



# INHERITANCE OF MORPHOLOGICAL CHARACTERS IN PIGEONPEA

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## KEYWORDS

Genetic inheritance  
Growth habit  
Plant height  
Seed coat  
Colour  
Chi-square  
Monogenic  
F<sub>2</sub> and Test cross

Received on :  
03.05.2014

Accepted on :  
15.10.2014

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## ABSTRACT

Detection of assortment, selection of pure strains, mechanized crop production and proficient management practices in commercial varieties in pigeonpea is generally based on growth habit, plant height and seed coat color as they are the expedient traits. In the present investigation inheritance of growth habit, plant height and seed coat color was studied with seven populations (parents, F<sub>2</sub>, reciprocal, F<sub>2</sub> and both back cross) of eight, ten and two crosses with respective characters. Data analysis of segregating populations (F<sub>2</sub>s and test crosses) was carried out with the help of chi-square test. Results showed that indeterminate growth habit, tall plant height and brown seed coat color was dominant over determinate, dwarf and cream white seed coat color respectively. No reciprocal differences were observed, indicating no material effect to govern the traits. Over the F<sub>2</sub> families, 2244 plants were indeterminate and 723 were determinate, 2666 were tall plant type and 945 were dwarf type and also 481 plants were brown seeded and 144 plants were cream white, fitting the overall segregation into a well fit of 3:1 ratio with *P*-value 0.44, 0.10 and 0.27 respectively. F<sub>2</sub> inheritance study showed that all traits were governed by single gene and it was confirmed with the help of test cross progenies as its segregated and well fitted 1:1 ratio. All traits being monogenic, the expression of these visible markers are independent of environment and therefore, can be incorporated effectively as a marker in pigeonpea genome. A genetic inheritance study is essential for transferring these traits in productive pigeonpea background.

## INTRODUCTION

Pigeonpea [*Cajanuscajan* (L.) Mills P.] is the second most important pulse crop of India belonging to the Cajaninae sub-tribe of the economically important leguminous tribe phaseoleae. Morphological variants with distinct phenotypic expression can be used to establish linkage plots and indirect assortments. However, a large number of distinct morphological traits are required to construct linkage maps. Numerous morphological variants for distinct plants have been reported and among them growth habit, plant height and seed color have found efficient markers to interpret and understand linkage. For example short stature of the determinate plant types makes them amenable to efficient crop management practices, such as foliar insecticide application and mechanized harvesting. Indeterminate plants, on the other hand, grow taller; hence, efficient management and mechanization become difficult. Most of the traditional medium (maturing in 160-200 days) and long-duration (maturing in >200 days) pigeonpea cultivars are tall unstipulated resulting in low productivity specifically because of inefficient pest control (mainly *Helicoverpa armigera* pod borer) (Gupta and Kappor, 1991). The seed color is a major trait that affects consumer's acceptability and as Paltak and Dixit (1992) reported that the consumer's preference for this trait differs from region to region. From a practical viewpoint, inheritance study of seed coat color is of great interest because

seed coat color is very important in the selection of pure strains and in the detection of mixtures in commercial varieties. Knowledge of basic genetic information in pigeonpea has been initiated decades ago. No significant work had been done recently on qualitative inheritance pattern of vital traits in pigeonpea. The present study unravels the importance of these characters in pigeonpea and aims to study the inheritance of these characters using a set of cultivars.

## MATERIALS AND METHODS

The present investigation was carried out during *kharif*, 2009-10 to *kharif* 2011-2012 at experimental field of Pulses Research Unit, Dr. PDKV, Akola. The experimental materials were developed from ten crosses using female parents AKT-8811 (P1) and TAT-10 (P2) were crossed with male parents Dwarf 30 (P3), Dwarf 45 white seeded (P4), Dwarf 45 brown seeded (P5), Dwarf 60 (P6) and Dwarf 90 (P7) in *kharif* season 2009, to obtain the first filial generation. The plants of F<sub>1</sub>s were selfed with bee-proof cages to produce F<sub>2</sub> and simultaneously back crosses were made with female and male parents to produce back cross populations. Pigeonpea height variants (female) crossed with P1 and P2 (male) to produce reciprocal generations in *kharif* season 2010. All these seven populations viz., parents, F<sub>1</sub>s, reciprocals, F<sub>2</sub>s and back cross populations which were sown on 12<sup>th</sup> July 2011 at spacing 60 × 20 cm and populations were grown sufficiently for inheritance

studies. Evaluation of all mention populations was carried out at same *kharif* season. Data on growth habit, height, stem color, leaf shape, number of leaflet, flower color (dorsal side of standard), pod color, pod constriction, seed color and seed shape were recorded, among that only contrasting characters were present in parents like growth habit, plant height and seed colour was used for genetic inheritance study. The list of crosses and the morphological characterization of parents are given in Table 1. Yate's correction was used where only two classes were involved (Yates, 1959). It consist of subtracting 0.5 from the absolute value of the difference (o - e) before these are squared. Therefore corrected chi-square was obtained by the formula.

$$\text{Corrected } X^2 = \frac{\sum \left[ \frac{o - e}{2} \right]^2}{e}$$

**Table 1: Morphological characterization of parents**

Sr. No.	Parents	Growth habit	Plant height	Stem colour	Leaf shape	No. of leaf let	Flower colour	(Dorsal side of standard)	Pod colour	Pod constriction	Seed coat colour	Seed shape
1	AKT-8811 (P1)	Indt	Tall	Green	Lanceolate	Trifoliolate	Yellow	G B S	Slight	Brown	Oval	Oval
2	TAT-10 (P2)	Indt	Tall	Green	Lanceolate	Trifoliolate	Yellow	G B S	Slight	Brown	Oval	Oval
3	Dwarf 30 (P3)	Dt	Dwarf	Green	Lanceolate	Trifoliolate	Yellow	G B S	Slight	Brown	Oval	Oval
4	Dwarf 45 white seeded (P4)	Dt	Dwarf	Green	Lanceolate	Trifoliolate	Yellow	G B S	Slight	Cream	Oval	Oval
5	Dwarf 45 brown seeded (P5)	Dt	Dwarf	Green	Lanceolate	Trifoliolate	Yellow	G B S	Slight	Brown	Oval	Oval
6	Dwarf 60 (P6)	Dt	Dwarf	Green	Lanceolate	Trifoliolate	Yellow	G B S	Slight	Brown	Oval	Oval
7	Dwarf 90 (P7)	Indt	Dwarf	Green	Lanceolate	Trifoliolate	Yellow	G B S	Slight	Brown	Oval	Oval

Note: Indt = Indeterminate, Dt = Determinate, Tall = More than 125 cm plant height, Dwarf = less than 125 cm plant height and GBS = Green colour pods with brown steaks

**Table 2: Observed phenotypes and chi-square test of F<sub>2</sub> and backcross generation between indeterminate and determinate growth habit**

Generation	Crosses	Phenotypes observed in F1 & Reciprocal		Expected ratio	X <sup>2</sup>	df	P-value	
		Indt	Dt					
F2	P1 X P3 (1)	Indt	453	127	3:01	2.8	1	0.09
	P2 X P3 (2)	Indt	390	125	3:01	0.1	1	0.75
	P1 X P4 (3)	Indt	254	89	3:01	1.1	1	0.3
	P2 X P4 (4)	Indt	216	65	3:01	0.4	1	0.51
	P1 X P5 (5)	Indt	215	79	3:01	0.5	1	0.5
	P2 X P5 (6)	Indt	198	70	3:01	0.1	1	0.72
	P1 X P6 (7)	Indt	323	98	3:01	0.6	1	0.44
	P2 X P6 (8)	Indt	195	70	3:01	0.2	1	0.64
Overall	-	Indt	2244	723	3:01	0.6	1	0.44
BC	F1 X Determinate							
	F1 (1) X P3		54	45	1:01	0.6	1	0.42
	F1 (2) X P3		46	44	1:01	0	1	0.92
	F1 (3) X P4		25	23	1:01	0	1	0.88
	F1 (4) X P4		26	20	1:01	0.5	1	0.47
	F1 (5) X P5		38	27	1:01	1.5	1	0.21
	F1 (6) X P5		29	25	1:01	0.2	1	0.68
	F1 (7) X P6		48	40	1:01	0.6	1	0.45
	F1 (8) X P6		29	25	1:01	0.2	1	0.68
Overall	-		295	249	1:01	3.7	1	0.05
BC	F1 X Indeterminate							
	F1 (1) X P1		98	-	-	-	-	-
	F1 (2) X P2		90	-	-	-	-	-
	F1 (3) X P1		97	-	-	-	-	-
	F1 (4) X P2		85	-	-	-	-	-
	F1 (5) X P1		81	-	-	-	-	-
	F1 (6) X P2		72	-	-	-	-	-
	F1 (7) X P1		78	-	-	-	-	-
F1 (8) X P2		74	-	-	-	-	-	

X<sup>2</sup> (Chi-squared) values of observed F<sub>2</sub> and back cross ratio were then compared to the 'p' values from Fisher's (1922) contingency table of X<sup>2</sup> (Chi-squared). Actual 'P' values were calculated by interpolation.

## RESULTS AND DISCUSSION

### Growth habit

For the character segregation analysis was done using eight crosses representing indeterminate × determinate parents (AKT-8811 × Dwarf 30, TAT-10 × Dwarf 30, AKT-8811 × Dwarf 45 white seeded, TAT-10 × Dwarf 45 white seeded, AKT-8811 × Dwarf 45 brown seeded, TAT-10 × Dwarf 45 brown seeded, AKT-8811 × Dwarf 60 and TAT-10 × Dwarf 60). In all the eight crosses, all F<sub>1</sub>, reciprocal and back cross with dominant parent was indeterminate indicating dominance of this character with no material effect. The F<sub>2</sub> population of

**Table 3: Observed phenotypes and chi-square test of F<sub>2</sub> and backcross generation between tall and dwarf plant height**

Generation	Crosses	Phenotypes observed in F <sub>1</sub> & Reciprocal	Phenotypes observed		Expected ratio	X <sup>2</sup>	df	P-value
			Tall	Dwarf				
F <sub>2</sub>	P1 X P3 (1)	Tall	451	129	3:01	2.2	1	0.13
	P2 X P3 (2)	Tall	383	132	3:10	0.1	1	0.79
	P1 X P4 (3)	Tall	260	83	3:01	0.1	1	0.77
	P2 X P4 (4)	Tall	211	70	3:01	0	1	0.92
	P1 X P5 (5)	Tall	209	85	3:01	2.2	1	0.13
	P2 X P5 (6)	Tall	191	77	3:01	1.8	1	0.18
	P1 X P6 (7)	Tall	311	110	3:01	0.2	1	63
	P2 XP6 (8)	Tall	188	77	3:01	2.1	1	0.14
	P1 X P7 (9)	Tall	240	95	3:01	1.8	1	0.17
	P2 XP8 (10)	Tall	222	87	3:01	1.5	1	0.22
Overall	-	Tall	2666	945	3:01	2.6	1	0.1
BC	F1 X Dwarf							
	F1 (1) X P3		58	41	1:01	2.6	1	0.1
	F1 (2) X P3		43	47	1:01	0.3	1	0.57
	F1 (3) X P4		26	22	1:01	0.2	1	0.66
	F1 (4) X P4		25	21	1:01	0.2	1	0.66
	F1 (5) X P5		35	30	1:01	0.2	1	0.61
	F1 (6) X P5		28	26	1:01	0	1	0.92
	F1 (7) X P6		46	42	1:01	0.1	1	0.74
	F1 (8) X P6		29	25	1:01	0.2	1	0.68
	F1 (9) X P7		55	44	1:01	1	1	0.31
F1 (10) X P7		26	23	1:01	0.1	1	0.77	
Overall	-		371	321	1:01	3.5	1	0.06
BC	F1 X Tall							
	F1 (1) X P1		98	-	-	-	-	-
	F1 (2) X P2		90	-	-	-	-	-
	F1 (3) X P1		97	-	-	-	-	-
	F1 (4) X P2		85	-	-	-	-	-
	F1 (5) X P1		81	-	-	-	-	-
	F1 (6) X P2		72	-	-	-	-	-
	F1 (7) X P1		78	-	-	-	-	-
	F1 (8) X P2		74	-	-	-	-	-
	F1 (9) X P1		89	-	-	-	-	-
F1 (10) X P2		75	-	-	-	-	-	

**Table 4: Observed phenotypes and chi-square test of F<sub>2</sub> and backcross generation between brown and cream white seed colour**

Generation	Crosses	Phenotypes observed in F <sub>1</sub> & Reciprocal	Phenotypes observed		Expected ratio	X <sup>2</sup>	df	P-value
			Brown	Cream white				
F <sub>2</sub>	P1 X P4 (3)	Brown	262	82	3:01	0.2	1	0.66
	P2 X P4 (4)	Brown	219	62	3:01	1.1	1	0.28
Overall	-	Brown	481	144	3:01	1.2	1	0.27
BC	F1 X Cream white							
	F1 (3) X P4		28	20	1:01	1	1	0.31
	F1 (4) X P4		24	22	1:01	0	1	0.88
Overall	-		52	44	1:01	0.9	1	0.35
BC	F1 X Brown							
	F1 (3) X P1		97	-	-	-	-	-
	F1 (4) X P2		85	-	-	-	-	-

each of this crosses fitted for the monohybrid ratio of 3:1 indicating that the parents differed for a single gene. Over the F<sub>2</sub> families, 2244 plants were indeterminate and 723 were determinate fitting the overall segregation into a well fit of 3:1 ratio. Single gene for growth habit observed in F<sub>2</sub> was confirmed by making test cross. Chi-square test for all test cross population of respective crosses showed fitting to 1:1 ratio (Table 2). Over the test cross families, 295 plants exhibited indeterminate and 239 determinate growth habits with well-fitting to 1:1 ratio.

These results are in agreement with Reddy and Rao (1974) as the inheritance of indeterminate and determinate types in *Cajanus* revealed that the determinate type was recessive with a single factor difference. Gupta and Kapoor (1991) studied inheritance of DT and IDT growth habits in short-duration pigeonpea in F<sub>1</sub>, F<sub>2</sub>, and BC<sub>1</sub>F<sub>1</sub> generations of 15 crosses involving six parents. The segregation pattern in the crosses involving IDT and DT parent indicates that IDT growth habit is governed by a single dominant allele.

### Plant Height

For plant height, F<sub>1</sub>, reciprocal and back cross of dominant parent progenies of AKT-8811 × Dwarf 30, TAT-10 × Dwarf 30, AKT-8811 × Dwarf 45 white seeded, TAT-10 × Dwarf 45 white seeded, AKT-8811 × Dwarf 45 brown seeded, TAT-10 × Dwarf 45 brown seeded, AKT-8811 × Dwarf 60, TAT-10 × Dwarf 60, AKT-8811 × Dwarf 90 and TAT-10 × Dwarf 90 were tall indicating dominance of this trait over dwarf plant height with no cytoplasmic gene effect. Further, individual F<sub>2</sub> analysis of each cross inherited with a fitting in to 3:1 and also these crosses together resulted in 2666 tall plants out of 3611 plants and remaining plants (945) showed dwarf plant. These results fit into 3:1 ratio suggesting plant height is controlled by single gene. In view to confirmed the monogenic inheritance for plant height, all individual test cross progenies and overall testcross families segregated for 1:1 ratio (Table 3). Similar type of finding was also reported by Sheriff *et al* (1975) who found that dwarfness was under the control of a single recessive gene. Segregation in the F<sub>2</sub> population provided a ratio of 3 tall: 1 dwarf, representing that tallness is governed by a single pair of genes with dominance effect. Marekaret *al* (1978) observed complete dominance of tallness over dwarfness and this result confirmed with F<sub>2</sub> segregation. Gupta *et al.* (1992) crossed identified spontaneous dwarf mutant 011 with three tall lines (ICPL 146, ICPL 85024, ICPL 85037) and a 01 dwarf (ICPL 85059). The segregation pattern in F<sub>1</sub>, F<sub>2</sub>, backcrosses of both the parents and F<sub>3</sub> plants suggested that dwarfness is governed by a single recessive gene in homozygous condition.

### Seed coat colour

Regarding the seed coat colour two parents AKT-8811(P1) and TAT-10 (P2) were distinct for seed color with Dwarf 45 white seeded (P4); a female parent P1 and P2 was brown seed coat color while male parent P4 had cream white seed coat color. The F<sub>1</sub>, reciprocal and back cross with P1 and P2 parent was brown seed coat color indicating dominance of brown seed coat color over white color type and also no reciprocal differences were observed. F<sub>2</sub> segregation of each and every cross showed that seed coat color was governed by single gene. Overall F<sub>2</sub> segregation analysis of both crosses was done using 625 plants. Of the 625 F<sub>2</sub> plants observed, 481 were brown seed coat and 144 were white seed coat color well fitting for 3:1 (monogenic) ratio. Monogenic inheritance for seed coat color was confirmed with both test cross ratio. Overall segregation of test cross families segregated into 52 brown seeded plants and 42 cream white seeded plants and chi-

square test well fitted for 1:1 ratio. Details of segregation for seed coat color are given in Table 4. Monogenic inheritance of seed coat color was reported by earlier workers like Chaudhari and Thombre (1975) studied inheritance of different morphological characters including seed coat color in pigeonpea and observed seed coat color ratio of 3 brown: 1 white color in F<sub>2</sub> population. Mohar Singh (2014) reported that seed colour was governed by single gene. Similarly D'Cruz *et al.* (1974) and Deokar *et al.* (1972) reported seed coat colour ratio in F<sub>2</sub> population as 3 brown: 1 white.

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