Analysis of Application Status and Recommendations for Shade-Tolerant Lawns and Ground Cover Plants in the West Lake Scenic Area

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Abstract Taking 8 parks in Xihu Scenic Area as the survey objects, this study found that there are 77 kinds of shade-tolerant lawns and ground cover plants under the forest in good growth condition, and there are 3 types of application forms: dense forest, sparse forest and forest edge. In response to the existing problems, it is proposed that it is necessary to adhere to principles of ecology, adapt to local conditions and plant suitable varieties in accordance with local conditions, develop and use new varieties of wild shade-tolerant lawns and ground cover plants, and strengthen the promotion of the mixed planting model of shade-tolerant lawns and ground cover plants, so as to provide guidance for the better use of shade-tolerant lawns and ground cover under the forest in the West Lake Scenic Area in the future.

Key words West Lake Scenic Area, Shade-tolerant lawn and ground cover plants, Application, strategies

1 Introduction

The size of the ecological benefits of green space depends on the total leaf area of green plants and the leaf area index[1]. Constructing multilayer plant communities is an important way to improve the ecological benefits of unit green spaces[2]. As lawn and ground cover plants in the community, their growth is most affected by light[3], and improper selection leads to the formation of weeds or baldness. Therefore, it is very important to choose and screen suitable plant varieties for planting lawns and groundcover under the forest. In this study, we selected 8 representative parks in the West Lake Scenic Area to conduct field survey and analyze the types, forms and problems of shade-tolerant lawns and ground cover plants under the forest. Through analysis, we came up with some improvement strategies to provide a reference for better use of shade-tolerant lawns and ground cover plants in the future.

2 Location, content and method of the survey

2.1 Survey location We selected eight representative parks, namely, Orioles Singing in the Willows, Curved Yard and Lotus Pool in Summer, Prince Bay, Fish Viewing at the Flower Pond, Botanical Garden, Hangzhou Flower Nursery, Changqiao Stream Ecological Restoration Park, and Jiangyangfan Ecological Park, and conducted a field survey of shade-tolerant lawns and ground cover plants under the forest in April to June of 2022.

2.2 Survey content and method We carried out a detailed survey of the understory lawns and ground cover plants in these parks, and made a record of the species names, life types, growth conditions and application forms of the understory lawns and ground cover plants that appear in each survey site.

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3 Types and forms of application

3.1 Types of application Through survey, it found that there were 77 species of shade-tolerant lawn and ground cover plants, which belong to 33 families and 58 genera, including 29 species of herbs, 33 species of shrubs, 10 species of vines, 4 species of dwarf bamboos and 1 species of ferns.

3.2 Forms of application

3.2.1 Dense forest planting. The canopy density of the dense forest community is generally above 0.8, and the ground cover plants are shade-tolerant and hygrophilous. Common shade-tolerant ground cover plants used under forests in scenic spots are *Ophiopogon bodinieri*, *Ophiopogon japonicus*, *Trachelospermum jasminoides*, *Reineckia carnea*, *Farfugium japonicum* and *Fatsia japonica* (Fig. 1). These ground cover plants have strong shade tolerance and can form a stable artificial complex community with upper trees and shrubs, which has a strong sense of hierarchy.

3.2.2 Sparse forest planting. In the sparse forest community, the canopy density is in the range of 0.4 - 0.6, and the form of sparse forest is "arbor + ground cover or lawn". Lawns include *Zoysia pacifica* (Goudswaard) M. Hotta & S. Kuroki), *Zoysia japonica* and *Festuca elata*; ground cover plants such as *Curculigo capitulate*, *Hosta plantaginea*, *Rhododendron pulchurum*, *Sedum sarmentosum*, *Nandina domestica*, *Camellia sasanqua*, and *Oxalis corymbosa* (Fig. 2).

3.2.3 Forest edge planting. Forest edge is the spatial boundary of green space, planting lawn and ground cover plants to highlight the naturalness of the forest landscape. The light at the forest edge is good, the canopy density is below 0.4, and the ground cover plants with shade tolerance or semi-shade tolerance are applied. Scenic spots commonly use plants such as *Rhododendron simsii*

Planch, *Iris tectorum*, *Pleioblastus fortunei* (v. Houtte) Nakai, *Vinca major*, *Trifolium repens*, and *Liriope cymbidiomorpha* (Fig. 3).

Fig. 1 ***Reineckia carnea*** **planted in dense forest**

Fig. 2 ***Hosta plantaginea*** **and** ***Oxalis corymbosa*** **planted in sparse forest**

Fig. 3 ***Rhododendron simsii*** **Planch planted in forest edge**

4 Problems

4.1 Failure to properly deal with the relationship between light intensity and shade tolerance of plants Planting lawn grass under the forest, due to the growth of trees, the light under the forest becomes less, resulting in the death of the lawns. Some scenic spots plant color-leafed ground covers under the forest, such as *Ligustrum sinense* 'Jinji', *Hosta planta ginea* 'Fairy Variegata', *Ligustrum japonicum* 'Howardii', *Nandina domestica* 'Firepower', and *Pyracantha fortuneana* 'Harlequin'. With the growth of trees, the light under the forest is less and less, and the color leaf character of these color leaf ground covers is degraded, so that the color leaf effect of leaves is lost.

4.2 Traditional treatment method leading to single planting form It was found that the ecological function of the ground cover plant community was not paid attention to when planting, and the mixed planting of various species was neglected. Most of them are planted with a single species, which often results in a single landscape effect. For many ground cover plants, the above-ground parts will die in autumn and winter, leading to a large area of bare land.

4.3 Insufficient species of native wild shade-tolerant lawn and flowering ground cover plants suitable for understory planting Native wild ground cover plants have the characteristics of strong adaptability, low cost of management and maintenance, and reflecting regional characteristics[4-5]. The survey found that the number of native ground cover plants used in scenic spots was not large, and most of them were foliage ground cover plants, and the color-leafed varieties used in foliage ground cover were introduced from foreign countries.

5 Recommendations for improving shade-tolerant lawns and ground cover plants in scenic spots

5.1 Following the principles of ecology, adjusting measures to local conditions and planting in the suitable place It is necessary to consider the relationship between shade environment and light, as well as the relationship between shade-tolerant plants and light. When the light transmittance under the dense forest is poor, the canopy density is high, and most of the areas are shaded and humid, it is recommended to select the shade-tolerant ground cover plants. To create a sparse forest and grassland landscape, *Festuca elata* and *Dichondra micrantha* with good shade tolerance can be used as lawns. For sparse forests and forest edges, semi-shade-tolerant ornamental or color-leafed ground cover plants can be used.

5.2 Developing and utilizing new varieties of wild native shade-tolerant lawn and ground cover plants There are abundant wild resources of lawn and ground cover plants in Hangzhou. It is recommended to develop wild native shade-tolerant flowering groundcover plants such as *Ophiorrhiza japonica*, *Disporopsis pernyi* and *Pachysandra terminalis*. In addition, the development and utilization of pteridophyte resources is also an effective way to enrich the diversity of shade-tolerant ground cover plants. Furthermore, it is recommended to develop shade-tolerant, trampleresi-

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[28] KOTODA N, WADA M, KOMORI S, *et al.* Expression pattern of homologues of floral meristem identity genes *LFY* and *AP*1 during flower development in apple[J]. Journal of the American Society for Horticultural Science, 2000, 125(4): 398 -403.
[29] WADA M, CAO QF, KOTODA N, *et al.* Apple has two orthologues of *FLORICAULA/LEAFY* involved in flowering[J]. Plant Molecular Biology, 2002(49): 567 -577.
[30] CAO QF, WATA MN, MENG YP, *et al.* Cloning and expression analysis of LEAFY homologues genes from apple[J]. Acta Horticulturae Sinica, 2003, 30(3): 267 -271. (in Chinese).
[31] ZHANG LS. Morphological differentiation of apple floral bud and cloning and expression analysis of genes related to flower initiation[D]. Baoding: Agricultural University of Hebei, 2009. (in Chinese).
[32] KOTODA N. Overexpression of *MdMADS*5, an *APETALA*1-like gene of apple, causes early flowering in transgenic Arabidopsis[J]. Plant Science, 2002(162): 679 -687.
[33] SUNG SK, YU GH, AN G. Characterization of *MdMADS*2, a member of the *SQUAMOSA* subfamily of genes, in apple [J]. Plant Physiology, 1999(120): 969 -978.
[34] KOTODA N, WADA M. *MdTFL*1, a *MdTFL*1-like gene of apple, retards the transition from the vegetative to reproductive phase in transgenic *Arabidopsis*[J]. Plant Science, 2005(168): 95 -104.
[35] CUI RF, MENG Z. Functional conservation and diversity of floral homeotic *MADS*-box genes in angiosperms[J]. Chinese Bulletin of Botany, 2007, 24(1): 31 -41. (in Chinese).
[36] SUNG SK, AN G. Molecular cloning and characterization of a *MADS*-Box cDNA clone of the Fuji apple[J]. Plant Cell Physiology, 1997, 38(4): 484 -489.
[37] SUN SK, YU GH, NAM JM. Developmentally regulated expression of two *MADS*-box genes, *MdMADS*3 and *MdMADS*4, in the morphogenesis of flower buds and fruits in apple[J]. Plant, 2000(210): 519 -528.
[38] ZHOU SM, SU HY, WANG L, *et al.* Cloning and transformation of apetala2 homologues genes from apple [J]. Acta Horticulturae Sinica, 2006, 33(2): 239 -243. (in Chinese).

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stant, heat-resistant and evergreen native wild lawns to solve the problem of "no lawn under the forest".

5.3 Strengthening the promotion of mixed planting mode of shade-tolerant lawn and ground cover plants Mixed planting of two or more shade-tolerant lawns or ground cover plants can make up for the defects of single ground cover plant planting and enrich the ornamental effect and seasonal landscape of ground cover plants. According to the ecological habits and ornamental value of shade-tolerant lawn and ground cover plants, mixed planting can make the varieties complement each other, improve the landscape stability and homogeneity of ground cover communities, and prolong the ornamental period.

References

[1] ZHANG LQ, ZHOU Q, XIAO CL. Advances in research of shade tolerance of garden plant[J]. Journal of Anhui Agricultural Sciences, 2006(19): 4851 -4853. (in Chinese).
[2] REN BB, SHANG R, LI F, *et al.* Close-to-nature plant community construction in urban greenspace of Beijing[J]. Chinese Journal of Ecology, 2019, 38(10): 2911 -2917. (in Chinese).
[3] QIAN YY. Analysis of shade-tolerant plants for urban multi-layer plant community construction[J]. Garden, 2013(3): 14 -15. (in Chinese).
[4] DOU J, ZHOU SY, XU ZF. Tropical native groundcover plants resources of southern Yunnan and their sustainable use in landscape[J]. Journal of Zhejiang Forestry College, 2004, 21(1): 54 -60. (in Chinese).
[5] SUN WB. Importance of indigenous plants in their application to the modern urban landscape architecture[J]. Journal of Chinese Landscape Architecture, 2003(7): 63 -65. (in Chinese).
[6] WEI SL, JIANG MH. The distribution characteristics of light intensity and plants application for greening space on ground level roads under elevated highways of diverse structures[J]. Chinese Landscape Architecture, 2016(1): 78 -82. (in Chinese).