# Application of Indoor Landscape with Iresineherbstiihook and Brassicajunceaplants on Tropical House Thermal Environment Performance as Passive Cooling Strategy

**Agung Murti Nugroho**[1]
1) Department of Architecture, Faculty of Engineering
University of Brawijaya Malang, Indonesia
email: sasimurti@yahoo.co.id

***Abstract***-Living organisms, in this case the plant used as a tool to solve the problem of the microclimate in buildings.This paper aims to investigate the thermal effects to provide reference for plant selection in indoor landscape. Temperature and relative humidity reduction experiments are carried out on two types of plants (iresineherbstiihook and brassicajuncea) in Malang, Indonesia. The methodology was developed and applied using field measurement on indoor and outdoor. In increasing thermal environment, its impact, higher levels of vertical garden gap (distance from house facade) produced the indoor air temperature reduction. Further, several modifications were found to produce a potential building cooling load reduction of up to 5°C by the use iresineherbstiihook (bayam merah). In fact, the optimum improvement of both outdoor and indoor environment was influenced by two major vertical garden factors, namely, larger vertical garden gap and type of vegetable plant. Thus, it is suggested that appropriate guidelines, influencing implementation of these improvements could be implemented in order to increase thermal environment in hot humid climate.

**Keyword**: Iresineherbstiihook and Brassicajunceaplants, Thermal Environment Performance, Passive Cooling Strategy

## I. INTRODUCTION

The phenomenon of urban expansion has made green spaces relatively scarce. Built environment built with materials with the characteristics of high heat retention and absorption increase the environmentally stored heatin urban areas and create urban heating [1]. The heat island effect creates a main problem of urban energy consumption. The heat from the city increasing the temperature and the use of air conditioning. Previous researchers have indicated that the most effective way toreduce the heat island effect is to increase the area of greenery. Vertical garden is a general technique that has been used in hot and humid climates. Currently, its functions are widely utilized and researched, especially for passive cooling and energy conservation . “Urban vertical garden” is an effective approach in improving the quality of living environments and reaching the important indicators for low energy and reduction of carbon emissions. Vertical garden have been used as an environmentally friendly product to encourage sustainable development, especially for urban high density. Vertical garden are classified as intensive and extensive according to their purpose and characteristics. Intensive vertical gardens are associated with wall; need a reasonable depth of soil and require constant maintenance. Extensive vertical gardens are designed to be virtually self-sustaining, therefore require low maintenance. Vertical gardens are built for both their aesthetic and functional values. A side from providing temperature control, architectural enhancement, hydrological benefits, and food. Vertical garden present a number of advantages. They can cool the rooms beside them, especially during hot days.Therefore, the goal of this paper is to enhance plant selection and configuration for vertical garden by testing the air temperature reduction of plants specific to the climate of Malang, Indonesia. This research aims to realize the aesthetic benefits of vertical garden (VG) by vegetable plants. It also aims to find the optimum planting that produce the best air temperature reduction in tropical climates. This paper examines two different plant substrates *(iresineherbstiihook or bayam merah and brassicajuncea or sawi hijau)* and two types of vertikal garden gap to find the most efficient combination that can enable vertical landscape to provide maximum air temperature reduction.

## II. METHOD

There is one basic types of vertical garden. They modification according to the vertical garden gap (G) and the type of plants (iresineherbstiihook=I and brassicajuncea =B). The two different plants were planted into the 24 containers (polyback). For better experimental comparison, two vertical gap samples were prepared for each condition (12 hours during 3 days). To control the variables, the measuring points were positioned center of vertical gap, outdoor and indoor of the house (Fig.2). The experiment commenced in March 2013. For purposes of detailed discussion, data from 1-3 March 2013 were used.

Fig. 1. The application of vertical garden on modern house

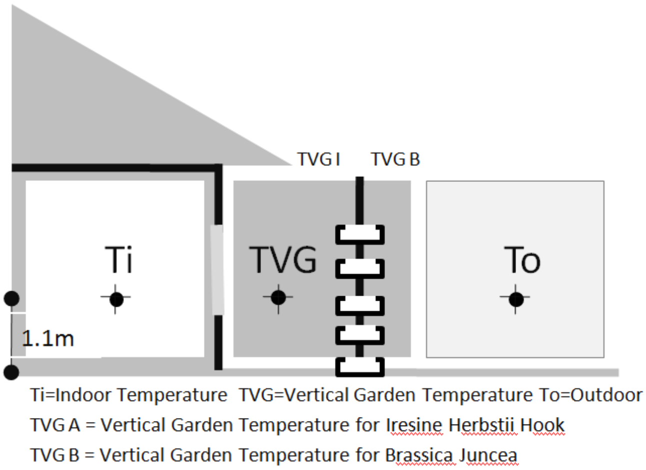


Fig. 2. Measurement point for air temperature.

## III. RESULT AND DISCUSSION

Malang, Indonesia has a dry season temperature of up to 32°C. For this reason, data collected in March 2013 were used to discuss the vertical garden (VG). March 2013 had the high average temperature and had less rainfall.

### 3.1. Indoor cooling effect

The indoor air temperatures of the existing house with vertical garden showed significant differences. For better illustration, we chose a three-day sequence, 1-3 March, 2013. There was no rainfall in the ten previous days. Figs. 3 and 4 show the significant air temperature changes on the modern house with vertical garden. The average indoor temperature was reduced until 28°C (vertical garden with iresineherbstiihook) and 27°C(vertical garden with brassicajuncea).

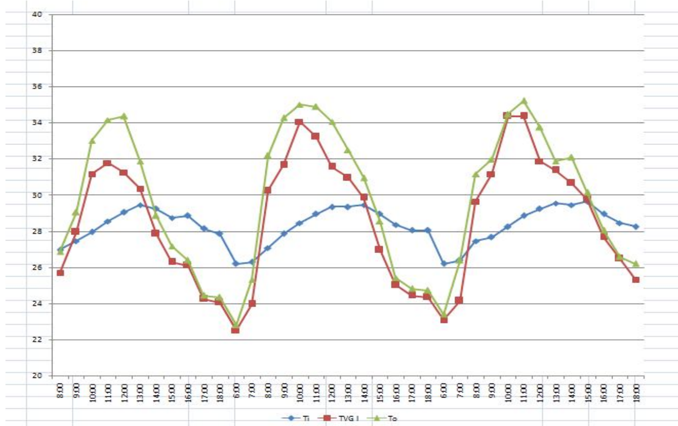

Fig.3. The comparison of indoor (Ti), garden (TVG) and outdoor (To) air temperatureby the use *iresine herbstii hook* plant (bayam merah).

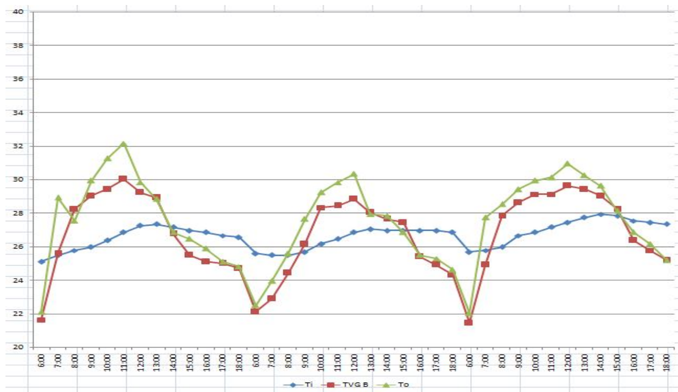

Fig. 4. The comparison of indoor (Ti), garden (TVG) and outdoor (To) air temperatureby the use *brassicajuncea*plant (sawi hijau)

The measured air temperature reduction levels are expressed in 5°C, and are shown for both the situation with iresineherbstiihook and brassicajuncea. In Fig. 3, the relative effect of the vertical garden with the use iresineherbstiihook (VG I) is shown. Positive values indicate that VG I provide indoor passive cooling. Comparing the outdoor air temperature shows that the indoor air temperature is lowest than outdoor. The minimum indoor air temperature observed is 26°C and maximum is 29.5°C.

Temperature differences between indoor and outdoor the modern house with vertical garden, indicating that extensive green garden have excellent heat insulation performance. As to heat conduction, at 06.00h until 12.00h when the solar radiation is the strongest, the exposed east fasade would directly conduct the heat of radiation into the rooms within the building, while the heat on the vertical garden on east side of the modern house would flow from the indoors to the outdoors. In tropical areas, the electric consumption of air conditioning systems can be cut down by 6% when the temperature is reduced by 1°C [2].

### 3.2. The impact of vegetable plant for air temperature reduction

In case vertical garden by brassicajuncea, effects are either slightly positive (up to 2°C) or no effect relative to the reference garden is seen. For the use iresineherbstii, the vertical garden give important air temperature reduction benefits. The red colour of slave is probably responsible for this large effect. At light colour slave there is no net effect by the presence of the vertical garden. It is well-known that when the tipe of slave plant relative a dark colour, the absorption of solar heat increases significantly.

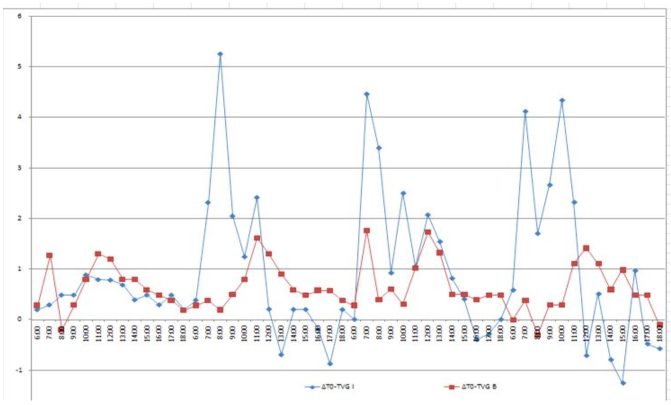

Fig. 5. The comparison of air temperature reduction (°C) for *iresine herbstii hook* and *brassicajuncea*

The colour slave of the vegetable plant is therefore less important when looking at the air temperature reduction improvement. At the darkness slave, positive effects are nearly not present anymore. Among the vegetable plant, iresineherbstiihook or *bayam merah* had the best air temperature reduction until 6°C. According to Edwards (2012) with the increase of grass coverage, ambient air temperatures are lower and more evenly distributed [3]. However, they are considerably less effective in urban cooling than tree planting. Planting trees at the ground level can reduce pedestrian-level air temperatures more notably than grass surfaces. This is because trees can provide shading to surfaces, which is more effective in reducing the radiant temperature.

### 3.3. Impact of vertical garden gap for air temperature reduction

Since 0,5m vertical garden gap results is reported in detail and discussed. Afterwards, the experiment results of cases with vertical garden gap 1m are reported. The cooling affects are reported by comparing the experiment results, as in Figs. 6 and 8. Fig. 7 reports the results of the effects of vertical garden gap by iresineherbstiihook vegetable planting (VG I G 0.5 and VG I G 1); and Fig. 9 reports the results of the effects of vertical garden gap by brassicajuncea vegetable planting (VVG B G 0.5 and VVG B G 1).

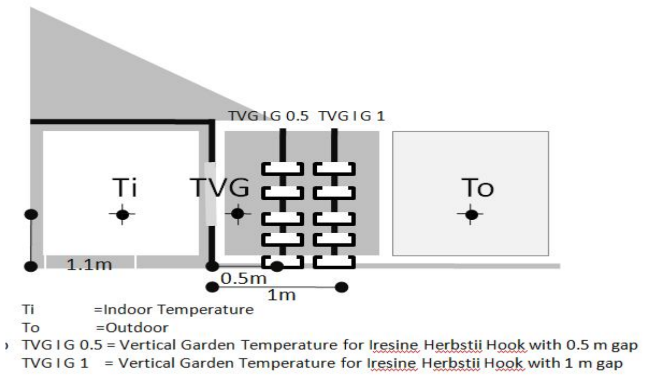


Fig. 6. The modification of *iresine herbstii hook* vertical garden gap

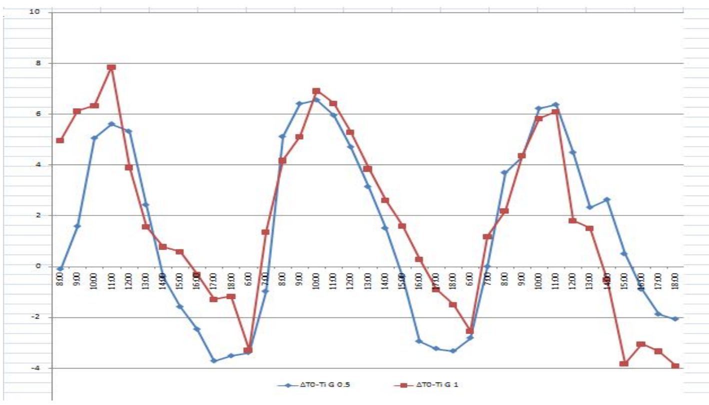

Fig. 7. The comparison of air temperature reduction (°C) for vertical gap 0.5m and 1m on *iresine herbstii hook* vertical garden

For vertical garden gap, as presented in Fig. 7, Case VG I, with gap of 0.5 m, began to contribute to a maximum air temperature reduction of about 6.5°C. By increasing the vertical garden gap to 1 m in VG I, the maximum air temperature reduction can reach 8°C. In Case VB B, with vertical garden gap of 0.5m, the maximum air temperature reduction could be up to 4°C lesser when compared with the case VB B with 0.5 m vertical garden gap.

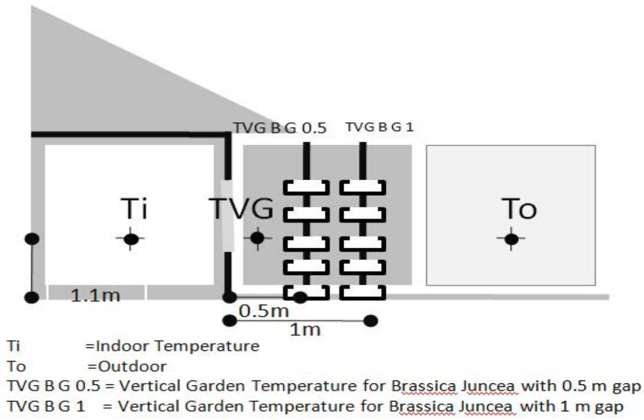


Fig. 8. The modification of *brassicajuncea*vertical garden

When the vertical gap is greater than 0.5m, the overall temperature across the area fluctuated less, which is another thermal benefit in addition to the absolute temperature reduction. For both the deeper vertical gap in case vertical garden by iresineherbstiihook (VG I) and vertical garden by *brassicajuncea* (VG B), air temperature reduction to a large extent since the vertical garden is located to far the building facade. From experiment it is known that the negative effect of an air temperature reducing measure is rather location independent in such a closed house facade.

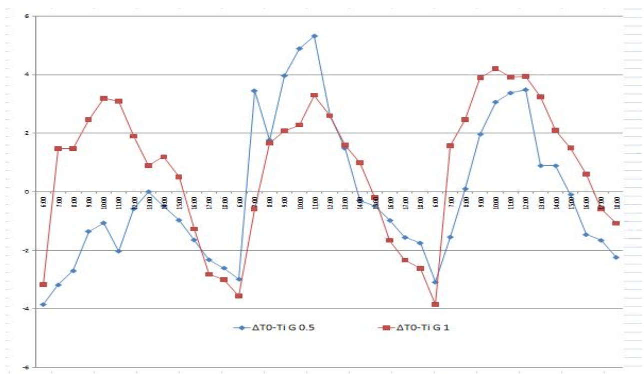


Fig. 9. The comparison of air temperature reduction (°C) for vertical gap 0.5m and 1m on *brassicajuncea*vertical garden.

As in Fig. 9, the cooling benefits of vertical garden with brassicajuncea when vertical garden gap (at1m) are higher than the cooling benefits when buildings are deeper (at 0.5m). That being said, the differences between results of the study cases with 0.5m and 1m are more significant. The observation is valid for both iresineherbstiihook and brassicajuncea vegetable planting. The comparative results of Case VVG I and VVG B, indicate that vertical garden with 1 m gap could yield useful cooling effects at the indoor and garden level. At this juncture, it may be initially speculated that vertical garden gap 1m may be a more useful greening strategy to adopt.

3.4. Aesthetics, carbon reduction and urban cooling,

Aesthetics are important in the designing of VVG; however, an objective estimation of its economic impact is difficult. Aesthetics can be valued with a stated preference method. According to Wise (2010) asks individuals for their willingness to pay extra for a given good or accept compensation for a given harm [4]. For the particular case of VG, stated preference methods asks how much more is a consumer willing to pay, if the same vertical garden is located in a different area. That willingness to expend more can be identified as the value of esthetic. Vertical vegetable garden do not provide the same level of benefits as local parks. This study assumes that the aesthetics benefit obtained from extensive vertical garden varies of property value. This social benefit was estimated as a percentage of the initial cost of vertical garden. Different types of plants can be grown on VG. Evidently, the oxygen-carbon dioxide exchange rate differs between plant types. Nevertheless, previous investigations have shown that 1 ha of green roofs remove between 72 kg and 85 kg of pollutants [5][6]. According to the cooling potential of the different greening strategies is related to the building morphology. Relevant investigations are therefore necessary to understand whether the basic building morphology can increase or decrease the cooling potentials brought about by greening overall densely built urban areas. Several observations on the effects of building heights and greening on the urban cooling potentials were revealed by comparative results. Despite various building heights, tree planting was in general more beneficial than grass surfacing.

## IV. CONCLUSION

The study focuses on the thermal environment; further work includes investigation of cooling benefits using vertical garden under different greening schemes. The two plant types, iresineherbstiihook and brassicajuncea are suitable for vertical garden because they can adapt to hot and humid climate environments for longer periods. They provide great heat insulation as vertical garden. Therefore, both are suitable for vertical greeneries because they give good temperature reduction and have comparatively increase carbon reduction. The garden have an implication on the cooling benefits of planting on vertical section. It is important therefore that greening and more importantly tree planting be positioned nearer to the human activities levels. Vertical garden provide personal and social benefits. From a personal perspective, the potential profit of an intensive vertical green is much higher than its potential losses. In fact, when social costs and benefits are considered in the net present value estimation, the profitability of the investment is higher. Furthermore, vertical landscape should be seen as a part of a suite of environmentally friendly private garden practices. Green buildings must be considered as economically feasible private garden systems. In summary, vertical garden provide excellent heat insulation, are readily available, and they can conserve energy. Innovation and further research is required to decrease the carbon footprint of vertical landscape by the use of the herbal plants *(i.e. Gynuradivaricata and Strobilanthescrispus).*

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