

THE INHERITANCE OF FLOWER AND POD COLOR
IN PHASEOLUS VULGARIS AND P. COCCINEUS

by

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B.Sc., Horticulture, Alfattah University, Faculty
of Agriculture, 1975

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture

KANSAS STATE UNIVERSITY
Manhattan, Kansas
1979

Approved by:



Major Professor

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ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Dr. Carl D. Clayberg, major professor, for his assistance and patience in carrying out this research and writing the thesis.

I would like to thank Dr. J. K. Greig and G. H. Liang, members of my supervisory committee, for their assistance and encouragement.

Thanks are also due to the Libyan Government for sponsoring my graduate study at Kansas State University.

Finally, my special thanks and appreciation to my parents and brothers and sisters for their encouragement and support.

The inheritance of flower and pod color
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HUSEIN A. FRAG AND CARL D. CLAYBERG

The genetic control of flower color in Phaseolus vulgaris L., the garden bean, is due in part to a series of alleles at the V locus, with V producing Bishops Violet (81A, Royal Horticultural Society Colour Chart¹²) flowers, v_{1ae} laelia (lilac) flowers, and v white flowers⁵. The sequence of dominance is V, v_{1ae}, v with v the most recessive; but the heterozygotes Vv and v_{1ae}v are reported to be less pigmented than the corresponding dominant homozygotes VV and v_{1ae}v_{1ae}⁴. In addition, V produces red stem color and v_{1ae} rose stem color⁵. Two dominant basic genes, P and Gri, are required for color in any plant part but produce no color of themselves^{5, 11}; and T is also required for flower color but likewise produces no color alone⁴.

Genes in P. vulgaris responsible for pod color include Pur for purple pod and Ro for rose pod, which interact so that PurRo = deep purple pod⁷. Dark purple pods have also been reported to result from the interactions of Ro and v¹⁰.

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Another study has described purple pods as due to homozygosity for a single gene, with the heterozygote having green pods streaked with purple⁹.

The inheritance of the scarlet flower color of P. coccineus (Lam.) in crosses with P. vulgaris has been described as requiring four dominant genes from P. coccineus: Am, Sal, No, and Beg^{6, 8}. Each of these genes alone reportedly produces a different shade of red, but all of their interactions have not been described. Scarlet flower color in this cross has also been attributed to a single dominant gene, when scarlet-flowered P. coccineus was crossed as female with white-flowered P. vulgaris³. In the reciprocal cross, which likewise showed monogenic segregation, the dominant phenotype was geranium pink, not scarlet, and behaved as if due to genic-cytoplasmic interaction.

The purpose of the present study was to see if scarlet flower color from P. coccineus could be combined with dark purple pod color of P. vulgaris. In the process we felt it desirable to confirm the inheritance of dark purple pod color within P. vulgaris.

MATERIAL AND METHODS

Two cultivars of Phaseolus vulgaris were used in the crosses. 'Royal Burgundy' was obtained from Stokes Seed Company, Buffalo, New York and has purple flowers (80A), purple pods (79A) and purplish foliage. 'Bush Blue Lake 290' was received from Asgrow Seed Company, Kalamazoo, Michigan and has white flowers, green pods, and green foliage lacking anthocyanin. The latter cultivar was crossed with the former to verify the inheritance of flower and pod color in an exclusively P. vulgaris genetic background. The P. coccineus parent used was PI 175,858 from the W-6 Plant Introduction Station, Pullman, Washington. It has scarlet flowers (33A) and green pods and foliage lacking anthocyanin pigmentation.

'Bush Blue Lake 290' was used as female parent in the cross with 'Royal Burgundy'. Phaseolus coccineus was used as male in the cross with 'Royal Burgundy'. Pollination was done using the rubbing and hooking methods described by Buishand².

Backcross and F₁ progenies were grown in the greenhouse and F₂ families in the field.

RESULTS AND DISCUSSION

Segregation for flower and pod color in Phaseolus vulgaris

The F_1 progeny consisted of 5 plants which were all medium purple for flower and pod color (Table I). The F_2 gave the results summarized in Table I.

Table I. Segregation for flower and pod color in Phaseolus vulgaris.

Generation	Observed frequencies for color of					χ^2 *	P
	Flower:	purple		white			
	Pod:	dark purple	medium purple	green	green		
P_1 (Bush Blue Lake 290)					5		
P_2 (Royal Burgundy)	5						
F_1 ($P_1 \times P_2$)			5				
F_2 ($P_1 \times P_2$)	76	64	46	66	0.29	>0.95	

* Chi square was calculated to fit a ratio of 5:4:3:4

These results can be simply explained as resulting from segregation for two pairs of unlinked genes. One gene pair is V-v, which controls flower, stem, and pod color⁶. The other gene pair is described here for the first time as Prp-prp for Purple pod color. Prp interacts with V to produce dark purple pod. The remaining interactions can be explained by the following scheme.

Flower Color		Immature pod color		
		Prp Prp	Prp prp	prp prp
purple	VV	dark purple	dark purple	green
purple	Vv	dark purple	medium purple	green
white	vv	green	green	green

F₂: 5 dark purple: 4 medium purple: 7 green (P > 0.90)

It is hypothesized by Lamprecht⁷ that two genes control pod color according to the following scheme, with ro epistatic to Pur.

		Immature pod color	
		Ro	ro
Pur		dark purple	green
pur		rose	green

On the other hand, Moraes and Vieira¹⁰ reported that three alleles each at two unlinked loci controlled pod color. Their results are given in the following diagram.

Flower Color		Immature pod color		
		A	a ^a	a
purple	v	dark purple	striped purple	dark pink
pink	v _{1ae}	red	yellow	yellow
white	v	red	yellow	yellow

Moraes and Vieira¹⁰ said that A and a^a are equal to Ro and ro, respectively, of Lamprecht⁷. However, they found that v a^a was yellow striped with purple, while Lamprecht reported that

Pur ro was green. If V corresponds to Pur, it is possible that the darker green pigmentation concealed the purple for Lamprecht.

It was necessary for us to describe the new gene, Prp, because neither Lamprecht⁷ nor Vieira and Moraes¹⁰ reported two features we observed: (1) two shades of purple pods, and (2) the green phenotype of v Prp.

Segregation for flower color in P. vulgaris x P. coccineus

The F₁ progeny of this cross consisted of three plants, all with salmon-colored flowers (42B) and dark purple pods (Table II). Two of the plants showed the T dwarf characteristics described by Bemis and Kedar¹: compact, dwarf plant habit and leaves with many small necrotic spots. The third plant was normal in appearance but failed to set any pods containing seeds from natural selfing or when used as a female parent in backcrosses with 'Royal Burgundy'. This plant, whose pollen stainability was 88.8%, was used successfully as male in the backcross to 'Royal Burgundy'.

Table II. Segregation for flower color in the cross of P. vulgaris and P. coccineus

Generation	Observed frequencies for flower color*						X ² †	P
	S	SL	R	PR	RP	P		
P ₁ (<u>P. vulgaris</u> 'Royal Burgundy')						5		
P ₂ (<u>P. coccineus</u> PI 175,858)	1							
F ₁ (P ₁ × P ₂)		3						
BC ₁ (P ₁ × F ₁)			2	2	3	3	0.40	> 0.90

* Color of corolla standard: S = scarlet (R.H.S. Colour Chart¹² 33A), SL = salmon (42B), R = red (53B), PR = purplish red (64B), RP = reddish purple (74C), P = purple (80A)

† Chi square was calculated to fit a ratio of 1:1:1:1

Ten backcross plants were obtained from more than 100 pollinations, and these plants could be grouped for flower color into four classes, as given in Table II. The results can be explained as segregation for two pairs of dominant, unlinked genes additive in action, with the dominant allele at one locus causing a higher level of red pigment production than the dominant allele at the other locus.

The ten backcross plants all had purple pods. Their pollen stainability ranged from 65% to 95% with an overall average of 82%. Recovery of fertility in backcrosses of this interspecific cross has also been reported by Lamprecht⁶.

Our results provide no evidence that four separate dominant genes from P. coccineus are required for the production of scarlet flowers. Although we did not recover in backcross

the scarlet color of P. coccineus, or the similar salmon color of the F_1 , the red segregants we obtained are consistent with the color shift from orange red to purplish red observed upon interspecific backcross transfer of genes for scarlet corolla from Sinningia cardinalis into Sinningia eumorpha (Clayberg, unpublished).

The present results also do not agree with the single gene inheritance described for this cross by Ibrahim and Coyne³. Our F_1 was fully pigmented, not diluted to pink like theirs, and the salmon-colored F_1 we observed indicates nearly complete epistasis of the genes for scarlet color from P. coccineus over the V allele from 'Royal Burgundy'. The BC_1 color shift is probably due to background modifiers in 'Royal Burgundy', but further backcrosses and sibcrosses are needed to verify this assumption.

The results obtained here demonstrate that scarlet, or red, flower color can be recombined with purple pod color in a P. vulgaris background, although these crosses did not allow us to determine whether the flower color genes from P. coccineus had any effect on pod color.

SUMMARY

Intraspecific crosses with P. vulgaris showed that the dark purple pods of the cultivar 'Royal Burgundy' resulted from the interaction of two genes: V and Prp, the latter gene not previously described. In the cross P. vulgaris 'Royal Burgundy' x P. coccineus flower color segregation in BC_1 indicated that the scarlet flower color of P. coccineus is due to two dominant, unlinked, additive genes of unequal action, both epistatic to V.

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ABSTRACT

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