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Inheritance of Seed-coat colour in Gram

(Cicer arietinum)

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It was stated in a previous paper by Ramanatha Ayyar and Balasubrahmanyan (1936) that the seed-coat colour Rood's brown corresponding to the seed grade CS 12 was formed by the addition of factor T^1 to CS 10 and that T^1 had no effect when P was absent. The inheritance and interaction of factor T^1 studied further on other genetic backgrounds form the subject-matter of this paper.

Six pure lines of gram whose genic constitutions are already known and given in Table 1 formed the parents of the five crosses made and studied in detail. Crosses between two Pusa types were generally of low productivity and as such failed to give sufficient population in second and third generations while other crosses with local type 19 were generally prolific yielding fairly large populations.

TABLE 1.

Variety	Petal colour	Seed-coat colour	Genic formula
T6	White	CS1	CbP $f^r t^1 t^2$
T8	do.	CS2	CbP $F^r t^1 t^2$
T10	do.	CS3	CbP $f^r t^1 T^2$
T21, T24, 19	Pink	CS12	CBP $f^r T^1 T^2$

Experimental results:

(a) Pinkish cinnamon (CS 3) CbP $f^r t^1 T^2$

×

Rood's brown (CS 12) CBP $f^r T^1 T^2$

Two crosses viz., T 10 × T 24 and T 10 × 19 were studied under this group and their segregations are detailed in Table 2.

TABLE 2.

Nature of Cross studied	Generation	No. of families studied	Total nuber of plants	Actual number of plants obtained in CS: 13 (Pink flower)	12	11	10	22	21	9	8	20 (White flower)	19	4	3	18	17	2	1	Expected ratio	Value of P greater than
				$CBPF^rT^1T^2$	$CBPf^rT^1T^2$	$CBPF^rt^1T^2$	$CBPf^rt^1T^2$	$CBPF^rT^1t^2$	$CBPf^rT^1t^2$	$CBPF^rt^1t^2$	$CBPf^rt^1t^2$	$CbPF^rT^1T^2$	$CbPf^rT^1T^2$	$CbPF^rt^1T^2$	$CbPf^rt^1T^2$	$CbPF^rT^1t^2$	$CbPf^rT^1t^2$	$CbPF^rt^1t^2$	$CbPf^rt^1t^2$		
T 10 × 19	F2	5	244		138		48						46		12					9: 3: 3: 1	0·80
T 10 × T 24	F2	2	37		20		7						6		4						0·70
T 6 × 19	F2	10	472		194		74		67		16		74		20		19		8	27:9:9:3:9:3:3:1	0·70
T 8 × 19	F2	4	219	72	26	23	6	25	3	8	1	24	10	10	2	5	1	3		81:27:27:9:27:9:9:3:	0·80
T 8 × T 21	F2	7	56	16	7	8	3	2	1	2	2	3	3	2	2		1	31		:27:9:9:3:9:3:3:1	0·04

The parents differed in factors B and T^1 and the observed segregation agreed with an independant di-hybrid ratio. Of the four phenotypes in second generation, CS 12 and CS 3 are parental types and CSs 10 and 19 are new combinations. The genetic constitution of CS 10 already known; (Ramanatha Ayyar and Balasubrahmanyan 1936) and therefore CS 19 should be CbP $f^r T^1 T^2$. The addition of factor T^1 to CS 3 imparts a fawn colour which is styled as CS 19.

(b) Warm buff (CS 1) CbP $f^r t^1 t^2$
×
Rood's brown (CS 12) CBP $f^r T^1 T^2$

The segregation of one cross viz., T 6 × 19 studied up to the second generation is given in Table 2. The number of phenotypes and the observed number of plants in each phenotype agreed very closely with the expected ratio. Seed grades CS 21 and 17 have not been described before and their genic constitutions are easy to fix on account of their differences in petal colour. Pink flower will have factor B while white flower will lack it. It may again be noticed that the genic constitutions of these two new grades differ from CSs 8 and 1 respectively by a single factor T^1.

(c) Pale ochraceous salmon (CS 2) CbP $F^r t^1 t^2$
×
Rood's brown (CS 12) CBP $f^r T^1 T^2$

Two crosses viz., T 8 × 19 and T 8 × T 21 were made and studied. Sixteen phenotypes conforming to a four-factor hypothesis were noticed and the relative observed populations in these classes agreed with the expectations on the basis of independent segregation. Due to smallness of F_2 numbers in T 8 × T 21, the P value was lower than 0 05 but the behaviour in the following F_3 generations was according to the four factor hypothesis. The four new round seeds of grade CSs 13, 22, 20 and 18 should have been formed by the addition of factor T^1 to the old grades CSs 11, 9, 4 and 2 respectively. The available plants were studied in F_3. Figures are not given since their behaviour was as expected. Their genic constitutions and colours as matched with the colour standards of Ridgeway (1912) are given in the following Table 3.

TABLE 3.

Genic constitutions of the new synthesised grades with factor T^1.

Seedgrade	Petal colour	Genic formula	Colour standard
CS17	White	CbP $f^r T^1 t^2$	Vinaceous buff
CS18	do.	CbP $F^r T^1 t^2$	do.
CS19	do.	CbP $f^r T^1 T^2$	Fawn

Seedgrade	Petal colour	Genic formula	Colour standard
CS20	do.	CbP $F^rT^1T^2$	Wood brown
CS21	Pink	CBP $f^rT^1t^2$	Avellaneous
CS22	do.	CBP $F^rT^1t^2$	do.
CS12	do.	CBP $f^rT^1T^2$	Rood's brown
CS13	do.	CBP $F^rT^1T^2$	Vandyke brown

CSs 17 and 18 have the same colour vinaceous buff and similarly CSs 21 and 22 conform to a common colour avellaneous. There is difference in seed shape only. All these four grades lack factor T^2 and it looks as though that the effect of T^1 on the t^2 base is the same within each group irrespective of differences in factor F^r.

There was no linkage between factors T^1-T^2, F^r-T^1, and $B-T^1$.

Discussion: Hukum Singh and Ekbote (1936) suggested three new seed colour factors A, R and D in addition to the two petal colour factors B and P for explaining the results of three crosses studied by them. They stated that (1) factor A had no action on petal colour but imparted a bluish brown seed coat colour, round shape and smooth surface. (2) Factor R modified the action of A by converting the colour to reddish-brown and changing the round shape to irregular. (3) Factor B produced blue petals and had the same kind of action on seed coat as factor A. (4) Factor P converted blue petal to pink when occurring with B and the bluish-brown round seeds were changed to yellowish-brown irregular seeds when in association with B or A. (5) Factor modified the action of P by turning yellowish-brown seeds to dark-reddish-brown colour. The authors added a footnote to [the above hypothesis by stating that if factor P was presumed to produce yellowish-brown independently, the new factor A proposed was not necessary, and it that was retained since the factor P possessed by types T 1, T 2 and T 9 had yellowish-brown seeds.

Their whole scheme of factorial hypothesis was based on the assumption that there were only two petal colour factors B and P under which BP would be pink, Bp blue, bP or bp would be white. It would be therefore impossible to obtain a pink or a blue petal by crossing two whites. It was however, shown by Ramanatha Ayyar and Balasubrahmanyan (1936) that the petal colour in gram was controlled by three factors C, B, P in which C and B were complementary and P supplementary to B. When all these were present together the colour was pink, when CB alone were present it was blue while in six other combinations viz., cbp, Cbp,

cBp, cbP, CbP and cBP it was white. It was also demonstrated in the same paper that factor pair C-c had no effect on seed coat, while B and P had pleiotropic effects. Two factors T^1 and T^2 affected seed coat colour only while factor F^r affected both seed colour and seed surface. The genetic constitutions of the parents and crosses studied by Hukum Singh and Ekbote are given in Table 4.

TABLE 4.

Type	Petal colour	As per Singh and Ekbote			As per Ramanatha Ayyar and Balasubrahmanyan.	
		Shape of seed	Seed colour	Factorial cnstitution	Seed grade	Factorial constitution
T11	White	Round	Bluish brown	Arbpd	CS7	$cBpT^2t^1f^r$
T12	White	Irregular.	Reddish brown	ARbpd	CS10	$cBPT^2t^1f^r$
T52	Pink	do.	Yellowish brown	ArBPd	CS10	$CBPT^2t^1f^r$
T21	Pink	do.	Dark red brown	ArBPD	CS12	$CBPT^2T^1f^r$
T11xT12 F1	White	do.	Yellowish to reddish-brown.	ARbpd	CS10	$cBPT^rt^1f^r$
T11xT52 F1	Pink	do.	Yellowish-brown	ArBPd	CS10	$CBPT^2t^1f^r$
T11xT21 F1	Pink	do.	Dark reddish brown	ArBPD	CS12	$CBPT^2T^1f^r$

The flower colour constitutions of T11 and T12 given as same as per column 5 are not correct as proved by the petal colour segregations noticed in two crosses viz T8 × T11 and T8 × T12 which gave in F2 modified trihybrid ratios of 27: 9: 28: for pink, blue and white petals and dihybrid ratio of 9:7 for pink and white petals respectively as per factorial scheme in column 7. The observed behaviour of the three crosses studied for petal colour and shape character will be the same under both the hypothesis. The F1 of T11 × T12 has been described by Singh and Ekbote as showing a range of variation from reddish-brown to yellowish-brown as also the F_2. If the yellowish and reddish-brown seeds are two different and distinct colour grades governed by different genes, then it is extremely unlikely for the two grades to have occurred in one and the same plant. It is well known that the qualitative and quantitative expression of a factor is often affected by environment but the major effect of the factor is always distinguishable from the smaller effects. All seeds produced on a plant are generally not of the same hue and often variations from yellowish to reddish-brown are present in seed grade CS10. The ultimate grading is usually the result of mass effect of the preponderant tint ignoring the existence of minor colour variations in the same sample. A reasonable allowance must be made for the small variations existing in the seed colour in the produce of same plant and these limits should be invariably taken for fixing the colour range of the particular grade in classifications. The cross T12 × T11 studied by Ramanatha Ayyar and Balasubrahmanyan did not have the identical hue of the standard CS10 but exhibited slight variations in colour too small to be stated as new types. The finer shades of colour when sown separately and studied, failed to breed true to the parental grades but behaved alike indicating that slight differences had no genetic significance. The hypothesis developed by Ramanatha Ayyar and Balasubrahmanyan took into consideration the results of nine different crosses covering most of the genetic constitutions and this hypothesis has been found to be adequate for explaining the mode of segregations in later crosses too. The results of seed coat in all the crosses studied by Hukum Singh and Ekbote may therefore be explained on the basis of factors B, P and T only (T^2 being common to all.)

Summary: 1. Factor T^1 is independent of seed grade factor T^2. Eight grades viz., 13, 12, 22, 21, 20, 19, 18 and 17 formed by the addition of the factor T^1 to the old grades CSs 11, 10, 9, 8, 4, 3, 2 and 1 respectively are described.

2. There was no linkage between factor T^1 and T^2 or F^r or B.

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