

## ORIGINAL RESEARCH ARTICLE

# Analysis of main botanical characters of 56 *Momordica charantia* varieties

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### ABSTRACT

In order to scientifically evaluate the germplasm resources of *Momordica charantia* in southern China, the diversity, correlation and cluster analysis were carried out on the main botanical characters of 56 *Momordica charantia* varieties, such as melon length, melon transverse diameter, single melon weight, internode length, stem diameter, leaf length and leaf width. The results showed that the variation coefficients of 7 agronomic characters of 56 *Momordica charantia* varieties ranged from 8.81% to 19.44%, the average variation coefficient was 14.21%, the maximum variation coefficient of single melon weight was 19.44%, and the minimum variation coefficient of melon cross diameter was 8.81%. The correlation analysis showed that there were correlations among the agronomic traits. The positive correlation coefficient between leaf length and leaf width was up to 0.978, and the negative correlation coefficient between single melon weight and internode length was up to 0.451. The 56 varieties were divided into 3 groups by cluster analysis, of which 92.86% of the materials were concentrated in the first and second groups, and there were only 4 materials in the third group. The results can provide a reference for the cultivation, utilization and genetic improvement of *Momordica charantia* resources in southern China.

**Keywords:** *Momordica charantia*; Botanical Characters; Diversity Analysis; Correlation Analysis; Cluster Analysis; Genetic Markers; Genetic Relationship

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## 1. Introduction

*Momordica charantia* is an annual climbing herb of Cucurbitaceae. Compendium of Materia Medica points out that *Momordica charantia* has high therapeutic value, such as clearing away heat and toxin, clearing the heart and eyes, supplementing Qi and Yang, and treating diabetes<sup>[1]</sup>. The research on plant genetic diversity is not only closely related to the collection, preservation and renewal of germplasm resources, but also the basis of germplasm resources innovation and variety improvement. On the basis of genetic diversity evaluation, the research on the genetic distance and systematic classification relationship between germplasm resources by comparing the similarity and dissimilarity between germplasm resources has become an important content of crop germplasm resources research<sup>[2]</sup>. In the study of *Momordica charantia* resources, Liu *et al.*<sup>[3]</sup> and Wu *et al.*<sup>[4]</sup> conducted cluster analysis on different types of *Momordica charantia*. The results showed that there was a long genetic relationship between wild *Momordica charantia* and cultivated *Momordica charantia*, but there was little difference between cultivated varieties. Zhang *et al.*<sup>[5]</sup> evaluated and classified 51 *Momordica charantia* resources by using multivariate statistical analysis method.

It was found that the variation coefficients of 23 different phenotypic traits of 51 strains were between 5.88% and 47.90%, and 51 materials could be divided into 5 groups by cluster analysis. Some authors also conducted preliminary studies on the agronomic traits<sup>[6-8]</sup>, quality traits<sup>[9]</sup>, seed number and seed coat color<sup>[10]</sup> of *Momordica charantia*, and found that there were varying degrees of variation in these traits. Genetic markers are also widely used in the study of genetic diversity of *Momordica charantia* resources<sup>[11-13]</sup>. The results show that *Momordica charantia* resources can be divided into different groups. Wang *et al.*<sup>[14,15]</sup> used SSR and SRAP markers to study the genetic relationship between *Momordica charantia* germplasm. The results showed that this method could successfully define the genetic relationship between *Momordica charantia* germplasm.

Studies on the diversity and correlation of *Momordica charantia* and the division of intraspecific populations have promoted the understanding and utilization of *Momordica charantia* resources. However, different germplasm resources still need to be cultivated and investigated in different regions to avoid the blindness of breeding and speed up the breeding process. Taking the opportunity of the “2018 Annual Meeting of the South Melon Industry Cooperation” held in Changsha, this study planted 56 *Momordica charantia* varieties (combinations) collected from 10 southern provinces in Changsha. Through the observation and research on the growth of plants and fruits, the diversity, correlation and cluster analysis of their main botanical characters were carried out, in order to enrich the basic research of *Momordica charantia* resources and provide reference for the effective use of *Momordica charantia* resources.

## 2. Materials and methods

### 2.1 Test time and place

The field experiment of this study was carried out in batches in the experimental base of Hunan Vegetable Research Institute in Gaoqiao Town, Changsha County in the spring of 2018, in which late

maturing varieties were sown on April 5 and planted on April 29, and early maturing varieties were sown on April 28 and planted on May 15.

### 2.2 Test materials

56 *Momordica charantia* varieties (combinations) collected at the “2018 annual meeting of the South Melon Industry Cooperation Association” were used as test materials, as shown in **Table 1**.

### 2.3 Test method

#### 2.3.1 Test design

The experiment was conducted in the experimental base of Hunan Vegetable Research Institute in Gaoqiao Town, Changsha County. The 56 *Momordica charantia* varieties were cultivated in nutrient bowl and planted in batches. The late maturing varieties were planted on April 29 and the early maturing varieties on May 15. Before planting, dig the land deeply and apply 750 kg/hm<sup>2</sup> of nitrogen, phosphorus and potassium ternary compound fertilizer, 1,500 kg/hm<sup>2</sup> of dried vegetables and 45,000 kg/hm<sup>2</sup> of decomposed cow dung as base fertilizer. 4 m open trunk (furrow), plant spacing 0.5 m, double row planting. After planting seedlings, a simple steel frame arch shed shall be built in time, with a covering of 30 cm × the special climbing net for melons and vegetables with a hole spacing of 30 cm shall be tightened and fixed, and the vine shall be introduced in time. All the side vines below 1 m of the main vine shall be removed. Other field management measures are the same as the conventional management. 10 plants shall be planted for each variety, and the random block design shall be repeated for 3 times. Results the internode length, stem diameter and leaf size of the main stem at the same node in the middle of the plant were recorded at the peak stage; the melon length, melon thickness and average weight per melon were recorded 15 days after flowering.

#### 2.3.2 Data processing and analysis

All measured data were analyzed by Excel 2013 and SPSS 20.0 software for diversity, correlation and cluster analysis.

**Table 1.** Name and source of *Momordica charantia* varieties (combinations) tested

No.	Variety name	Breeding unit	No.	Variety name	Breeding unit
1	K309	Hunan Vegetable Research Institute	29	2017-19	Fujian Crop Research Institute
2	K307	Hunan Vegetable Research Institute	30	2017-23	Fujian Crop Research Institute
3	K387	Hunan Vegetable Research Institute	31	1304	Fujian Institute of agricultural biological resources
4	2015NS8	Changsha Vegetable Research Institute	32	1604	Fujian Institute of agricultural biological resources
5	2017F30	Changsha Vegetable Research Institute	33	1634	Fujian Institute of agricultural biological resources
6	Bitter gourd No.1	Hunan Xiangmeizi Agricultural Technology Co., Ltd.	34	1014	Fujian Institute of agricultural biological resources
7	Bitter gourd No.2	Hunan Xiangmeizi Agricultural Technology Co., Ltd.	35	Lvzhu 2	Zhuhai modern agriculture development center, Guangdong Province
8	White <i>Momordica charantia</i> combination	Changde Vegetable Research Institute	36	Lvzhu 8	Zhuhai modern agriculture development center, Guangdong Province
9	Green <i>Momordica charantia</i> combination	Changde Vegetable Research Institute	37	Lvzhu 9	Zhuhai modern agriculture development center, Guangdong Province
10	Xiuyu 1	Jiangsu Vegetable Research Institute	38	E23-4 Pearl <i>Momordica charantia</i>	Guangdong Vegetable Research Institute
11	Xiuyu 4	Jiangsu Vegetable Research Institute	39	Meiyu No.1 Pearl <i>Momordica charantia</i>	Guangdong Vegetable Research Institute
12	Snow white	Jiangsu Vegetable Research Institute	40	118 Pearl <i>Momordica charantia</i>	Jiangmen Agricultural Science Research Institute
13	Xiuyu 3	Jiangsu Vegetable Research Institute	41	Guifeng 2	Jiangmen Agricultural Science Research Institute
14	GK24110	Jiangsu Vegetable Research Institute	42	Baisha 1704 <i>Momordica charantia</i>	Shantou Baisha Vegetable Seed Institute
15	Combination kg02	Zhejiang Academy of Agricultural Sciences	43	Baisha 1705 <i>Momordica charantia</i>	Shantou Baisha Vegetable Seed Institute
16	Combination kg03	Zhejiang Academy of Agricultural Sciences	44	Baisha 1601 <i>Momordica charantia</i>	Shantou Baisha Vegetable Seed Institute
17	Guanchun 9	Sichuan Institute of Horticulture	45	<i>Momordica charantia</i> No.1	Guangxi Vegetable Research Institute
18	Lvfeng 875	Chongqing Academy of Agricultural Sciences	46	<i>Momordica charantia</i> No.2	Guangxi Vegetable Research Institute
19	Green crown 68	Chongqing Academy of Agricultural Sciences	47	<i>Momordica charantia</i> No.3	Guangxi Vegetable Research Institute
20	Gan <i>Momordica charantia</i> No. 4	Jiangxi Vegetable and Flower Research Institute	48	<i>Momordica charantia</i> No.4	Guangxi Vegetable Research Institute
21	JX1514	Jiangxi Vegetable and Flower Research Institute	49	Haiyan No.2	Hainan Qiongyan Melon and Vegetable Seed Development Co., ltd
22	JX1525	Jiangxi Vegetable and Flower Research Institute	50	Qiwang <i>Momordica charantia</i>	Guangzhou Vegetable Research Institute
23	WKG-1	Wuhan Vegetable Science Research Institute	51	Bitui 3	Guangzhou Vegetable Research Institute
24	WKG-2	Wuhan Vegetable Science Research Institute	52	Cui 4 <i>Momordica charantia</i>	Guangzhou Vegetable Research Institute
25	WKG-3	Wuhan Vegetable Science Research Institute	53	Cui 5 <i>Momordica charantia</i>	Guangzhou Vegetable Research Institute
26	2017-1	Fujian Crop Research Institute	54	Z1706	Institute of Thermal Science
27	2017-9	Fujian Crop Research Institute	55	Z1717	Institute of Thermal Science
28	2017-12	Fujian Crop Research Institute	56	Z1721	Institute of Thermal Science

### 3. Results and analysis

#### 3.1 Variation of main agronomic characters

The variation analysis results of main agronomic characters of 56 *Momordica charantia* varieties are shown in **Table 2**. Among the 7 main agronomic traits selected for investigation, the coefficient of variation ranged from 8.81% to 19.44%, with an average coefficient of variation of 14.21%.

The variation range of melon length, internode length, stem diameter, leaf length and leaf width were not large. The reason may be that the materials selected in this study were collected from several southern provinces in China, with close spatial

distance and small differences in planting environment, so the coefficient of variation among these varieties was small. The coefficient of variation of single melon weight was the largest, reaching 19.44%. The average value of single melon weight of 56 tested varieties was 0.36 kg, of which “Bicui No.3” was the largest, reaching 0.53 kg, and “No.2 *Momordica charantia*” was the smallest, only 0.24 kg. The coefficient of variation of melon transverse diameter was the smallest, which was 8.81%. The average value of melon transverse diameter of all tested varieties was 5.56 cm, of which “1014” was the largest, reaching 6.67 cm, and “Xiuyu 1” was the smallest, only 4.67 cm.

**Table 2.** Analysis of 7 Main agronomic characters of 56 *Momordica charantia* varieties (combinations)

Investigation character	Melon length/cm	Melon transverse diameter/cm	Single melon weight/kg	Internode length/cm	Stem diameter/cm	Blade length/cm	Blade width/cm
Maximum value	34.33	6.67	0.53	14.33	1.20	28.65	28.60
Minimum value	14.33	4.67	0.24	7.33	0.70	16.63	16.33
Average value	27.52	5.56	0.36	10.51	0.85	23.76	23.75
Standard deviation <i>SD</i>	3.84	0.49	0.07	1.74	0.12	3.15	3.16
Coefficient of variation <i>CV</i> /%	13.95	8.81	19.44	16.56	14.12	13.26	13.31

#### 3.2 Correlation analysis of different characters of *Momordica charantia* Germplasm

The correlation analysis of 7 main agronomic characters of 56 *Momordica charantia* germplasm materials was carried out. The results (**Table 3**) showed that there was a very significant positive correlation between melon length and single melon weight, melon transverse diameter and single melon

weight, melon transverse diameter and leaf length, melon transverse diameter and leaf width, and leaf length and leaf width; there was a very significant negative correlation between the transverse diameter of melon and internode length, and between the weight of single melon and internode length; there was a significant positive correlation between single melon weight and leaf length.

**Table 3.** correlation coefficients among Main Agronomic Characters of *Momordica charantia*

	Melon length	Transverse diameter of melon	Single melon weight	Internode length	Stem diameter	Blade length	Blade width
Melon length	1						
Transverse diameter of melon	-0.076	1					
Single melon weight	0.509**	0.487**	1				
Internode length	-0.150	-0.371**	-0.451**	1			
Stem diameter	0.065	-0.067	0.040	-0.164	1		
Blade length	-0.069	0.405**	0.271*	-0.104	-0.206	1	
Blade width	-0.065	0.400**	0.235	-0.056	-0.224	0.978**	1

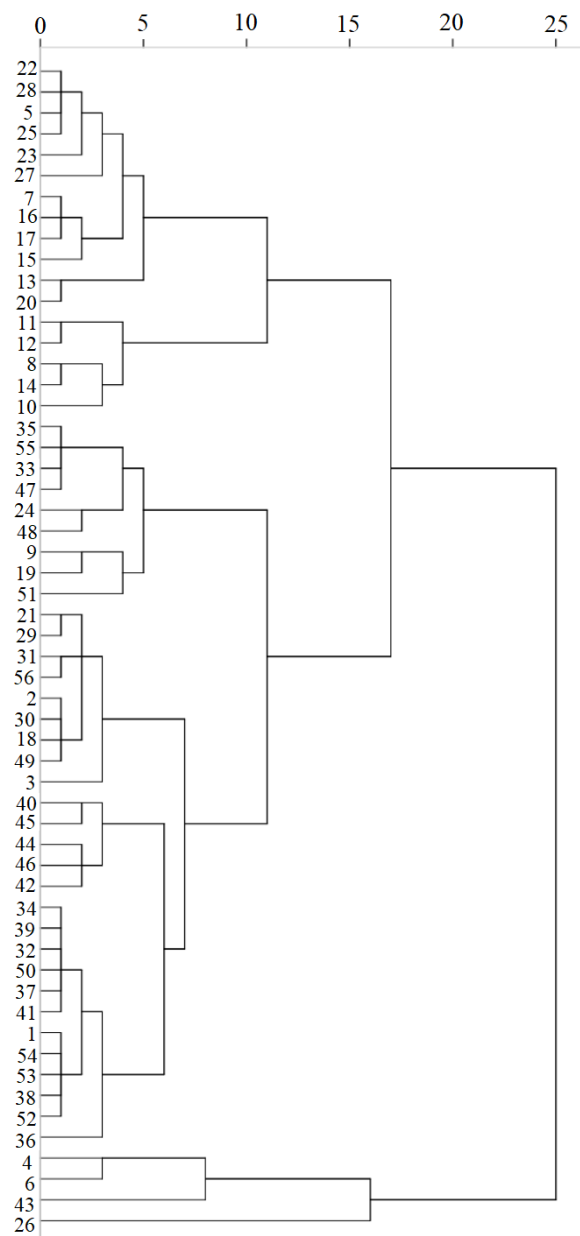
Note: \* indicates significant difference at 0.05 Level (bilateral), and \*\* indicates significant difference at 0.01 Level (bilateral).

Melon length and stem diameter, single melon weight and stem diameter, single melon weight and leaf width are positively correlated, while melon length and melon transverse diameter, melon length and internode length, melon length and leaf length, melon length and leaf width, melon transverse diameter and stem diameter, internode length and stem diameter, internode length and leaf length, internode length and leaf width, stem diameter and leaf length, stem diameter and leaf width are negatively correlated, but the correlation has not reached a significant level. The positive correlation coefficient between leaf length and leaf width is the largest, reaching 0.978, which indicates that the transverse and longitudinal growth of *Momordica charantia* leaves are relatively consistent, and the longer the leaves are, the wider they will be; the negative correlation coefficient between single melon weight and internode length was the largest, reaching 0.451, indicating that the longer the internode, the smaller the single melon weight.

### 3.3 Cluster analysis of main agronomic characters

The average connection (between groups) method in systematic clustering was used to cluster the 7 traits of 56 *Momordica charantia*, and the square Euclidean distance was used as the genetic distance for cluster analysis, as shown in **Figure 1**. When the square Euclidean distance was about 16, 56 varieties could be divided into 3 groups, and the characteristics of each group were shown in **Table 4**. There are 17 materials in group 1, accounting for 30.36% of all materials. The remarkable feature of this group is that the melon length is longer than other groups, while the melon transverse diameter, leaf length and leaf width are significantly smaller than the other two groups, indicating that the fruits of this group are long strip type, the plant growth potential is slightly weak, and most of them are early maturing *Momordica charantia* varieties. There are 35 materials in the second group, accounting for 62.5% of the tested materials. The fruit length and width of this group are in the middle, most of them are cylindrical, the weight of single melon, leaf length and leaf width are higher than the other two

groups, and the growth momentum is relatively strong. Most of them are late maturing varieties, which are the main varieties of *Momordica charantia* cultivated in southern provinces. In the third group, there were only 4 materials, namely “2015NS8”, “No.1 *Momordica charantia*”, “2017-1” and “Baisha 1705 *Momordica charantia*”, accounting for only 7.14% of the tested materials. The fruit of this group is short and wide, the weight of a single melon is relatively small, in the shape of a short stick, relatively easy to transport, the plant growth is medium, the field resistance is strong, and the adaptability in Changsha is good.



**Figure 1.** Cluster analysis of 56 *Momordica charantia* varieties.

### 3. Conclusion

Through the diversity, correlation and cluster analysis of the main botanical characters of 56 *Momordica charantia* varieties, it was found that the coefficient of variation of single melon weight was the largest and the coefficient of variation of melon transverse diameter was the smallest; there were correlations among all traits, and some traits reached very significant or significant levels, which provided a reference for the improvement of breeding

objectives; cluster analysis showed that 56 varieties could be divided into 3 groups, but there was little difference between groups, indicating that there was little difference in materials among *Momordica charantia* breeding units in southern China. In order to make a breakthrough in *Momordica charantia* breeding, it is necessary to broaden the source of *Momordica charantia* germplasm resources. This study provides a reference for the cultivation, utilization and genetic improvement of *Momordica charantia* resources in southern China.

**Table 4.** Characteristics of *Momordica charantia* varieties in different groups

Investigation character	Group 1	Group 2	Group 3
Melon length/cm	29.60	27.49	18.96
Melon transverse diameter/cm	5.21	5.71	5.75
Single melon weight/kg	0.34	0.38	0.30
Internode length/cm	10.50	10.48	10.83
Stem diameter/cm	0.86	0.85	0.84
Blade length/cm	20.34	25.62	22.08
Blade width/cm	20.38	25.60	21.92

### 4. Discussion

The research on genetic diversity of germplasm resources is not only conducive to the evaluation and utilization of germplasm resources, but also conducive to the innovative research of core germplasm<sup>[16]</sup>. The evaluation of *Momordica charantia* germplasm resources is widely used in the genetic improvement of *Momordica charantia*, which is the basis of *Momordica charantia* breeding. The study on genetic evaluation of 56 *Momordica charantia* varieties is of great significance for the evaluation and utilization of *Momordica charantia* resources and the breeding of new *Momordica charantia* varieties.

The polymorphism of the same trait among plant intraspecific germplasms is determined by alleles, which brings more opportunities for crop breeding<sup>[17]</sup>. In this study, the coefficient of variation of main agronomic characters of 56 *Momordica charantia* varieties was analyzed. The results showed that the variation range of melon transverse diameter, leaf length and leaf width was small, and the variation range of single melon weight, melon length, internode length and stem diameter was large, indicating that it was feasible to improve these

characters with large variation range, which was consistent with the research conclusion of Zhang *et al.*<sup>[18]</sup> on *Momordica charantia*.

The correlation analysis shows that there is correlation among the seven traits investigated, which is consistent with the research conclusions of Huang *et al.*<sup>[19]</sup>, Li *et al.*<sup>[20]</sup>, Wang *et al.*<sup>[21]</sup> There is a very significant positive correlation between melon length and single melon weight, melon transverse diameter and single melon weight, melon transverse diameter and leaf length, melon transverse diameter and leaf width, and leaf length and leaf width. There is a very significant positive correlation between melon transverse diameter and leaf size, which can indirectly increase single melon weight by improving leaf size. There is a very significant negative correlation between internode length and melon cross diameter and single melon weight, indicating that the materials with shorter internode length can indirectly increase melon cross diameter and single melon weight. In the process of breeding and selection, when a character is improved, it can be improved indirectly by improving the character with high correlation, so as to achieve the purpose of variety improvement<sup>[22]</sup>.

The cluster analysis of 56 *Momordica charantia*

varieties showed that when the genetic distance was 16, these varieties could be divided into three categories, most of which were concentrated in group 1 and group 2, which accounted for 92.86% of the total germplasm. The similarity between the two groups was high, the difference in melon length and leaf size was relatively large, and there was little difference in other agronomic traits. Group 3 has only 4 materials, accounting for only 7.14% of the tested materials. The fruit of this group is short and wide, in the shape of a short stick, the weight of a single melon is relatively small, the growth potential of the plant is medium, the field resistance is strong, and the adaptability in Changsha is good. The above results show that there is little difference between the *Momordica charantia* germplasms used in this experiment, and the genetic basis is relatively narrow. The reason may be that these germplasms come from southern China, with small regional differences and similar materials in various units. Therefore, in order to improve the breeding level of *Momordica charantia* in Southern China, it is urgent to broaden the source of breeding materials and introduce new germplasms under different environmental conditions.

There are many *Momordica charantia* germplasm resources selected in this experiment (56), but only 7 agronomic traits were selected for investigation during the experiment, and there are many other traits to be investigated and studied. In particular, there is no specific investigation and Analysis on *Momordica charantia* yield. The main reason is that *Momordica charantia* is harvested many times in production, and the harvest time is about 4 months. It is difficult to make complete statistics on yield under the experimental conditions. At the same time, relevant studies have shown that the planting method<sup>[23]</sup>, soil fertility<sup>[24]</sup>, planting year<sup>[25]</sup> and other factors will affect the agronomic properties of the plant. In the next step, we should investigate the *Momordica charantia* resources under different conditions, further improve the genetic analysis of *Momordica charantia* resources, and lay a foundation for the evaluation and utilization of *Momordica charantia* resources.

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## Conflict of interest

The authors declare that they have no conflict of interest.

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