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A gene inhibiting flower colour in chickpea (*Cicer arietinum* L.)

P. M. Gaur and V. K. Gour

Department of Plant Breeding and Genetics, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur 482 004

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Abstract

Inheritance was studied for pink-veined white flower in chickpea (*Cicer arietinum* L.). This flower colour is rare in this legume which commonly has pink, white and less frequently blue flowers. A recessive gene, designated *ifc*, was found to inhibit flower colour without affecting vein colour of the corolla. When *ifc* was present in homozygous condition, *P- B-* and *pp B-* genotypes gave pink-veined white flower and blue-veined white flower, respectively.

Key words : Chickpea, flower colour, pink-veined white flower, inheritance

Introduction

Three main classes of flower colour occur in chickpea, pink and white colour constitute major classes while blue colour constitutes minor class. A survey of world collection of over 12,000 chickpea accessions indicated that 80.67% accessions had pink flowers (includes dark pink, pink and light pink), 18.87% had white flowers and 0.46% had blue flowers [1].

The inheritance of pink, blue and white flower colour has generally been attributed to segregation at two pairs of genes, *P* and *B* [2, 3]. The dominant *B* gene is responsible for blue corolla, whereas *P* in the presence of *B* produces pink corolla. White flowers occur when *B* is recessive, irrespective of *P*. An additional gene *C* was also suggested for flower colour in one study [4]. Their data indicated that *C* is complementary to *B* and that *P* is supplementary to *B*. Thus, the corolla is pink when all three genes (*P*, *B* and *C*) are present in the dominant condition, blue when *P* is homozygous recessive and white in all other situations.

In pink and blue flowers, the veins of vexillum show darker shades of the colour of vexillum. It led to the conclusion that the gene(s) for colour of vexillum has pleiotropic effect on colour of the veins of vexillum [5-7]. The accession ICC 4929 of desi type chickpea was found to have pink-veined white flowers which indicated that colour of vexillum and the colour of the veins of vexillum may be affected differently. This report describes inheritance of pink-veined white flower for the first time and identifies a gene that inhibits flower colour without affecting vein colour of the corolla.

Materials and methods

Flower colour was studied in F_1 and F_2 of 21 crosses of chickpea involving eight parents. The parents included four pink flowered (ICC 4957, ICC 5325, ICC 10034, ICC 10301), one pink-veined white flowered (ICC 4929), one blue flowered (ICC 12450) and two white flowered (ICC 5316, ICC 8151) accessions. Crosses were made to produce all possible combinations of flower colour. The F_1 and the F_2 were grown in normal field conditions using recommended cultural practices. Freshly opened flowers were used for recording flower colour of individual F_1 and F_2 plants of each cross. The data was analysed using goodness-of-fit X^2 test for appropriate F_2 phenotypic ratio.

Results and discussion

The parents used in this study represented four types of flower colour - pink, pink-veined white, blue and white. All six possible combinations of flower colour were studied. The results obtained from each cross combination are discussed below :

1. *Pink vs. pink-veined white flowers* : The pink-veined white flowered accession (ICC 4929) was crossed with four pink flowered accessions. All four crosses gave pink flowered F1 and segregated in a ratio of 3 pink : 1 pink-veined white flowered plants in F_2 (Table 1). It suggested that corolla colour is inhibited when a recessive gene, designated *ifc*, is present in homozygous condition. This gene, however, does not have any effect on vein colour of the corolla. As the presence of domanant *P* and *B* genes is needed to give pink flower [2, 3], the genotypes of the pink and the pink-veined white flowered parents are suggested to be *PP BB Ifc Ifc* and *PP BB ifc ifc*, respectively.

Table 1. Goodness-of-fit (X^2) tests for F_2 segregation of flower colour in chickpea

Cross	Flower colour of F_1	No. of plants in each F_2 phenotypic class: Pink	Pink-veined white	Blue	Blue-veined white	White	Expected genetic ratio	X^2	P
Pink vs. Pink-veined white									
ICC 4929 × ICC 4957	Pink	100	30	-	-	-	3:1	0.26	0.61
ICC 4929 × ICC 5325	Pink	282	98	-	-	-	3:1	0.13	0.72
ICC 4929 × ICC 10034	Pink	203	60	-	-	-	3:1	0.67	0.41
ICC 4929 × ICC 10301	Pink	235	65	-	-	-	3:1	1.78	0.18
Pooled data								1.16	0.28
Heterogeneity								1.68	0.64
Pink vs. blue									
ICC 4957 × ICC 12450	Pink	125	-	35	-	-	3:1	0.83	0.36
ICC 5325 × ICC 12450	Pink	264	-	76	-	-	3:1	1.27	0.26
ICC 10034 × ICC 12450	Pink	145	-	42	-	-	3:1	0.64	0.42
ICC 10301 × ICC 12450	Pink	208	-	67	-	-	3:1	0.06	0.81
Pooled data								2.33	0.13
Heterogeneity								0.48	0.92
Pink vs. white									
ICC 4957 × ICC 5316	Pink	153	-	-	-	51	3:1	0.00	1.00
ICC 4957 × ICC 8151	Pink	144	-	-	-	45	3:1	0.14	0.71
ICC 5316 × ICC 5325	Pink	183	-	-	-	71	3:1	1.18	0.28
ICC 5316 × ICC 10034	Pink	164	-	-	-	66	3:1	1.68	0.19
ICC 5316 × ICC 10301	Pink	106	-	-	-	30	3:1	0.63	0.43
ICC 8151 × ICC 5325	Pink	190	-	-	-	64	3:1	0.01	0.92
ICC 8151 × ICC 10034	Pink	155	-	-	-	31	3:1	6.89	0.01
ICC 8151 × ICC 10301	Pink	270	-	-	-	80	3:1	0.86	0.35
Pooled data								0.48	0.35
Heterogeneity								10.90	0.14
Pink-veined white vs. blue									
ICC 4929 × ICC 12450	Pink	198	50	57	15	-	9:3:3:1	4.87	0.18
Pink-veined white vs. white									
ICC 4929 × ICC 5316	Pink	115	29	-	-	43	9:3:4	2.26	0.32
ICC 4929 × ICC 8151	Pink	146	35	-	-	64	9:3:4	3.21	0.20
Pooled data								4.91	0.09
Heterogeneity								2.22	0.14
Blue vs. white									
ICC 5316 × ICC 12450	Pink	141	-	40	-	66	9:3:4	0.91	0.63
ICC 8151 × ICC 12450	Pink	206	-	75	-	92	9:3:4	0.45	0.80
Pooled data								0.08	0.96
Heterogeneity								1.28	0.26

2. *Pink vs. blue flowers* : The crosses between pink flowered and blue flowered parents gave pink flowered hybrids and segregated in a ratio of 3 pink: 1 blue flowered plants in the F_2 (Table 1). These results are in agreement to the earlier reports on similar crosses [8, 9]. Thus, only one locus, *P*, was segregating in these crosses. As there was no inhibition of corolla colour in any of the parents, F_1s or F_2s, the proposed *Ifc* gene must be present in homozygous dominant condition in both the parents. The genotypes of the pink and the blue flowered plants should, therefore, be *PP BB Ifc Ifc* and *pp BB Ifc Ifc*, respectively.

3. *Pink vs. white flowers* : All eight crosses between pink flowered and white flowered parents gave pink flowered F_1. A good fit to a 3:1 ratio for pink and white flowered plants was observed in the F_2 of all crosses except one (ICC 8151 × ICC 10034) which gave a significnat X^2 value (Table 1). It may be due to chance as the observed frequencies of this cross did not give a good fit to any other possible genetic ratio. The pooled data of all crosses was homogeneous and gave a good fit to a 3:1 ratio. A single gene difference has been reported between pink and white flowered parents by several researchers [6, 10-16]. These reports and the results of this study suggest that the pink flowered and white flowered parents differ only at *B* locus and, thus, their genotypes are *PP BB Ifc Ifc* and PP bb Ifc Ifc, respectively.

4. *Pink-veined white vs. blue flowers* : A cross between pink-veined white flowered parent (*PP BB ifc ifc*) and blue flowered parent (*pp BB Ifc Ifc*) gave pink flowered F_1. The F_2 gave a good fit to 9 pink (*P- BB Ifc-*): 3 pink-veined white (*P- BB ifc ifc*): 3 blue (*pp BB Ifc-*): 1 blue-veined white (*pp BB ifc ifc*) flowered plants (Table 1). These results clearly indicate that when *Ifc* gene is present in dominant condition, the genotypes *P- B-* and *pp B-* produce pink and blue flowers, respectively. But when the *Ifc* gene is present in homozygous recessive condition, it inhibits corolla colour without affecting the veins colour of the corolla and, thus, the genotypes *P- B-* and pp B- produce pink-veined white and blue-veined white flowers, respectively.

5. *Pink-veined white vs. white flowers* : When pink-veined white flowered accession was crossed with white flowered accession, the hybrids were pink flowered and the F_2 segregated in a ratio of 9 pink : 3 pink-veined white : 4 white flowered plants. As the genotypes of the pink-veined white flowered parent is *PP BB ifc ifc* and the white flowered parent is *PP bb Ifc Ifc*, the F_2 between these parents segregated at *B* and *Ifc* loci. The genotypes *PP B- Ifc-*, *PP B- ifc ifc*, *PP bb Ifc-* and *PP bb ifc ifc* gave pink, pink-veined white, white and white flowered plants, respectively.

6. *Blue vs. white flowers* : The genotypes *P-bb* and *pp bb* both give white flowered plants [2-3]. Crosses between pink and white flowered plants suggested that a dominant *P* gene was present in white flowered parents. It was further confirmed from the study of crosses between blue and white flowered parents. The F_1s obtained from crosses between blue (*pp BB Ifc Ifc*) and white (*PP bb Ifc Ifc*) flowered parents were pink flowered and the F_2 segregated in the ratio of 9 pink (*P- B- Ifc Ifc*): 3 blue (*pp B- Ifc Ifc*): 4 white (*P- bb Ifc Ifc, pp bb Ifc Ifc*) flowered plants (Table 1) which is in accordance to the digenic segregation involving *P* and *B* loci.

The results obtained from all six cross combinations of pink, pink-veined white, blue and white flowered parents have clearly shown that a recessive gene, *ifc*, is present in pink- veined white flowered accession ICC 4929. This gene when present in homozygous recessive condition changes the flower colour of pink flowered plants to pink-veined white and of blue flowered plants to blue-veined white. Thus, it inhibits corolla colour without affecting vein colour of the corolla.

A correct identification of the segregating gene and use of uniform gene symbols is essential for linkage studies. The results of this study will help in identification of the segregating gene(s) for flower colour and, thus, facilitate linkage studies.

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