Evaluation of Application Value of 30 Introduced Flowering Shrubs in Landscape in Hefei City Based on AHP Method

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Abstract The application effect of 30 introduced flowering shrubs in landscape in Hefei City was comprehensively evaluated by the analytic hierarchy process (APH). A comprehensive evaluation model was established by using factors such as plant type, resistance and drought tolerance of introduced flowering shrubs. The results show that the application effect of grade-I introduced flowering shrubs (including 12 kinds, e.g. *Lantana camara*) was the best ($j \geqslant 2.6$), and that of grade-II introduced flowering shrubs (including 14 kinds, e.g. *Abelia* × *grandiflora* 'Francis Mason') was better ($2.2 \leqslant j < 2.6$), while that of grade-III introduced flowering shrubs (including 4 kinds, e.g. *Ligustrum* × *vicaryi*) was moderate ($j < 2.2$). The evaluation results can provide reference for the application effect of introduced flowering shrubs in landscape in Hefei City.

Keywords Introduced flowering shrubs, Landscape effect, Comprehensive evaluation, Analytic hierarchy process

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Introducing flowering shrubs is a design technique that creates a garden or landscape by introducing exotic plant species[1]. This method can not only beautify and increase the ornamental effect of landscape, but also resist common diseases and pests, and reduce pest control work and the dosage of pesticides. Common introduced varieties include *Lantana camara*, *Camellia sasanqua*, *Lonicera hypoglauca* and so on. These flower and shrub varieties have been widely used in the introduction of flowering shrubs and proved to have good adaptability and ornamental value[2]. Selecting suitable varieties for local climate and soil conditions and using reasonable design techniques can create rich and diverse combinations of plants to provide a beautiful and pleasant living environment for people[3].

In this study, by using analytic hierarchy process (AHP), a comprehensive evaluation index system for the application effect of introduced flowering shrubs was established[4], and from the aspects of ornamental value and resource potential, etc., the application effects of 30 kinds of introduced flower shrubs in Hefei City were analyzed to comprehensively, scientifically and intuitively reflect different landscape value levels and then obtain the real comprehensive evaluation of introduced flowering shrub landscape. The aim is to provide scientific basis for the selection and application of shrub flowers in urban flower border.

1 Natural situation of the study area

Hefei City, which is located in the middle of Anhui Province in East China, is the political, economic and cultural center of Anhui Province. Hefei has a subtropical monsoon climate, which is hot and humid in summer and cold and dry in winter. The four seasons are obvious, and the climate is mild. The precipitation is abundant, and the annual average temperature is 13−16 °C. The natural environment of Hefei is good, and the forest coverage rate is about 32%. There are many natural scenic spots around it, so it attracts a large number of tourists.

2 Evaluation process and results

2.1 Evaluation process

2.1.1 Establishment of landscape value evaluation model. Based on the investigation and analysis of 30 introduced flower shrubs in various natural environments and parks in Hefei, as well as the shape characteristics and biological characteristics of introduced flower shrubs themselves, a 4-stage evaluation model of application effect in landscape was established (Table 1), consisting of four parts: evaluation objective, evaluation criteria, evaluation factors and evaluation scheme[5]. The evaluation objective is to evaluate the application effect of the introduced flower shrubs in landscape from the aspects of appearance, growth characteristics and safety. The evaluation criteria are the binding factors for the 30 introduced flowering shrubs to be evaluated. The evaluation factors are to refine the evaluation criteria again and evaluate them from multiple aspects[6]. The evaluation scheme refers to the 30 introduced flowering shrub landscape to be evaluated[7].

2.1.2 Construction of judgment matrix and consistency test. According to the established analytic hierarchy process evaluation matrix, the 1−9 ratio scale method (Table 2) was used to compare the evaluation criteria and evaluation factors in the matrix, so as to form a judgment matrix and then make a more detailed judgment on the application effect of introduced flowering shrubs in landscape[8].

According to the matrix model, three evaluation criteria and 13 evaluation factors were compared and scored, and finally four judgment matrices were obtained[9]. Then the consistency test was carried out on the data of the judgment matrix. After the verification, weight W was calculated first, and then λ_{max} was calculated according to the formula[10]. Finally, CR was obtained according to the formulas $CI=(\lambda-n)/(N-1)$ (n is the order) and $CR=CI/RI$. If $CR < 0.10$, it is proved that the judgment is valid; if $CR > 0.10$, it is false, and the data needs to be adjusted twice[11].

2.1.3 Calculation of the total ranking weight and establishment of the scoring criteria. In the process of evaluating the application effect of introduced flowering shrubs, the ranking of different levels is the key link[12]. The total ranking weight can distinguish the importance

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levels of all evaluation factors[13]. After sorting, it is concluded that C_1 (plant type), C_3 (flower type), C_7 (drought tolerance) and C_{11} (thorn) are the most important factors, and can be as important factors in the evaluation of the application effect of introduced flowering shrubs[14]. Finally, the scoring standard of the evaluation factors were established according to their weights and ranking (Table 3).

2.2 Evaluation results and grading

According to the score of landscape value *j*, the introduced flowering shrub landscape was divided into three levels, including grade I ($j \geqslant 2.6$), grade I ($2.2 \leqslant j < 2.6$), and grade III ($j < 2.2$) (Table 4).

3 Conclusions

The evaluation results show that most of the introduced flowering shrubs have good application effect in parks, roads, natural environment and other spaces in Hefei City, but there are some shortcomings. For example, *Ligustrum* × *vicaryi* is easy to survive, and the plant is large, but the leaf viewing effect is poor, so the overall score is low. *Cornus alba* has a good ornamental effect, but it is not resistant to high temperature, and will stop growing under a high-temperature environment. For example, the introduced flower shrubs, such as *L. camara* and *W. florida* '*Red Prince*', have a good ornamental effect and are easy to survive, so the overall score is high, and they have a high application effect in the landscape of Hefei City.

According to the comprehensive score of introduced flowering shrubs, the application effect of the introduced flower shrubs led by *L. camara* and other plants have better effect, and can be given priority in the selection of flowering shrubs. The score of grade-II introduced

Table 1 Comprehensive evaluation model of the application effect of introduced flower shrubs in landscape

Evaluation objective A	Evaluation criteria B	Evaluation factors C	Evaluation scheme D
Evaluation of the application effect of introduced flower shrubs in landscape	Ornamental value B_1	Plant type C_1, leaf C_2, flower type C_3, fruit C_4, and green leaf stage C_5	30 introduced flowering shrub landscape to be evaluated
	Adaptability B_2	Cold resistance C_6, drought resistance C_7, shade resistance C_8, and water resistance C_9	
	Security B_3	Pungent odor C_{10}, thorn C_{11}, sensitization C_{12}, and toxicity C_{13}	

Table 2 Judgment matrix and consistency test

Model level		Judgment matrix and scale					W	Consistency test
A−B		C_1	C_2	C_3				
	B_1 Ornamental value	1	1/3	2			0.250	λ_{max}=3.02
	B_2 Adaptability	3	1	4			0.660	*CI*=0.01
	B_3 Security	1/2	1/4	1			0.150	*CR*=0.019<0.01
B_1−C		C_1	C_2	C_3	C_4	C_5		
	C_1 Plant type	1	1/2	1/3	2	3	0.310	λ_{max}=5.034
	C_2 Leaf	2	1	1/2	3	5	0.266	*CI*=0.008 5
	C_3 Flower type	3	2	1	4	7	0.531	*CR*=0.007 5<0.1
	C_4 Fruit	1/2	1/3	1/4	1	2	0.094	
	C_5 Green leaf stage	1/3	1/5	1/7	1/2	1	0.054	
B_2−C		C_6	C_7	C_8	C_9			
	C_6 Cold resistance	1	1/2	5	3		0.154	λ_{max}=4.211
	C_7 Drought resistance	2	1	7	4		0.431	*CI*=0.007 03
	C_8 Shade resistance	1/5	1/7	1	2		0.091	*CR*=0.079<0.10
	C_9 Water resistance	1/3	1/4	1/2	1		0.084	
B_3−C		C_{10}	C_{11}	C_{12}	C_{13}			
	C_{10} Pungent odor	1	1/4	2	1/3		0.117	λ_{max}=4.015
	C_{11} Thorn	4	1	8	2		0.518	*CI*=0.005
	C_{12} Sensitization	1/2	1/8	1	1/5		0.061	*CR*=0.005 6<0.1
	C_{13} Toxicity	3	1/2	5	1		0.303	

Table 3 Ranking weights and scoring criteria of specific evaluation indicators of flowering shrubs

Evaluation indicators	Ranking weight	Order	Score		
			3	2	1
C_1 Plant type	0.206	2	Good	Moderate	Bad
C_2 Leaf	0.067	5	Leaves are bright in color and beautiful in shape	Evergreen	Dark
C_3 Flower type	0.341	1	Flowers are beautiful and have a fragrance	Flowers are beautiful	Flowers are few and small
C_4 Fruit	0.024	10	Fruits are large and oddly shaped	Fruits are large	Fruits are small and few
C_5 Green leaf stage	0.014	12	Evergreen	Evergreen semi-deciduous	Deciduous
C_6 Cold resistance	0.038	9	Strong	Moderate	Weak
C_7 Drought resistance	0.108	3	Strong	Moderate	Weak
C_8 Shade resistance	0.060	6	Strong	Moderate	Weak
C_9 Water resistance	0.056	7	It can grow in a water environment for a long time	It can grow in a water environment for a short time	Weak
C_{10} Pungent odor	0.018	11	No	Slight	Strong
C_{11} Thorn	0.079	4	No	Few	Long and dense
C_{12} Sensitization	0.009	13	No	Slight	Severe
C_{13} Toxicity	0.046	8	No	Slight	Strong

Table 4 Evaluation results of specific evaluation indicators of flowering shrubs

No.	Flowering shrubs	Score	Grade
1	*Lantana camara*	2.956	I
2	*Weigela florida* 'Red Prince'	2.912	I
3	*Spiraea japonica* 'Goldflame'	2.806	I
4	*Camellia sasanqua*	2.765	I
5	*Viburnum macrocephalum*	2.746	I
6	*Viburnum tinus*	2.724	I
7	*Buddleja colvilei*	2.714	I
8	*Hydrangea macrophylla*	2.687	I
9	*Cuphea hookeriana*	2.655	I
10	*Rosmarinus officinalis*	2.634	I
11	*Rosa rugosa*	2.618	I
12	*Ceratostigma plumbaginoides* Bunge	2.609	I
13	*Nandina domestica* 'Firepower'	2.587	II
14	*Abelia* × *grandiflora* 'Francis Mason'	2.564	II
15	*Vitex agnus-castus*	2.526	II
16	*Lonicera hypoglauca*	2.498	II
17	*Spiraea thunbergii*	2.487	II
18	*Spiraea cantoniensis*	2.472	II
19	*Hypericum monogynum*	2.468	II
20	*Physocarpus opulifolius*	2.462	II
21	*Forsythia viridissima*	2.453	II
22	*Rhododendron hybridum*	2.449	II
23	*Hibiscus hamabo*	2.436	II
24	*Spiraea thunbergii*	2.413	II
25	*Caragana sinica*	2.385	II
26	*Elaeagnus pungens*	2.207	II
27	*Ligustrum* × *vicaryi*	2.186	III
28	*Spartium junceum*	2.145	III
29	*Duranta erecta* 'Golden Leaves'	2.126	III
30	*Cornus alba*	2.112	III

flowering shrubs led by *A.* × *grandiflora* 'Francis Mason' and *N. domestica* 'Fire-power' is lower than that of grade-I introduced flowering shrubs, but some plants are superior to those of grade-I introduced flowers in terms of resistance, cold resistance and high-temperature resistance, and some areas are more suitable for planting. Although the score ranking of introduced flower shrubs according to analytic hierarchy process has certain reference value, the actual situation should be considered in the selection of urban greening and natural plants. For instance, although the ornamental effect of *Ligustrum* × *vicaryi* is poor, it is indeed an important part of urban greening. Only by combining the comprehensive characteristics of plants with the actual environment can the application effect of introduced flowering shrubs be fully realized.

This study has important reference value for the construction of future cities and the application and development of park landscape, can greatly improve the effect of urban landscape, create a more beautiful and pleasant environment for citizens and tourists, and promote economic development. At the same time, it can reduce the investment in landscape plants, reduce the risk, and make it more convenient to choose suitable plants for planting greening, which has important research significance.

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and lower level governments, fully leveraging the advantages of all parties and promoting the implementation of integrated development in the fishing and tourism industry. This will help promote resource sharing and complementary advantages, improve the comprehensive efficiency of the fishing and tourism industry, and promote the sustainable development and enhancement of local economy. At the same time, the comprehensive coordination agency can also strengthen publicity and promotion, rational planning, and resource management, enhancing the competitiveness and influence of the fishing and tourism industry in domestic and foreign markets. Safety issues, specific approval authority, environmental protection, fire protection, etc. could be coordinated. Based on the establishment of comprehensive institutions, the supervision and approval of projects such as the construction of offshore accommodation facilities and the right to use sea routes for sightseeing yachts are implemented to improve the efficiency of project promotion.

4.2 Introducing policies and standards related to the integration projects of fishery and tourism

Referring to the relevant plans and opinions prepared by the Fujian Provincial Bureau of Oceanography and Fisheries and the Fujian Provincial Department of Culture and Tourism on promoting the integrated development of the three industries of fisheries, measures and opinions on promoting the integrated development of marine fisheries and tourism in Ningde City are formulated, and the development direction of the fishing and tourism industry in Ningde City is comprehensively guided, in order to build a good policy environment for promoting the integrated development of fishing and tourism industries in Ningde City.

It is recommended that the Ningde Marine Fisheries Bureau, in collaboration with the Cultural and Tourism Bureau, commission relevant units to conduct sufficient research, introduce and implement group standards for fishing raft homestays, fishing raft catering, etc.

Recently, according to the evaluation criteria for "water towns and fishing villages", support has been provided for the brand construction of local "water towns and fishing villages", achieving a gradual development from point to area. In the medium and long term, standards and service specifications for the integration of fishing and tourism will be introduced, and demonstration and standard projects for the integration of fishing and tourism will be regularly selected to strengthen supervision.

4.3 Strengthening communication and investment attraction

It should organize communication and learning. Through methods such as "inviting in and going out", it should visit successful enterprises or project sites in the fishing and tourism industry in Zhejiang, Taiwan, and other regions for learning and exchange. At the same time, relevant successful enterprises are invited to share their experiences.

It should strengthen communication and cooperation with relevant departments and lower level governments. By regularly holding meetings, symposiums, and seminars, it could promote in-depth exchanges and cooperation among all parties, and jointly formulate policies and plans for the integrated development of fishing and tourism. An information sharing mechanism could be established, to timely transmit the latest information and opportunities for investment promotion, and provide comprehensive market intelligence and policy guidance for investors.

It should strengthen marketing and brand promotion. By utilizing various media channels, targeted investment project information and development prospects could be disseminated, to enhance the visibility and image of integrated development of fishing and tourism. It could organize promotional activities in key domestic and international markets, participate in industry exhibitions and exchange conferences, strengthen connections with investment institutions, travel agencies, hotel groups and other partners, expand investment channels, and attract more funds and resources to invest in the integration projects of fishing and tourism.

It should coordinate with the Fujian Provincial Oceanic and Fisheries Bureau, Fujian Provincial Department of Culture and Tourism, and actively participate in project promotion and investment fairs to enhance its visibility and reputation. At the same time, measures such as setting up special support funds and promoting the role of financial services should be taken to effectively carry out the construction of fishing and tourism projects. It is recommended that the government provide special subsidies for the problem of repairing the shoreline of tourist areas (artificial beaches). It is suggested that the Marine Fisheries Administration strengthen its coordination role in the integrated development of marine fishing and tourism, and require subsidies for newly built fishing rafts that meet the requirements of the integrated fishing and tourism projects to be based on past government subsidy standards.

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