

INDOOR PLANT SPECIES SURVIVAL UNDER DIFFERENT ENVIRONMENT IN INDOOR VERTICAL GARDEN

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ABSTRACT : One way to measure the efficacy of a vertical garden is the survival of the plants that cover the growing area, which affects the beauty of a vertical garden. Thus, this research aimed to study the survival of some indoor plant species in with and without air conditioning. We selected plants from 15 families in a total of 20 plant species by review the documents related to the indoor plant and based on duplication of the top 20 plant species, and popular in the market. The study was conducted by incubating in a room with air conditioning (average of temperature and light at 25.6 Celsius and 396.6 Lux, respectively) and without air conditioning (average of temperature and light at 31.9 Celsius and 2,044.1 Lux, respectively), 8 hrs./day average light, watering one time in the initial experiment and noticed the water saturated soil. The survival condition was recorded in 3 levels, namely, the normal condition was 1, the withered condition was 2 and the dead condition was 3. The data was collected for 15 days. The results were 7 species of plants that tolerated both conditioning included as *Philodendron* 'Moonlight', *Aechmea fasciata*, *Tradescantia zebrina*, *Chlorophytum comosum*, *Dracaena surculosa*, *Tillandsia usneoides* and *Nephrolepis cordifolia*. There were in Araceae, Commelinaceae, Agavaceae, Neprolepidaceae and Bromeliaceae families.

Keywords: Indoor plant species, Vertical garden, Plant species survival, Indoor vertical garden

1. INTRODUCTION

Vertical gardens (also referred to as green walls, green façades and living walls) are an important factor in improving urban environments [1]. Most people in urban society spend 80% to 90% of their time indoors every day [2]. From past studies, it is clearly that indoor environmental quality can play an important role in work performance, productivity and the health of building users [3]. Plants improved a person's perception of the environment, and a space occupied with plants was judged to be more acceptable than one without plants. There is growing evidence to support the notion that plants can play an important role in providing a higher quality living environment. These is an effective and qualitative characteristic of an interior-landscaped office [4].

In additional, the human body's response was showed significant changes when plant conditions varied. These outcomes provided design strategies for incorporating the plants into the interior office spaces and also provided the physiological variables to evaluate human comfort in the outside environment [5]. Evapotranspiration from plants helps lowering the temperature around the planting environment and this can be utilized for air cooling and humidity control [6]. The limitation on space for landscaping by vertical gardening is a more popular choice, and also has many benefits, especially improving the urban environment. Nowadays, it is popular both inside and outside the building.

A living wall with a fabric system is one of the types that is used inside the building. The efficiency of this system depends on the water supply system, structure, and plants that affect the efficacy of cover and beauty. It was found that 5-10 percent of a plant in the indoor living wall death and must be planted to replace. This high-cost was loss by planted to replace [7]. Considerations for choosing plants depend on moisture and light which may not be direct sunlight but it can be light bulbs [8]. Therefore, the efficiency maintenance of living wall which is the plant selection for an aesthetic and living. This research aims to test the survival plants that are arranged in a vertical garden, both with air conditioning and without air conditioning. This information is useful for the landscape designers and gardeners for choosing a plant that anesthetic and living to save on the maintenance cost.

2. MATERIALS AND METHODS

1) Establish a vertical garden structure from steel material, box size 1.00 x 2.00 meters, choose the type of plants that are popularly planted on the vertical garden, 23 species, using the planting sheet (Felt) attached to the structure and penetrate the planting box. Using 4 plants per species, first watering once, until the soil is saturated with water.

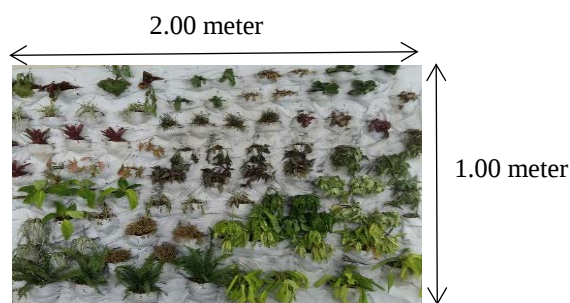


Fig1 . Size Box

2) Place in the interior of the building with air conditioning and without air conditioning turned to the east, both conditions.

3) Recording data for 15 days by temperature and light (Light intensity meter model TM-213 TENMARS), which 3 times daily at 9.00 am, 12.00 am and 16.00 am and also the survey record in survival landscape (The survival landscape is the survival plants, which beauty in landscape visibility.) was representative 1 as normal, 2 as withered (With more than 50% withered leaves of the leaves) and 3 as dead.



Fig. 1 Survival landscape status

4) Using the data to analyze with descriptive statistics and interpretation of values obtained from the average survival conditions in the landscape, there was 1.00 - 1.67 means normal, 1.68 - 2.33 means withered and 2.34 - 3.00 means death. Comparing the survival conditions of both plant conditions with the Chi-Square hypothesis test.

3. RESULTS

3.1 Survival Landscape Survey Results

Based on the study of ornamental plants that are suitable for use in vertical garden, comprising 16 families [9]-[11] including Araceae, Aspleniaceae, Liliaceae, Commelinaceae, Bromeliaceae, Labiatae, Polypodiaceae, Urticaceae, Gesneriaceae, Apocynaceae, Acroleanidae, Neprolepidaceae, Convallariaceae, Lythraceae, Piperaceae and Agavaceae. There were chosen 23 species of plants

that the book recommends, and also considered the popularity and available in the market. 23 Plants experimented with 16 Families as shown in Table 1 and 2.

The results found both landscape survival conditions were "normal" including *Chlorophytum comosum* (*Anthesicum Vittatum*), *Aechmea fasciata*, *Tradescantia zebrina* Loudon (*Zebrina pendula* Schnizl.), *Philodendron 'Moonlight'*, *Dracaena surculosa*, *Nephrolepis cordifolia* and *Tillandsia usneoides*, which are in family of Bromeliaceae Commelinaceae Araceae Agavaceae Neprolepidaceae and Bromeliaceae, respectively. On the other hand, *Fittonia albivenis*, *Pilea cadierei*, *Lectranthus scutellarioides* and *Cuphea hyssopifolia* died in both conditions, which are in family of Acanthaceae Urticaceae Labiatae Lythraceae, respectively. Further, it was found that withered plants in both conditions, *Platyserium holttumii*, *Asplenium nidus*, *Syngonium podophyllum*, and *Epipremnum aureum*, which are the family of Polypodiaceae, Aspleniaceae, Araceae, respectively.

In additional *Pellionia repens* (Lour.) Merr was found dead in air condition but the normal condition in without air conditioner, which belongs to the Urticaceae and also two species are *Ophiopogon japonicus* (Convallariaceae) and *Chlorophytum comosum* (*Anthesicum Picturatum*) (Liliaceae), which died in air conditioning but withered in the without air conditioning. Moreover, there are two types of Araceae; *Epipremnum aureum* 'Marble Queen' and *Philodendron erubescens* K.Koch & Augustin 'Lemon Lime', and *Dischidia* 'White Diamond' (Apocynaceae), there were normally in air conditioning but withered in without air conditioning. On the other hand, it was found two species; *Peperomia obtusifolia* (Piperaceae) and *Episcia* spp. & Hybrid (Gesneriaceae) which is withered in the air conditioning and normally in the without air conditioning.

It can be seen that found to survive both conditions is Araceae but found that some species withered in both conditions in this family include *Syngonium podophyllum* and *Epipremnum aureum*. *Pellionia repens* (Lour.) Merr. and *Pilea cadierei* is in the Urticaceae, were died in both conditioning, but *Pilea cadierei* survived without air conditioning. The air-conditioned rooms have a "dead" plant rather than in a room without air conditioning. While in a room without air conditioners were found less "withered" plants and also "dead" plants condition than rooms with air conditioning.



Chlorophytum comosum)



(*Aechmea fasciata*)



(*Tradescantia zebrina*)



(*Dracaena surculosa*)



(*Philodendron 'Moonlight'*) (*Nephrolepis cordifolia*)



(*Tillandsia usneoides*)

Fig. 2 Survival landscape plants in both condition

Table 1 23 Plant species of experimented

No.	Scientific name	Family name
1	<i>Fittonia albivenis</i>	Acanthaceae
2	<i>Pilea cadieri</i>	Urticaceae
3	<i>lectranthus scutellarioides</i>	Labiatae
4	<i>Cuphea hyssopifolia</i>	Lythraceae
5	<i>Platynerium holtumii</i>	Polypodiaceae
6	<i>Asplenium nidus</i>	Aspleniaceae
7	<i>Syngonium podophyllum</i>	Araceae
8	<i>Epipremnum aureum</i>	Araceae

No.	Scientific name	Family name
9	<i>Chlorophytum comosum</i> (Anthesicum Vittatum)	Liliaceae
10	<i>Aechmea fasciata</i>	Bromeliaceae
11	<i>Tradescantia zebrina</i> Loudon (<i>Zebrina pendula</i> Schnizl.)	Commelinaceae
12	<i>Philodendron 'Moonlight'</i>	Araceae
13	<i>Dracaena surculosa</i>	Agavaceae
14	<i>Nephrolepis cordifolia</i>	Neprolepidaceae
15	<i>Tillandsia usneoides</i>	Bromeliaceae
16	<i>Ophiopogon japonicus</i>	Convallariaceae
17	<i>Pellionia repens</i> (Lour.) Merr.	Urticaceae
18	<i>Chlorophytum comosum</i> (Anthesicum Picturatum)	Liliaceae
19	<i>Epipremnum aureum</i> 'Marble Queen'	Araceae
20	<i>Philodendron erubescens</i> K.Koch & Augustin 'Lemon Lime'	Araceae
21	<i>Dischidia</i> 'White Diamond'	Apocynaceae
22	<i>Peperomia obtusifolia</i>	Piperaceae
23	<i>Episcia</i> spp. & hybrid	Gesneriaceae

Table 2 landscape survival status in air-conditioning

No.	Plant species	Air condition room (Temperature average 25.6)		
		landscape survival status ($\bar{x}$)	SD	Mean-ing
1	<i>Fittonia albivenis</i>	2.69	0.24	D
2	<i>Pilea cadieri</i>	2.40	0.26	D
3	<i>lectranthus scutellar ioides</i>	2.58	0.26	D
4	<i>Cuphea hyssopifolia</i>	2.47	0.27	D
5	<i>Platynerium holtumii</i>	1.76	0.14	w
6	<i>Asplenium nidus</i>	2.32	0.26	w
7	<i>Syngonium podophyllum</i>	2.24	0.24	w
8	<i>Epipremnum aureum</i>	2.30	0.23	w
9	<i>Chlorophytum comosum</i> (Anthesicum Vittatum)	1.00	0.00	N
10	<i>Aechmea fasciata</i>	1.00	0.00	N
11	<i>Tradescantia zebrina</i> Loudon (<i>Zeb</i>	1.00	0.00	N

No.	Plant species	Air condition room (Temperature average 25.6)		
		landscape survival status ($\bar{x}$)	SD	Meaning
	<i>rinala pendula</i> Schnizl.)			
12	<i>Philodendron</i> 'Moon light'	1.00	0.00	N
13	<i>Dracaena surculosa</i>	1.48	0.13	N
14	<i>Nephrolepis cordifolia</i>	1.00	0.00	N
15	<i>Tillandsia usneoides</i>	1.00	0.00	N
16	<i>Ophiopogon japonicus</i>	2.34	0.27	D
17	<i>Pellionia repens</i> (Lour.) Merr.	2.47	0.21	D
18	<i>Chlorophytum comosum</i> (Anthesicum Picturatum)	2.54	0.17	D
19	<i>Epipremnum aureum</i> 'Marble Queen'	1.67	0.17	N
20	<i>Philodendron erubescens</i> K.Koch & Augustin 'Lemon Lime'	1.11	0.06	N
21	<i>Dischidia</i> 'White Diamond'	1.00	0.00	N
22	<i>Peperomia obtusifolia</i>	1.77	0.20	w
23	<i>Episcia</i> spp. & hybrid	1.77	0.20	w

Note: D is died, W is withered, and N is Normal

Table 3 landscape survival status without air-conditioning

No.	Plant species	Without air condition room (Temperature average 31.9)		
		landscape survival status ($\bar{x}$)	SD	Meaning
1	<i>Fittonia albivenis</i>	2.73	0.59	D
2	<i>Pilea cadieri</i>	2.57	0.67	D
3	<i>lectranthus scutellaroides</i>	2.35	0.88	D

No.	Plant species	Without air condition room (Temperature average 31.9)		
		landscape survival status ($\bar{x}$)	SD	Meaning
4	<i>Cuphea hyssopifolia</i>	2.57	0.77	D
5	<i>Platynerium holttumii</i>	2.20	0.51	w
6	<i>Asplenium nidus</i>	2.08	0.86	w
7	<i>Syngonium podophyllum</i>	1.77	0.73	w
8	<i>Epipremnum aureum</i>	2.00	0.93	w
9	<i>Chlorophytum comosum</i> (Anthesicum Vittatum)	1.60	0.51	N
10	<i>Aechmea fasciata</i>	1.15	0.58	N
11	<i>Tradescantia zebrina</i> Loudon (<i>Zebrina pendula</i> Schnizl.)	1.40	0.51	N
12	<i>Philodendron</i> 'Moon light'	1.40	0.51	N
13	<i>Dracaena surculosa</i>	1.53	0.52	N
14	<i>Nephrolepis cordifolia</i>	1.13	0.52	N
15	<i>Tillandsia usneoides</i>	1.23	0.42	N
16	<i>Ophiopogon japonicus</i>	2.20	0.94	w
17	<i>Pellionia repens</i> (Lour.) Merr.	1.62	0.31	N
18	<i>Chlorophytum comosum</i> (Anthesicum Picturatum)	1.98	0.93	w
19	<i>Epipremnum aureum</i> 'Marble Queen'	1.93	0.88	w
20	<i>Philodendron erubescens</i> K.Koch & Augustin 'Lemon Lime'	1.68	0.71	w
21	<i>Dischidia</i> 'White Diamond'	1.83	0.94	w
22	<i>Peperomia obtusifolia</i>	1.52	0.59	N
23	<i>Episcia</i> spp. & hybrid	1.52	0.59	N

Note: D is died, W is withered, and N is Normal

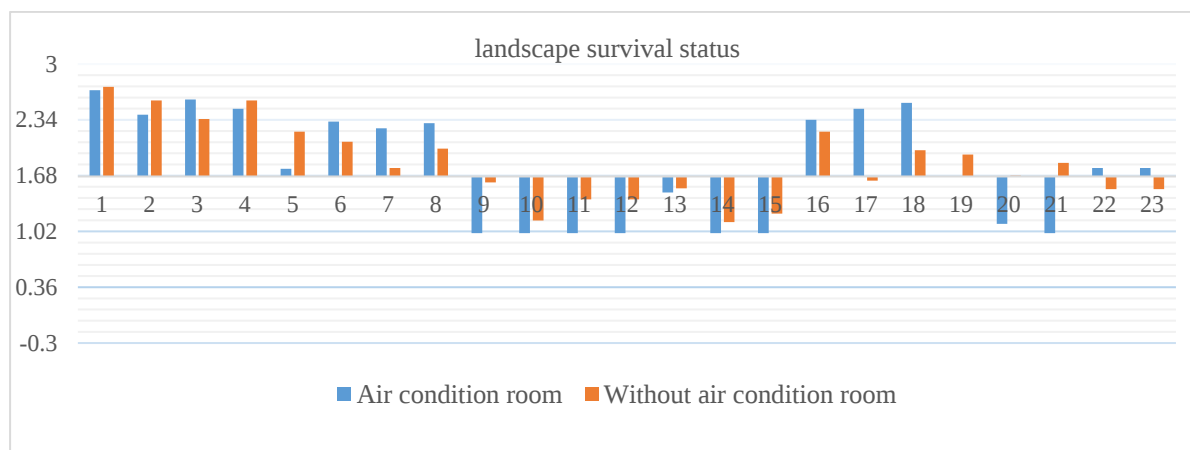


Fig. 3 Comparison plant survival landscape plants in both condition

Note: horizontal axis means No. of plant name vertical axis means survival landscape of plant species, 1.00 - 1.67 means normal, 1.68 - 2.33 means withered, 2.34 - 3.00 means death

3.2 Hypothesis Results

Comparison of survival landscape of plant species in each condition was found that each plant is not different in both conditions of a survival landscape. There were the same results as 0.317, therefore it was accepted the main hypothesis that each plant not significantly different at the level of 0.05 of survival landscape. Based on the main hypothesis that plants are in the air-conditioning and without air-conditioning have no difference in a survival landscape. It is found that significance at 1.88, therefore both conditions had no difference in a survival landscape of a significant level at 0.05.

DISCUSSION

Light temperature and relative humidity were averaged relative rooms with and without air conditioning 25.6, 31.9 degrees Celsius, and 396.6, 2,044.1 lux and 56.45% 51.25%, respectively. There was a light average of 8 hours/day. Gunawardena K. and Steemers K. [12] said that the relative humidity of humans and plants are that occupant comfort in the room is 20-28 degrees Celsius and 30-50% relative humidity and also Blanc P. [13] said that some plant species selected tend to require high canopy humidity to maintain good foliage health (RH85–95%). This comfort level RH may present the risk of foliage water stress. Vertical plant canopies however rare observed to maintain a self-hydrating microclimate that mitigates this risk to an extent. In additional, Jongrunklang N. [14] said that the temperature and humidity in the air is a factor that affects the dehydration of plants. This affects the growth process of plants, and Techawongstien S. "In press" [15] says that moisture in the air is a low effect on a lot of dehydration plants. This is consistent with the results of the study that air-conditioned rooms have a "dead" landscape survival rather than in rooms without air conditioning. Therefore, the relative humidity level in

the experiment was at the level that humans and plants are occupant comfort but a relative humidity that likely to be more maintained to good foliage health. As corresponds to the results of the air condition room which the lower relative humidity, was "dead" plant rather than in another.

The study was found that the plants survival landscape both conditions are *Tradescantia zebrina* Loudon (*Zebrina pendula* Schnizl.) of the Commelinaceae family which is a plant with crater and leaf similar to succulent characteristics. According to the study Gunawardena K. and Steemers K. [16], one of the most popular plants is succulent plants. This corresponded to Rochanavibhata [17] found that indoor shrub plants that are resistant to low-light environments or light frenzy are mostly succulent plants. The family is similar to succulent plants namely the *Philodendron* in the Araceae and the *Dracaena surculosa* in the Agavaceae which is Semi-succulent plants [18]. In additional plants that tolerate both conditions were *Nephrolepis cordifolia* in the Nephrolepidaceae, *Aechmea fasciata* and *Tillandsia usneoides* in the Bromeliaceae both families are generated with wax leaf. These plants are suitable for planting in a vertical garden especially in a living wall. Due to the leaves can reduce dehydration and also reduce the capture of dust "In press" [19].

CONCLUSION

Although the hypothesis test shown that the survival landscape conditions of each plant and both conditions do not differ at the significance level 0.05. These results of temperature and relative humidity have affected the survival of plants. The indoor should have a temperature of 20-28 degrees Celsius and relative humidity of 30-50% so that people and plants are comfortable. It can maintain good foliage health in an indoor vertical garden without air conditioning, which a temperature of 28-32 degrees

Celsius and relative humidity at 85-95%. On the other hand, an indoor vertical garden with air conditioning suggests to Commelinaceae, Araceae, Agavaceae, Neprolepidaceae, and Bromeliaceae.

From the results, appropriate plants are recommended in the vertical garden (Living wall), which with and without air conditioning, including *Philodendron* 'Moonlight', *Aechmea fasciata*, *Tradescantia zebrina*, *Chlorophytum comosum*, *Dracaena surculosa*, *Tillandsia usneoides*, and *Nephrolepis cordifolia*.

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