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Opinion

The Possibility of Sustainable Urban Horticulture Based on Nature Therapy

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Abstract: Population growth and increased stress caused by urbanization have led to social problems that are predicted to intensify in the future. In these conditions, the recently established "nature therapy" has revealed that an environment rich in various plant life significantly contributes to the relief of physical and mental stress. Meanwhile, from the perspective of reduction in the energy required for transportation and the retention of plant freshness, urban horticulture, in which plant life exists harmoniously with the city, has attracted considerable attention. Interactions between humans and plants in urban horticulture are considered to contribute to the good health and wellbeing of people. Therefore, we incorporate human-centered thinking based on nature therapy into horticultural produce-centered thinking based on conventional urban horticulture. By introducing a pioneering urban horticulture plant factory as an example, we propose the possibility of sustainable urban horticulture based on nature therapy.

Keywords: stressful society; nature therapy; plant factory; urban green; sustainable cities; human-centered horticulture; health promotion; immunity

1. Introduction

This article proposes the possibility of sustainable urban horticulture based on nature therapy by merging human-centered thinking with conventional horticultural produce-centered thinking in the field of urban horticulture. We believe that incorporating the element of good health and wellbeing into horticultural produce-centered thinking will be closely linked to the sustainable development of urban horticulture.

First, we state the current situation of urban horticulture and introduce a pioneering urban horticulture plant factory as an example. Second, the benefits of nature and green space to humans are described while demonstrating the concept of nature therapy. Finally, the benefits and challenges of urban horticulture are discussed.

1.1. Current Urban Horticulture

The world population will reportedly reach 9.6 billion people by 2050, approximately 70% of whom are predicted to live in urban areas [1]. This will require more provisions each year to feed the increasing population. Producing food near or inside cities would considerably reduce the fuel consumption and CO_2 emissions associated with its transportation. Importantly, high-tech urban horticulture produces food more efficiently than traditional farming. Recently developed plant factory technologies can grow fresh, safe, and high-nutrient produce inside cities year-round without the influence of climate changes [2]. The water- and land-use efficiencies of these technologies are high, and the labor required is lower than that for traditional farming.

The growth of horticultural products inside a city provides people with more opportunities to interact with green plants and flowers. For example, in many cities, people engage in flower-bed activities to improve the green spaces and landscape of their cities. This demonstrates that plants are tools to form communities. Furthermore, these activities not only contribute to the beautification of cities but also have a positive impact on the health and quality of life of the participants [3].

Urban horticulture can be used as a complementary form of green space with a unique value rather than as a substitute for parks [4]. Relaxing effects are expected from both the production and consumption of horticultural products. Therefore, urban horticulture is a promising solution for meeting several Sustainable Development Goals (SDGs), such as "Goal 3, good health and wellbeing," "Goal 11, sustainable cities and communities," and "Goal 12, responsible consumption and production," which were set by the United Nations General Assembly in 2015 [5]. However, knowledge about the benefits of urban horticulture on good health and wellbeing is limited and not yet well organized. We believe that focusing only on productivity and management is no longer sufficient for urban horticulture to become a sustainable industry, and the element of good health and wellbeing must be incorporated. In such a case, applying the idea of nature therapy will be extremely effective.

1.2. Advanced Urban Horticulture Technique—Plant Factory

Urban horticulture is defined as horticulture that is located inside the city and exists in harmony with the city. In urban horticulture, plant factories are facilities producing high-quality, edible, ornamental, medicinal, or industrial plants year-round with extremely high plant productivity and efficiency. A multitier system (up to 16 vertical layers) can be built to enable the mass production of plants in a small land area. Unlike urban green spaces, which are usually accessible outdoors, plant factories are enclosed or semi-closed horticultural systems. In addition to increasing attention to health improvement, the demand for fresh and safe food has been growing rapidly worldwide [6]. Rather than receiving pharmaceutical treatments, people prefer to prevent disease by eating fresh food or consuming health products derived from natural plants. Indeed, bioactive compounds in plants have been intensively evaluated for their effects on human health. Many of these have clinically relevant benefits against various types of diseases, such as anticancer, antiallergic, anti-inflammatory, and antidepressant effects [7]. Moreover, because of unpredictable climate variations, overuse of pesticides, and air pollution, food safety issues have been increasing and nutrient quality is inconsistent. The trends toward a reduction in farmland and fewer young people aspiring to be farmers have also necessitated new solutions. The sustainable production of high-quality plants has become extraordinarily urgent [2].

Plant factories with artificial lighting (PFALs) satisfy specific demands on growth and bioactive compound accumulation in plants. All environmental factors inside a plant factory can be controlled without limitations of climate or location [2,8]. Particularly, by regulating light-emitting diode (LED) light and root-zone environments, the production of bioactive compounds in plants can be largely enhanced [9–11]. The development of PFALs is creating new business opportunities and sustainable solutions for water recycling, and is decreasing chemical use. Environmental factors (light, CO_2, water, fertilizer, etc.) inside a plant factory can be controlled as precisely as desired for plant growth. PFALs have been used in many countries, including Japan, America, and China, for the commercial production of leafy greens, herbs, and medicinal plants [12]. However, the effects of these unique environments on human (producer) health remain unclear.

2. Concept of Nature Therapy

2.1. Background—Stress in Modern Society

Urbanization is a key factor in the increased life expectancies around the world [13,14] and in the improvement of living conditions [15]. However, following improvements in health and nutrition, illness has shifted from acute infections in children to chronic, generally noncommunicable diseases in adults [13,16,17].

Artificial environments and rapid urbanization have caused environmental changes such as increased traffic, reduced horticultural land and natural open spaces [18], air and water pollution, and anthropogenic climate change [19], which threaten our health and quality of life [18,19]. Higher temperatures have been recorded in cities [20–22], associating them with sensations of discomfort and heat stress [23,24]. Additionally, urban air pollution has various adverse health effects, including heart and respiratory diseases and mortality [25]. Physical inactivity due to convenient transportation methods and office work is another problem, as it leads to increased sedentary behavior [26,27]. Information technology's rapid increase has caused a surge in stress, referred to as "technostress" in a 1984 book [28], which is caused by an inability to cope with new computer technologies in a healthy manner.

These types of stress are associated with poor psychological health [29,30]. Many studies have reported the negative physiological effects of stress on organisms [31–33]. It has been reported that urban areas characterized by a low percentage of green spaces have a high incidence of mental disorders [34], children raised in urban areas with very few green spaces are at an increased risk of developing mental disorders [35], and urban residence in developed countries increases the risk of depression among the elderly [36].

2.2. Relaxing Effect of Nature

For approximately 6–7 million years when our ancestors started evolving from a subset of primates into our current form, humans have spent most of their time living in natural environments. Consequently, our bodies are likely still best adapted to living in a natural environment [37–39]. The gap between natural settings, to which our physiological functions are best adapted, and the highly urbanized and artificial environment that we inhabit contributes to stress in modern society.

Therefore, nature therapy, which is a health-promotion method using medically proven effects such as relaxation by exposure to natural stimuli from forests, urban green spaces, plants, and wooden materials, has been receiving increasing attention [40]. Exposure to stimuli from natural sources increases parasympathetic nervous activity [41–48], suppresses sympathetic nervous activity [41–47], reduces stress hormone levels [44–50], and sedates prefrontal cortex activity [50], thereby rendering a relaxed state in people, which can progress to a normal relaxed state wherein a person feels comfortable.

Nature therapy is defined as "a set of practices aimed at achieving 'preventive medical effects' via exposure to natural stimuli that render a state of physiological relaxation and boost weakened immune functions to prevent diseases" [40,51]. Unlike "specific effects" anticipated from pharmacological treatments, nature therapy aims to improve immunity, prevent illnesses, and maintain and promote health via exposure to nature and, consequently, a relaxed state [51,52].

Urbanization is expected to be further promoted in the future, and nature therapy is considered to be effective in improving the stress caused by urbanization.

3. Benefits of Urban Green Spaces in Nature Therapy

This section introduces the nature therapy effects of green space, where knowledge is organized while showing some specific examples.

Healthcare has focused on shifting from treating diseases to promoting health, preventing diseases, and improving the quality of life. Several studies have shown a significant positive relation between exposure to natural environments and physical and mental health. Questionnaire-based studies have reported restorative effects that counter psychological stressors or mental fatigue [53–56], and have found improved mood states and cognitive function [57–60]. Improved physiological measurement techniques have generated additional scientific evidence that time spent in a forest can reduce systolic and diastolic blood pressures [44–46,49] and pulse rate [44–49], suppress sympathetic nervous activity (which increases in stressful situations) [41–47], increase parasympathetic nervous activity (which enhances during relaxation) [41–48], decrease salivary cortisol levels (a typical stress hormone) [44–50], and decrease cerebral blood flow in the prefrontal cortex [50]. Visiting a forested environment enhanced human natural killer cell activity and improved immunity in both male [61] and female [62] participants, and the effects lasted for approximately a month in males [63]. These studies suggest that human beings are more relaxed in forested environments. Therefore, exposure to nature provides physiological and psychological relaxation and enhances immunity, demonstrating nature's preventive medical effects [40,51,52]. However, more data including the impacts on immunity need to be accumulated in the future.

However, in today's society, opportunities for such interactions with nature are limited. Recently, studies have focused on the potential health benefits of urban green spaces, and have found a positive relation between exposure to urban green spaces and the residents' perceived general health [64–66]. Residing in areas with accessible green spaces for walking increased the longevity of senior citizens independent of age, sex, marital status, baseline functional status, and socioeconomic status [66]. Moreover, a brief walk in an urban green space more directly resulted in relaxation effects [67–69]. Therefore, the physiological and psychological benefits of walking in urban green spaces are significant, and these spaces are considered essential for promoting health in the future.

In addition to the interest in green spaces, there is a growing interest in the effect of nature-derived stimuli that can be used daily for stress relief and relaxation. To achieve contact with nature in an indoor setting, foliage or fresh flowers can be used. It is known that indoor plants not only improve the quality of air [70–72], but also have a physiological relaxation effect by providing visual stimulation [40,73–76]. Studies have demonstrated that compared with the absence of indoor plants, viewing indoor plants decreased oxyhemoglobin (oxy-Hb) concentrations in the prefrontal cortex [73,76]; enhanced parasympathetic nervous activity, which increases in the relaxed state; suppressed sympathetic nervous activity, which increases in the aroused or stressed state; and decreased pulse rate [74–76]. Furthermore, psychological benefits (increased positive emotion and improved social behavior) have also been reported [73,76,77].

The health benefits of policies aimed at establishing urban green spaces and indoor plants should be considered, as creating green spaces can be a simple, accessible, and cost-effective method for improving urban residents' quality of life and health.

4. Benefits and Challenges of Urban Horticulture

In this section, we organize our findings on the effects of urban horticulture on human health based on the concept of nature therapy introduced in Section 3. Moreover, for sustainable development, future issues of urban horticulture are described from the perspective of nature therapy.

4.1. Benefits of Urban Horticulture

Benefits of Urban Horticulture through Nature-Related Activity

The physiologically relaxing effects of nature-related activities, including gardening or horticultural activity, are well-known. To date, various studies have demonstrated that gardening or horticultural activities reduce stress [78] and improve self-esteem, social interactions [79], and cognitive health [80]. Several attempts have been made to measure physiological responses to activities involving plants as an active participant in nature, such as transplanting or pot-transfer activities. These studies showed that nature-related activities could decrease oxy-Hb concentrations in the prefrontal cortex and suppress sympathetic nervous activity, which is increased in the aroused or stressed state [81–83]. However, scientific data based on physiological indicators that support the various physiological effects on producers have not been addressed yet.

The use of urban horticulture (e.g., plant factories) is expected to simplify and lighten producer's work, and the employment of elderly people and people with disabilities is actively under consideration. It is important to verify the physiological relaxing effect that plant-based work brings to workers, and it is expected to be utilized not only as a job but also as beneficially therapeutic horticultural work.

Various mini plant factories have been developed for residents whose access to horticultural plants is limited [84]. These systems enable residents to enjoy indoor farming and are convenient tools for restaurants, offices, schools, and hospitals to provide people with fresh vegetables and educational or healing activities. Indoor plants have reduced the symptoms of discomfort in people working in offices and hospitals, and in school students [85]. Therefore, mini plant factories may improve the quality of life of urban citizens around the world [2]. These mini plant factories have also been used in nursing homes or emergency dwellings after disasters to provide socialization opportunities to the elderly. Furthermore, because hydroponic systems are commonly used in mini plant factories instead of soil, the pleasant sound of water can be incorporated into the design of mini plant factories [86]. Therefore, the relaxing effects of the interactions between people and activities associated with mini plant factories also need to be examined.

4.2. Challenges of Urban Horticulture

4.2.1. Evaluation of Environmental Load and Workload

Farmers and farmhands are usually obliged to work under harsh environments, such as environments with high temperatures, high solar radiation, and polluted air. Therefore, traditional horticulture activities have some risk of causing adverse effects on producers' health. In particular, some studies on the physiological and psychological effects of pesticides on producers have reported that pesticides could have adverse effects on the farmers' health [87–90], and exposure to pesticides may reduce fecundability, increase the risk of deformity in children, and increase the rates of abortion and prematurity in female workers [91–93]. These findings indicate that the reduction of pesticide use is important for producers' health and for the concept of human-centered urban horticulture.

By contrast, few studies have investigated the effects of other harsh environmental factors (e.g., high temperatures and solar radiation) on horticultural producers. Jurewicz et al. [94] demonstrated that the infants of mothers who performed heavy work in a greenhouse during pregnancy had lower average birth weight than the infants of mothers who worked out of a greenhouse. However, studies are limited to physiological and psychological loads associated with farm work. To make urban horticultural development sustainable, it is necessary to investigate the effects of the working environment on producers' health per economic efficiency and environmental loads and to create a suitable working environment that benefits human health.

4.2.2. Challenges in Plant Factories

LEDs have been widely used in lighting in industrial and commercial environments. The application of LEDs in plant cultivation followed the LED development in high-efficiency red LEDs and blue LEDs in the 1980s and 1990s [95]. The use of blue LEDs (400–500 nm) and red LEDs (600–700 nm) became a prime option for plant producers because these wavelengths are efficiently absorbed by primary plant pigments. However, the mixed blue and red light generates an overall purple color throughout the entire plant factory. This light looks darker than white light, makes people feel lethargic, and causes eye discomfort. Employees working inside a plant factory may suffer from headaches and dizziness after exposure to this light for a prolonged period [96]. The visually uncomfortable lighting conditions may lead to eyestrain [97]. As the broad-spectrum white LEDs for home and office uses have rapidly developed, the plant factory companies have more choices to select suitable white LEDs for plant production [95]. These white LEDs usually contain large percentages of blue light at 400–500 nm. Recent experimental evidence has shown that blue light can induce photoreceptor-derived cell damage [98] and that blue-light-excited retinas can induce cytotoxicity [99]. Therefore, it is important to investigate the effects of LED-based light sources on workers in plant factories to minimize the risk that may be associated with blue light exposure.

A high CO_2 concentration is needed in plant factories in order to increase plant production. In an open natural environment, the CO_2 concentrations are approximately 350–400 ppm. However, a 3–5 times higher CO_2 concentration (1000–2000 ppm) is commonly used in plant factories [100]. The average working time is 8 h inside plant factories. Research has found that CO_2 and volatile organic compounds have direct and negative effects on human cognition and decision making [101]. However, reports have also stated that there are many benefits with being surrounded by green plants. There is a lack of scientific data on the combined effect of simultaneous exposure to high CO_2 concentrations and green plants, such as in plant factory environments. Therefore, relevant data must be obtained.

5. Conclusions

In proposing sustainable urban horticulture based on nature therapy, we described the current situation of urban horticulture in the present era and introduced the pioneering urban horticulture plant factory as an example. Additionally, we stated the current status of stress in modern society and the relaxing effects of nature therapy.

To promote the development of sustainable urban horticulture, as shown by the United Nations General Assembly in 2015, good health and wellbeing are important viewpoints. Scientific evidence on the effects of urban horticulture on good health and wellbeing needs to be accumulated through a multidisciplinary approach, which is still not sufficiently proposed. Therefore, we highlight that incorporating human-centered thinking into the conventional horticultural produce-centered thinking in the urban horticulture field will be of great importance in the future. We believe this change in concept will be closely connected to the sustainable development of urban horticulture. The Center for Environment, Health and Field Sciences in Chiba University has been working on sustainable urban horticulture research from this perspective for many years, and we advance this concept in the present "Opinion." We have introduced the plant factory only as an example in this article; however, in the future, the universality of sustainable urban horticulture should be also established.

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