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Rapid Communication

Quantitative Taxonomy of *Osmanthus fragrans* Cultivars in Jingzhou

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ABSTRACT

This investigation had been implemented for checking *Osmanthus fragrans* Resources. In this paper, 29 classified characters were selected based on our preliminary research foundation of *O. fragrans* in Jingzhou city parks, then *O. fragrans* quantitative classification of 24 cultivars was carried out by SPSS analysis. The results showed principal component contribution rate was scattered, which is not an ideal method for quantitative classification of *O. fragrans* cultivars. The method of Walder was the best among seven clustering methods. The clustering results showed that there was a long relationship between autumn *Osmanthus* and Asiaticus Group. In addition, flowering season, flower color and fertility were very important for *O. fragrans* cultivars classification. The evolution of *O. fragrans* petals color might be complex and multi-way. The *O. fragrans* cultivars classification should not be too entangled with their color, but mainly based on flowering date. The comprehensive evaluation of inflorescence type, flower color, leaf color and other morphological characteristics played necessary reference role for the traditional variety classification method and the modern quantitative classification method.

Keywords: *Osmanthus fragrans*; Quantitative classification; Principal component analysis; cluster analysis

INTRODUCTION

Osmanthus fragrans is a species of Oleaceae family. It is one of the well-known flowers in China for its wonderful meaning, pleasant aroma and good economical values in food, medicine, industry and landscape architecture [1-5]. Because the origin and distribution center of *O. fragrans* locates in China, there are plenty of cultivars, which composed of colorful and fragrance cultivars [6] and color-leaves [7]. Different characteristics for every Cultivars Group. Luteus Group is more suitable for food processing, nutrition and health products development. Asiaticus Group plays vital important role in offsetting flower gap in winter. It was necessary to find out the current situation of *O. fragrans* cultivars in local areas, which had theoretical and practical significance for improving the effect of urban greening and beautification.

Quantitative taxonomy, as a frontier discipline, has developed rapidly in recent years with the development of computer technology, especially with the emergence of various statistical software. Quantitative taxonomy has gradually become an important method for studying variety classification [8,9]. The study on quantitative classification of *O. fragrans* cultivarshad great significance to the improvement of *O. fragrans* classification system in future [10-12].

MATERIALS AND METHODS

This research was carried out based on the tradition classification of *O. fragrans* in Jingzhou [13]. All the materials were distributed in Mingyue Park, Sanguo Park, Zhongshan Park and Binjiang Park respectively. All materials, *O. fragrans* tree, were listed in Table 1.

Selection and coding of classified characters

Through the observation and analysis of *O. fragrans* cultivars, 29 relatively stable traits reflecting the differences of characteristics among cultivars were selected as quantitative classification traits. Five of them were binary traits (abbreviated as "two"), 16 were polymorphic traits (abbreviated as "many"), and eight were continuous numerical traits (abbreviated as "number"). The detailed information was presented in Table 2.

Statistics and analysis

The principal component analysis and cluster analysis had been carried out by SPSS 25.0 software according to those selected 29 classical traits of *O. fragrans*. As for cluster analysis methods, the Wald method and Square Euclidean distance had been chosen, and then operations were carried out. Intergroup connection, Intragroup connection, nearest element, Farthest neighbor element, Centroid clustering and Median clustering were utilized

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Table 1: Cultivar names of *Osmanthus fragrans* in Jingzhou.

Number	Cultivars name	Investigation sites	Number	Cultivars name	Investigation sites
1	Sijigui	MY	13	Taoyehuang	SG
2	Dahua Zaoyingui	MY	14	Jiaorong	SG
3	Zhaoxia	SG	15	Juye Sijigui	SG
4	Chi Dangui	SG	16	Chuizhihuang	ZS
5	Zhusha Dangui	SG	17	Yinsu	ZS
6	Zidangui	SG	18	Dayehuang Jingui	ZS
7	Chenghong Dangui	SG	19	Daye Yingui	ZS
8	Wuhan Qiancheng	SG	20	Zigeng	ZS
9	Jinqiugui	SG	21	Xiaoye Sijigui	ZS
10	Hongshizi	SG	22	Duanbingzi Yingui	ZS
11	Boye Jingui	SG	23	Jiangnanliren	BJ
12	Daye Sijigui	SG	24	Liuyesugui	BJ

Note: MY-Mingyue Park; SG-Sanguo Park; ZS-Zhongshan Park; BJ-Binjiang Park

Table 2: The characters and codes of *Osmanthus fragrans* cultivars.

Number	Traits	Coding type	Coding value
1	Crown tightness	Many	dense crown(0); middle(1); Sparse crown(2)
2	Branchlet growth	Many	strong(0); middle(1); slim(2)
3	Annual branch length	Number	Short(0) : ≤8cm; middle(1):9-15cm; long(2):≥16cm
4	Leaf type	Two	single(0); doubles(1)
5	Leaf shape	Many	Long oval(0); oval (1); wide oval (2); Obovate-oval (3); ovate-oval (4)
6	Leaf texture	Two	Leathery(0); Thick leathery(1)
7	Leaf vein	Two	Obvious(0); less obvious(1)
8	Leaf margin	Many	Entire leaf(0; entire leaf or little serrate(1; exceed 1/2 serrate(2); serrate(3)
9	Edge curvature	Many	flat(0); slightly ripple (1); ripple(2)
10	Leaf involute	Many	flat(0); slightly involute(1); V shape(2)
11	Leaf apex shape	Many	acute(0); acuminate(1); mucronate(2); trailing edge(3)
12	Leaf base shape	Many	circular(0); broad wedge(1); wedge(2); Leaf base extension(3)
13	Leaf gloss	Many	glossiness(0); little gloss(1); gloss(2)
14	Leaf length	Number	short(0) : 6-7cm; middle(1):8-12cm; long (2):17-20cm
15	Leaf width	Number	Narrow(0) : 2.5-3cm; middle(1) : 3-4cm; wide (2) : ≥7cm
16	Lateral vein	Number	Few(0) : ≤7pairs; middle(1) : 7-10 pairs; many(2):≥10 pairs
17	Petiole length	Number	short(0) : ≤7mm; middle(1) : 7-12mm; long(2) : ≥12mm
18	Blossom season	Two	everblooming (0); Autumn(1)
19	Blossom period	Many	Early(0) : Mid-late August-early September; middle(1) : Mid-September to Mid-October; late(2): in Mid-October and later
20	Peduncle	Two	yes(0); no(1)
21	Peduncle color	Many	Yellow-green (0); apex green and base red (1); red or Purplish red (2)
22	Petal shape	Many	Narrow (0); Obovate (1); Obovate oval (2); broad rounded (3)
23	Petal morphology	Many	flat(0); Oblique(1); slightly involute(2); involute(3); Tai Ge(4)
24	Petal color	Many	Creamy yellow(0); orange yellow(1); light orange(2); orange-red(3); golden yellow (4); yellow (5); light yellow (6); dark yellow (7); yellow-white(8)
25	Ovary development	Many	Development(0); Development but no fruit (1); degeneration(2)

26	Flower numbers	Number	few(0) : ≤5 ; middle(1):6-7; many(2) : ≥8
27	Peduncle length	Number	short(0):<7mm; middle (1) : 7-11mm; long (2):>11mm
28	Flower diameter	Number	small(0) : <7mm; middle(1):7-9mm; big(2):>9mm
29	Fruit shape	Many	No (0); egg shape(1); ellipsoid(2); sub-globose(3)

as reference. Next comparison and analysis had been implemented between the former and the latter.

RESULTS AND ANALYSIS

After the standardization of the original data, the total variance explanations of 29 principal components of traits (some of the principal components involved in the analysis are listed in Tables 3 and 4) and the tree clustering maps of Q-type clustering of 26 traits are obtained by SPSS software operation (Figures 1 and 2).

Results of principal component analysis

10 principal components were extracted from the principal component analysis, with a cumulative contribution rate of 84.985% (Table 3). This result illustrated that the contribution rate of principal components was relatively scattered, and the principal component analysis method was not feasible in the study of quantitative classification of O. *fragrans*. However, it also showed the characteristics diversity and the complexity of O. *fragrans* cultivars. It also showed that O. *fragrans* cultivars were evolving in many directions, which resulted in different branching groups. The principal component analysis method provided a quantitative basis for the evolution of O. *fragrans*.

In addition, the contribution rates of the top four principal components were 14.348%, 12.729%, 12.621% and 10.091% respectively Tables 3 and 4. Among them, flowering season (0.832), annual branch length (0.690), flowering period (0.637), and other characteristics were more important composition of the first principal component. Branchlet growth (0.905), pedicel color (0.723), leaf margin (0.516) had more contribution to the second principal component than others. Similarly, traits with higher contribution to other principal components can be identified also. According to the results of principal component analysis, when classifying O. *fragrans* cultivars, priority should be given to the characteristics of flowering period, pedicel color, petal shape, petal color, leaf shape, leaf texture and leaf gloss.

Results of cluster analysis

Although the same data, the analyzed outcomes would be varied in pace with different clustering methods. Before clustering data analysis had been done, clustering analysis methods should be compared and taken a decision [10]. This paper compares inter-group join, intra-group join, nearest neighbor element, farthest neighbor element, centroid clustering, median clustering and Walder method (Figures 1 and 2). Cluster map reflects the distance of the genetic relationship of sample materials, the earlier they gather together, the closer the genetic relationship. From the graph, we can see that different clustering methods have different results.

We chose the Walder method, which had the best clustering effect for analysis, after comparing with all the others clustering graph illustrated in Figure 3. Twenty-four O. *fragrans* cultivars were grouped into five groups when L1 (lambda=16.992) was taken as the binding line (Figure 1). The first group consisted of two cultivars of Asiaticus Group ('Citrus leaf Sijigui', 'Big leaf Sijigui'); the second group consisted of three cultivars of Asiaticus ('Sijigui', 'Xiaoye Sijigui', 'Dongxianghong'); the third group consisted

Table 3: Interpretation of total variance of partial traits.

Component	Initial eigenvalue			Extracting Square Sum of Load		
	Total	Variance Proportion	Accumulate (%)	Total	Variance Proportion	Accumulate (%)
1	4.018	14.348	14.348	4.018	14.348	14.348
2	3.564	12.729	27.077	3.564	12.729	27.077
3	3.534	12.621	39.697	3.534	12.621	39.697
4	2.826	10.091	49.789	2.826	10.091	49.789
5	2.359	8.426	58.215	2.359	8.426	58.215
6	2.064	7.370	65.585	2.064	7.370	65.585
7	1.821	6.502	72.087	1.821	6.502	72.087
8	1.370	4.894	76.981	1.370	4.894	76.981
9	1.233	4.402	81.383	1.233	4.402	81.383
10	1.009	3.602	84.985	1.009	3.602	84.985

Table 4: Partial trait component matrix.

Traits	Component									
	1	2	3	4	5	6	7	8	9	10
Crown dense	.322	-.440	.277	.351	.354	-.239	-.075	-.030	-.281	.161
Branchlet growth	.099	.905	.084	-.131	-.010	-.229	.024	-.109	-.037	.022
Annual shoot length	.690	.380	-.048	.328	.110	.276	.017	.020	.077	-.050
Leaf type	-.832	.095	.280	-.266	.095	.266	-.152	-.004	-.037	-.112
Leaf shape	-.575	.096	-.052	.243	.214	-.222	-.052	.064	.307	.466
Leaf texture	-.072	-.584	-.245	.241	-.040	.249	.428	.311	.216	-.240
Leaf vein	-.129	-.461	-.250	-.466	.055	-.207	.407	-.244	.202	.154
Leaf margin	.350	.516	.022	-.428	.157	-.154	.135	.100	.008	-.322
Edge curvature	.029	-.002	.441	.297	.287	-.010	-.106	.251	-.618	-.011
Leaf involute	-.210	.015	.367	.265	.545	-.039	.398	.268	.077	-.145
Leaf base	-.258	-.317	-.477	.057	-.060	-.569	.082	-.241	-.144	-.028
Leaf apex	.168	.084	.573	-.198	-.257	-.286	.303	-.137	-.086	.185
Leaf gloss	-.170	.498	-.419	.082	.298	.499	-.019	-.107	.053	.257
Leaf length	.267	-.102	.758	-.021	-.358	.216	.217	-.114	.144	.144
Leaf wide	.267	-.102	.758	-.021	-.358	.216	.217	-.114	.144	.144
lateral vein pairs	.268	.140	-.261	.247	-.051	.576	-.172	-.441	-.087	.112
Leaf petiole	-.117	.143	.552	.577	.246	.047	-.082	.144	.217	.085
Flowering season	.832	-.095	-.280	.266	-.095	-.266	.152	.004	.037	.112
Flowering period	.637	-.012	-.328	.464	.061	-.142	.125	.030	.115	.070
Peduncle color	.071	.723	-.124	.052	-.054	-.081	.462	.154	.163	-.209
Petal shape	.218	-.604	-.109	-.141	.219	.254	-.180	.331	.290	.047
Corolla shape	-.106	-.156	-.382	.174	-.607	.467	.192	.099	-.262	-.118
Petal color	.109	.343	-.354	.080	-.302	-.255	-.450	.389	.181	.168
Ovary development	-.547	.104	.076	.645	-.319	-.211	.025	-.078	.084	-.223
Flower numbers per Inflorescence	.070	-.025	-.012	.017	.709	.102	.067	-.516	.214	-.201
Peduncle length	.263	-.094	.389	-.330	-.167	-.074	-.577	.049	.358	-.217
Corolla diameter	.327	-.296	.113	.250	.020	-.163	-.395	-.283	.041	-.357
Fruit shape	.451	-.076	-.083	-.674	.353	.118	.049	.268	-.197	.108

Note: extraction method: a. Ten principal components were extracted.

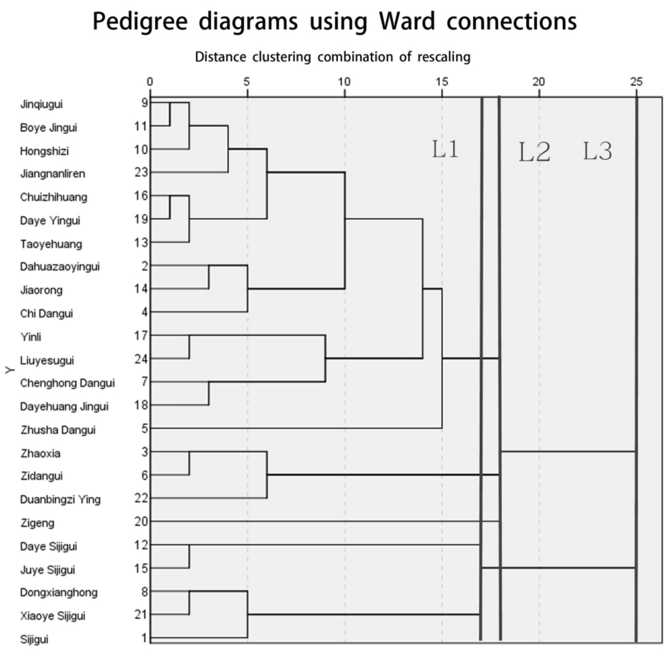

Figure 1: The Walder Cluster Map for 24 *Osmanthus fragrans* cultivars in Jingzhou city

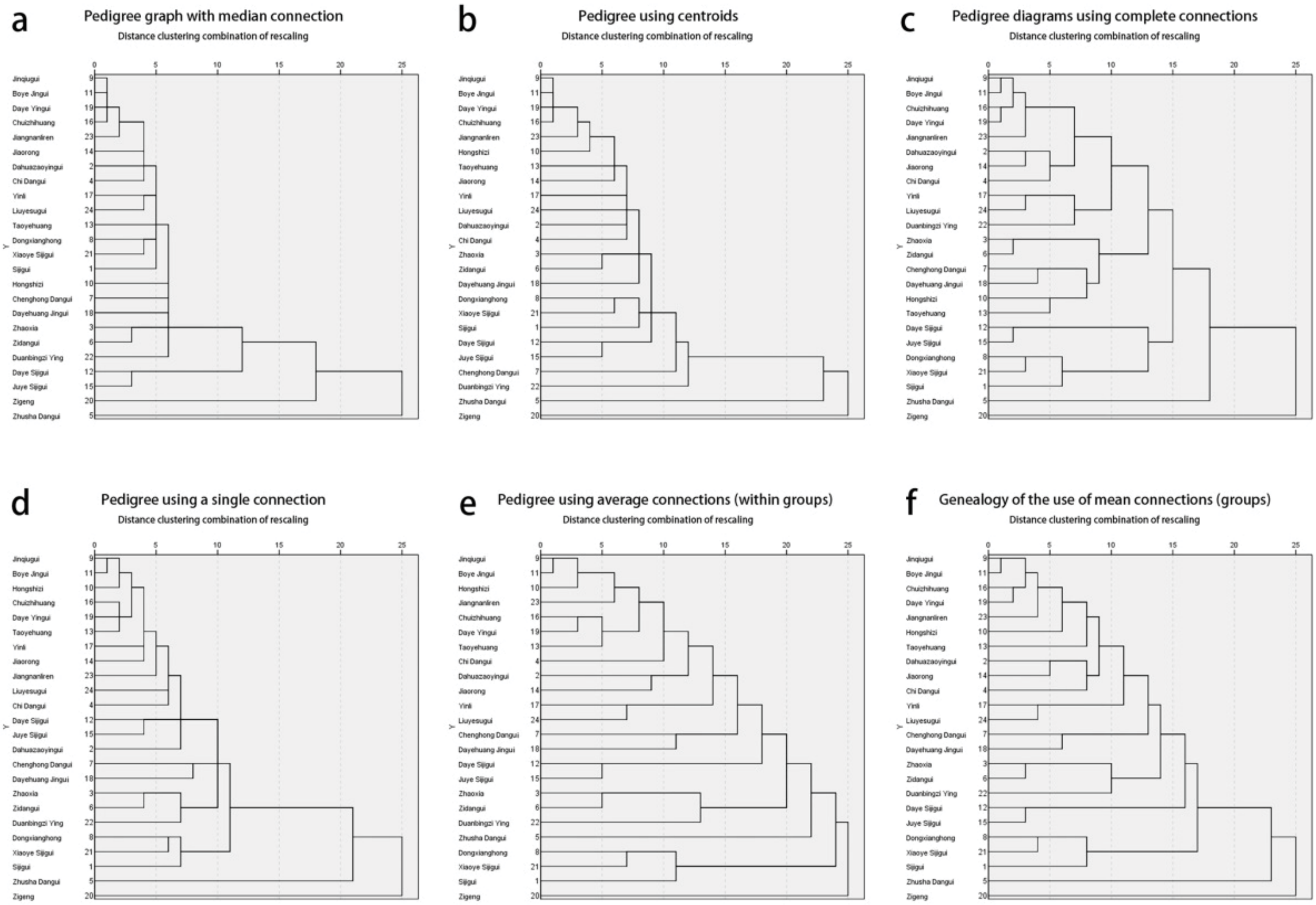

Figure 2: Other 6 kinds Clustering results for 24 *Osmanthus fragrans* cultivars in Jingzhou city

of purple stalks clustered into a single group, the fourth group consisted of two Aurantiacus Group ('Seed Dangui', 'Zhao Xia') and one Albus Group (Short stalk Seed Silver Gui); the remaining 15 cultivars included Luteus Group (6) and Albus Group (4) and Aurantiacus cultivar groups (5) were clustered into the fifth group.

When L2 (lambda=18.031) was taken as the binding line, 24 *O. fragrans* cultivars were clustered into four groups. The first group was Asiaticus cultivar group, which included 5 Asiaticus cultivars. The second, third and fourth groups are the third, fourth and fifth groups when L1 is chosen as the dividing line. When L3 (λ = 24.991) was taken as the binding line, 24 *O. fragrans* cultivars were clustered into two groups. The first group consisted of five cultivars of Asiaticus, and the second group included 19 cultivars such as 'Jinqiugui', 'Red Cross' and 'Jiangnan Liren'.

Based on the above analysis results, it can be concluded that the genetic relationship among Autumn *Osmanthus* (Jingui, Dangui and Yingui) was more close than between Asiaticus Group and Autumn *Osmanthus*. At the same time, on the three lambda, different blossom seasons of *O. fragrans* were aggregated separately, which reflected that took the flowering season as a high-level criterion for classification of *O. fragrans* cultivars is more appropriate.

CONCLUSION

The characters selected by the system clustering were quantified according to certain criteria, which avoided the influence of subjective factors to a certain extent and makes up for the shortcomings of traditional morphological classification. Based on the quantitative classification of *O. fragrans* cultivars in Jingzhou Park, the feasibility of principal component analysis (PCA) of *O. fragrans* cultivars was discussed. The significance of florescence, pedicel color, petal shape and other characteristics was discussed. The genetic relationship among the cultivars was discussed by Q-type clustering, and some useful conclusions were obtained.

(1) Although the quantitative classification method based on phenotypic traits has limitations in practical application, such as strong subjectivity in the selection and coding of traits, the results obtained by different treatment methods are generally different. However, the method can synthesize various traits from different sources, a general classification system can be obtained, which can be compared with the traditional classification method. The two classification methods can do complements each other.

(2) The evolution of *O. fragrans* flower color should be complex and multi-way. Besides the evolution direction of "Albus (white) - Luteus (yellow) - Aurantiacus (orange yellow, orange red)", there should be other ways. Therefore, the classification of *Osmanthus* cultivars should not be too entangled with flower color. We conclude flowering stage, and comprehensive evaluation of inflorescence type, flower color, leaf color and other morphological characteristics should be taken into account mainly, while encounter classification of *O. fragrans* cultivars.

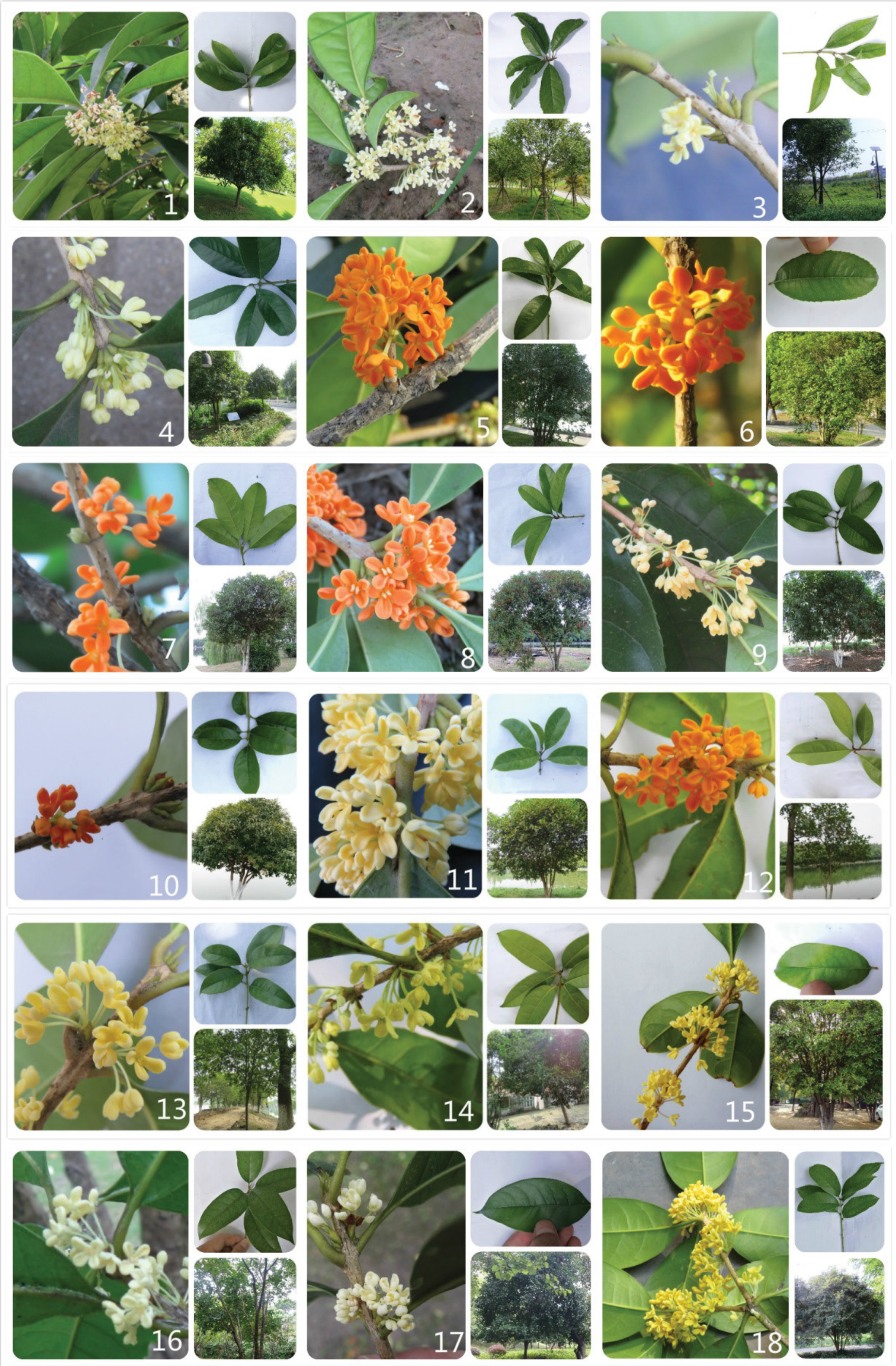

Figure 3: Identified *Osmanthus fragrans* cultivars in Jingzhou (illuminated some cultivars)
1 Daye Yingui, 2 Jiangnanliren, 3 Liuyesugui, 4 Sijigui, 5 Zhaoxia, 6 Chi Dangui, 7 Zidangui, 8 Chenghong Dangui, 9 Dahuazaoyingui, 10 Dongxianghong, 11 Jinqiugui, 12 Hongshizi, 13 Boye Jingui, 14 Taoyehuang, 15 Juye Sijigui, 16 Houban Yingui, 17 Yinsu, 18 Dayehuang Jingui.

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REFERENCES

1. Yang XL, Song JN, Zhao F, Wang NG. Effects of cold storage on major nutrients of five *Osmanthus fragrans* cultivars. Southwest China J Agri Sci. 2014;27(6):2720-2722.
2. Ye C, Zhang L, Wang P, Shang YZ, Wang LM. Comparative study on contents of amino acids and trace elements of 4 *Osmanthus fragrans* Cultivars. J Food Ind. 2013;34(6):203-205.
3. Sheng YZ, Yu LJ, Wang LM. Screening and evaluation of natural food preservatives. Food Sci Technol. 2009;34(8):204-207.
4. Yin W, Yu Y, Ma QL, Chen T, Zhang GS. Study on chemical constituents and antitumor activities of leaves of *Osmanthus fragrans*. J Tropical and Subtropical Botany. 2018;26(2):178-184.
5. Shi TT, Yang XL, Wang LG. Study on the aroma component emission pattern of *Osmanthus fragrans* 'Boye Jingui'. J Nanjing Forestry University (Natural sciences Edition). 2018;42(2):97-104.
6. Zang DK, Xiang QB, Liu YL. Notes on cultivar classification in Osmanthus. Scientia Silvae Inicae. 2006;42(5):17-21.
7. Yu L, Li JH, Bai WF, Nie DL, Wu SZ, Yi JX. A New *Osmanthus fragrans* cultivar Caihong. Acta Horticulturae Sinica. 2018;45(5):207-208.
8. Liu LC, Xiang QB. Study on numerical taxonomy of sweet *osmanthus* cultivars. J Fujian College of Forestry. 2004;24(3):233-236.
9. Tang DQ. A study on numerical classification of the cultivars of sweet *osmanthus* (*Osmanthus fragrans* (thunb.)lour.). J Nanjing Forestry Univ. 1998;22(1):37-42.
10. Duan YF, Wang XR, Lliang LL, Xiang QB, Yi XG. A numerical classification of the sweet *osmanthus* cultivars in xian'ning of Hubei Province. J of Hubei Univ for Nationalities (Natural Science Edition). 2010;28(3)289-293.
11. Zeng MY. Study on quantitative classification of *Osmanthus fragrans* cultivars in Sichuan province. South China agriculture. 2009;3(2):68-70.
12. Zhao XM, Chen ZF. Studies on the numerical taxonomy of *Osmanthus fragrans* Lour cultivars in Wuhan. J Hubei Institute for Nationalities. 1998;6:11-15.
13. Sun TZ, Zhao F, Li DL, Mu HN. Variety identification and landscape application of *Osmanthus fragrans* in Jingzhou City. J Hortic. 2019;6(1):1-4.