

Stimulating Urban Environment Sustainability through Edible Garden Plants

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ABSTRACT: This article discusses the role of gardens, small plots or areas surrounding a house designated for edible plants or flowers and its contribution towards environment sustainability. A study on transpiration was done on chilly plant (*Capsicum frutescens*). Its popularity as an edible garden plant in urban residences is due to lower planting cost but higher economic revenue to the planters. The finding shows that for an average surface area of 7.02 square centimetres, every chilli leaf has the potential of evaporating 0.045 millilitres of water in 24 hours. For this reason, neither chilly nor other plants in edible gardens that are capable in producing water have the potential to become sustainable source in lowering the temperature and hence creating a sustainable urban environment.

Keywords: Environment sustainability, urban, temperature, economic

Introduction

The effect of heat warming in urban places has become an issue towards the urban residents recently. However, the level of heat warming in Malaysia cities is still tolerable compared to some hottest cities in the world such as El Azzizia in Libya which once recorded a highest temperature of 57.8°C. The city of Dallol, Ethiopia also once recorded a very high temperature with an average annual temperature reaching 34.4°C and the lowest level of air moisture. Other cities such as Jizan in Saudi Arabia, Djibouti in Djibouty; Al Hudayah in Yemen were recorded a temperature of 30°C. The temperature of Dhahran in Saudi Arabia was once also reached a reading of 42°C with a humidity level of 95%. In Australia, Wyndham has recorded a temperature of 29.5°C without any humidity. The temperature recorded at Death Valley in California once reached 57°C. The longest

period (i.e. 150 days) reading of the hottest temperature that exceeded 37°C was recorded in Marble Bar, an interior area of Pilbara located in the south of Australia (HAP, 2010). A temperature of 46.5°C was also recorded in Perth, Australia. Many other cities also listed as one of the hottest cities were Madurai, Tamil Nadu in India (28.9°C); Niamey, Nigeria (28.8°C); Aden, Southern Yemen (28.8 °C); Tiruchirapalli, Tamil Nadu, India (28.8°C); Madras, Tamil Nadu, India (28.6°C) and Ouagadougou, Upper Volta (28.6°C).

Without taking into account the geographical location of the hottest cities mentioned above, the urban climate is obviously hotter than the outskirts areas due to the greenhouse effect that occurs when gases such as carbon dioxide (CO₂) acts an insulator or blanket that shrouds the atmosphere and

trap the heat from escaping to outer space. A research by Anon in 2001 reported that CO₂ contributes 64% of gases from the green house effect in Victoria State, Australia. It is estimated that the concentration CO₂ in the atmosphere until 2007 was at the level of 380 ppm and is increasing at an average rate of 2 to 3 ppm annually (Rohrer, 2010).

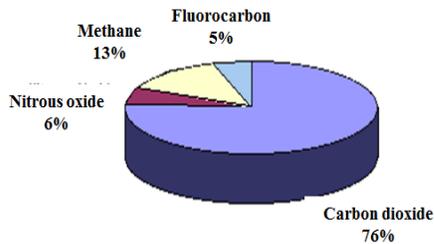


FIGURE 1-Modified from Greenhouse Gases Source: ABC News, 1998.

A decrease in green areas, an increase in the total number of brick buildings, a rise in the number of vehicles and population are some of the key factors contribute to the increase of greenhouse effect. (Cruz, 2010). Gas emission from vehicles contributes 22-24% of greenhouse gases globally. It is also estimated that 49.6% of CO₂ released to the earth atmosphere could have come from the burning of fuel or fuel related energy (American Forest, 1999). Three methods proposed to lessen the emission of greenhouse gases include firstly through habit; secondly, through changes in distance travelled, and thirdly, through fuel technology (Lloyd, 2004). It is estimated that by the year 2020, there would be a total of 1.6 billion motor vehicles in the world, an increase of 224% since 1995 (OECD and EMCT, 1995) with a larger increase in developing countries.

The process of photosynthesis by green plants is considered as one of the solution to remediate global greenhouse effect because

environmental CO₂ is changed to sugar and oxygen (O₂) during the process of photosynthesis and this process has a direct relation with the plant transpiration (He, 2001; Roberta, 2006). Note that, transpiration is a process of sweating in plants where water is absorbed by the plants and released back to the atmosphere. Transpiration is controlled by the temperature of the environment (Sir, 2008). Botanically, it is a process of vaporisation at the leaves surface (The Columbia Encyclopaedia, 2004) causing the water to flow from the roots to the stomata (Meinzers, 2006). It aims to provide moisture to the plants for the process of diffusion i.e. the intake of CO₂ from the air and the release of O₂ from the leaves. The rate of transpiration among tropical plants is between 1.75 to 325 litres per day depending on the size of its canopy or sclera (Kline, 1970). For an acre of forest, it could absorb 150 tonnes to 200 tonnes of CO₂ in its first 40 years of age (American Forest, 1999). These facts explain the importance of plants to the atmosphere and to human life (Cross, 2008).

Literature

Environmentalists, has a direct relationship to the greenhouse gas emissions (Anon, 2000). The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change in reducing the greenhouse gas (GHG) emissions. The United States aims to reduce GHG by 7%, Japan by 6% and European Unions by 8% from emissions level in 1990 (Nick and Jordan, 2010; US Department of State, 1998). Besides reducing the emissions of CO₂ through the reduction in burning of fossil materials, we could also reduce the emissions of CO₂. Campaigns on planting of trees shall be encouraged to reduce CO₂ emissions but also increase the amount of O₂ in the air

simultaneously because plants take in CO₂ during the process of photosynthesis and release oxygen to the air especially in urban areas where trees are lacking. Many researches are conducted in food preparations (Ballard *et al.*, 1970; Norman, 1992) and its genetic (Steward *et al.*, 2007) but hardly involved the study in the relations between the process of transpirations in chilli plants and the emissions of greenhouse gases in urban areas.

A leaf consists of an apex, a margin and a base (Visual Dictionary, 2002; Tobias, 2008). Leaves absorb CO₂ through the air and oxygen and hydrogen through the flow of water (Surya and Uzi, 2010). Leaves are the main sites where photosynthesis and transpiration occur (Joseph, 2003). Transpiration is the evaporation of water from plants. The rate of transpirations depends on the conditions of the leaves such as its healthiness observed on cucumber (Miriam *et al.*, 2005), paddy (O'Toole *et al.*, 1979), beans (Pacherpky *et al.*, 1999), and longan plants (Main, 2010) and also on the age of the leaves itself (Donald and Milthorpe, 1972).



FIGURE 2- Chillies (*Capsicum frutescens*)

Research on greenhouse effect is often related to urban climates (Roy, 2010) particularly where the urban temperature is higher than the temperature at the suburban or the rural areas (Berthier *et al.*, 2006).

Urban warming is mainly related to the high emissions of CO₂ and carbon monoxide (CO) with both gases being emitted in volumes by vehicles, houses and factories. Many researches were conducted on greenhouse gases and several conclusions were derived especially the impact of these greenhouse gases on life. Urban heat gives rise to uncomfortable situation on building residents (Godish, 2001) and pedestrians walking on streets (Siti, 2004). The greenhouse effect can create a heat island phenomenon in urban areas i.e. an example of the climate change when the process of urbanisation changed the earth surface characteristics and its atmospheres. Heat intensities were measured in order to ascertain the strength or magnitude of a heat island. During night time, the surface of a canopy would have a temperature between 1°C to 3°C, while under certain conditions the temperature could increase to 12°C. These situations would make the urban residents uncomfortable compared to the rural areas residents.

Edible garden has been discussed through various scopes, such as the use of suitable plants (Gaya Peneroka, 2010); as a source of income (Jane, 2008) and from the aspect of economy (Felda, 2010) and also chilli plants (Bernama, 2009). This paper investigates the potential of chilli plants in sustaining the environment through the transpiration process. Chilli or *Capsicum frutescens*, is one of a popular kitchen (Berta *et al.*, 2000). Plants grown by local communities can even be easily grown as potted plants or in the gardens. Chilli plants can be cultivated through farming in a dimension of 100 cm x 100 cm (3 ft x 3 ft for every plant) reaching a density of 9000 plants for every one hectare of land (200 to 300 plants for an acre). Chillies can be harvested after 75 days and done once in every three days or twice for every two weeks. For every plant, the estimated yield is at 1.5 to 2.0 kilograms

with a market price of RM 12 –RM 14 per kilograms. The plants are suitable to be grown in an open space because chillies need a warm weather. Chillies have life span of only 3 years. Due to its popularity as an edible plant in urban setting, it may play a role to help improve the uncomfortable environment in the urban as the result of higher temperature compared to the rural areas. The use of chillies is relevant due to its low planting cost and with high economic revenue to the planters. More importantly, this plant has the potential to become a more sustainable source in lowering the temperature and help create a sustainable urban environment.

Methodology

Samples were taken on the 27th until 29th of August 2010. The evaporation rates were measured. The plants used were between 1 to 2 months old. One of the stems was taken randomly from every plant, all the various sizes of leaves on the stem were measured and it was found that for a 2 month old chilli plant, it has a total of 50 leaves. The number of leaves on the plant depends on its age and several other factors including the environment. Base on a 24 hour observations, the amount of water collected from the process of evaporations of the plants was 16 millilitres.

Three pieces of leaves were taken randomly as samples size. The sizes of the leaves were measured using graph papers. In brief, three leaves of various sizes were taken and placed on separate pieces of graph papers. The leaves were drawn on the graph papers and their sizes measured according to the number of boxes on the graph papers. The results were as follow:

Leaf 1: 12.49 cm²
Leaf 2: 5.38 cm²
Leaf 3: 3.20 cm²

The average size of the chilli leaves was 7.02 cm². The rate of water evaporation from a leaf depends on the surface area of the leaf. The larger the leaves, the more water collected from the process of evaporation of the leaves. The density of the leaves also determines the amount of water collected. The higher the density of the leaves, the bigger amount of water collected from the evaporation process. Hence, there is a directly proportional relation between the density and size of leaves and the amount of water intake of a plant and water from the soil.

Finding and Discussion

The transpirations experiment done on the chilli plants gave an interesting indication. For a period of 24 hours, 16 ml of water were collected from the process of transpiration of 50 pieces of leaves. This shows that a piece of chilli leaf can produce at least 0.32 ml of water. There are a lot of factors that influence the rate of evaporation of chilli leaves such as temperature, the sun hotness and also the wind factor. For an average surface area of 7.02 cm², every chilli leaf has the potential of evaporating 0.045 ml of water in 24 hours. Hence, the finding from this research indicates that the size of the leaves is directly related to the amount of water released to the atmosphere through the process of transpirations or evaporations.

In another experiment, a stem from a chilli plant was taken and the same procedures from the first experiment were repeated on this second experiment. It was observed that this stem contained 29 leaves with different sizes. After enclosing the stem in a plastic covering for 24 hours, an amount of 7.5 ml of water were collected. Base on the result, each leaf averagely produces 0.26 ml of water in a day.

Visual examination shows that each chilli plant has an average of 20 stems. Each stem contained 29 to 50 leaves or around 580 to 1000 leaves for any given time. If each leaf can produce 0.26 ml to 0.33 ml of water for a day, a chilli plant is able to produce 150.8 ml to 260.0 ml a day. In a hectare a total of 1,357,200 ml to 2,880,000 ml of water can be produced through the process of evaporation per day or a total of 95.378 million ml a year for a hectare of land grown with chilli plants.

City of Georgetown, located at the north-east of Penang Island has 99,530 units of houses (until 1995). If every single unit grows a chilli plant in their compound or kitchen, hence there are a total of 99,530 chilli plants in Georgetown, Penang. For a period of 24 hours, there would be a total of 15.01 million ml to 25.9 million ml of water or a maximum of 18.5 million ml to 31.85 million ml of water collected through the process of evaporations. This would mean that the atmosphere of Georgetown, for a year would be able to receive at least 5,478.65 million ml to 11,625.25 million ml of water vapour through the process of evaporations.

If these efforts were widened to government agencies, state government administration offices and also private sectors, it would generate more chilli plants to be grown. Not only the number of chilli plants grown would increase but the areas involved would also be widened. The colony of chilli plants could also be grown at the compounds of houses not only in the city outskirts but also inside flower pots in the heart of the city where condominiums, apartments, terrace houses and bungalows stood tall.

Note that evaporation is related to the process of cooling in the urban atmosphere. Through the process of evaporations in chilli plants, the warm temperature in urban areas

could be reduced by convection where the hot and dry air that is lighter would rise into the atmosphere. Without green trees, evaporations could not take place and resulted dry and hot air in urban areas as experienced in Georgetown. Water vapour in the cold air brought from the surface of the sea would firstly vaporise at the urban surface making the phenomena of rain difficult to occur in that area especially convective rain. Convective rain is rain that is able to bring about heavy rainfall and could result in flash floods (Shaharuddin and Noorazuan, 2006).

Note also, Georgetown is situated on a low-lying area in the North East of Penang Island. It is bordered by the Bukit Bendera watershed as its backbone. The Bukit Bendera watershed is the main catchment area for Sungai Pinang river that flows in the heart of the city. The high pressured cold wind from the sea could bring in heavy rain, hence resulting in flash floods due to overflow of water from the river like as frequently occur in Jalan P. Ramlee.

Evaporation is directly related to the amount of oxygen gas given out to the atmosphere. Chilli plants have a stem diameter below 1.8 m and thus fall in the category of Diameter at Breast Height (DBH) in between 0 – 3 (Cris, 2009). The plants in this category are able to produce 6 lbs (2.72 kg) of oxygen annually. For a hectare of these plants, they are able to give out 54,000 lbs (24,293.99 kg) to the atmosphere every year (Dwyer *et al.*, 2003 in review; Nowak, 1995; 2006 and 2009).

According to a research done by Broecker in 1970, a human uses 400 lbs (181.4 kg) of oxygen if he/she stays dormant yearly at a temperature of 20°C (minimum temperature in Malaysia is at 26°C) with a pressure of 760 Hg (standard pressure). Hence, for a hectare of land cultivated with chilli plants

would produce 54,000 lbs (24,493.99 kg) of oxygen daily or 24,090,040 lbs (10,927,040.193 kg) yearly. This should be able to accommodate the needs of oxygen for a total of 60,225 of urban residents. Based on a census done in 2006, the city of Georgetown has a total of 300,000 residents. If five hectares of landscape within the city that were planted with chilli plants, the oxygen released would probably be able to accommodate the needs of the city residents.

One of the sources of CO₂ pollution is human while about 30% CO₂ emission come from the exhaust of motor vehicles as until 1999 (GHG, 2010). In 2006 only, the number of registered motor vehicles in Georgetown reached 101,505 units (Main, 2009) while the cumulative number of registered motor vehicles until 2000 were 1,010,708 units. From this number, 61.47% were motorcycles, 33.37% for cars, 0.6% for buses, taxis and hired cars, 3.5% was goods carriers and 1.1% for other type of vehicles. Considering the estimation used by Ganesh (1995), the growth rate of registered vehicles for cars was at 9.5% annually and 7.2% annually for motorcycles and they released 2.3 tonnes or annual CO₂. (Nowark, 1995) Taking this rate into considerations, this means that the residents of Georgetown produced not less than 0.69 million tonnes of carbon dioxide annually.

Until 2010, the number of vehicles in Penang could reach 2 million units. Using the ratio of various vehicles, the number of cars in Penang could reach 667,400 units. For the case of Georgetown with 300,000 of residents, if we assume a family having three to five members, the number of families could become 60,000 to 100,000. With each family having at least one to two cars, bringing the number of cars in Georgetown at 60,000 to 200,000, exclusive the incoming cars plying into and out of the city daily. The same applies to other type of vehicles such

as motorcycles, public transports and other transport vehicles. The amount of CO₂ emission from vehicles in Georgetown could be estimated between 14,000 lbs (6350.293 kg) per mile or 3968.9 kilogram per kilometre to 17,400 lbs (1892.507 kg) per mile or 4,932.8 kilogram per kilometre of distance taken. The total amount of carbon dioxide emitted by vehicles in the city of Georgetown could reach between 52,800 lbs (23,949.677 kg) per mile or 14,968.6 kg per km to 176,000 lbs (79,832.257 kg) per mile or 49,895.2 kg per km. Hence, the amount of carbon dioxide emitted by vehicles in a year could reach between 1.4268 million lbs (647,185.6 kg) to 4.576 million lbs (2,075,638.685 kg).

Since the green technology based on the natural system has a great potential in the effort of sustaining the urban environment from a serious pollution of the greenhouse gases especially carbon dioxide, the edible garden is the most significant solution (Hanim *et al.*, 2009). Convincingly, chilli plant could be one of the popular edible plants because of its multi-functional and easy to manage. Perhaps chilli plants could also play its role as a cleanser for the urban environment if it is planted aggregately in every unit of houses and space of premises available in the city.

Conclusion

It is clear that the time has come for an extensive usage of the green technology in the form of *in situ* development through developing the CO₂ cleaning technology by planting edible plants like chilli in the compounds or kitchen areas. The processes of photosynthesis and transpiration in edible plants could bring down the urban temperature to a moderate level. The process of transpiration could not only balance the amount of carbon monoxide and CO₂ in the atmosphere but also produce a more

sustainable natural aeration process compared to air-conditioners. Planting trees such as chilli plants is also cheaper and very effective in absorbing carbon dioxide from the atmosphere.

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