeping Fig
薜荔
桑科
Moraceae

薜荔為本地原生種，喜歡吸附於樹幹、岩石及牆壁上。由榕小蜂授粉才會開花結果。其枝、葉及果有藥效，能治關節炎。果含有果膠，可製涼粉。



花期：4至12月
果期：4至12月



Pyrostegia venusta
Firecracker Vine
炮仗花
紫葳科
Bignoniaceae

炮仗花原產於巴西。春季和冬季開花。橙紅色的花，密集成叢，像鞭炮一樣閃閃發亮，故稱為炮仗花。其花和葉有藥效，能潤肺止咳，清熱利喉。



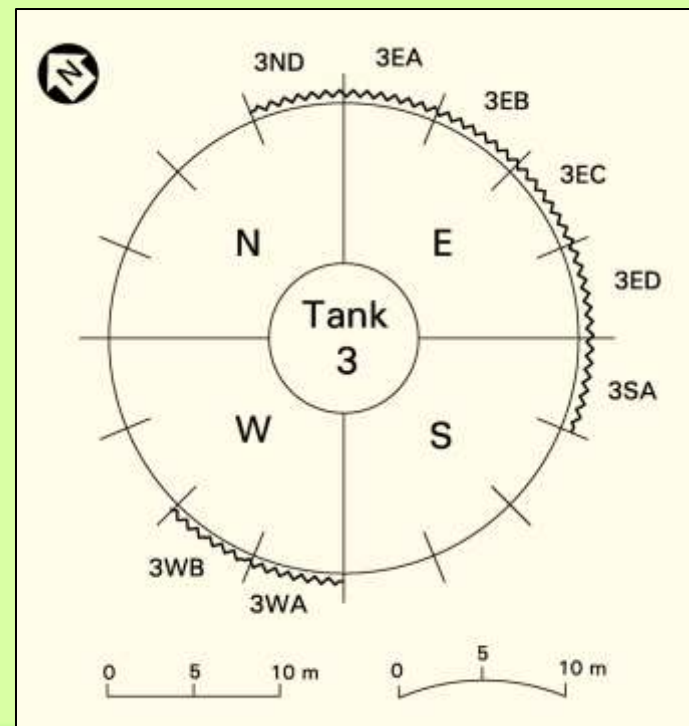
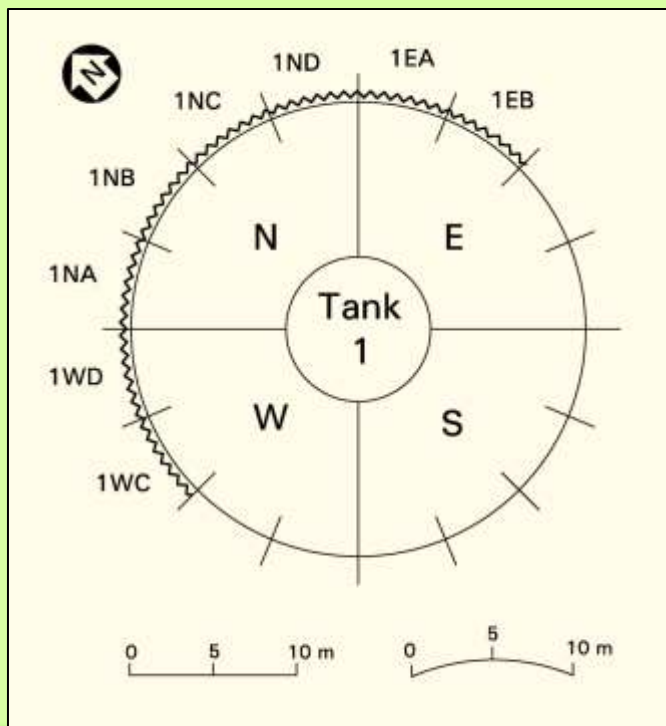
花期：1至3月
果期：5至8月



Experiment II: Tanks 1 & 3: Climber species trial

Test growth performance of climber species

- 16 available experimental plots
 - Test 16 climber species
 - Tank 1: 8 plots, mesh
 - Tank 3: 8 plots, concrete
 - All plots use original soil



Climber species used in the experiments

Table 1. Climber plant species used in the vertical greening experiments.							
Expt. plot	Climber attachment	Climber species	Common name	Chinese name	Seasonality	Provenance	Climbing habit
Tank 1 (Experiment II):							
1EA-y	Mesh	<i>Quisqualis indica</i>	Chinese Honeysuckle	使君子	Evergreen	Exotic	Thorn
1WB-x	Mesh	<i>Antigonon leptopus</i>	Coral Vine	珊瑚藤	Deciduous	Exotic	Tendrils
1WC-x	Mesh	<i>Vitis vinifera</i> *	Grape	葡萄	Deciduous	Exotic	Tendrils
1WD-y	Mesh	<i>Pseudocalymma alliaceum</i> *	Garlic Vine	蒜香藤	Evergreen	Exotic	Tendrils
1NA-y	Mesh	<i>Podranea ricasoliana</i> *	Pink Trumpet Vine	紫芸藤	Evergreen	Exotic	Twining
1NB-y	Mesh	<i>Bougainvillea spp.</i>	Bougainvillea	籐杜鵑	Evergreen	Exotic	Twining
1NC-y	Mesh	<i>Wisteria sinensis</i>	Chinese Wisteria	紫藤	Deciduous	Exotic	Twining
1ND-y	Mesh	<i>Lonicera japonica</i>	Honeysuckle	金銀花	Deciduous	Exotic	Twining
Tank 3 (Experiment II):							
3EA-z	Concrete	<i>Parthenocissus dalzielii</i>	Diverse Leaf Creeper	異葉爬山虎	Deciduous	Exotic	Sticky disk
3EB-x	Concrete	<i>Hedera helix</i>	Common Ivy	洋常春藤	Evergreen	Exotic	Aerial root
3EC-x	Concrete	<i>Philodendron scandens</i>	Heart Leaf Philodendron	圓葉蔓綠絨	Evergreen	Exotic	Aerial root
3ED-x	Concrete	<i>Ficus pumila cv variegata</i>	Variiegated Creeping Fig	花葉辟荔	Evergreen	Exotic	Sticky disk
3SA-x	Concrete	<i>Epipremnum aureum</i> *	Devil's Ivy	黃金葛	Evergreen	Exotic	Aerial root
3WA-x	Concrete	<i>Sygonium podophyllum 'White Butterfly'</i> *	Arrowhead Vine	合果芋	Evergreen	Exotic	Aerial root
3WB-x	Concrete	<i>Hedera nepalensis var. sinensis</i>	Mabled Dragon Ivy	中華常春藤	Evergreen	Exotic	Aerial root
3ND-z	Concrete	<i>Trachelospermum jasminoides</i>	Star Jasmine	絡石	Evergreen	Exotic	Aerial root
Tanks 2 and 4 (Experiment I):							
See Table 3	Mesh	<i>Bauhinia corymbosa</i>	Camel's Foot	首冠藤	Evergreen	Exotic	Tendrils
See Table 3	Mesh	<i>Pyrostegia venusta</i>	Firecracker Vine	炮仗花	Evergreen	Exotic	Tendrils
See Table 3	Concrete	<i>Campsis grandiflora</i>	Chinese Trumpet Creeper	凌霄	Deciduous	Exotic	Aerial root
See Table 3	Concrete	<i>Ficus pumila</i>	Creeping Fig	辟荔	Evergreen	Exotic	Sticky disk

* Substitute species because the first-choice species could not be supplied by the landscape contractor.

Experiment II: Tanks 1 & 3: Climber species trial



Quisqualis indica
Chinese Honeysuckle

使君子

使君子科
Combretaceae

使君子原產於東南亞，為木質藤本。枝葉茂密，花多艷麗。花初放時為粉白色，後漸變紅。相傳古時有位叫郭使君的醫生以此植物治病，功效顯著，故稱它為使君子。



花期：夏季
果期：秋季



Antigonon leptopus
Coral Vine

珊瑚藤

蓼科
Polygonaceae

珊瑚藤原產於墨西哥，為半落葉藤本。莖前端具卷鬚，枝條蔓延力強。花果期長，夏至秋季最盛，盛開時串串粉紅色的花苞晶瑩美豔，絢麗奪目。



花期：8至12月
果期：8至12月



Vitis vinifera
Grape

葡萄

葡萄科
Vitaceae

葡萄原產於亞洲西部，為落葉藤本，可攀達三十五米高。全球約有六十種，其中有分觀賞品種、釀酒品系和食品品系等。其營養價值極高，可製成葡萄乾、葡萄汁和葡萄酒等。



花期：4至5月
果期：6至10月



Pseudocalymma alliaceum
Garlic Vine

蒜香藤

紫葳科
Bignoniaceae

蒜香藤原產於巴西。其花和葉均帶有濃烈的大蒜味，故稱為蒜香藤。花初開時為粉紫色帶紅，受粉後漸變為淡紫，花形密集呈串。



花期：3至5月
果期：2月



Experiment II: Tanks 1 & 3: Climber species trial



Podranea ricasoliana
Pink Trumpet Vine
紫雲藤
紫葳科
Bignoniaceae

紫雲藤原產於非洲南部。花期甚長，花冠呈鈴形，花瓣為粉紅色至淡紫色，並有紫紅色條紋，具芳香。



花期：春、秋
和冬季
果期：—



Bougainvillea spp.
Bougainvillea
簕杜鵑
茉莉科
Nyctaginaceae

簕杜鵑原產於熱帶美洲。花色豐富，曾被稱為七姊妹，現多被稱為簕杜鵑。其花由三塊色彩斑斕的苞片及三朵小花蕊組成。由於花苞如紙般薄，所以也有「紙花」(Paper Flower)之稱。



花期：春季和
冬季
果期：—



Wisteria sinensis
Chinese Wisteria
紫藤
豆科
Fabaceae

紫藤原產於中國，為落葉藤本，成株蔓延力強。花呈蝶形，初放時帶紫色，後漸變為淡藍色。其花可提煉芳香油，莖皮可解毒或製成驅蟲劑，種子也可作防腐、止痛劑用。



花期：4至5月
果期：5至8月



Lonicera japonica
Honeysuckle
金銀花
忍冬科
Caprifoliaceae

金銀花又名忍冬，為本地原生常綠蔓性藤本。花初放時帶銀白色，後漸變為金黃色，故稱金銀花。金銀花是常用的清熱解毒藥，為五花茶的材料之一。



花期：4月
果期：9月

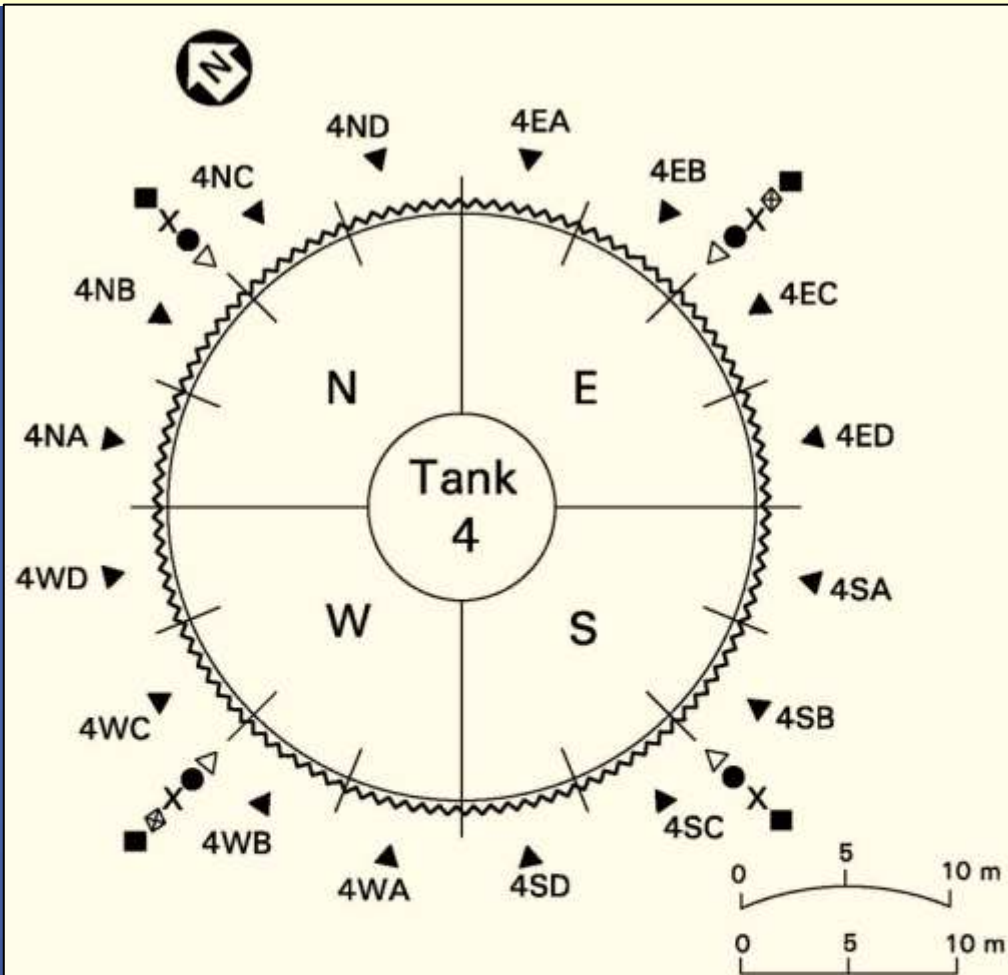


Experiment III: Tanks 4: Cooling effect

Monitor cooling effect

- Tank 4
 - Complete complement of 16 plots
- Mounting of environmental sensors
 - Within plots: Species effect
 - Between plots: Control (baseline)
- Measured parameters
 - Air temperature
 - Surface temperature: exposed concrete
 - Surface temperature: shaded concrete
 - Surface temperature: foliage
 - Soil moisture
- Data taken at 15 minutes intervals
 - Stored in data loggers
- Site weather data provided by DSD

Tank 4: Setup of environmental sensors



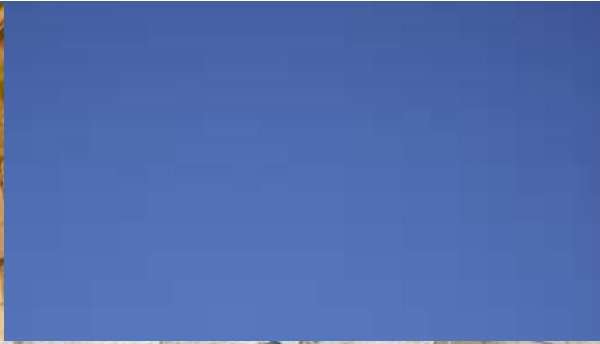
- ▶ Infrared surface temperature sensor (experiment)
- ▷ Infrared surface temperature sensor (control)
- X Air temperature & relative humidity sensor
- Pyranometer (solar radiation) sensor
- ⊕ Soil moisture sensor
- Weather-proof data logger
(in moisture-resistant and heat-insulated box)

Tank 4: Setup of environmental sensors

Table 2. The purpose of the proposed sensors, data loggers and mains power supply.

	Equipment or installation	Measurement parameter	Unit
A	Infrared radiometer	Surface temperature of tank covered by climbers	°C
		Surface temperature of tank without vegetation	°C
B	Air temperature/RH	Air temperature and relative humidity near tank surface	°C & %
		Air temperature and relative humidity on tank top	°C & %
C	Pyranometer	Solar radiation (visible and infrared) on tank surface	W.m ⁻²
		Solar radiation (visible and infrared) on tank top	W.m ⁻²
D	PAR	Photosynthetically active radiation on tank top	W.m ⁻²
E	Soil moisture	Topsoil moisture content at at 10 cm depth	v/v %
		Subsoil moisture content at at 50 cm depth	v/v %
F	Logger in weather-proof box	High-end data logger to store infrared sensor data	
		Standard data logger to store other sensor data	
G	13A double socket	Provide mains electrical power to loggers and sensors	

Tank 4: Setup of environmental sensors



Tank 4: Setup of environmental sensors



Tank 4: Setup of environmental sensors



DSD Vertical Greening Study

1. Introduction
2. Experimental design
3. Results: Experiment I
4. Results: Experiment II
5. Results: Experiment III

Results: Experiment I: Site factor effect

Table 2. Tentative results of of climber species growth performance in Experiment I on tanks 2 and 4 on 10 January 2012.

Expt. plot	Climber attachment	Climber species	Growth height (m)	Growth density (lower portion)	Growth density (upper portion)	Gap between stems	Vigour
Original soil:							
2EA-y	Concrete	<i>Campsis grandiflora</i>	4	Sparse	Sparse	Medium	Medium
2EB-z	Mesh	<i>Bauhinia corymbosa</i>	13	Sparse	Sparse	Narrow	Medium
2EC-z	Concrete	<i>Ficus pumila</i>	2	Medium	Sparse	Narrow	Low
2ED-z	Mesh	<i>Pyrostegia venusta</i>	13	Sparse	Sparse	Narrow	Medium
2SA-z	Concrete	<i>Campsis grandiflora</i>	4.8	Medium	Sparse	Medium	Medium
2SD-y	Mesh	<i>Pyrostegia venusta</i>	11.7	Sparse	Sparse	Narrow	Medium
2WA-y	Concrete	<i>Campsis grandiflora</i>	9	Sparse	Sparse	Narrow	High
2WB-y	Mesh	<i>Bauhinia corymbosa</i>	13	Medium	Medium	Narrow	High
2WC-y	Concrete	<i>Ficus pumila</i>	4	Medium	Medium	Narrow	Low
2WD-y	Mesh	<i>Pyrostegia venusta</i>	12.8	Sparse	Sparse	Medium	Medium
2NA-y	Concrete	<i>Campsis grandiflora</i>	5.7	Medium	Sparse	Medium	High
2NC-y	Concrete	<i>Ficus pumila</i>	4	Medium	Sparse	Narrow	Medium
2ND-y	Mesh	<i>Pyrostegia venusta</i>	13	Sparse	Sparse	Medium	Medium
Replaced soil:							
4EA-y	Concrete	<i>Campsis grandiflora</i>	9	Sparse	Sparse	Medium	Medium
4EB-z	Mesh	<i>Bauhinia corymbosa</i>	13.5	Medium	Medium	Narrow	High
4EC-y	Concrete	<i>Ficus pumila</i>	8	Medium	Sparse	Narrow	Medium
4ED-x	Mesh	<i>Pyrostegia venusta</i>	12	Sparse	Medium	Medium	Medium
4SA-x	Concrete	<i>Campsis grandiflora</i>	9.8	Medium	Medium	Medium	High
4SB-y	Mesh	<i>Bauhinia corymbosa</i>	13.6	Medium	Dense	Narrow	High
4SC-y	Concrete	<i>Ficus pumila</i>	11.7	Medium	Sparse	Narrow	High
4SD-x	Mesh	<i>Pyrostegia venusta</i>	13	Sparse	Sparse	Medium	Medium
4WA-z	Concrete	<i>Campsis grandiflora</i>	11	Medium	Dense	Narrow	High
4WB-x	Mesh	<i>Bauhinia corymbosa</i>	11.7	Sparse	Dense	Narrow	High
4WC-z	Concrete	<i>Ficus pumila</i>	10	Dense	Medium	Narrow	High
4WD-y	Mesh	<i>Pyrostegia venusta</i>	11.5	Sparse	Medium	Medium	High
4NA-y	Concrete	<i>Campsis grandiflora</i>	11	Medium	Medium	Medium	High
4NB-z	Mesh	<i>Bauhinia corymbosa</i>	13	Sparse	Medium	Narrow	High
4NC-z	Concrete	<i>Ficus pumila</i>	13	Dense	Medium	Narrow	High
4ND-y	Mesh	<i>Pyrostegia venusta</i>	9	Sparse	Sparse	Medium	Medium

Results: Experiment I: Site factor effect

Table 3. The notional scores of four groups of treatments tested in Experiment I on 10 January 2012.

Attribute	Category	N	Growth height (m)	Growth density (lower portion)	Growth density (upper portion)	Gap between stems	Vigour
Climber attachment	Concrete	15	7.80	1.93	1.47	1.40	2.40
	Mesh	14	12.41	1.21	1.64	1.43	2.36
Soil type	Original soil	13	8.46	1.46	1.15	1.38	2.08
	Replaced soil	16	11.30	1.69	1.88	1.44	2.63
Species	<i>Bauhinia corymbosa</i>	6	12.97	1.50	2.17	1.00	2.83
	<i>Campsis grandiflora</i>	8	8.04	1.63	1.50	1.75	2.63
	<i>Ficus pumila</i>	7	7.53	2.29	1.43	1.00	2.14
	<i>Pyrostegia venusta</i>	8	12.00	1.00	1.25	1.75	2.00
Orientation	East	3.16	9.31	1.38	1.25	1.38	2.00
	South	5.17	10.77	1.67	1.50	1.50	2.50
	West	4.81	10.38	1.63	2.00	1.25	2.63
	North	3.14	9.81	1.71	1.43	1.57	2.43

Growth density: 1=Sparse, 2=Medium, 3=Dense.

Gap between stems: 1=Narrow, 2=Medium, 3=Wide.

Vigour: 1=Low, 2=Medium, 3=High.

DSD Vertical Greening Study

1. Introduction
2. Experimental design
3. Results: Experiment I
4. Results: Experiment II
5. Results: Experiment III

Results: Experiment II: Climber species performance

Table 4. Tentative results of growth performance of climber species tests in Experiment II on tanks 1 and 3 on 10 January 2012.

Expt. plot	Climber attachment	Climber species	Growth height (m)	Growth density (lower portion)	Growth density (upper portion)	Notable gap between stems	Vigour
Tank 1:							
1EA-y	Mesh	<i>Quisqualis indica</i>	11.6	Sparse	Dense	Narrow	Medium
1WB-x	Mesh	<i>Antigonon leptopus</i>	13.2	Sparse	Medium	Narrow	Low
1WC-x	Mesh	<i>Vitis vinifera</i>	12.4	Medium	Sparse	Narrow	Medium
1WD-y	Mesh	<i>Pseudocalymma alliaceum</i>	12.8	Medium	Medium	Medium	High
1NA-y	Mesh	<i>Podranea ricasoliana</i>	12.8	Sparse	Sparse	Medium	High
1NB-y	Mesh	<i>Bougainvillea spp.</i>	12.8	Dense	Medium	Narrow	High
1NC-y	Mesh	<i>Wisteria sinensis</i>	13.1	Medium	Medium	Narrow	High
1ND-y	Mesh	<i>Lonicera japonica</i>	13.1	Dense	Dense	No	High
Tank 3:							
3EA-z	Concrete	<i>Parthenocissus dalzielii</i>	13	Dense	Dense	No	High
3EB-x	Concrete	<i>Hedera helix</i>	<1 (dead)	Sparse	Sparse	Wide	Low
3EC-x	Concrete	<i>Philodendron scandens</i>	5	Dense	Sparse	Medium	Medium
3ED-x	Concrete	<i>Ficus pumila cv variegata</i>	1.8	Sparse	Sparse	Wide	Low
3SA-x	Concrete	<i>Epipremnum aureum</i>	<1 (dead)	Sparse	Sparse	Wide	Low
3WA-x	Concrete	<i>Sygonium podophyllum</i>	3	Dense	Dense	No	High
3WB-x	Concrete	<i>Hedera nepalensis var. sinensis</i>	<1 (dead)	Sparse	Sparse	Wide	Low
3ND-z	Concrete	<i>Trachelospermum jasminoides</i>	5	Medium	Sparse	Medium	Low

Climber performance: sequential photos

Sample photos (from monthly records)

- Experiment 1
 - 16 species
- Spanning 17 months and two growing seasons
 - from August 2010 to October 2012 (27 months)
 - Covering different seasons
 - 11 sample months
 - August 2010 December 2010
 - February 2011 June 2011
 - August 2011 November 2011
 - January 2012 March 2012
 - June 2012 August 2012
 - October 2012

Plot 1EA *Quisqualis indica*
(Chinese Honeysuckle, 使君子)



11 August 2010



07 December 2010



08 February 2011

Plot 1EA *Quisqualis indica*
(Chinese Honeysuckle, 使君子)



09 June 2011



12 August 2011



03 November 2011

Plot 1EA *Quisqualis indica*
(Chinese Honeysuckle, 使君子)



10 January 2012



13 March 2012



07 June 2012

Plot 1EA *Quisqualis indica*
(Chinese Honeysuckle, 使君子)



07 August 2012



11 October 2012

Plot 1WB *Antigonum leptopus*
(Coral Vine, 珊瑚藤)



11 August 2010



07 December 2010



08 February 2011

**Plot 1WB *Antigonum leptopus*
(Coral Vine, 珊瑚藤)**



09 June 2011



12 August 2011



03 November 2011

**Plot 1WB *Antigonum leptopus*
(Coral Vine, 珊瑚藤)**



10 January 2012



13 March 2012



07 June 2012

**Plot 1WB *Antigonum leptopus*
(Coral Vine, 珊瑚藤)**



07 August 2012



11 October 2012

Plot 1WC *Vitis vinifera*
(Grape, 葡萄)



11 August 2010



07 December 2010

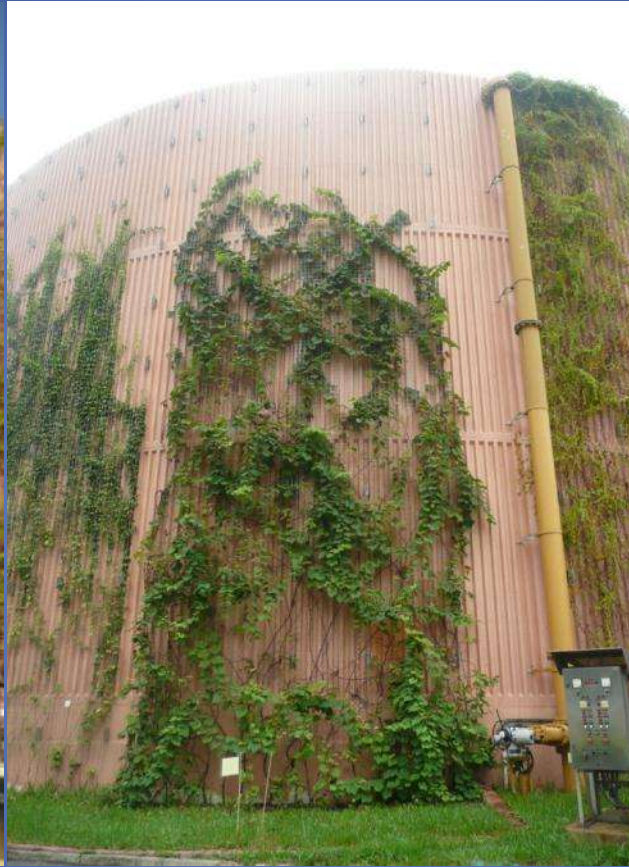


08 February 2011

Plot 1WC *Vitis vinifera*
(Grape, 葡萄)



09 June 2011



12 August 2011



03 November 2011

Plot 1WC *Vitis vinifera*
(Grape, 葡萄)



10 January 2012



13 March 2012



07 June 2012

Plot 1WC *Vitis vinifera*
(Grape, 葡萄)



07 August 2012



11 October 2012

Plot 1WD *Pseudocalymma alliaceum*
(Garlic Vine, 蒜香藤)



11 August 2010



07 December 2010



08 February 2011

**Plot 1WD *Pseudocalymma alliaceum*
(Garlic Vine, 蒜香藤)**



09 June 2011



12 August 2011



03 November 2011

Plot 1WD *Pseudocalymma alliaceum*
(Garlic Vine, 蒜香藤)



10 January 2012



13 March 2012



07 June 2012

**Plot 1WD *Pseudocalymma alliaceum*
(Garlic Vine, 蒜香藤)**



07 August 2012



11 October 2012

**Plot 1NA *Podranea ricasoliana*
(Pink Trumpet Vine, 紫芸藤)**



11 August 2010



07 December 2010



08 February 2011

Plot 1NA *Podranea ricasoliana*
(Pink Trumpet Vine, 紫芸藤)



09 June 2011



12 August 2011



03 November 2011

**Plot 1NA *Podranea ricasoliana*
(Pink Trumpet Vine, 紫芸藤)**



10 January 2012



13 March 2012



07 June 2012

**Plot 1NA *Podranea ricasoliana*
(Pink Trumpet Vine, 紫芸藤)**



07 August 2012



11 October 2012

Plot 1NB *Bougainvillea* spp.
(Bougainvillea, 簕杜鵑)



11 August 2010



07 December 2010



08 February 2011

Plot 1NB *Bougainvillea* spp.
(*Bougainvillea*, 簕杜鹃)



09 June 2011



12 August 2011



03 November 2011

Plot 1NB *Bougainvillea* spp.
(*Bougainvillea*, 簕杜鵑)



10 January 2012

13 March 2012

07 June 2012

**Plot 1NB *Bougainvillea* spp.
(*Bougainvillea*, 簕杜鵑)**



07 August 2012



11 October 2012

**Plot 1NC *Wisteria sinensis*
(Chinese Wisteria, 紫藤)**



11 August 2010



07 December 2010



08 February 2011

Plot 1NC *Wisteria sinensis*
(Chinese Wisteria, 紫藤)



09 June 2011



12 August 2011



03 November 2011

**Plot 1NC *Wisteria sinensis*
(Chinese Wisteria, 紫藤)**



10 January 2012



13 March 2012



07 June 2012

**Plot 1NC *Wisteria sinensis*
(Chinese Wisteria, 紫藤)**



07 August 2012



11 October 2012

**Plot 1ND *Lonicera japonica*
(Honeysuckle, 金銀花)**



11 August 2010



07 December 2010



08 February 2011

Plot 1ND *Lonicera japonica*
(Honeysuckle, 金銀花)



09 June 2011



12 August 2011



03 November 2011

**Plot 1ND *Lonicera japonica*
(Honeysuckle, 金銀花)**



10 January 2012



13 March 2012



07 June 2012

**Plot 1ND *Lonicera japonica*
(Honeysuckle, 金銀花)**



07 August 2012



11 October 2012

Plot 3EA *Parthenocissus dalzielii*
(Diverse Leaf Creeper, 異葉爬山虎)



11 August 2010



07 December 2010



08 February 2011

Plot 3EA *Parthenocissus dalzielii*
(Diverse Leaf Creeper, 異葉爬山虎)



09 June 2011



12 August 2011



03 November 2011

Plot 3EA *Parthenocissus dalzielii*
(Diverse Leaf Creeper, 異葉爬山虎)



10 January 2012

13 March 2012



07 June 2012

Plot 3EA *Parthenocissus dalzielii*
(Diverse Leaf Creeper, 異葉爬山虎)



07 August 2012



11 October 2012

**Plot 3EB *Hedera helix*
(Common Ivy, 洋常春藤)**



11 August 2010



07 December 2010



08 February 2011

**Plot 3EB *Hedera helix*
(Common Ivy, 洋常春藤)**



09 June 2011



12 August 2011



03 November 2011

Plot 3EB *Hedera helix*
(Common Ivy, 洋常春藤)



10 January 2012



13 March 2012



07 June 2012

**Plot 3EB *Hedera helix*
(Common Ivy, 洋常春藤)**



07 August 2012



11 October 2012

**Plot 3EC *Philodendron scandens*
(Heart Leaf Philodendron, 圓葉蔓綠絨)**



11 August 2010



07 December 2010



08 February 2011

**Plot 3EC *Philodendron scandens*
(Heart Leaf Philodendron, 圓葉蔓綠絨)**



09 June 2011



12 August 2011



03 November 2011

Plot 3EC *Philodendron scandens*
(Heart Leaf Philodendron, 圓葉蔓綠絨)



10 January 2012



13 March 2012



07 June 2012

**Plot 3EC *Philodendron scandens*
(Heart Leaf Philodendron, 圓葉蔓綠絨)**



07 August 2012



11 October 2012

Plot 3ED *Ficus pumila* cv *variegata*
(Variegated Creeping Fig, 花葉辟荔)



11 August 2010



07 December 2010



08 February 2011

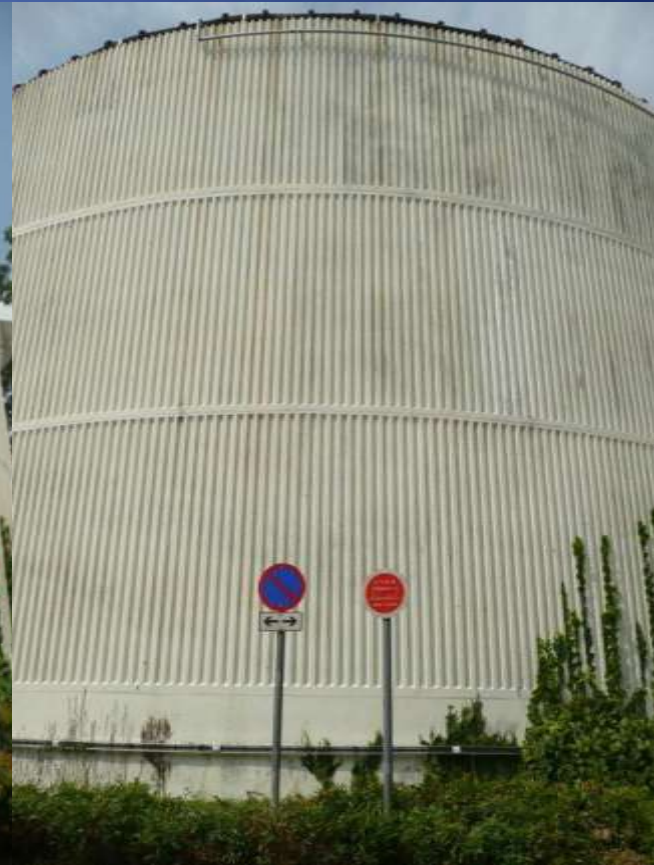
Plot 3ED *Ficus pumila* cv *variegata*
(Variegated Creeping Fig, 花葉辟荔)



09 June 2011



12 August 2011



03 November 2011

Plot 3ED *Ficus pumila* cv *variegata*
(Variegated Creeping Fig, 花葉辟荔)



10 January 2012



13 March 2012



07 June 2012

Plot 3ED *Ficus pumila* cv *variegata*
(Variegated Creeping Fig, 花葉辟荔)



07 August 2012



11 October 2012

**Plot 3SA *Epipremnum aureum*
(Devil's Ivy, 黃金葛)**



11 August 2010



07 December 2010



08 February 2011

Plot 3SA *Epipremnum aureum*
(Devil's Ivy, 黃金葛)



09 June 2011



12 August 2011



03 November 2011

Plot 3SA *Epipremnum aureum*
(Devil's Ivy, 黃金葛)



10 January 2012



13 March 2012



07 June 2012

Plot 3SA *Epipremnum aureum*
(Devil's Ivy, 黃金葛)



07 August 2012



11 October 2012

**Plot 3WA *Sygonium podophyllum*
(Arrowhead Vine, 合果芋)**



11 August 2010



07 December 2010



08 February 2011

**Plot 3WA *Sygonium podophyllum*
(Arrowhead Vine, 合果芋)**



09 June 2011



12 August 2011



03 November 2011

**Plot 3WA *Sygonium podophyllum*
(Arrowhead Vine, 合果芋)**



10 January 2012



13 March 2012



07 June 2012

**Plot 3WA *Sygonium podophyllum*
(Arrowhead Vine, 合果芋)**



07 August 2012



11 October 2012

**Plot 3WB *Hedera nepalensis* var. *sinensis*
(Mabled Dragon Ivy, 中華常春藤)**



11 August 2010



07 December 2010



08 February 2011

**Plot 3WB *Hedera nepalensis* var. *sinensis*
(Mabled Dragon Ivy, 中華常春藤)**



09 June 2011



12 August 2011



03 November 2011

**Plot 3WB *Hedera nepalensis* var. *sinensis*
(Mabled Dragon Ivy, 中華常春藤)**



10 January 2012



13 March 2012



07 June 2012

Plot 3WB *Hedera nepalensis* var. *sinensis*
(Mabled Dragon Ivy, 中華常春藤)



07 August 2012



11 October 2012

**Plot 3ND *Trachelospermum jasminoides*
(Star Jasmine, 絡石)**



11 August 2010



07 December 2010



08 February 2011

**Plot 3ND *Trachelospermum jasminoides*
(Star Jasmine, 絡石)**



09 June 2011



12 August 2011



03 November 2011

**Plot 3ND *Trachelospermum jasminoides*
(Star Jasmine, 絡石)**



10 January 2012



13 March 2012



07 June 2012

Plot 3ND *Trachelospermum jasminoides*
(Star Jasmine, 絡石)



07 August 2012

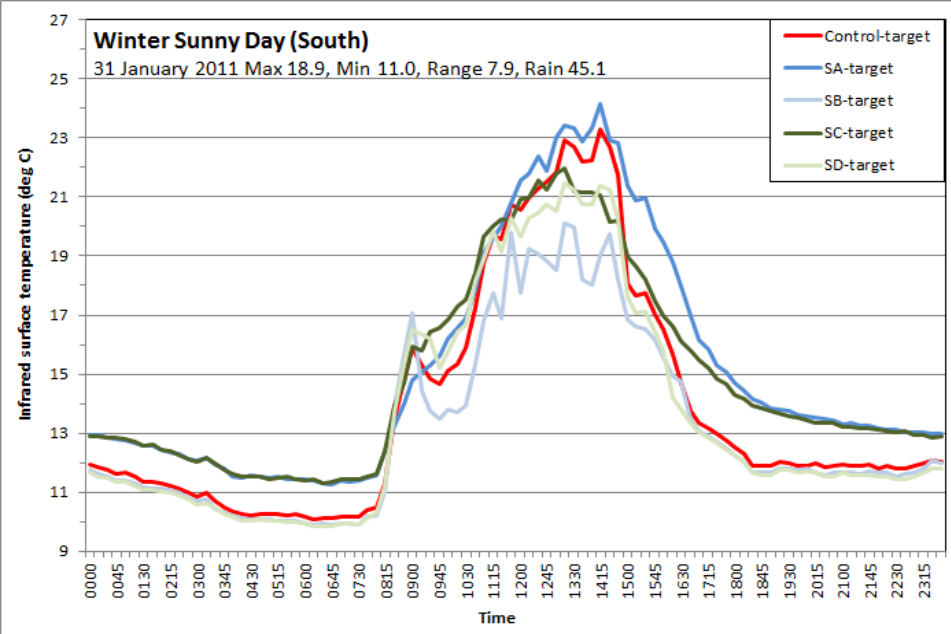
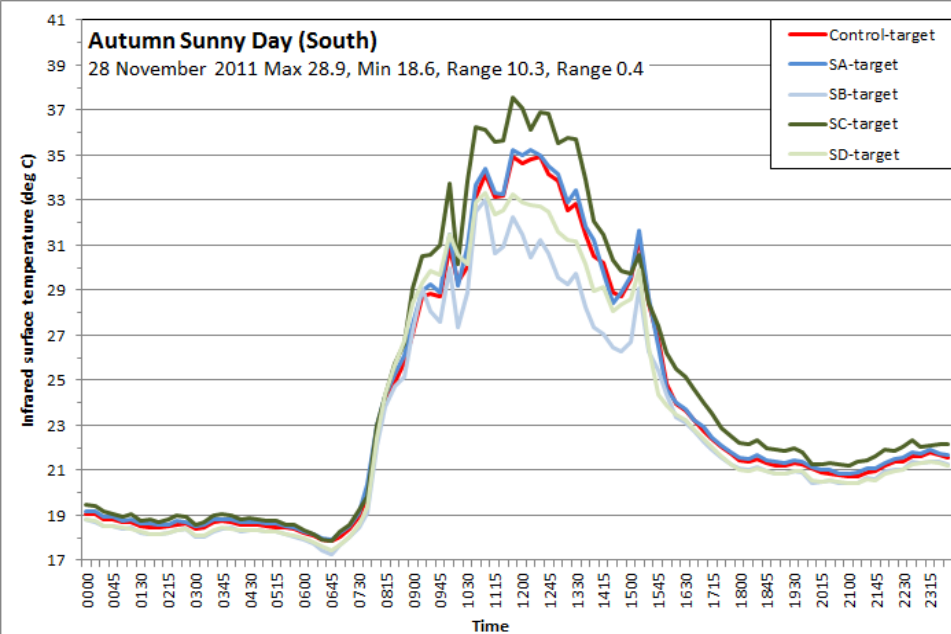
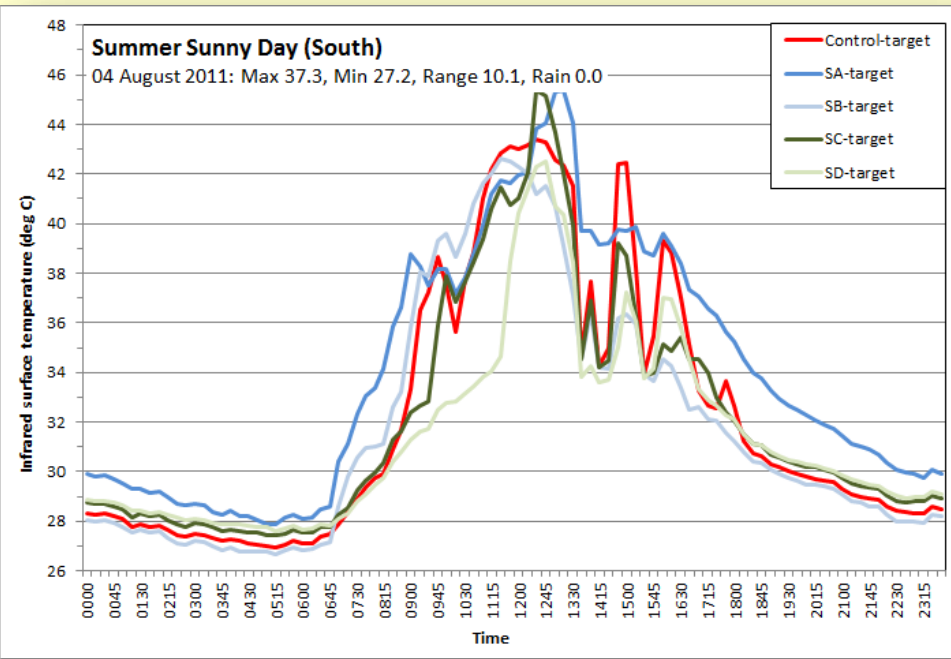
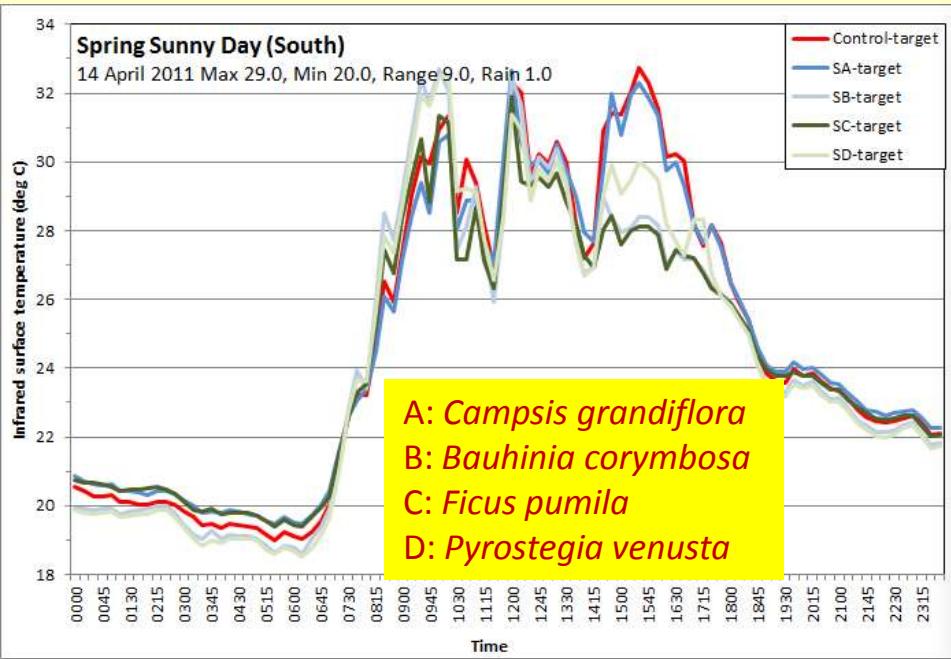


11 October 2012

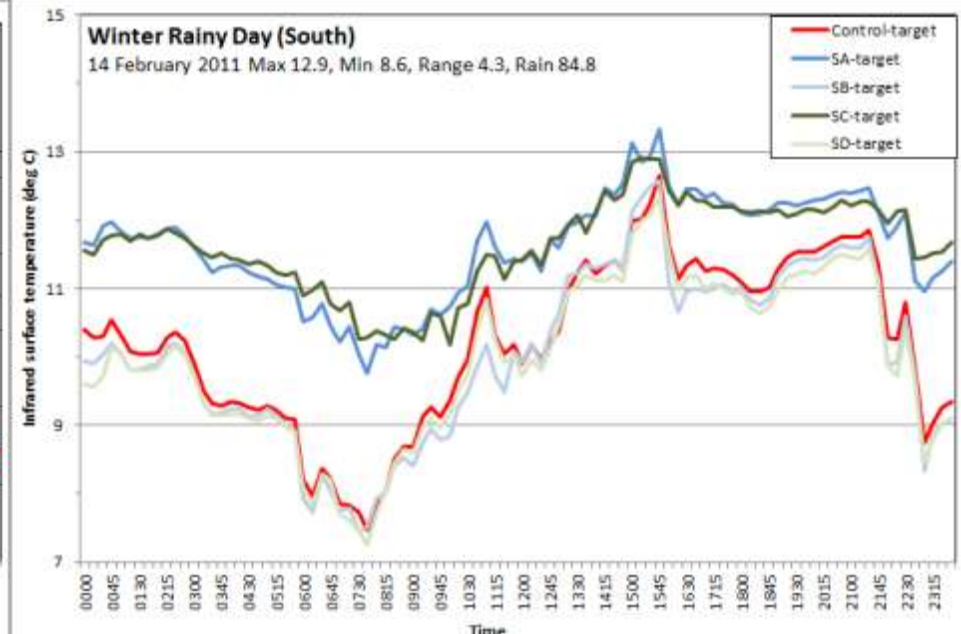
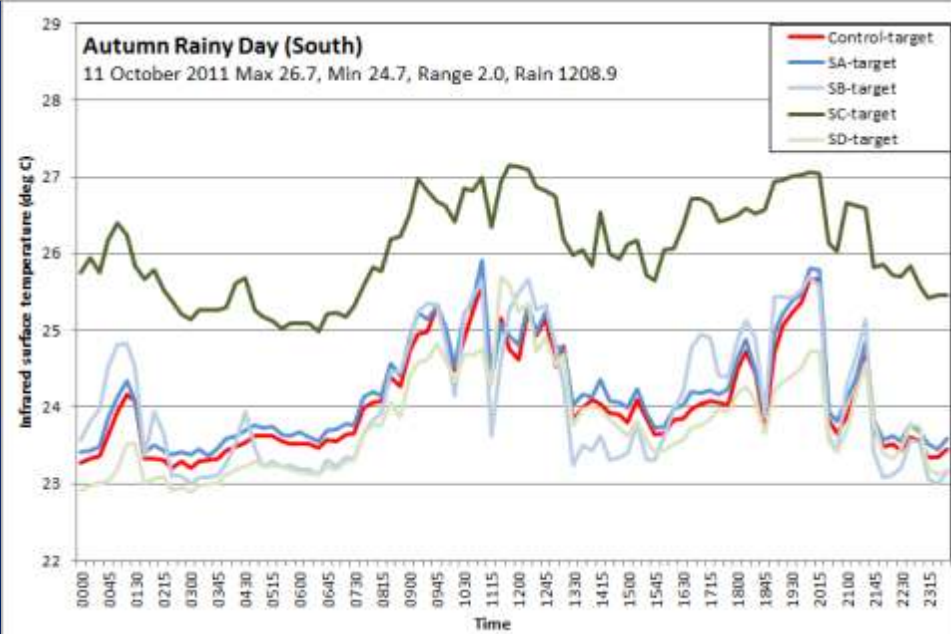
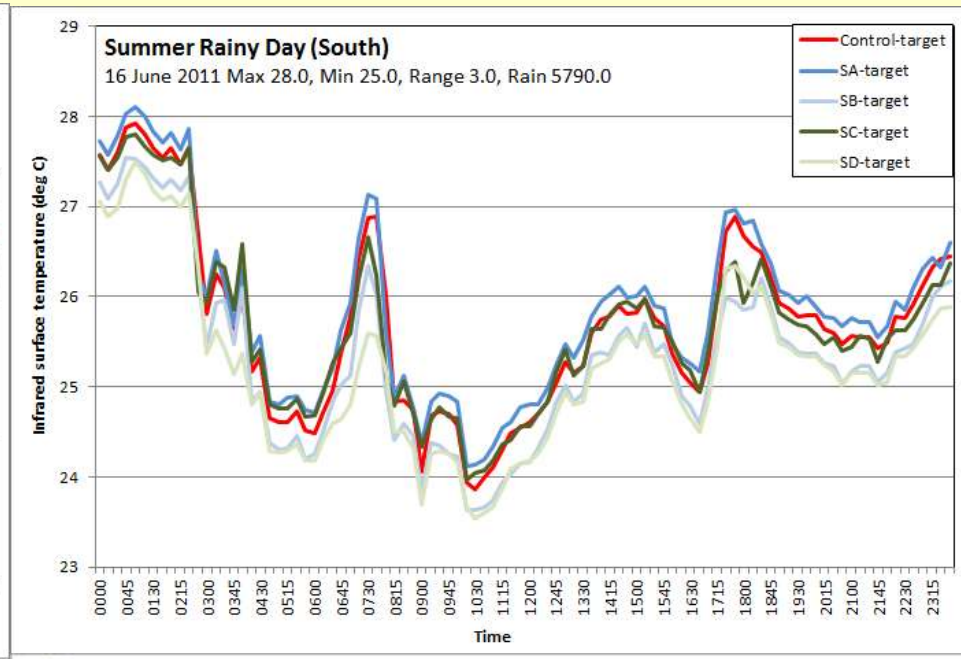
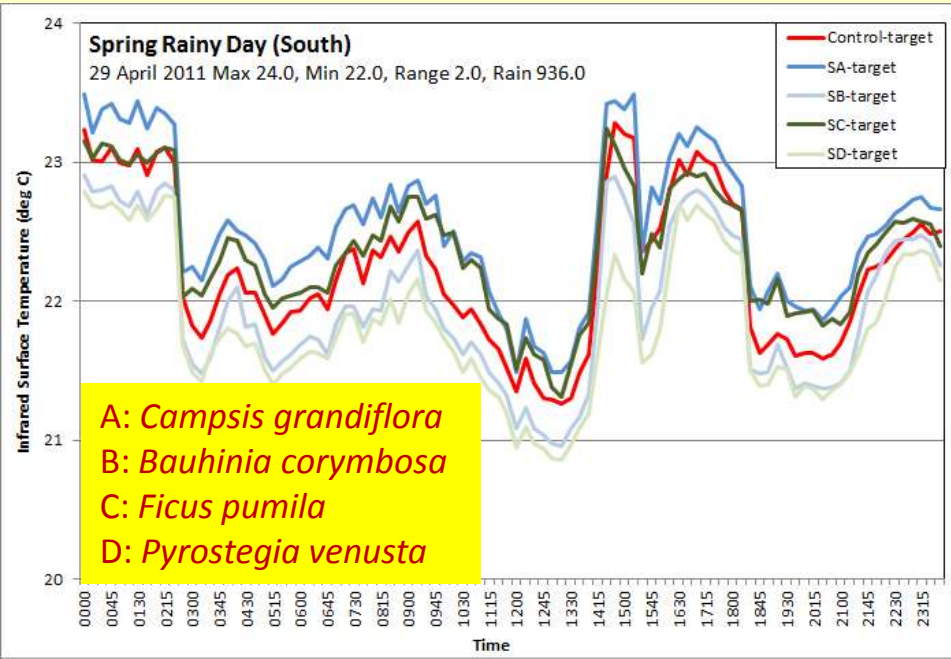
DSD Vertical Greening Study

1. Introduction
2. Experimental design
3. Results: Experiment I
4. Results: Experiment II
5. Results: Experiment III

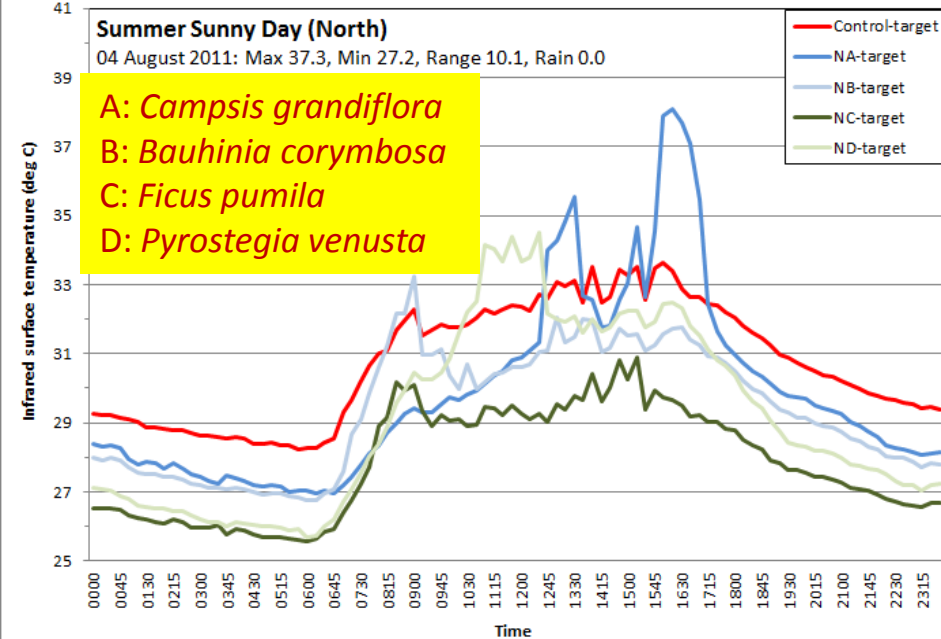
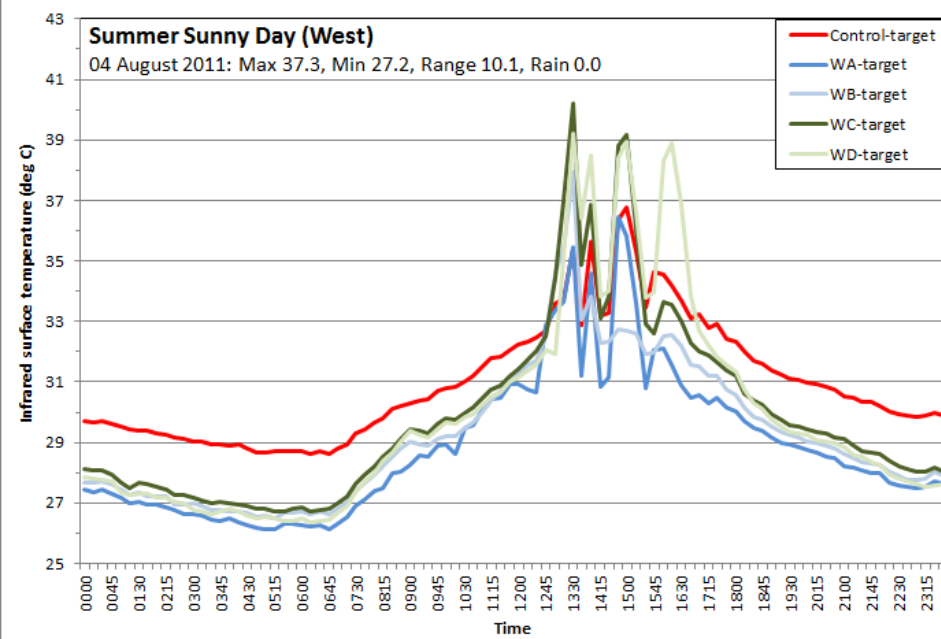
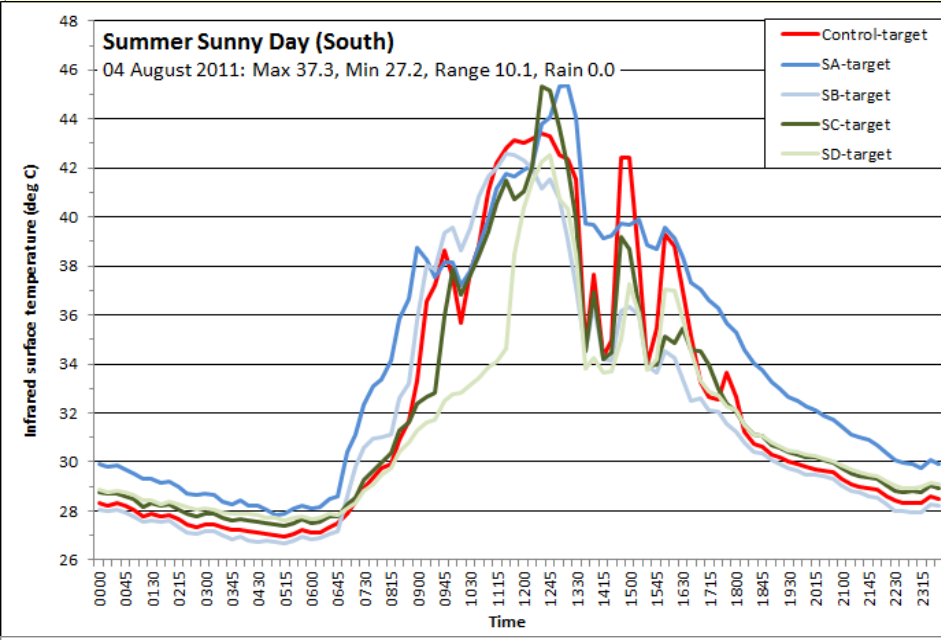
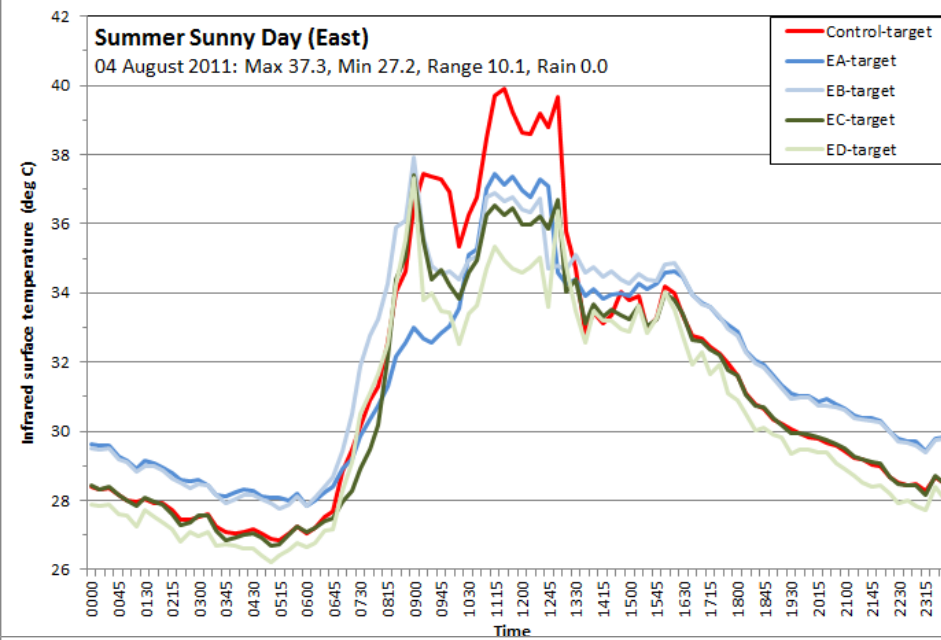
Experiment III: Cooling effect on sunny day: Four seasons



Experiment III: Cooling effect on rainy day: Four seasons



Experiment III: Cooling effect on summer sunny day: Four aspects



Skyrise Greenery and HKILA Awards 2012 (Research)

Sha Tin Sewage Treatment Works Vertical Greening Study



Background

Vertical greening is a new concept of greening in recent years. It is also an ideal option to increase green cover in urban areas and enhance the quality of our living environment. In order to collect research data in vertical greening applications, we have commenced a vertical greening study on four circular sludge holding tanks at Sha Tin Sewage Treatment Works in June 2009 to evaluate the growth and environmental performance of various climber species and to identify the suitable species for growing in Hong Kong.

Experimental Design



Objectives of Study

- To carry out a review based on published literature on selection of climber species and identify suitable species for planting on wall surfaces.
- To evaluate the performance of climber species in relation to growth parameters, such as aspects, supporting systems and soil quality.
- To monitor the cooling effect of green wall using a combination of environmental monitoring equipment.

Colourful Wall

It is interesting to note that vertical greening is not restricted to "green" only. It could be very colorful also (see photos).



Experiment I : Site Factor Effect

The orientation, climber attachment mode and soil quality of four climber species on Tank 2 and 4 are studied systematically in this experiment.



Findings

- Orientation**
 - For the same species, climbers growing in south and west quarters perform better than those in east and north in terms of plant vigor, growth height and density.
- Climber Attachment Mode**
 - Beauveria corymbosa (黃粉蝶) and Pyrostegia venusta (錦紅花) that rely on mesh system perform much better than the other two self-climbing species, Compsea grandiflora (蓮蕹) and Ipomoea pes-caprae (錦紫), in terms of growth rate. However, self-climbing species have the distinct advantage of not requiring the installation of a metal mesh which can save both capital and recurrent expenditure.
- Soil Type**
 - Plants growing in improved soil perform better than those in original soil by 24% in growth height.

Experiment II : Climber Species Trial

Study the growth and performance of 16 climber species on Tank 1 and 3

Tank 1 (with mesh)	Tank 3 (without mesh)
<i>Lonicera japonica</i> 金銀花	<i>Perthoecis distalis</i> 黃葉爬山虎
<i>Quercus indica</i> 橡樹子	<i>Hedera helix</i> 常春藤
<i>Antigonon leptopus</i> 黃連蕹	<i>Philodendron scandens</i> 蔓綠絨
<i>Xisya sibirica</i> 雙色	<i>Pilea pumila</i> var. <i>variegata</i> 巧葉吊蘭
<i>Pseudelephantopus altissimus</i> 絲瓜藤	<i>Synedrella aspera</i> 銀絲藤
<i>Pentstemon stratosolens</i> 紫萼藤	<i>Synedrella pentaphylla</i> White Butterfly 白蝴蝶
<i>Rougevillaria spp.</i> 藍花藤	<i>Hedera nepalensis</i> var. <i>sinensis</i> 中國常春藤
<i>Mitella sinensis</i> 雙瓣	<i>Trachelospermum jasminoides</i> 白



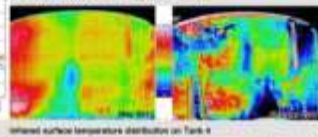
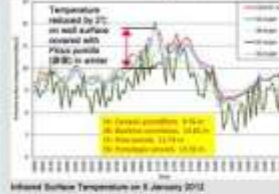
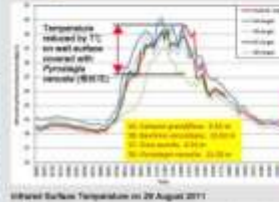
Findings

- Tank 1 (with mesh)**
 - Quercus indica* (橡樹子) and *Mitella sinensis* (雙瓣) on Tank 1 are the best performers. They have good green coverage and reach the top of tank within 6 months. The remaining species also can reach the top within 1.5 years.
- Tank 3 (without mesh)**
 - Except *Perthoecis distalis* (黃葉爬山虎), the 7 species on Tank 3 have all developed quite slowly. *Philodendron scandens* (蔓綠絨) climbs up to 15m in 2.5 years and have developed a dense foliage. However, the two *Hedera* spp. have not been able to adapt to site conditions and found dead.

Experiment III : Monitoring of Cooling Effect


Temperature sensors are installed on Tank 4 to monitor the wall surface and air temperature reduction efficacy of vertical greening. Readings on concrete surface of the tank are also taken to serve as a baseline for comparison. Data of air temperature, relative humidity, solar radiation and photosynthetically active radiation (PAR) are also collected for analysis.

Findings



Dec 2009 Feb 2010 Mar 2010 May 2010 Jun 2010 Aug 2010 Oct 2010 Dec 2010 Feb 2011 Jun 2011 Aug 2011 Oct 2011 Dec 2011 Feb 2012 Sep 2012





**Thank You
Comments and Questions
are Welcome**