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INHERITANCE OF SOME OF THE QUALITATIVE CHARACTERS OF GARDEN STOCK, *MATTHIOLA INCANA* (L. R. Br.)

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Mode of inheritance of the qualitative characters : growth patttern (branching vs non-branching), foliage colour (green vs grey), foliage shape (normal vs curly) and nature of flowers (single vs double) and flower colour were studied in case of garden stock. The branching habit has been found to be monogenic character, branching being dominant over non-branching. The foliage colour is a multigenic character. The foliage shape was closely linked with foliage colour. All the green foliage plants were of normal leaf shape and those with grey foliage were curly.

In some of the progenies single vs double flowering character was inherited in a normal Mendelian fashion, the singleness being dominant to doubleness. The other progenies belonging to 'eversporting' race in which a gene for singleness is closely linked with a pollen lethal 'l' so that all the male gametes with S^1 genes were non-functional, and some of the female gametes with S^1 genotypes were also rendered functioneless. In those progenies the number of doubles exceeded the singles.

The orchid purple flower colour proved dominant to all the other colours. The campanula violet colour was dominant to persian rose and white, while persian rose was dominant to white flower colour. which was recessive to all other colours.

INTRODUCTION

Stock, *Matthiola incana* (L.) R. Br. is a magnificient flowering plant, grown with profound love, in almost all the gardens. This plant has two distinctive forms: the single flowering and the double flowering. The growers of stock, both florists and amateurs, are interested exclusively in double form, because 'singles' are of little or no value as cut flowers while the 'doubles' are more attractive and bloom over a longer period.

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The seed crop of stock is also of considerable importance, as this plant is unique in that double form is devoid of any reproductive organs, anthers or pistils; and produces no seed at all.

The present studies were under-taken in order to determine the genetic nature of certain characteristics.

REVIEW OF LITERATURE

Allen (1924) investigated that inheritance of singleness and doubleness in the pure breeding race was strictly mendelian, while in an other strain the singles were always eversproting and on selfing gave singles and doubles in approximately equal numbers. Emswellar *et al* (1937) stated that in the eversporting race single was actually a balanced lethal and the doubleness was associated with a pollen lethal. The gene for the singleness was linked to the pollen lethal.

Barber (1954) revealed that there were two types of stock plants, one type gave single and double flowers in the ratio of 3:1, respectiyely, while, other type gave roughly equal numbers of double and single flowers.

Johnson and Barnhart (1955) found that eversporting plants produced about 54 percent of doubles because some of the eggs carrying the lethal allell (l) did not funotion, therefore, the proportion of doubles was shout 54 percent rather than the expected 5 percent. They obtained clear evidence to show that l-occasionally became seperated from S by crossing over.

According to Crane and Lawrence (1956) the experiments of many workers have revealed that the genes C and R were both necessary for the production of anthocyanin in the flower. B converted red anthocyanin colour in to blue. V caused the difference between pure V and Impure v colour. They further stated that the dilute colours rose, and pale were dominant, respectively, to the deep colours carmine, marine, purple and terracotta. On the other hand certain deep one like rose was dominant to pale lilac. They also stated that the hoariness of the foliage was governed by three gene pairs Cc. Rr and Kk and three multiple allelomorphs H,H. and h. Any combination C,R,K and H or H_1 was hoary all the others being glabrous.

MATERIALS AND METHODS

Seed of two garden stock cultivars namely '7 weeks trisomic' and 'Giant Imperial' obtained from U.S.A. (Burpee) were sown at Lyallpur in 1966. Both of these were early blooming, the former was dwarf and earlier than later. Since then the crop was sown every year and seed of segregating plants were collected seperately and resown next year. During this course as many as twelve strains segregated. Selected plants from these strains, the characters of which are shown in table 1 were used for selfing and making various crosses.

TABLE 1. *Characteristics of different plants used for selfing and making various crosses.*

Type No.	Plant size	Flower colour	Growth habit	Foliage colour	Folige shape
7101	dwarf	campanula violet	branching	green	normal
7102	dwarf	orchid purple	branching	green	normal
7103	dwarf	persian rose	branching	green	normal
7104	tall	orchid purple	non-branching	grey	curly
7105	tall	persian rose	non–branching	grey	curly
7106	tall	white	non–branching	grey	normal
7107	tall	persian rose	non–branching	green	normal
7108	tall	white	non–branching	green	normal
7109	tall	campanula violet	nod–branching	green	normal

The crosses were made between the plants with different growth and flower characters in spring, 1972.

Data were recorded on growth habit, foliage colour, foliage shape, number of single, double and non–flowering plants and the flower colour. The inheritance ratio were checked by Chi square test.

EXPERIMENTAL RESULTS

Growth Characters :

i) Growth habit :

The segregation data on the growth of plants in the populations of

35 different progenies are given in table 2. The data pertaining to all the crosses, with both parents having branching growth habit have been pooled together, similarly the data in respect of all crosses involving branching x non–branching parents and vice versa and non–branching x non-branching parents have been considered.

a) Branching x branching : All the descendents of the ten crosses : 72.8, 72.9, 72.20, 72.24, 72.25, 72.26, 72.S.73, 72.S.74, 72.S.76 and 72.S.78 numbering 16, 9, 19, 17, 6, 8, 6, 22, 10 and 11 plants, respectively, possessed branching character.

Branching x non-branching : Progenies , 72.1, 72.11, 72.13, 72.22, and 72.23 which consisted of 7, 19, 16, 13 and 9 plants, respectively, indidually showed 1:1 ratio of branching and non-branching plants. With the application of Chi squre test it was found that there was no difference between the observed and the expected values.

c) Non-branching x branching : A segregation of 1 branching : 1 non-branching plants were observed in the populations of four progenies : 72.4, 72.15, 72.16, and 72.23 with 14, 16, 14 and 18 plants, respectively. According to Chi square test there was no difference between the observed and the expected values.

d) Non-branching x non-branching : All the off-springs of the thirteen progenies : 72.5, 72.6, 72.7, 72.10, 72.14, 72.17, 72.18, 72.19, 72.20, 72.S.75, 72.S.77, 72.S.79 and 72.S.80 consisting of 6,8,11, 10,13,8,12,5,3,4,9,34, and 39 plants, respectively, possessed a non-branching habit of growth.

ii) Foliage colour :

The pertinent data in respect of green and grey foliage colour as observed in all the 35 progenies are presented in table 2. The data on the progenies from green x green, green x grey and reciprocal and grey x grey parents have baen pooled together, respectively.

a) Green x green : It has been observed that all the parents of sixteen progenies : 72.4, 72.8, 72.9, 72.15, 72.16, 72.21, 72.22, 72.24, 72.25, 72.26, 72.27, 72.S.73, 72.S.74, 72.S.76 72.S.78 and 72.S.80 consisting of 14, 16, 9, 16, 14, 19, 13, 17, 6, 8, 18, 6, 22, 10, 11 and 39 plants, respectively, had normal green foliage,

b) Green x grey : Six progenies : 72.1, 72.3, 71.5, 72.13, 72.14 and 72.23 with 7, 13, 6, 16, 13, 9 plants, respectively, individually showed approximately 3:1 ratio of green: grey colour of foliage. Three progensie 72.2, 72.11 and 72.12 with 12,19 and 14 plants, respectively, gave approximately 1:1 ratio of green: grey leaf colour. Chi square test showed that there was no difference between the observed and the expected values.

c) Grey x green : The progeny no. 72.18 with 12 plants showed, approximately. 1:3 ratio of green : grey leaf colour and according to Chi square these observed values were similar to the expected values.

d) Grey x grey : All the dscendents of nine progenies : 72.6, 72.7, 72.10, 72.17, 72.19, 72.20, 72.S.75, 72.S.77 and 72.S.79 with 8, 11, 10, 8, 5, 3, 4, 9 and 34 plants, respectively, exhibited grey colour of foliage.

iii) Foliage shape :

The data on the following characters viz. normal and curly shaped leaves in all the 35 progenies are given in table 2. The results of the progenies with similar parents (normal and curly) are described catagory-wise.

a) Normal x normal : It has been observed that all the plants of sixteen progenies : 72.4, 72.8, 72.9, 72.15, 72.16, 72.22, 72.24, 72.25. 72.26, 72.27, 72.S.73, 72.S.74, 72.S.76, 72 S.78 and 72.S.80 consisting of 14, 16, 9, 16, 14, 19, 13, 17, 6, 8, 18, 6, 23, 10, 11, and 39 plants, respectively, produced leaves of normal shape.

b) Normal x curly : The populations beloing to six progenies : 72.1, 72.3, 72.5, 72.13, 72.14, and 72.23 with 7, 13, 6, 16, 13 and 9 plants, respectively, individually showed approximately 3:1 ratio of plants with normal and curly leaves, while three progenies : 72. 2, 72.11 and 72.12 with 12, 19 and 14 plants, respectively gave approximatcly 1:1 ratio of normal and curly foliage plants. According to Chi square test the observed values were similar to that of expected values in each case.

c) Curly x normal : Progeny no 72.18 consisting of 12 plants showed approximately 1:3 ratio of normal leaf shape and according to Chi square test the observed value was similar to the expected one.

d) Curl x curly : All the off- springs of the nine progenies : 72.6, 72.7, 72.10, 72.17, 72.10, 72.20, 72.S.75, 72.S,77 and 72.S.79 with 8, 11, 10, 8, 5, 3, 4, 9 and 34 plants, respectively, possessed leaves of curly shape.

TABLE 2. *Summarized data on various growth characters of the progenies of 35 crosses:*

Progeny No.	Popu lations	Bran- ching	Non Bran- ching	Normal leaf	Curly leaf	Green leaf	Grey leaf
72.1	7	4	3	6	1	6	1
72.2	12	—	12	4	8	4	8
72.3	13	9	4	9	4	9	4
72.4	14	9	5	14	—	14	—
72.5	6	—	6	—	6	—	6
72.6	8	—	8	—	8	—	8
72.7	11	—	11	—	11	—	11
72.8	16	16	—	16	—	16	—
72.9	9	9	—	9	—	9	—
72.10	10	—	10	—	10	—	10
72.11	19	11	8	11	8	11	8
72.12	14	9	5	8	6	8	6
72.13	16	11	5	11	5	11	5
72.14	13	—	13	9	4	9	4
72.15	16	12	4	16	—	16	—
72.16	14	9	5	14	—	14	—
72.17	8	—	8	—	8	—	8
72.18	12	—	10	2	10	2	10
72.19	5	—	5	—	5	—	5
72.20	3	—	3	—	3	—	3
72.21	19	19	—	19	—	19	
72.22	13	6	7	13	—	13	—
72.23	9	6	3	6	3	6	3
72.24	17	17	—	17	—	17	—
72.25	6	6	—	6	—	6	—
72.26	8	8	—	8	—	8	—
72.27	18	12	6	18	—	18	—
72.S.73	6	6	—	6	—	6	—
72.S.74	22	22	—	22	—	22	—
72.S.75	4	—	4	3	4	3	4
72.S.76	10	10	—	10	—	10	—
72.S.77	9	—	9	—	9	—	9
72.S.78	11	11	—	11	—	11	—
72.S.79	34	—	34	15	19	15	19
72.S.80	39	—	39	39	—	39	—

Flower Characters

i) Double, single and non-flowering plants : The pertinent data of all the 35 progenies are set in table 3. All the plants of nine progenies : 72.1 72.2, 72.3, 72.4, 72.5, 72.6. 72.7, 72.S.73, and 72.S.75 consisting of 7, 12, 13, 14, 6, 8, 11. 6, and 4 plants, respectively, produced single flowers. In a selfed progeny number 72.S.80 out of 39 plants 20 produced single flowers while rest of plants did not produce any flower.

Twelve progenies : 72. 8, 72.9, 72.10, 72.11, 72.12, 72 13, 72.15, 72.16, 72.17, 72.18, 72.19 and 72.S.78 which consisted of 16, 9, 10, 19, 14, 16, 16, 14, 8, 12, 5, and 11 plants, respectively, individually, showed approximately a ratio of 3:1 (single : double flowers).

Two progenies : 72.14 and 72.S.79 with 13 and 34 plants, respectively, showed a 3:1 ratio of single : double flowers. One plant in the progeny of cross 72.14 and four from 72.S.79 did not flower. The ratio was tested with Chi square test and it was found that the observed values were equal to the expected values.

1:1 segregation ratio of single to double flowering plants appeared in the progenies of five crosses : 72.21, 72.22. 72.26, 72.27, and 72.S.77 with populations of 19, 13, 8, 18, and 9 plants, respectively. This ratio corresponded with the expected ratio according to Chi square test.

About 80 per cent or more double flowering plants appeared in the populations of five progenies : 72.23, 72.24, 72,25, 72.S.74 and 72.S.76 which consisted of 9, 17, 6, 10, and 22 plants, respectively and it was found to be according to the expectations while using Chi square test.

ii) Flower colour : The data regarding the flower colour in the different progenies are presented in table 3. The flower colour were matched with the Horticulture colour charts and only four colours viz. Orchid purple (31), Campanula violet (37), Persian rose (628/2) and white were distinguished. The segregation ratios as mentioned for each cross hereunder were tested with Chi square test and found to correspond to the expected ratios.

a) Orchid purple x orchid purple : A selfed progeny no. 72.S.77 from an orchid purple flowering plant consisted of nine plants. All of them produced orchid purple flowers.

b) Orchid purple x campanula violet : The progenies : 72.9, 72.24, and 72.26 from orchid purple x campanula violet crosses consisted of 9, 17 and 8 plants, respectively. The two colours segregated in the ratio of 3:1 (orchid purple : campanula violet), One progeny no. 72.16 with a population of 14 plants showed a ratio of 8:1.

c) Orchid purple x persian rose : Progeny 72.6 with a population of 8 plants gave a 3:1 ratio of orchid purple x persian rose flowering plants while progeny no. 72.27 with 18 plants exhibted a ratio of 1:1 (orchid purple persian rose plants).

d) Orchid purple x white : From the crosses involving orchid purple and white flowering parents, five progenies : 72.7, 72.12, 72.13, 72.17 and 72.20 consisting of 11, 14, 16, 8 and 3 plants, respectively, were raised, each of them showed a segregation of 3 orchid purple : 1 white.

e) Campanula violet x persian rose : Two progenies 72.1 and 72.23 consisting of 7 and 9 plants, respectively showed approximately 1:1 ratio of campanuala violet : persian rose, while in three progenies : 72.4, 72.8 and 72.25 with 14, 16 and 6 plants, respectively, the campanula violet and persian rose flowering plants segregated in a ratio of 3:1.

f) Campanula violet x white : One progeny no. 72.5 consisting of 6 plants showed a segregation ratio of 3 campanula violet : 1 white.

g) Campanula x capmanula violet : All the plants beloning to four progenies : 72.21, 72.22, 72.S.73 and 72.S.80 consisting of 19, 13, 6 and 39 plants, respectivcly, produced campanula violet flowers.

h) Persian rose x white : The populations of five progenies : 72.2, 72.3, 72.10, 72.18 and 72.19 consisting of 12, 13, 10, 12, and 5 plants, respectively, showed a ratio of 3 persian rose : 1 white flowering plants.

i) Persian rose x persian rose : All the off-springs of four progenies : 72.11, 72.14, 72.S.76 and 72.S.79 consisting of 19, 13, 10 and 34 plants, repectively, produced flowers of persian rose colour.

j) White x white : All the plants belonging to progenies : 72.S.75 and 72.S.78 with 4 and 11 plants, respectively, produced all white flowers.

TABLE 3. *Summarized data on various flower characters of the progenies of 35 crosses.*

Progeny No.	Single flower	Double flower	Non-flowering	Orchid purple	Campanula violet	Persian rose	White
72.1	7	—	—	—	4	3	—
72.2	12	—	—	—	—	8	4
72.3	13	—	—	—	—	9	4
72.4	14	—	—	—	9	5	—
72.5	6	—	—	—	4	—	2
72.6	8	—	—	5	—	3	—
72.7	11	—	—	8	—	—	3
72.2	10	6	—	—	11	5	—
72.9	6	3	—	7	2	—	—
72.10	7	3	—	—	—	7	3
72.11	13	6	—	—	—	19	—
72.12	9	5	—	10	—	—	4
72.13	10	6	—	10	—	—	6
72.14	8	4	1	—	—	13	—
72.15	11	5	—	—	—	16	—
72.16	10	4	—	8	6	—	—
72.17	6	2	—	6	—	—	2
72.18	9	3	—	—	—	9	3
72.19	4	1	—	—	—	4	1
72.20	2	1	—	2	—	—	1
72.21	7	12	—	—	19	—	—
72.22	6	7	—	—	13	—	—
72.23	1	8	—	—	5	4	—
72.24	6	11	—	11	6	—	—
72.25	2	4	—	—	4	2	—
72.26	4	4	—	5	3	—	—
72.27	10	8	—	10	—	8	—
72.S.73	6	—	—	—	6	—	—
72.S.74	8	14	—	—	—	22	—
72.S.75	4	—	—	—	—	—	4
72.S.76	3	7	—	—	—	10	—
72.S.77	4	5	—	9	—	—	—
72.S.78	8	3	—	—	—	—	11
72.S.79	26	4	4	—	—	30	—
72.S.80	20	—	19	—	20	—	—

DISCUSSION

The seed of two stock varieties namely 7 weeks trisomic' and Giant Imperial' was sown in 1966. Since then the crop was sown every year from the previous year's seed, during this period twelve different strains were selected. In autumn, 1971 the seed of these strains were sown and the off-springs were studied morphologically for their character analysis.

The off-springs resulting from crosses involving both the parents with branching growth' were of branching type, it can be concluded that either both the parents of these progenies were homozygous (BB) for the dominant branching character or one was homozygous (BB) and the other heterozygous (Bb). Crosses between non-branching parents gave all the non-branching progenies suggesting that their parents were homozygous (bb) for the recessive alleles.

The populations resulting from crosses between branching and non-branching parents (and reciprocal crosses) segregated in a 1 : 1 ratio of branching : non-branching plants. Apperantly branching parents were heterozygous (Bb) and the non-branching were homozygous (bb) for the recessive alleles.

Regarding foliage colour different segregation ratios were obtained in different progenies. In the light of information from Crane and Lawrence (1956) that this character is controlled by four genes C,R,K, and H. The genotypes of these crosses can be worked out.

The populations consisting of all the green foliage plants should have arison from the crosses of parents, in which either both the parents were homozygous (CCRRKKHH) or one was homozygous and the other heterozygous (CcRrKkHh) for the dominant green foliage character. The progenies consisting of all the grey foliage plants should have resulted from the crosses between the parents which were homozygous (ccrrkkhh) for the recessive allels, conditioning this character.

In the case of progenies which segregated in a 1 green: 1 grey ratio, one parent should have been homozyous (ccrrkkhh) for all the four recessive alleles and the other heterozygous for any one, two, three or even all the four genes. (CcRRKKHH, CcRrKKHH, CcRrKkHH or CcRrKkHh).

A ratio of 3:1 in some progenies could be obtained by crossing a parent which was heterozygous for any one of the four genes and homozygous for the remaining three dominant allels (CCRRKKHH) with an other parent which was heterozygous for three genes and homozygous for the remaining one dominant character (CcRrKkHH).

In case of populations which exhibited 1 : 3 (green:grey) segregation ratio one parent should have been heterozygous for two or three genes (CCRrKkHH), and homozygous for the remaining dominant genes and the other should have been homozygous for all the recessive genes (ccrrkkhh) or homozygous for two dominant allels and two recessive allels (ccrrKkHH).

The experimental results for the foliage shape corresponded with the foliage colour. All the plants which were green in foliage had normal leaf shape, and those with grey foliage had curly leaves, suggesting that the foliage shape character was closely linked with the foliage colour or the same gene were of plieotropic nature, affecting two different characters of the foliage.

Among the progenies of the crosses the number of non-flowering plants was much less as compared to the parental strains. The percentage of such plants was 12 per cent, 49 per cent and 76 per cent in three progenies: 72.14, 72.S.70 and 72.S.80, respectively.

The non–flowering plants were shorter in height as compared to the flowering plants, but were healthy and normal with large sized and slightly dantate leaves. The short size of these plants bould be explained on the basis of their lacking all together in the terminal inflorescence, which normally counts for 50 per cent of the total plant height.

An example of non-flowering plants of strawberries has been cited by Khan and Bringhurst (1965). The crosses between cal. 39, 117-4 and the *Vesca orientalis* tetraploid hybrids resulted in a progeny in which about half of the seedlings had 'tatter' leaves and the other half were normal. The 'tatter' leaf plants never flowered. They concluded from thier studies that cal. 39.117-4 was heterozygous for a chromosomal or genetic condition responsible for this abnormal phenotype.

The probable reason for the occurence of the non-flowering plants could be saught in the consequences of trisomic nature of the origional seed. The meiosis in trisomic plants is usually erratic and it is attended by different types of meiotic irregularties in the gametes with unbalanced genetic make-up and union of such abberant gametes might give rise to such abnormal plants. Regarding the single and double flowering character, the progenies of all the crosses could be classified in to four groups : i) all plants with single flowers, ii) single and double flowering plants in the ratio of 3:1, iii) single and double flowering plants in the ratio of 1 : 1 and iv) appearence of 'doubles' in more than 80 percent of the plants.

The plants which gave single flowers apparently came from the crosses whose both the parents were either homozygous for S gene for singleness or one was homozygous and the other heterozygous for this character. These plants were of the type as mentioned by Allen (1924) i.e. pure breeding race which gave pure single flowers.

The plants of the progenies which gave 3 : 1 ratio of single: double flowers were obviously heterozygous Ss in nature, just the same as referred by Allen (1924) and Barber (1954).

The progenies which gave higher proportions of double flowers, apparently resulted from cosses involving the 'eversporting' plants, which according to Allen (1924) and Barber (1954) gave 1:1 ratio of single and double flowers. Emswellar *et al* (1937) gave it the name of 'eversporting race.

Johnson and Barnhart (1937) stated that the eversporting plants gave 54 percent of double flowers. In these plants one chromosome of a specific pair carried the gene for double flowers-s-, while the other member of the pair carried the dominant gene for single flowers-S-, and it was closely linked with a pollen lethal factor-l, so that at the meiosis half of the gametes received single flower-gene and the pollen lethal factor -Sl-, and half received double flower gene -s-, and giving rise to two types of plants : eversporting singles -Sl/s- and doubles in almost equal numbers.

They further stated that some of the female gametes were also affected by the lethal effects of the pollen lethal alleles and consequently the transmission of the gametes with S alleles, accompanied with -l- was very much

decreased. In other words all the male gametes and large number of female gametes with S^1 constitution were rendered non-functional by the lethal effects of -l- alleles.

In view of the foregoing reasons, the proportion of 'doubles' can increase and go higher than 80 percent. In some of the parental strains there was a preponderance of the single flowering plants so that the double flowering plants were only few. Johnson and Barnhart (1955) have explained the reasons for such drops in the percentage of doubles in the progeny of eversporting race. They provided a clear evidence that crossing over between S and l genes occurs with certain ferquency so that S and l genes are seperated from each other. When a gamete bearing the new S chromosome fertilizes normal S^1 and s gametes, exceptional single flowered plants S/S^1 and S/s are produced. These non-eversporting plants are similar in appearance to eversporting plants, but S/S^1 will produce only singles and S/s 25 percent of doubles while eversporting plants will produce 54 percent of doubles.

Regarding the inheritance of flower colour, all the offsprings of the crosses involving both the parents with orchid purple flowers produced orchid purple flowers Likewise, crosses involing both the parents with campanula violet flowers and those having both the parents with persian rose flower colour, resulted in progenies in which all the offsprings were of campanula violet and persian rose, respectively. Similarly the offsprings of the crosses between the parents with white flowers, produced white flowers.

In other crosses such as orchid purple x campanula violet, orchid purple x persian rose and orchid purple x white, etc., it was observed that orchid purple flowers were dominant to all the other colours showing large number of plants with orchid purple flowers. The character of campanula violet flower colour was dominant to persian rose and white. Persian rose flower colour was dominant to only white flower character. The white flower colour was recessive to all the colours, noted in these studies.

Segregation ratio of 3 : 1 were observed in the progenies of different crosses. According to Crane and Lawrence (1956) at least four genes are involved in the production of flower colour in stocks. The populations of the progenies studied here were too small to warrent any genetic explanation for the segregation ratios observed.

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