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Phenotypic performance of six interspecific carnation genotypes obtained from hybridization of *Dianthus caryophyllus* “Liberty” x *Dianthus chinensis* “SK 11-1”

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Phenotypic performance of six interspecific carnation genotypes obtained from hybridization of *Dianthus caryophyllus* “Liberty” x *Dianthus chinensis* “SK 11-1”

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Abstract. Interspecific hybridization can be an effective strategy in ornamental plant breeding. Interspecific hybridization in the genus *Dianthus* is relatively easy to do. Therefore, the introduction of good character carriers from other *Dianthus* species into carnations will give prospect. The objective of this study was to produce new type interspecific carnation genotypes. The experiment was conducted at the Indonesian Ornamental Crops Research Institute experiment station in Cipanas – Cianjur, from November 2014 – July 2015. The experiment was conducted with an experimental method using randomized block design (RBD). The treatment consisted of six genotypes of interspecific carnation, female parent “Liberty” and male parent “SK 11-1” with four replications. The result showed that the flower color of the purplish red and red interspecific genotypes was different from the female parent yellow-flowered. The character of flower type, petal edges and leaf texture of the six progeny genotypes resemble male parent, while the flower shape character of the six interspecific carnation genotypes resemble female parent. Genotype D1 had a combination of the character of plant height, stem diameter and diameter of the appropriate flower as carnations of cut flowers, while genotype D5 had the character of plant height, the number of flowers blooming at one time, the diameter of the flower, the freshness of the flower suitable as garden carnations or pots.

1. Introduction

The genus *Dianthus* belongs to the family Caryophyllaceae (Order Caryophyllales). The Caryophyllaceae comprises over 80 genera and 3000 species [1]. Over 300 species of *Dianthus* are described, and they are commonly known as carnations or pinks [2]. The common name ‘carnation’ is used to refer to *D. caryophyllus* and its cultivars. It also applies to hybrids between *D. caryophyllus* and other species of *Dianthus* [3]. Carnation is an important flower crop having great commercial value as a cut flower due to its excellent keeping quality, wide array of colour and forms [4].

In this modern era, with the increasing demand, development of Carnation cultivars with more desirable floral characteristics and higher productivity are found to be very important [4]. Interspecific hybridization can be an effective strategy in ornamental plant breeding [5]. Interspecific hybridization in the genus *Dianthus* is relatively easy to do. Therefore, the introduction of good character carriers from other *Dianthus* species into carnations will give prospect [6]. Interspecific hybridization between carnation and other species of *Dianthus* with very different characters are expected to produce new



types hybrid with color characters and new color patterns or shorter life cycles [7]. Hybrids between *D. caryophyllus* and *D. japonicus* have expressed traits that may prove useful in breeding programmes specific for the Japanese climate [8]. Crosses between carnations and other *Dianthus* species to generate progeny with desirable floral characteristics such as colour patterns, bud number, flower arrangement; and improving year-round flowering (for northern Europe) have also been successful [9]. The purpose of this experiment was to produce a new type of carnation hybrid as a potted or garden ornamental plant. While the hypothesis is that at least one pot or garden type of hybrid interspecific carnation is obtained.

2. Materials and Methods

2.1. Plant materials

Six interspecific carnation hybrids obtained from crossing of *D. caryophyllus* 'Liberty' x *D. chinensis* 'SK 11-1' in 2013 in Indonesian Ornamental Crops Research Institute (IOCRI) were used in this study excluding their parents (Figure 1). The six clones were maintained by vegetative propagation. During the experimental period, all the plants were cultivated in polybag in IOCRI's screen house 1100 m asl. The experiment was conducted with an experimental method using randomized block design (RBD) with four replications from November 2014 – July 2015. The crossing method : before pollination, flower of the female parent is castrated by cutting the petals and stamens and then covered with oil paper to avoid pollination from unwanted pollen. Pollination is carried out in the morning against female flowers that already have receptive pistils, which are marked by the styles starting to curve outward and the papillae appeared fuzzy. Pollination is done by smearing the pistil with mature pollen. Hybridization is succesfull if two weeks after the crossing, the ovary are enlarged. Fruit from the cross is harvested about four weeks after pollination.



Figure 1. (a) Seed pod parent (*Dianthus caryophyllus* 'Liberty') dan (b) Pollen parent (*Dianthus chinensis* 'SK 11-1').

2.2. Characterization

Five plants from each treatment were selected randomly for recording observations on plant height (cm), stem diameter (cm), number of branches, leaf length (cm), leaf width (cm), leaf tip shape, flowering initiation (DAP), flowering time (DAP), flower diameter (cm), flower freshness time (day), number of flowers blooms in one time, stem color, leaf color, petal color, pistil and anther color, leaf texture (plain or hairy), flower type (standard or spray), flower shape (double or single), petal edge shape (flat or jagged), petal color number and the scent of flowers. The observation was conducted when the plant started flowering. Size of the flowers was observed in fully bloom. Stem, leaf and flower color was standardized using the Royal Horticultural Society Color Chart (Figure 2).



Figure 2. Observation of the color of (a) stems, (b) leaves and (c) flowers using the Royal Horticultural Society Color Chart.

2.3. Data analysis

The data were subjected to analysis of variance for Randomized Block Design.

3. Results and Discussion

3.1. Results

The D population (*D. caryophyllus* ‘Liberty’ x *D. chinensis* ‘SK 11-1’) consisted six genotypes which had a variety of stem colors which did not resemble the two parent’s stem color. D4 genotype had a stem with two colors, green and purple gray, very different from the two parents. The leaf color of D genotype was relatively not different from the leaf color of both parents, namely green group. The leaf texture of the six D genotypes resembled the leaf texture of male parent, hairy. All of plants had pointed shape leaf tip (Table 1).

The pistil color of sixth genotype D red purplish, while the anther colors vary. The anther color of genotype D1 resembled with male parent, black group. The D6 genotype had anther color like its female parents, white group. D3 and D5 genotypes had grey anther color, while D2 genotype had no anther (Table 2).

Table 1. Stem and leaf character of D population (“Liberty” x SK11_1).

Genotype	Stem color	Leaf color	Leaf texture	Leaf tip shape
Liberty	GG 139B	GG 138A	plain	pointed
SK11_1	GG 137A	GG 138A	hairy	pointed
D1	GG 138A	GG 137A	hairy	pointed
D2	GG 138A	GG 137A	hairy	pointed
D3	GG 138A	GG 137A	hairy	pointed
D4	GGG 197A GPG 183A	GG 137A	hairy	pointed
D5	GG 138A	GG 137B	hairy	pointed
D6	YGG 147A	GG 137B	hairy	pointed

GG = Green Group, YGG = Yellow Green Group, GGG = Greyed Green Group, GPG = Greyed Purple Group

D population which was the result of hybridization between parents of yellow female with purplish red male producing five interspecific hybrids with purplish red flowers and one hybrid with red flower group. Flower color of female parent not revealed.

Table 2. Flower character of D population.

Genotype	Petal color	Pistil color	Anther color	Petal color number	Flower type	Flower shape	Petal edge shape	Scent
Liberty	YG 4C	WG 155C	WG 155A	1	standard	double	Rather flat	exist
SK11_1	RPG N 67A + RPG 61B	RPG 70A + WG 155C	BG 202B	2	spray	single	jagged	exist
D1	RPG N 57A	RPG 59A	BG 202B	1	spray	double	jagged	exist
D2	RPG N 66B	RPG 71A	-	1	spray	double	jagged	exist
D3	RPG 58A	RPG 59A	GG 201A	1	spray	double	jagged	exist
D4	RPG 58A	RPG 59B	GGG 198D	1	spray	double	jagged	exist
D5	RPG 66B	RPG 71A	GG 201B	1	spray	double	jagged	exist
D6	RG 55B	RPG 67A	WG 155A	1	spray	double	jagged	exist

RG = Red Group, YG = Yellow Group, RPG = Red Purple Group, GG = Grey Group, WG = White Group, GGG = Greyed Green Group, BG = Black Group

The plant height range of genotype D was between 36.20 cm (D6) – 78.05 cm (D1). The height of D1 genotype exceeds the height of the female parent, namely ‘Liberty’ with 73.33 cm height. Genotype D6 height was almost as high as the male parent, namely SK 11-1 of 31.73 cm. Although population D consisted of only six genotypes, the plant height characters were very diverse. The stem diameter varied from 0.25 cm until 0.41 cm. The branches number of population D ranged from 2.60 – 14.69. Genotype D6 had long (9.01 cm) and wide leaves (1.51 cm), while the genotype D3 had long (10.18 cm) and narrow leaves (1.21 cm) (Table 3).

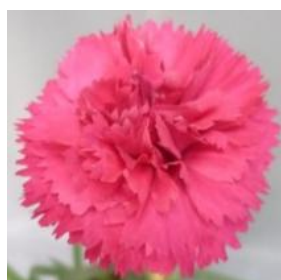
**Figure 3.** Progeny D1.**Figure 4.** Progeny D2.**Figure 5.** Progeny D3.**Figure 6.** Progeny D4.**Figure 7.** Progeny D5.**Figure 8.** Progeny D6.

Table 3. Difference of plant height, stem diameter, branches number, leaf length and leaf length Leaf width characters on six D genotypes.

No.	Genotype	Character									
		PH		SDm		NB		LL		LW	
1.	D1	78,05	a	0,41	a	14,69	a	10,15	a	1,18	c
2.	D2	53,61	c	0,25	d	3,80	c	6,29	d	0,74	d
3.	D3	76,16	a	0,37	ab	2,60	d	10,18	a	1,21	c
4.	D4	70,98	b	0,33	c	4,95	c	7,97	c	1,31	b
5.	D5	49,81	c	0,26	d	4,02	c	6,69	d	1,19	c
6.	D6	36,20	d	0,31	bc	9,71	b	9,01	b	1,51	a

* Different letters indicate significant differences among treatments as determined by Duncan multiple range test 5%

PH = plant height, SDm = stem diameter, NB = branches number, LL = leaf length, LW = leaf width

Genotype D5 is the fastest in flowering, ie 48.10 days after planting, while the longest D1 genotype was 107.95 days after planting. Flowering initiation character along with the character of flowering time. Flowers from buds to blooms taken around 17 – 22 days (Table 4).

Genotype D5 had smallest flower diameter, ie 3.85 cm, while genotype D1 had the largest one, that was 5.10 cm. Flower of genotype D2 had the longest flower freshness, ie 11.68 days. Genotype D6 flower at 7.65 days had withered. The D5 genotype had the most blooms in one time followed by the D6 genotype. Genotype D2 had the least number of blooms in one time, which was 2.09 flowers. The flower of genotype D2 had a combination characters : large diameter, longest freshness and the least amount of blossom in one time, while the genotype D5 had a fast flower initiation/bloom, small diameter and many flowers bloom in one time (Table 4).

The highest petal number was the D2 genotype, ie 45.15 petals, while the D6 genotype had the smallest number of petal, ie 11.35 petals and not different from the D5 genotype. The highest anther number of D6 genotype was 7.52, followed by D1 and D5 genotype, 5.80 and 5.79 respectively. The pistil number of four D genotype, D1, D3, D4 and D5 was two, while D2 genotype had the most pistil number, totaling 2.5 pieces (Table 5).

Table 4. Difference of flowering initiation, flowering time, flower diameter, flower freshness Time and flower number in one time on six D genotypes.

No.	Genotype	Character									
		FI		FT		FD		FFT		FNOT	
1.	D1	107,95	a	127,28	a	5,10	a	7,91	bc	2,76	c
2.	D2	71,54	c	93,57	c	4,79	b	11,68	a	2,09	d
3.	D3	81,63	b	100,89	b	4,44	b	9,45	b	3,12	c
4.	D4	75,36	c	93,91	c	4,91	b	9,44	b	3,61	c
5.	D5	48,10	d	67,20	d	3,85	d	8,45	bc	6,90	a
6.	D6	69,29	c	86,22	c	4,21	c	7,65	c	5,14	b

*Different letters indicate significant differences among treatments as determined by Duncan multiple range test 5%

FI = flowering Initiation, FT = flowering time, FD = flower diameter, FFT = flower freshness time, FNOT = flowers number in one time

Table 5. Difference of petal number, anther number and pistil number on six D genotypes.

No.	Genotype	Character					
		Petal number		Anther number		Pistil number	
1.	D1	21,13	c	5,80	b	2,00	c
2.	D2	45,15	a	0,00	d	2,50	a
3.	D3	19,98	d	4,31	c	2,00	c
4.	D4	27,26	b	4,78	bc	2,00	c
5.	D5	12,26	e	5,79	b	2,00	c
6.	D6	11,35	e	7,52	a	2,43	b

*Different letters indicate significant differences among treatments as determined by Duncan multiple range test 5%

3.2. Discussion

Significant variation was noticed for plant height, stem diameter, branches number, flowering time, flower diameter, flower freshness time and flowers number in one time. *D. caryophyllus* is known to be having good cut flower values whereas *D. chinensis* is found to be advantageous for its easy cultivation as well as higher yield [3]. D1 – D6, the interspecific hybrids were found to have inherited the flower shape of *D. caryophyllus* and leaf texture, flower type and petal edge shape of *D. chinensis*.

There are several possible explanations for the characteristic of the progeny in crosses between *D. caryophyllus* and *D. chinensis*: [1] interactions between diverged sequences of the parental genomes; [2] global genomic rearrangements of the hybrid; and [3] widespread epigenetic reprogramming during development of floral organs [10].

F1 appearance which is different from both parents makes interspecific F1 can be used as a new type of ornamental plant. This interspecific derivative appearance is a characteristic of interspecific hybridization [11] and this also occurs in chrysanthemums [12] and Kalanchoe [13]. This can be explained by the pattern of inheritance based on polygenic control with additive effects [11].

The results of this study are in line with the Onozaki *et al.* results which showed that 111 progenies resulting from a cross between yellow flowering carnations and red or pink flower carnations, red or pink flowering with a ratio of 1: 1. This indicates that the yellow color is controlled by recessive alleles [14].

Leaf texture characters of all hybrids that follow the texture characteristics of the male parent show that this character is not inherited cytoplasmically, so the character control genes are at the nucleus. Male parent and F1 clones that have the texture character of hairy leaves are not attacked by orange aphid, whereas female parent with plain leaves are attacked by these insect. The hairy leaves as one of the physical / morphological properties of cotton plants had a close relationship with resistance to *Amrasca biguttula*. Hairy cotton varieties tend to be more resistant to these pest attacks compared to non-hairy varieties ([15].

D5 genotype only 48.10 days after planting has initiated to flower. The flowering velocity is related to the length of photosynthate accumulation needed to change physiological status from the vegetative phase to the generative phase. Flowering induction requires the availability of considerable energy, and each genotype has the ability to accumulate different photosynthates which are influenced by genetic factors [16].

The old character of flower freshness is one character that determines the economic value of the ornamental plant. Variations in the duration of flower freshness between genotypes associated with variations in carbohydrate accumulation since the genotype is able to produce excess leaves [17]. Leaves are an important functional unit for photosynthesis which has a major effect on growth and yield of flowers for some plants. Excess leaves with high chlorophyll content increase photosynthesis and carbohydrates. Carbohydrates are a source of energy for growing flower pots, blooming flowers

and flower freshness resistance [4]. The flower color character is very important. In ornamental plant commodities, the color of flowers is a major contributor to the economic value of flowers [18].

The variability of character is very important, this will facilitate the implementation of the selection. The plant height of D1 genotype like female elders can be used as cut ornamental flowers, while the shorter ones, such as the D5 genotype can be used as pots or garden-type ornamental plants. The combination of the character of the plant height, stem diameter and the number of branches that are proportional can form the performance of the plant to be compact.

4. Conclusion

Six interspecific carnation hybrids are new type of carnations. The character of flower type, petal edges and leaf texture of the interspecific carnation hybrids resemble male parent, while the flower shape character resemble female parent. Genotype D1 suitable as a cut flower carnation, while genotype D5 as a garden carnation.

5. References

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