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Variation in Flower Color among Hybrids of Jeoktanshim *Hibiscus syriacus* L

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ABSTRACT

This study was performed to provide basic information of the development and breeding of new cultivars of *Hibiscus syriacus* L., which have more beautiful and diverse flowers. Morphological characteristics of the flowers and leaves, and genetic variation of the flowers color of two Jeoktanshim-line cultivars, Bulsae and Pyungsung, were crossed each other. The result of the cross between Bulsae and Pyungsung are as follows: Mean flower height and width were 5.35 cm and 7.69 cm, respectively. Mean length and width of petal were 5.43 cm and 3.80 cm respectively, and mean length and width of flower pistil were 4.67 cm and 0.44 cm, respectively. The flower color of all ten individuals was the color of the Jeoktanshim-line, and Pyungsung, and all flower type were I-c type.

Key words : Breeding, cultivar, flower morphology, *Hibiscus syriacus*, Jeoktanshim,

INTRODUCTION

It is known that *Hibiscus syriacus* L. has been bred from many cultivars by hybridization for a long time, now about 200 kinds of it grow in the world (Shim *et al.*, 1993; Shim, 1994). It is recognized as very valuable landscape plant which can make its flowers bloom for about 100 days in summer for which other plants do not bloom (Yu and Yeam 1987; Pictorial Record of *Hibiscus Syriacus* 1993; Harris and Harris, 1994).

For *Hibiscus syriacus* to secure its position as true national flower (Kang, 1986), it is required to switch from quantitative growth which we have pursued to qualitative growth, and to achieve this, we need to make systematic establishment in growth and breeding nature and investigate its characteristics by genealogy, flower morphology, and cultivars. Therefore, this study aims at providing basic data required for breeding and development of more beautiful and diversified cultivars of *Hibiscus syriacus* and also suggesting the possibility in breeding new cultivar of *Hibiscus syriacus* by general investigation of qualitative and quantitative characters with an object of crossbred through crossing between two Jeoktanshim-line cultivars, Bulsae and Pyungsung.

MATERIAL AND METHOD

Circumstances of breeding and characteristics of

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new cultivar

The Circumstances of breeding and the characters of cultivars by strain selected for general investigation of flower color and leaf characteristic in *Hibiscus syriacus* through crossing in this study are as follows.

a. Bulsae

This cultivar was named by Korea society of *Hibiscus syriacus* in 1990 after reselection of 33 individuals selected from Open - Pollinated Progeny in 1985 by seed and breeding 11 cultivars in cultivar preservation garden at forest tree breeding laboratory in Korea Forest Service (1991). The color of flower is purplish scarlet, and the size is +/- 10cm, with 65 petal index. And the flower type belongs to I-a, as a single-petalled flower. The petal tends to be long and becoming narrow without full blooming, so it does not be reversed. Sometimes, the basic number of petal is 6 with small inner petal in some cases. The number of blooming amounts is about 2.8 in average per joint and segment, however, fruiting rate is low as 7.7%.

b. PS80-1, Pyungsung

This cultivar is named and selected by Tachibana as crossing between *Hibiscus paramutabilis* and *Hibiscus syriacus* in Japan (Yim, 1988). The color of flower is purply scarlet; however, it has the most reddish color in *Hibiscus syriacus*. The type of flower belongs to I-c (60 petal index) as a single-petaled flower. The size of flower tends to be big as 10.2 cm, with seldom-appeared inner petal. The flower is splendid and large looking thick and rough, but it blooms widely and hard to be reversed. The number of blooming amounts in average per joint and segment are about 1.9, which is close to small leaf-flower, and the fruiting rate is around 9.4%.

Crossing between cultivars

In this crossing, we used objects from seeding bred by Reciprocal Cross with declared cultivar of Bulsae and Pyungsung in 1997 which are widely known as thick Jeoktanshim *Hibiscus syriacus* L. (Table 1).

Artificial crossing

For artificial crossing, we removed all the petals and stamina of a budding flower which would bloom the next day from July to August in 1997, and wrapped with crossing bag. Then, we took the bag off and put pollen on top of pistil then wrapped again with the crossing bag and tagged. After that, we removed the bag in 2 to 3 days, and cropped crossing seeds in autumn of that year then, sowed seed in 1998. The number of crossed flowers and the fruiting rate, and the number of seed and sprouting rate are as seen in Table 2. In this study, we investigated morphological character of

Table 1. Design of Jeoktanshim kind cross combination.

Cross combination		Abbreviation	Replication of tree (flower)
Jeoktanshim's hybridization	Bulsae × Pyungsung	BP	10 (30)

Table 2. Summary of artificial crossing results by cross combinations.

Cross combination	No. of flowers pollinated (Ea)	No. of capsule (Ea)	No. of seed (Ea)	No. of seed Germination (Ea)	Germination rate(%) (Ea)(Ea)	No. of Individual tree (Ea)	No. of Selection tree (Ea)
BP*	32	6	105	63	60.5	25	10

* Abbreviations of cross combinations referred to Table 1.

flower and generic changes in flower color by following methods with objects of good ones among crossing seeding obtained by sowing gathered seeds according to each crossing.

Investigation methods

We investigated Segregation Ratio of flower color by crossings and individuals of *Hibiscus syriacus* then separated its type based on flower type model classified by Yu and Yeam (1987) (Fig. 1). We measured and examined flower height, flower width, length of petal (LP), width of petal (WP). length of flower Pistil (LFP), width of flower pistil (WFP), red eye width (RW) and the development of red eye.

In addition, morphological characteristics of flowers were considered by classification as narrow type for less than 1.17, medium type from 1.17 to 1.42, and wide type for more than 1.42 by estimating petal index (PI, LP/WP) which is measured petal length to petal width. Also, we estimated flower index (FL, FH/FW) and classified as narrow type for less than 0.50, Medium type from 0.50 to 0.68, and wide type for more than 0.68 so as to investigate its morphological characteristics as well as Petal Index.

We then used spectrum color meter (JX-777, Color Tech. Sys. Corp., Japan) to measure the color of flower, the location of measured color was limited to upper middle and its periphery excluded of red eye and radical sector from flower leaves, and the mean value by calculating 3 times was used as standard. Also, we indicated flower color with L*a*b color order system which was standardized by Commission Internationale de l'Eclairage in 1976 and currently adopted as KS in Korea.

For every researched data, we analyzed basic statistical amount using SAS statistics package (Ver. 6.12), and conduct multiple verification of Duncan to consider if there is any significant difference between crossings, and then studied correlation on morphological characteristics in crossing groups by utilizing analysis of variance such as cluster analysis, and principal component analysis.

RESULT AND DISCUSSION

Morphological characteristics of flowers

The result from investigation and analysis of morphological characteristics of flowers on 10 individuals in crossing between Bulsae and Pyungsung is as seen in Table 3. Mean flower height and width were 5.35 cm and 7.69 cm, respectively. In flower height, no 8 and no. 10 were the highest as 6.70 cm and 6.57 cm each, no,1 and no.7 were the lowest as 4.77 cm and 4.50 cm, respectively.

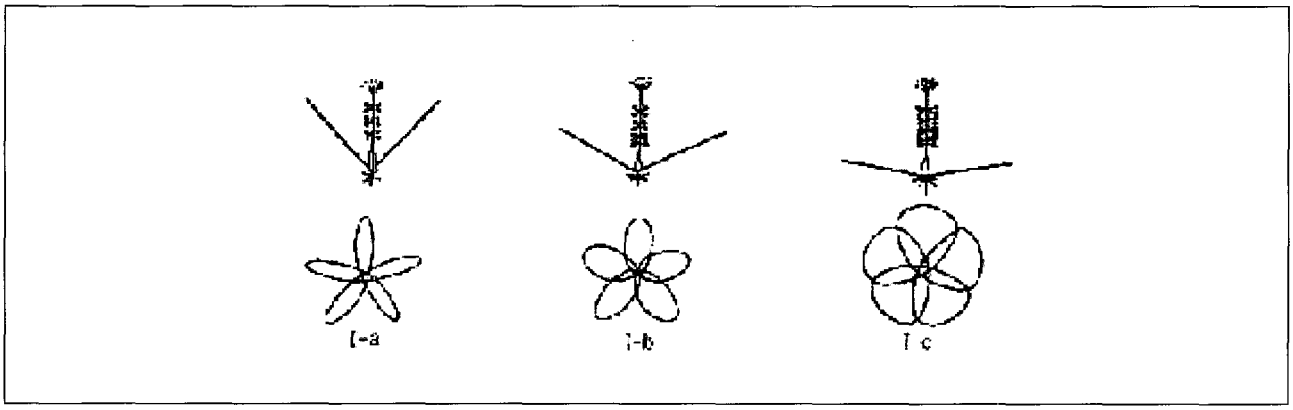

Fig. 1. Types of flower in *H. syriacus* L.

After calculating flower index with flower height to flower width rate to consider its morphological characteristics by crossings, mean flower type index was 0.70, and among 10 of them, no. 6 was the least as 0.61 to 0.68 which was less than mean index of flower type, in contrast, 4 individuals including no. 10 with 0.86 flower type index showed the range of 0.75 to 0.86 in flower type which was bigger than mean index. As the result of classification of flower type based on estimated flower type index, there was no individual shown as narrow type, and 6 in total including no. 1 were shown as wide type, telling flower height had much bigger changes than flower width in this crossing.

Mean length and width of petal were 5.43 cm and 3.80 cm respectively and there were no significant differences between individuals except no. 8 in the length of petal. Also, 6 individuals among ten were shorter in the length of petal which means this crossing shows short length of petal in general. On the other hand, In the length of petal, no. 8 was the longest as 7.30 cm as well as in the width of petal as 4.70 cm. No. 4, however, was the shortest in petal width as 3.17 cm.

After calculating Petal index with petal height to petal width rate to consider its morphological characteristics by crossings, mean petal type index was 1.44 and among 10 of them, no. 3 was the longest in petal length to width as 1.65. And No. 1, 2, 5, 6, and 7 individuals were analyzed to have smaller petal index than mean index as the range of 1.24 to 1.44. As the result of classification of petal type based on estimated petal type index, there was no individual shown as narrow type, and 6 individuals of 10 including no. 1 were shown as wide type.

The mean size of red eye was 1.49 cm, and 5 individuals including no.6 among 10 had the biggest as the range of 1.60~1.87 cm, No.2 had the smallest red eye as 1.10 cm. mean length and width of flower pistil were 4.67 cm and 0.44 cm, respectively, No. 3 and No.10 individuals were analyzed to have the longest and the widest pistil type as 5.27 cm and 0.43 cm in the length and 5.27 cm and 0.47 cm in the width respectively. In contrast, No.1, 2, and 4 individuals had the shortest length of pistil as the range of 3.93 to 4.07 cm. In pistil width character, 7 individuals were bigger

Table 3. Flower morphological characteristics of BP cross combination.

characters / No.	FH (cm)	FW (cm)	FI	LP (cm)	WP (cm)	PI	RW (cm)	DRL	LFP (cm)	WFP (cm)	Flower type	Petal type
BP-1	4.77c*	7.03bc	0.68b	5.13b	3.57bc	1.44abc	1.40abc**	1.67b	3.93c	0.43a	W	W
BP-2	4.90bc	7.07bc	0.69b`	4.93b	3.77abc	1.33bc	1.10c	1.33b	4.07c	0.43a	W	M
BP-3	5.20bc	8.63ab	0.61b	5.83b	3.53bc	1.65a	1.60ab	1.67b	5.27a	0.43a	M	W
BP-4	5.33bc	7.03bc	0.76ab	5.07b	3.17c	1.60a	1.67ab	1.67b	3.93c	0.47a	W	W
BP-5	5.20bc	8.27abc	0.63b	5.40b	3.87abc	1.42abc	1.60ab	2.00ab	4.77ab	0.47a	M	M
BP-6	6.10ab	8.23abc	0.75ab	5.70b	4.43ab	1.29bc	1.87a	3.00a	5.10ab	0.47a	W	M
BP-7	4.50c	6.97c	0.65b	4.93b	4.00abc	1.24c	1.30bc	2.33ab	4.47bc	0.40ab	M	M
BP-8	6.70a	8.90a	0.75ab	7.30a	4.70a	1.55ab	1.60ab	2.00ab	5.10ab	0.30b	W	W
BP-9	5.13bc	7.93abc	0.65b	5.30b	3.43bc	1.54ab	1.37bc	1.33b	5.07ab	0.40ab	M	W
BP-10	6.57a	7.63abc	0.86a	5.97b	4.13abc	1.45abc	1.43abc	1.67b	5.27a	0.47a	W	W
Mean	5.35	7.69	0.70	5.43	3.80	1.44	1.49	1.86	4.67	0.44		
SE	0.16	0.17	0.02	0.13	0.11	0.03	0.05	0.13	0.12	0.01		

* Different letters indicate Duncan's multiple range tests (Significant at $p<0.05$).

than mean width of pistil as 0.44 cm.

Flower Color characteristics

The mother trees of this crossing has purply scarlet color in their characteristics, the red color was the strongest in many cultivar of *Hibiscus syriacus* with large and splendid leaves, so it is said to be very valuable in cross breeding. As the result of crossing to utilize this advantage as much as possible, the flower color of all ten individuals was the color of the Jeoktanshim-line, and every flower type was classified as I-c type. Especially, No. 3 and 5 individuals showed 1 to 3 inner petals, from this fact it is considered that those individuals were affected by Bulsae which was their parent. After measuring flower color by individual with spectrum color meter, the flower color of all ten individuals was the color of the Jeoktanshim-line with 50 to 70 in lightness, which was a little bit darker than other crossings, so with this, we could see indirect color manifestation of Jeoktanshim-line.

Analysis of Principal components

The result from analysis of principal components on flower characteristics of crossing between Bulsae and Pyungsung and the contribution rate of each main component on the unique value and general changes are shown in Table 4.

As the result of analysis of its unique value obtained from principal main components analysis, the unique value of first main component was 4.49 which account for 45% in total, that of the second main component was 1.97 with 65%, and that of the third main component was 1.44 with 79% in total distribution. And, that of the fourth main component was 1.32 accounting for 92% which is very high in total distribution.

Table 5 is the result from analyzing unique value of each character on principal main components indicating correlation coefficients between each main component and the characteristics of flowers to estimate what characters does each main component has among those of 10 kinds of flowers.

As examining correlation from 1st principal component to 3rd principal component by Principal component analysis, first of all, in the 1st principal analysis, among characters of 10 flowers, only flower pistil width showed negative value while the other characteristics showed all positive value as the range of

Table 4. Eigenvalue and its contribution obtained from principal component analysis of flower morphological characteristics for BP combination.

Principal component	Eigenvalue	Difference	Proportion	Cumulative (%)
1	4.4871	2.5154	0.4487	44.87
2	1.9718	0.5365	0.1972	64.59
3	1.4353	0.1143	0.1435	78.94
4	1.3210	0.7148	0.1321	92.15
5	0.6061	0.4614	0.0606	98.21
6	0.1447	0.1130	0.0145	99.66
7	0.0318	0.0296	0.0032	99.98
8	0.0022	0.0021	0.0002	100.00
9	0.0001	0.0001	0..0000	100.00
10	0.0000	-	0.0000	100.00

Table 5. Eigenvector associating to eigenvalue obtained from principal component.

Flower characters	Prin 1	Prin 2	Prin 3
FH	0.4214	0.0411	0.0640
FW	0.3926	-0.2407	0.0795
FI	0.1946	0.2466	0.0813
LP	0.4382	-0.1842	-0.1475
WP	0.3644	0.2954	-0.3875
PI	0.0969	-0.5991	0.3609
RW	0.2892	0.1302	0.5501
DRL	0.2197	0.5278	0.0983
LFP	0.3647	-0.1082	0.0634
WFP	-0.1771	0.3037	0.0638

-0.1771 to 0.4382.

On the other hand, petal length was the highest in correlation followed by flower height, pistil length, and petal width, which means that those characters contributed more to analyze flower characteristics in crossing between Bulsae and Pyungsung with coefficient of 0.3644 to 0.4382. The 2nd principal component showed high correlation as development range of red eye line and characteristic in pistil width showed 0.5278 and 0.3037 respectively, followed by petal width and flower type index as 0.2954 and 0.2466 respectively. In the other hand, In 3rd principal component, the characteristics in red eye and petal index were the highest in correlation as 0.5501 and 0.3609 respectively, while other characteristics were relatively low in correlation as -0.3875 to 0.0983. After considering all those results the flower characteristic in crossing between Bulsae and Pyungsung had big contribution of many characters including petal length, flower height, flower width, pistil length, petal width, etc.

The result of presenting principal components from 10 individuals in crossing between Bulsae and Pyungsung is shown in Table 6. The result from arranging relations between the 1st and the 2nd principal components and the 1st and the 3rd principal components in 2 dimensional space are as seen in Fig. 2 and 3.

As arranging values from the 1st, the 2nd and the 3rd

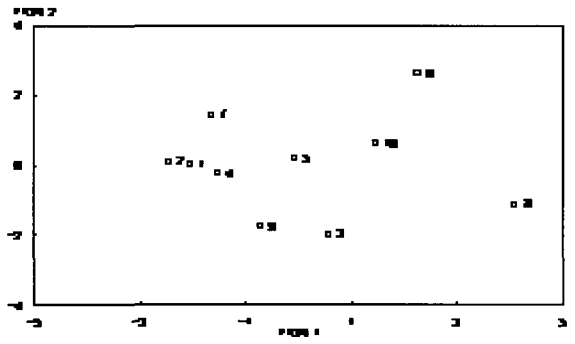

Fig. 2. Scatter diagram of 10 seedlings in BP combination based on principal component 1 and 2.

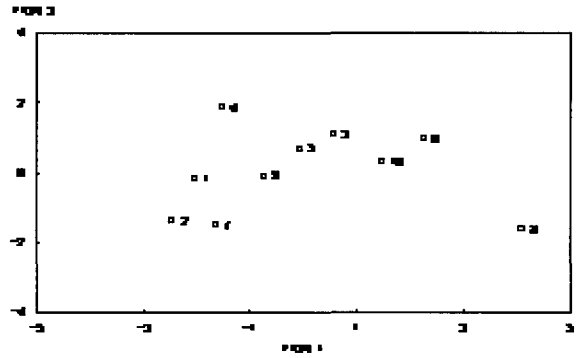

Fig. 3. Scatter diagram of 10 seedlings in BP combination based on principal component 1 and 3.

Table 6. Eigenvector associating to eigenvalue obtained from principal component for 10 flower morphological characteristics by 10 seedlings in BP cross combination.

No. \ Principal component	Prin 1	Prin 2	Prin 3
BP-1	-2.0415	0.0427	-0.1886
BP-2	-2.4492	0.1039	-1.3986
BP-3	0.5827	-1.9655	1.0544
BP-4	-1.5347	-0.2197	1.8517
BP-5	-0.0580	0.2027	0.6923
BP-6	2.2672	2.6506	0.9375
BP-7	-1.6451	1.4498	-1.5119
BP-8	4.1141	-1.1231	-1.6245
BP-9	-0.7257	-1.7413	-0.1120
BP-10	1.4902	0.5999	0.2998

principal components obtained by individuals in 2 dimensional spaces, 10 individuals were largely divided into 2 groups. On the basis of 0.5 of the 1st principal component, 4 individuals including no. 3, 6, 8, and 10 were on the right, while 6 individuals including No.1 were on the left. In particular, among individuals on the right, No.1 was significantly different from other individuals as showing 2.2672 and 2.6506 for the 1st and the 2nd principal components respectively, also No.8 had distinct difference from others with 4.1141 for the 1st principal component.

Cluster Analysis

The result from cluster analysis by Single linkage method based on 10 characteristics of flower investigated of 10 individuals in crossing between Bulsae and Pyungsung is as seen in Fig. 4.

As the result of cluster analysis, on the basis of 1.47, the distant level, they were largely divided into 2 groups. There are No. 1, 2, 4, and 7 in group 1, while 6 individuals including no. 3as well as No. 6 and No. 8 which we have previously examined in Principal component analysis are in group 2.

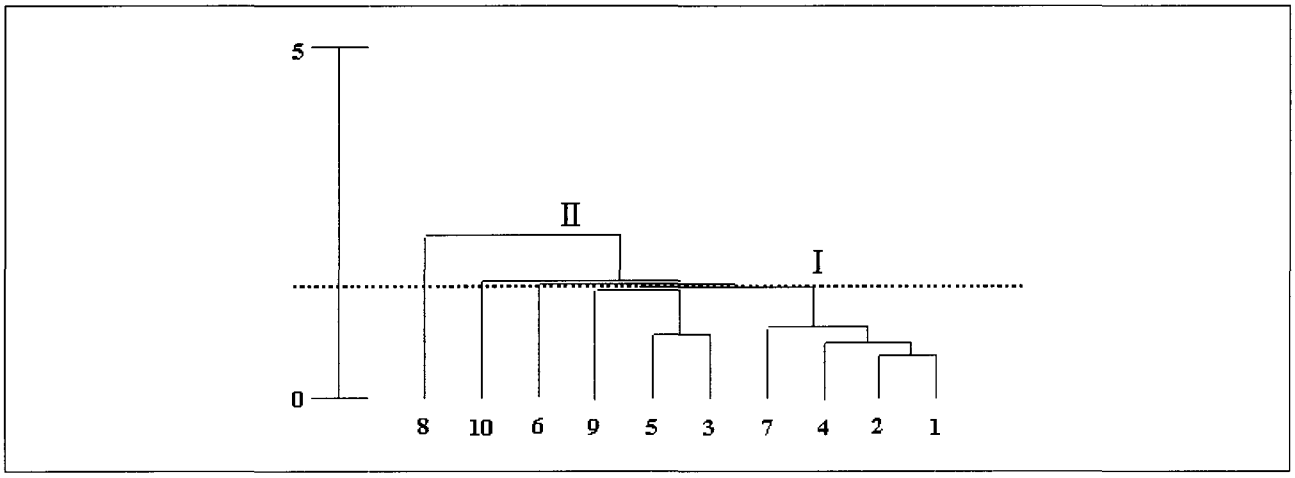

Fig. 4. Cluster dendrogram of 10 seedlings in BP combination based on 10 flower morphological characteristics.

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