The “Green Curtain” as an Educational Project for Spreading Sustainability Awareness

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Abstract. As global warming is an empirically verifiable scientific fact, human beings are facing a crucial point of no-return. Throughout the world, many governmental agencies, non-governmental organizations, and private corporations have been systematically working toward the achievement of a sustainable society; however, we are far from any noticeable advances. This study was conducted to examine the prospect of the potential utilization of a "Green Curtain (biological shutter)" in the UAE in order to facilitate awareness of, and participation in, sustainable development. The Clitoria ternatea L. green curtain was established by planting seedlings and examined for its developmental and morphological characteristics and its effects on microenvironmental conditions. Clitoria green curtains developed uniformly and effectively. The effects of the green curtains on the microenvironment were significant in terms of reducing air temperature and retaining higher humidity during mid-day. The green curtain project has the potential to reduce energy consumption and to be used as an innovative way of experiencing (and spreading awareness of) sustainability among the general public.

Keywords. Green curtain (biological shutter); education for sustainable development (ESD), sustainable community; greening

1. Introduction

“The Paris Agreement allows each delegation and group of countries to go back home with their heads held high. Our collective effort is worth more than the sum of our individual effort. Our responsibility to history is immense (UNFCCC, UN Climate Change Newsroom, 2015).” President of the COP 21 UN Climate Change Conference and French Foreign Minister Laurent Fabius commented about the agreement at the Paris Climate Change Conference on 12th December 2015 (UNFCCC. Conference of the Parties, 2015). As global warming is an empirically verified scientific fact, and as human beings are facing a critical period of no-return, the agreement is a global achievement. On this day, 195 nations agreed to work together to reduce greenhouse gas emissions, to live sustainably, and save the Planet Earth for future generations. It is an opening of a new era of optimism towards clean energy.

Since the 1998 Kyoto Protocol Agreement (UNFCCC, 1998), many governmental agencies, international organizations, and global corporations have been systematically working toward the reduction of greenhouse gas emissions. The UAE is one of the leading countries advancing this mission (Masdar, 2015). Prior to the Paris Agreement, the UAE Vision 2021 stated that the “National Agenda focuses on improving the quality of air, preserving water resources, increasing the contribution of clean energy, and implementing green growth plans. (Government of the UAE, 2015).”

Reflecting on ourselves, we are far behind following the national leaders’ views and values. All human beings are living in a minuscule, and closed, environment - “the Planet Earth Ship.” Thus, we have a mission to be more cognizant of, and adopt policies and behaviors to live within, the capacity to avoid a catastrophic disaster. As an educator and resident of the UAE
(which has the highest per capita ecological footprint in the world), I search for impactful ways to effectively incorporate sustainability into education curricula. Children and young adults should be cognizant of the positive influence they can have on building a sustainable environment by merely changing a few routine habits. Any large, grass-roots movement always begins with some small, incremental steps.

**Green Curtain Projects – Implementation of a Sustainable Community in Japan**

For the past decade, in the uber eco-conscious nation of Japan, a grass-roots movement known as the “Green Curtain” has been gaining exponential momentum (albeit quietly) in educational institutions, private and governmental sectors, as well as among the general population (Chubu Electric Power Company, 2015; Ministry of the Environment, Government of Japan, 2015). The green curtain is a biological shutter (made of naturally grown green plants that are planted outdoors) used to cover the windows and/or walls of buildings/residences to block sunlight. In Japan (which is located in a temperate climate zone), annual plants are mostly used for green curtains to block strong radiation during the hot summer but not during the cold winter. Some of the species commonly used are: bitter melon (**Momordica charantia**), sponge gourd/Egyptian cucumber (**Luffa aegyptiaca**), and morning glory (**Ipomoea nil**). The former two also add a joy of harvest at the end of summer.

The natural green curtains are reported to be effective to cool down outdoor and indoor temperatures (Kajita, 2009; Narita, 2007; Suzuki et al., 2015), reduce heat island effects (Fukuda et al. 2008), and provide natural green plant-life to urbanized environments, thus, also helping to heal people’s minds (Nobuhara et al., 2010). The amount of energy consumption that can be saved by a natural green curtain (by itself) is insignificant; however, if bundled, the effects can be dramatic. According to a simulation study conducted by Samata and Fukuda (2009), if a green curtain interrupts radiation for three months (from July to September in Japan), it will save an amount of energy equivalent to running an air conditioning unit (for a 14.6m² room) for 1-1.5 hours per day. The reduction of CO₂ emissions would save nine Japanese cedar trees.

The natural green curtain project has been widely adopted among educational programs, particularly in primary schools. This is having a great impact on the culture and mindset of an entire generation of citizens (Nobuhara and Asano, 2010). As the growing season of annual plants and the Japanese academic cycle (begins in April) are well fit, children plant seedlings in the early summer at schools, and they naturally develop a sustainable life-style, sustainable mind, and gain an intrinsic appreciation and value for nature through hands-on learning experiences. Among higher education institutions, Yamaguchi Prefectural University established the “Environmental System” course, in which the green curtain project serves as part of an education for sustainable development (ESD) initiative (Yamamoto et al., 2010). The implementation of green curtain projects in educational institutions will also help spread awareness among children and young adults and change the habits and values necessary to achieve a sustainable society.

**Green Curtain Mini-Pilot Study**

The objectives of this study were to: 1) determine the appropriate plant species to establish natural green curtains in the UAE; 2) identify the effect of green curtains on the surrounding microenvironments; and 3) advance the prospect for proceeding with larger scale projects of natural green curtains in the UAE.

**2. Materials and Methods**

Butterfly pea (**Clitoria ternatea** L.) was used as a trial plant material because of its: a) morphological characteristics (vigorous growth, extending vines, and pinnate leaves), b) drought tolerance (Talukdar, 2011), and c) easy availability in the UAE.

Experimental plots were established in a courtyard garden between academic buildings on the Zayed University Dubai campus (in the UAE). Existing flower beds with a drip irrigation...
pipe system were transferred to experimental plots. Each plot is approximately 2.5m wide, and 2.5m x 3.5m wire-meshed stockades were leaned toward the building wall (facing the South) at an inclination of 15°.

Three experimental plots were first established on the 6th August 2012. Eight young seedlings were planted at 50cm intervals in an alternating manner in two parallel rows (4 plants per row x 2 rows) (Figure 1). One flower bed without the Clitoria green curtain establishment was used as a control plot. Plots were irrigated through a dripping pipe with other garden plants at a standard (for the region) irrigation rate. As plants grew, vines were periodically pulled and tied to the wire mesh to facilitate vertical growth along the stockades.

Figure 1: Experimental plot of Clitoria green curtain

The biological characteristics examined were speed of growth and canopy development and the density, color, and uniformity of the canopy. Surrounding microenvironments were measured using an OM-PC Data Logger (Omega Engineering, Inc., USA). OM-PC Data Loggers were placed in ventilated boxes and hung on the backside of the stockades in experimental, and control (without a green curtain), plots. Micro-environment data was taken periodically after the establishment of green curtains.

3. Results and Discussion

Clitoria green curtains were established after approximately two months (64 days) from the day of planting (Figure 2). A few twining stems reached the top of the frame structure, and growing leaves covered a large area of screens. The canopy density was 68%, while human perception was much higher, particularly observation from the front. The leaves of Clitoria ternatm L. are pinnate (most with seven leaflets). Thus, green curtains spread relatively uniformly and quickly over the mesh frame, and at Day 86, the canopy density reached 85%. The color of the leaflets was light green, and, at maturation, turned to a slightly darker green. By Day 64, blue flowers began to bloom – which was a beautiful sight.

The effects of the green curtain were examined by analyzing microenvironment data collected from Day 80 to Day 86. As shown in Figure 3a, the microenvironment air temperatures were lower in Clitoria plots during mid-day, regardless of the daily maximum temperatures. To examine the significance of the effects of green curtains, microenvironment air temperatures during mid-day (10:30-15:30) were analyzed (Figure 4a). The mean air temperature in Clitoria plot for the week was 32.6°C, while that of a control plot was 39.2°C, and the difference (6.6°C) was strongly statistically significantly different (t-test). Interestingly, in the morning (9:30-10:30), when sunlight began to directly hit the experimental plots, the air temperature rapidly increased in a control plot, while in Clitoria plots, a short lag period (< 1h) was observed before the temperature began to rise (indicated by the blue arrow in Figure 3a). In addition, the air temperature in Clitoria plots rose more gradually than that of the control plot. On the contrary, in the afternoon (16:00-17:00) when the sunlight hid behind buildings, such time lags were not observed in Clitoria plots.
Figure 2: Development of *Clitoria* green curtain
The results suggest that the green curtains reduce the microenvironment air temperature - not only by physically blocking radiation but also though biological functions such as transpiration (which is highly active during the day time). Misaka et al., (2005) found in their green curtain study using *Hedera canariensis* that 25% of latent heat flux of net radiation is associated with transpiration. On the other hand, Narita (2011) reported, based on his precise measurements of leaf surfaces and vicinity air temperatures of green curtains, that the cooling effect of a green curtain is not evaporative. Therefore, the significant temperature decreases in *Clitoria* plots during the mid-day period would rely on the absorbance of latent heat by a green curtain leaf canopy.

**Figure 3:** Diurnal temperature and humidity changes between Day 80 and Day 86
Figure 4: Diurnal mid-day (10:30-15:30) temperature and humidity changes between Day 80 and Day 86
In the desert environment, as the sun rises and strong sunlight hits the ground, air temperature rapidly increases and humidity drastically drops (Figure 3b). In *Clitoria* plots, micro-environment humidity remained higher than that of the control plot during mid-day (Figure 4b). The mean humidity during mid-day (10:30-15:30) in the *Clitoria* plots for the seven days was 40.2%, while that of the control plots was 25.2%. The difference (15.0%) was statistically significant (*t*-test). A difference in humidity was only observed during the day time, which suggests that it is associated with the transpiration from the leaves. Correlations between air temperature and humidity during mid-day (10:30-15:30) in *Clitoria* and control plots were negative and moderate (*r* = -0.74 and *r* = -0.72, respectively) (Figure 5). A slight shift in the correlation tendency was determined in *Clitoria* plots. Nonetheless, data are not sufficient to determine if the higher humidity in *Clitoria* plots are due to biological effects of natural curtains or due to reduced microenvironment air temperatures.

In 2.5 months, small, delicate *Clitoria* seedlings developed into a thick, and uniform, green curtain with bright blue flowers. Observing the green curtain development process in daily life will foster (among people living an urban lifestyle) an awareness of the intrinsic value of nature. The effects of *Clitoria* green curtains on the microenvironment temperature are noticeably higher than the effects reported in other studies conducted in temperate climate zones (Fukuda et al., 2008; Kajita, 2009), suggesting that the implementation of the green curtain project in the GCC region could have a significant impact on saving energy consumption (particularly HVAC-based). In addition, since *Clitoria ternatea* L. is a perennial species, after the first establishment of green curtains, it will
sustainably mitigate the heat of the desert for several years (under standard domestic landscape management practices). The green curtain is a biological shutter. As such, it will also provide a healing of the mind (the psychological release from heat). By its natural green color, swaying leaves, and sunlight filtering through leaves, the green curtain project can be introduced as an alternative energy saving greening approach and as an innovative way of spreading awareness of sustainability among children, young adults, and the general public. Any large grass-root movements always begin with a small step, and the implementation of small projects such as the green curtain project can be the first step to achieve a sustainable society.

4. Conclusions

The study provided us with a prospect of the potential utilization of natural green curtains in the UAE. *Clitoria* green curtains developed uniformly and effectively. The effects of the green curtains on the microenvironment were significant in reducing air temperature and retaining higher humidity during mid-day. The project could be further adapted as an official project for education for sustainable development (ESD). Although the Paris Agreement is set, the destiny of the Planet Earth is in our hands. Fostering a sustainability mindset in younger generations and developing a culture that makes it desirable to live a sustainable lifestyle will be the key to our success.

References


