

Inheritance of Qualitative Characters in Dolichos Bean *Lablab purpureus* L. Sweet

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Abstract

Dolichos bean *Lablab purpureus* L. Sweet is one of the multipurpose legumes, used as a cosmopolitan crop around the world. The crop is mainly grown for its green pods, used as vegetables while the dry seeds are used as dhal making. It is one of the major sources of protein as dietary in southern India. Its productivity is low 228 kg/ha and its nature of photo insensitivity resulted hindrance in the dolichos bean improvement. To break the yield barrier, inheritance study of qualitative character along with quantitative character is important. In this context, inheritance and interrelationships for five qualitative characters viz., growth habit, color of leaf, leaf structure, pod curvature and fragrance in a cross of GL 153 × HA 4 were studied. Inheritance revealed the complementary gene interaction (9 : 7) for leaf structure. Whereas, growth habit and color of leaf were controlled by three genes (39 : 25)—a one basic gene, one inhibitory gene and one anti-inhibitory gene governing this character. The pod curvature and fragrance/aroma were governed by four genes with a ratio 117 : 139 revealing that two complementary genes, one inhibitory and one anti-inhibitory gene were involved in these characters. In the reciprocal cross (HA 4 × GL 153) inheritance revealed that one basic independent and two complementary genes (57 : 7) for growth habit, color of leaf and leaf structure were controlled by three complementary genes (54 : 10). Four genes controlling pod curvature (195 : 61) indicate two duplicate, one inhibitory and one anti-inhibitory gene governing this character. Fragrance/aroma was governed by two genes with a ratio 13 : 3 revealing that one inhibitory gene was involved in this characters. From the study it reveals growth habit was governed by three genes GH₁, GH₂ act as GH₁ and GH₃ act as GH_{AI}. Whereas leaf color inherited by three genes basic gene DG₁, DG₂ act as DG₁ and DG₃ act as Dg_{AI}. While leaf structure was governed by three genes Ls₁, LS₂, and Ls₃ act as Ls₁ or Ls₂. Pod curvature was governed by four genes PC₁, PC₂, PC₁ and PC_{AI}. Fragrance was governed by three genes S₁, S_{AI}, S₁ act as S₁ and S₂ act as S_{AI}. Joint segregation revealed that there was no linkage exists among characters. All the characters were segregating independently. These different genetic ratio of direct and reciprocal cross was due to characters governed by duplicate genes, multiple alleles, genetic and cytoplasmic effects, maternal effects, and their interactions.

Key words : Inheritance, Interrelationship, Characters, Dolichos bean.

Dolichos bean (*Lablab purpureus* L. Sweet) is one of the most important sources of protein rich human food and has most likely bean is used as crop since Neolithic times. As a cosmopolitan crop, it is being grown in many regions of India and also elsewhere in the world. In India, field bean cultivation mainly confined to peninsular areas viz. Karnataka, Tamil Nadu and Andhra Pradesh. Karnataka is a leading state, accounts for nearly 90% of both area and production in the country. Karnataka state records production of about 17,046 tonnes of dolichos bean from an area of 83,114 hectares and productivity of 228 kg/ha (1). Plant breeding efforts to develop high

yielding varieties, in addition to high fragrance and photoinensitive determinate types is the essentiality in this crop. Variability presents for both qualitative and quantitative characters. Hence, it is one of the best materials for genetics studies. Genetic manipulation of a genotype requires a thorough understanding of genetic architecture of the plant. Such studies were very few and scattered in dolichos bean, and studies on qualitative morphological characters are also economically important. Most of the quality characters viz. growth habit, color of leaf, leaf structure, pod curvature and fragrance are important agronomic characters inherited in a qualitative

Table 1. Behavior of qualitative characters of parents, F_1 and segregation of F_2 of direct and reciprocal cross in GL-153 \times HA4.

Characters	P_1	P_2	F_1	Ratio	F_2	Ratio	χ^2	P	
1 Growth habit GL-153 \times HA4	Prostrate	Erect	Erect	Obs	Domi- nant	Reces- sive	F_2 39 : 25	1.24	0.5—0.25
					848	510			
HA4 \times GL-153	Erect	Prostrate	Erect	Obs	828	530	57 : 7	0.19	0.75—0.50
					760	98			
2 Color of leaf GL-153 \times HA4	Green	Dark green	Dark green	Obs	764	94	39 : 25	0.03	0.95—0.90
					831	527			
HA4 \times GL-153	Dark green	Green	Dark green	Obs	828	530	54 : 10	0.22	0.75—0.50
					719	139			
3 Leaf structure GL-153 \times HA4	Smooth	Rough	Rough	Exp	724	134	9 : 7	0.71	0.5—0.25
					780	578			
HA4 \times GL-153	Rough	Smooth	Rough	Obs	764	594	54 : 10	0.43	0.75—0.50
					717	141			
4 Pod curvature GL-153 \times HA4	Straight	Curved	Curved	Obs	724	134	117 : 139	1.43	0.25—0.10
					642	716			
HA4 \times GL-153	Curved	Straight	Curved	Exp	620	738	195 : 61	0.64	0.75—0.50
					644	214			
5 Fragrance GL-153 \times HA4	Low	High	High	Obs	654	204	117 : 139	1.70	0.25—0.10
					644	714			
HA4 \times GL-153	High	Low	High	Obs	620	738	13 : 3	0.03	0.90—0.75
					695	163			
				Exp	697	161			

way in this crop. Estimation of the genes governing these characters is essential for the breeding of Dolichos bean.

Methods

Genetics of five characters viz. growth habit, color of leaf, leaf structure, pod curvature and fragrance in a cross GL-153 \times HA4 and its reciprocal cross were recorded using descriptor of AVRDC of Taiwan. The observations in parents were compared with corresponding observations in F_1 to distinguish the dominant and recessive forms of the characters. Number of genes governing the characters and the nature of their action were determined by observing the segregation ratios in F_2 which were confirmed by studying the breeding behavior for each of the characters in F_3 families. The goodness of fit of observed in F_2 ratios with the expected ratios and the observed breeding behavior with the expected breeding behavior in F_3 families were tested by X^2 method

(2). Joint segregation ratio of the all possible pairs of characters were studied in F_2 to detect linkage, if any between segregation with the expected F_2 ratios was also tested by χ^2 method.

Results and Discussion

The phenotype of parents, F_1 and the phenotypic segregation ratios in F_2 ratio for different characters are given in Tables 1 to 8. Joint segregation of growth habit, color of leaf, leaf structure, pod curvature and fragrance are given in Tables 2 and 3. The number of genes and the nature of the action of each of the characters were as follows.

Growth Habit

Erect growth habit was dominant over prostrate habit and it was confirmed in F_2 ratio (39 : 25) suggested that three genes difference between the parents. The genotype of parents, F_1 and F_2 are

Table 2. Joint segregation of growth habit, color of leaf, leaf structure, pod curvature and fragrance in cross GL-153×HA4. Ind = Independent assortment.

Cross GL-153×HA4 Characters		Joint ratio	Obs/ Exp	Remarks
1	Growth habit (39 : 25) Color of leaf (39 : 25)	1521 : 975 : 975 : 625	Obs Exp	Ind
2	Growth habit (39 : 25) Leaf structure (9 : 7)	351 : 225 : 273 : 175	Obs Exp	Ind
3	Growth habit (39 : 25) Pod curvature (117 : 139)	5421 : 3375 : 4719 : 3025	Obs Exp	Ind
4	Growth habit (39 : 25) Fragrance (117 : 139)	4563 : 2925 : 5421 : 3475	Obs Exp	Ind
5	Color of leaf (39 : 25) Leaf structure (9 : 7)	351 : 225 : 273 : 175	Obs Exp	Ind
6	Color of leaf (39 : 25) Pod curvature (117 : 139)	4563 : 2925 : 5421 : 3475	Obs Exp	Ind
7	Color of leaf (39 : 25) Fragrance (117 : 139)	4563 : 2925 : 5421 : 3475	Obs Exp	Ind
8	Leaf structure (9 : 7) Pod curvature (117 : 139)	1053 : 819 : 1251 : 973	Obs Exp	Ind
9	Leaf structure (9 : 7) Fragrance (117 : 139)	1053 : 819 : 1251 : 973	Obs Exp	Ind
10	Pod curvature (117 : 139) Fragrance (117 : 139)	13689 : 16263 : 16263 : 19321	Obs Exp	Ind

Table 2. Continued.

Cross GL-153×HA4 Characters		F ₂ Phenotypic Joint segregation				χ ²	P
		AB	Ab	aB	ab		
1	Growth habit (39 : 25) Color of leaf (39 : 25)	500	331	348	179	5.97	0.25—0.10
		505	323	323	207		
2	Growth habit (39 : 25) Leaf structure (9 : 7)	476	304	372	206	3.52	0.5—0.25
		466	298	362	232		
3	Growth habit (39 : 25) Pod curvature (117 : 139)	389	253	459	257	4.62	0.25—0.10
		379	241	449	289		
4	Growth habit (39 : 25) Fragrance (117 : 139)	390	254	450	256	4.97	0.25—0.10
		379	241	449	289		
5	Color of leaf (39 : 25) Leaf structure (9 : 7)	460	320	371	207	4.57	0.25—0.10
		466	298	362	232		
6	Color of leaf (39 : 25) Pod curvature (117 : 139)	381	261	450	266	3.50	0.50—0.25
		379	241	449	289		
7	Color of leaf (39 : 25) Fragrance (117 : 139)	401	243	430	284	0.54	0.95—0.90
		392	250	436	280		
8	Leaf structure (9 : 7) Pod curvature (117 : 139)	349	271	415	323	3.28	0.50—0.25
		360	282	420	296		
9	Leaf structure (9 : 7) Fragrance (117 : 139)	370	274	410	304	0.78	0.90—0.75
		361	281	403	313		
10	Pod curvature (117 : 139) Fragrance (117 : 139)	308	334	334	382	1.69	0.75—0.50
		293	349	327	389		

proposed as follows.

P₁ = gh₁ gh₁, GH₁ GH₁, GH_{AI} GH_{AI} = Prostrate
P₂ = GH₁ GH₁, gh₁ gh₁, gh_{ai} gh_{ai} = Erect

F₁ = GH₁ gh₁, GH₁ gh₁, GH_{AI} gh_{ai} = Erect
F₂ = 27 GH₁⁻ GH₁⁻ GH_{AI}⁻ GH_{AI}⁻ = Erect
9 GH₁⁻ GH₁⁻ = Prostrate

Table 3. Joint segregation of growth habit, color of leaf, leaf structure, pod curvature and fragrance in cross HA4 × GL-153. Ind = Independent assortment.

Cross HA4 × GL-153		Characters	Joint ratio	Obs/ Exp
1	Growth habit (57 : 7)	Color of leaf (54 : 10)	3078 : 378 : 570 : 70	Obs/Exp
2	Growth habit (57 : 7)	Leaf structure (54 : 10)	3078 : 378 : 570 : 70	Obs/Exp
3	Growth habit (57 : 7)	Pod curvature (195 : 61)	11115 : 1365 : 3477 : 427	Obs/Exp
4	Growth habit (57 : 7)	Fragrance (13 : 3)	741 : 91 : 171 : 21	Obs/Exp
5	Color of leaf (54 : 10)	Leaf structure (54 : 10)	2916 : 540 : 540 : 100	Obs/Exp
6	Color of leaf (54 : 10)	Pod curvature (195 : 61)	10530 : 1950 : 3294 : 610	Obs/Exp
7	Color of leaf (54 : 10)	Fragrance (13 : 3)	702 : 130 : 162 : 30	Obs/Exp
8	Leaf structure (54 : 10)	Pod curvature (195 : 61)	10530 : 1950 : 3294 : 610	Obs/Exp
9	Leaf structure (54 : 10)	Fragrance (135 : 121)	702 : 130 : 162 : 30	Obs/Exp
10	Pod curvature (195 : 61)	Fragrance (13 : 3)	2535 : 793 : 585 : 183	Obs/Exp

Table 3. Continued.

Cross HA4 × GL-153		Characters	Rem- arks	F ₂ Phenotypic Joint segregation				χ ²	P
1	Growth habit (57 : 7)	Color of leaf (54 : 10)		AB	Ab	aB	ab		
				648	76	116	18		
			Ind	646	73	114	25	2.12	0.75—0.50
2	Growth habit (57 : 7)	Leaf structure (54 : 10)		648	76	116	18		
			Ind	646	71	114	27	3.39	0.50—0.25
3	Growth habit (57 : 7)	Pod curvature (195 : 61)		630	84	130	14		
			Ind	636	76	128	18	1.82	0.75—0.50
4	Growth habit (57 : 7)	Fragrance (13 : 3)		621	76	143	18		
			Ind	619	76	141	22	0.77	0.90—0.75
5	Color of leaf (54 : 10)	Leaf structure (54 : 10)		609	108	110	31		
			Ind	611	113	113	21	5.06	0.25—0.11
6	Color of leaf (54 : 10)	Pod curvature (195 : 61)		628	91	123	16		
			Ind	630	94	110	24	4.31	0.25—0.11
7	Color of leaf (54 : 10)	Fragrance (13 : 3)		584	135	111	28		
			Ind	588	136	109	25	0.44	0.95—0.90
8	Leaf structure (54 : 10)	Pod curvature (195 : 61)		626	91	123	18		
			Ind	630	94	110	24	3.15	0.50—0.25
9	Leaf structure (54 : 10)	Fragrance (135 : 121)		580	115	137	26		
			Ind	588	107	136	25	0.75	0.90—0.75
10	Pod curvature (195 : 61)	Fragrance (13 : 3)		526	170	120	43		
			Ind	529	168	125	36	1.63	0.75—0.50

9 GH₁-GH_{Al}- = Erect
 9 GH₂-GH_{Al}- = Prostrate
 3 GH₁- = Erect
 3 GH₁- = Prostrate
 3 GH_{Al}- = Prostrate
 1 gh₁ gh₁ gh₁ gh₁ gh_{ai} gh_{ai} = Prostrate

Erect character was governed by one basic gene, one inhibitory gene and one anti-inhibitory gene giving F₂ ratio of 39 : 25. Similar results of gene action, was reported in cowpea (3).

In the reciprocal cross, phenotypic segregation ratios (57 : 7) in F₂ suggested that three genes different among the parents. Girish (4) reported dominant single gene governing erect growth habit character and showed F₂ ratio (3 : 1) in cowpea. Viswanatha and Jayshree (5) reported indeterminate growth habit was controlled by duplicate complementary genes over bushy growth habit in cowpea (54 : 10).

P₁ = GH₁ GH₁, GH₂ GH₂, GH₃ GH₃ = Erect

Table 4. Breeding behavior of growth habit in F_3 generation of both direct and reciprocal cross GL153 \times HA4.

Frequecies	Breeding true for straight pods	Families segregating into									Breeding true for curved pods	χ^2	<i>P</i>
GL153\timesHA4													
Observed frequencies	1 : 0 5.00	39 : 25 4.00	13 : 3 3.00	9 : 7 2.00	3 : 13 3.00	3 : 1 11.00	1 : 3 1.00	15 : 1 -	57 : 7 -	0 : 1 11.00	0.802	0.999— 0.995	
Expected frequencies on F_2 ratio 39 : 25 (7 : 8 : 4 : 4 : 4 : 16 : 2 : 19)	4.38	5.00	2.50	2.50	2.50	10.00	1.25	-	-	11.88			
HA4 \times GL153													
Observed frequencies	13.00	-	-	2.00	-	12.00	-	6.00	3.00	4.00	1.0285	0.95— 0.90	
Expected frequencies on F_2 ratio 57 : 7 (19 : 18 : 8 : 4 : 8 : 7)	11.88	-	-	2.50	-	11.25	-	5.00	5.00	4.38			

Table 5. Breeding behavior of leaf color in F_3 generation of both direct and reciprocal cross GL153 \times HA4.

Frequecies	Breeding true for straight pods	Families segregating into									Breeding true for curved pods	χ^2	<i>P</i>
GL153 \times HA4													
Observed frequencies	1 : 0 6.00	39 : 25 3.00	13 : 3 2.00	9 : 7 3.00	3 : 13 3.00	3 : 1 12.00	1 : 3 1.00	15 : 1 -	54 : 10 -	0 : 1 10.00	2.446	0.95— 0.90	
Expected frequencies on F_2 ratio 39:25 (7:8:4:4:4:16:2:19)	4.38	5.00	2.50	2.50	2.50	10.00	1.25	-	-	11.88			
HA4 \times GL153													
Observed frequencies	7.00	-	-	-	-	9.00	-	5.00	3.00	7.00	2.41	0.95— 0.90	
Expected frequencies on F_2 ratio 54:10 (10:12:12:8:12:10)	6.25	-	-	-	-	7.50	-	7.50	5.00	6.25			

Table 6. Breeding behavior of leaf structure in F₃ generation of direct and reciprocal cross GL153 × HA4.

Frequencies	Breeding true for straight pods	Families segregating into					Breeding true for curved pods	χ^2	<i>P</i>
GL153 × HA4									
Observed frequencies	1 : 0	9 : 7	3 : 1	15 : 1	54 : 10	0 : 1			
Expected frequencies on F ₂ ratio 9 : 7 (1 : 4 : 4 : 7)	2.00	8.00	11.00	–	–	19.00	0.73	0.95–0.90	
Expected frequencies on F ₂ ratio 9 : 7 (1 : 4 : 4 : 7)	2.50	10.00	10.00	–	–	17.50			
HA4 × GL153									
Observed frequencies	8.00	8.00	10.00	5.00	2.00	7.00	4.07	0.90–0.95	
Expected frequencies on F ₂ ratio 54 : 10 (10 : 12 : 12 : 8 : 12 : 10)	6.25	7.50	7.50	7.50	5.00	6.25			

P₂ = gh₁ gh₁, gh₂ gh₂, gh₃ gh₃ = Prostrate
 F₁ = GH₁ gh₁, GH₂ gh₂, GH₃ gh₃ = Erect
 F₂ = 27 GH₁–GH₂–GH₃– = Erect
 9 GH₁–GH₂– = Erect
 9 GH₁–GH₃– = Erect
 9 GH₂–GH₃– = Erect
 3 GH₁– = Erect
 3 GH₂– = Prostrate
 3 GH₃– = Prostrate
 1 gh₁ gh₁, gh₂ gh₂, gh₃ gh₃ = Prostrate

Erect character was governed by one basic independent and two complementary genes giving F₂ ratio of 57 : 7.

Color of Leaf

The contracting phenotypes were dark green and light green and in F₁ dark green was found to be dominant over light green. In F₂ of this cross, 39 : 25 ratio of dark green to light green was observed, which meant that three pairs of alleles were controlling this character. This variation was controlled by one basic gene, one inhibitory gene and one anti-inhibitory gene.

P₁ = dg₁ dg₁, DG₁ DG₁, DG_{AI} DG_{AI} = Light green
 P₂ = DG₁ DG₁, dg₁ dg₁, dg_{AI} dg_{AI} = Dark green
 F₁ = DG₁ dg₁, DG₁ dg₁, DG_{AI} dg_{AI} = Dark green
 F₂ = 27 DG₁–DG₁–DG_{AI}– = Dark green
 9 DG₁–DG₁– = Light green
 9 DG₁–DG_{AI}– = Dark green
 9 DG₁–DG_{AI}– = Light green

3 DG₁– = Dark green
 3 DG₁– = Light green
 3 DG_{AI}– = Light green
 1 dg₁ dg₁, dg₂ dg₂, dg₃ dg₃ = Light green

In its reciprocal cross, F₂ of this cross, 54 : 10 ratio of dark green to green was observed which meant that three complementary genes were controlling this character. Girish (4), Venugopal and Goud (6) indicated single dominant gene governing dark green color in cowpea. Kolhe (7) reported a 9 : 7 (dark green : green) ratio in F₂ for this character.

P₁ = DG₁ DG₁, DG₂ DG₂, DG₃ DG₃ = Dark green
 P₂ = dg₁ dg₁, dg₂ dg₂, dg₃ dg₃ = Light green
 F₁ = DG₁ dg₁, DG₂ dg₂, DG₃ dg₃ = Dark green
 F₂ = 27 DG₁ dg₁, DG₂ dg₂, DG₃ dg₃ = Dark green
 9 DG₁–DG₂– = Dark green
 9 DG₁–DG₃– = Dark green
 9 DG₂–DG₃– = Dark green
 3 DG₁– = Light green
 3 DG₂– = Light green
 3 DG₃– = Light green
 1 dg₁ dg₁, dg₂ dg₂, dg₃ dg₃ = Light green

Leaf Structure

The F₁ phenotype indicated that rough leaf structure was dominant over smooth type and F₂ ratio was 9 rough : 7 smooth indicating the two genes governing this character.

P₁ = ls₁ ls₁, ls₂ ls₂ = Smooth leaves

Table 7. Breeding behavior of pod curvature in F₃ generation of direct and reciprocal cross GL153 × HA4.

Frequencies	Breeding true for straight pods	Families segregating into						
GL153 × HA4								
Observed frequencies	1 : 0 1.00	117 : 139 1.00	39 : 25 2.00	27 : 37 1.00	9 : 55 1.00	13 : 3 1.00	9 : 7 5.00	3 : 13 2.00
Expected frequencies on F ₂ ratio 117 : 139 (7 : 16 : 16 : 8 : 8 : 4 : 36 : 12 : 26 : 2 : 121)	1.09	2.50	2.50	1.25	1.25	0.63	5.63	1.88
HA4 × GL153								
Observed frequencies	10	—	1.00	—	—	3.00	2.00	1.00
Expected frequencies on F ₂ ratio 195 : 61 (51 : 14 : 40 : 8 : 8 : 29 : 28 : 16 : 8 : 8 : 16 : 31)	7.97	—	2.5	—	—	4.38	1.25	1.25

Table 7. Continued.

Frequencies	Families segregating into							Breeding true for curved pods	χ ²	P
GL153 × HA4										
Observed frequencies	3 : 1 5.00	1 : 3 1.00	15 : 1 —	45 : 19 —	49 : 15 —	195 : 61 —	0 : 1 20	3.25	0.99–0.97	
Expected frequencies on F ₂ ratio 117 : 139 (7 : 16 : 16 : 8 : 8 : 4 : 36 : 12 : 26 : 2 : 121)	4.00	0.31	—	—	—	—	18.81			
HA4 × GL153										
Observed frequencies	6.00	3.00	1.00	0.0	1.00	0.0	7.00	10.0	0.5–0.9	
Expected frequencies on F ₂ ratio 195 : 61 (51 : 14 : 40 : 8 : 8 : 29 : 28 : 16 : 8 : 8 : 16 : 31)	6.25	2.19	4.38	1.25	1.25	2.5	4.85			

P₂ = LS₁ LS₁, LS₂ LS₂
 F₁ = LS₁ ls₁, LS₂ ls₂
 F₂ = 9 LS₁–LS₂–
 3 LS₁–ls₂ ls₂
 3 ls₁ ls₁ LS₂–
 1 ls₁ ls₁, ls₂ ls₂

= Rough leaves
 = Rough leaves
 = Rough leaves
 = Smooth leaves
 = Smooth leaves
 = Smooth leaves

type indicated that rough leaf structure was dominant over smooth type and F₂ ratio 54 rough : 10 smooth indicating three complementary genes were governing this character.

P₁ = LS₁ LS₁, LS₂ LS₂, LS₃ LS₃
 P₂ = ls₁ ls₁, ls₂ ls₂, ls₃ ls₃

= Rough leaves
 = Smooth leaves

Whereas in its reciprocal cross. The F₁ pheno-

Table 8. Breeding behavior of fragrance in F₃ generation of direct and reciprocal cross GL153 × HA4.

Frequencies	Breeding true for straight pods	Families segregating into					
GL153 × HA4							
Observed frequencies	1 : 0	117 : 139	39 : 25	27 : 37	9 : 55	13 : 3	9 : 7
Expected frequencies on F ₂ ratio 117 : 139 (7 : 16 : 16 : 8 : 8 : 4 : 36 : 12 : 26 : 2 : 121)	0	2	2	0	2	1	6
	1.09	2.50	2.50	1.25	1.25	0.63	5.63
HA4 × GL153							
Observed frequencies	19	—	—	—	—	13	—
Expected frequencies on F ₂ ratio 13 : 3 : 7 : 2 : 2 : 4 : 1	17	—	—	—	—	10	—

Table 8. Continued.

Frequencies	Families segregating into				Breeding true for curved pods	χ^2	<i>P</i>
GL153 × HA4							
Observed frequencies	3 : 13	3 : 1	1 : 3	15 : 1	0 : 1	3.753	0.97–0.95
Expected frequencies on F ₂ ratio 117 : 139 (7 : 16 : 16 : 8 : 8 : 4 : 36 : 12 : 26 : 2 : 121)	2	5	0	—	2		
	1.88	4.00	0.31	—	18.81		
HA4 × GL153							
Observed frequencies	—	3	—	4	1	5.45	0.90–0.95
Expected frequencies on F ₂ ratio 13 : 3 : 7 : 2 : 2 : 4 : 1	—	5	—	5	3		

F₁ = LS₁ ls₁, LS₂ ls₂, LS₃ ls₃ = Rough leaves
 F₂ = 27 LS₁ ls₁, LS₂ ls₂, LS₃ ls₃ = Rough leaves
 9 LS₁–LS₂ = Rough leaves
 9 LS₁–LS₃ = Rough leaves
 9 LS₂–LS₃ = Rough leaves
 3 LS₁– = Smooth
 3 LS₂– = Smooth
 3 LS₃– = Smooth
 1 ls₁ls₁, ls₂ls₂, ls₃ls₃ = Smooth

Pod Curvature

Curved and straight pods were the contrasting and F₁ character revealed that curved pods were dominant over straight pods. The F₂ ratio was 117 curved and 139 straight pods which meant that curved pod

character is governed by two complementary genes, one inhibitory and one anti-inhibitory gene.

P₁ = PC₁ PC₁, PC₂ PC₂, PC₁ PC₁, PC_{AI} PC_{AI} = Curved
 P₂ = pc₁ pc₁, pc₂ pc₂, pc_i pc_i, pc_{ai} pc_{ai} = Straight
 F₁ = PC₁ pc₁, PC₂ pc₂, PC₁ pc_i, PC₁ pc_{ai} = Curved
 F₂ = 81 PC₁–PC₂–PC₁–PC_{AI}– = Curved
 27 PC₁–PC₂–PC₁– = Straight
 27 PC₁–PC₂–PC_{AI}– = Curved
 27 PC₁–PC₃–PC_{AI}– = Straight
 27 PC₂–PC₃–PC_{AI}– = Straight
 9 PC₁–PC₂– = Curved
 9 PC₁–PC₁– = Straight
 9 PC₁–PC_{AI}– = Straight
 9 PC₂–PC₁– = Straight
 9 PC₂–PC_{AI}– = Straight
 9 PC₃–PC_{AI}– = Straight

3 PC ₁ -	= Straight
3 PC ₂ -	= Straight
3 PC ₁ -	= Straight
3 PC _{AI} -	= Straight
1 pc ₁ pc ₁ pc ₂ pc ₂ pc _i pc _i pc _{ai} pc _{ai}	= Straight

The reciprocal cross F₂ ratio was 195 curved 61 straight pods which meant that curved character is governed by a two duplicate, one inhibitory and one anti inhibitory gene. In cowpea, inhibitory gene action was governing this character (4).

P ₁ = pc ₁ pc ₁ , pc ₂ pc ₂ , pc _i pc _i , pc _{ai} pc _{ai}	= Straight
P ₂ = PC ₁ PC ₁ , PC ₂ PC ₂ , PC ₁ PC ₁ , PC _{AI} PC _{AI}	= Curved
F ₁ = PC ₁ pc ₁ , PC ₂ pc ₂ , PC ₁ pc _i , PC _{AI} pc _{ai}	= Curved
F ₂ = 81 PC ₁ -PC ₂ -PC ₁ -PC _{AI} -	= Curved
27 PC ₁ -PC ₂ -PC ₁ -	= Straight
27 PC ₁ -PC ₂ -PC _{AI} -	= Curved
27 PC ₁ -PC ₃ -PC _{AI} -	= Curved
27 PC ₂ -PC ₃ -PC _{AI} -	= Curved
9 PC ₁ -PC ₂ -	= Curved
9 PC ₁ -PC ₁ -	= Straight
9 PC ₁ -PC _{AI} -	= Curved
9 PC ₂ -PC ₁ -	= Straight
9 PC ₂ -PC _{AI} -	= Curved
9 PC ₃ -PC _{AI} -	= Straight
3 PC ₁ -	= Curved
3 PC ₂ -	= Curved
3 PC ₁ -	= Straight
3 PC _{AI} -	= Straight
1 pc ₁ pc ₁ pc ₂ pc ₂ pc _i pc _i pc _{ai} pc _{ai}	= Straight

Fragrance

The fragrance (aroma/dodenoic acid) in dolichos varies from genotype to genotype. There is no information on the genetics of this character. The F₁, F₂ and F₃ generation of this cross showing presence of high fragrance was dominant over absence of fragrance in dolichos. The non-significant result of χ² showed that two complementary genes, one inhibitory and one anti-inhibitory genes were involved to produce this variation i.e. four genes (117 high : 139 low) governing this character in dolichos. In rice four complementary genes have been postulated to determine scent as suggested by the ratio of 81 : 175 (8).

P ₁ = s ₁ s ₁ , s ₂ s ₂ , S ₁ S ₁ , S _{AI} S _{AI}	= Low
P ₂ = S ₁ S ₁ , S ₂ S ₂ , s ₁ s ₁ , S _{AI} S _{AI}	= High
F ₁ = S ₁ s ₁ , S ₂ s ₂ , S ₁ S ₁ , S _{AI} S _{AI}	= High
F ₂ = 81 S ₁ -S ₂ -S ₁ -	= High
27 S ₁ -S ₂ -S ₁ -	= Low
27 S ₁ -S ₂ -S _{AI} -	= High

27 S ₁ -S ₁ -S _{AI} -	= Low
27 S ₂ -S ₁ -S _{AI} -	= Low
9 S ₁ -S ₂ -	= High
9 S ₁ -S ₁ -	= Low
9 S ₁ -S _{AI} -	= Low
9 S ₂ -S ₁ -	= Low
9 S ₂ -S _{AI} -	= Low
9 S ₃ -S _{AI} -	= Low
3 S ₁ -	= Low
3 S ₂ -	= Low
3 S ₁ -	= Low
3 S _{AI} -	= Low
1 s ₁ s ₁ s ₂ s ₂ S ₁ S ₁ S _{AI} S _{AI}	= Low

In reciprocal cross the presence of fragrance was dominant character and in F₂ ratio it was governed by two genes with inhibitory and anti-inhibitory gene action. Scent has been reported to be monogenic and dominant over no scent (9—11). A digenic segregation of 9 scented : 7 non-scented (9) and 15 scented : 1 non-scented have been recorded (11, 12). A trigenic complementary ratio of 27 : 37 was obtained (13). Chakravarty (14) observed 13 non-scented : 3 scented, which pointed to action of an inhibitory gene. Ghose et al. (15) and Reddy and Reddy (16) found the non-scented condition to be monogenic and dominant over the scented condition.

P ₁ = S _{AI} S _{AI} , s ₁ s ₁	= High
P ₂ = s _{ai} s _{ai} , S ₁ S ₁	= Low
F ₁ = S _{AI} s _{ai} , S ₁ s ₁	= High
F ₂ = 9 S _{AI} -S ₁ -	= High
3 S _{AI} -s ₁	= High
3 s _{ai} S ₁ -	= Low
1 s _{ai} s _{ai} s ₁ s ₁	= High

The results pertaining joint segregation of various characters in F₂ in Table 2 indicating independent assortment was observed in all pairs of characters in dolichos indicating that there is no linkage exist between the characters on chromosome.

The present study indicates the growth habit was governed by three genes GH₁, GH₂ act as GH₁ and GH₃ act as GH_{AI}. Whereas leaf color inherited by three genes, basic gene DG₁, DG₂ act as DG₁ and DG₃ act as Dg_{AI}. While leaf structure was governed by three genes Ls₁, Ls₂, and Ls₃ act as Ls₁ or Ls₂. Pod curvature was governed by four genes PC₁, PC₂, PC₁ and PC_{AI}. Fragrance was governed by three genes S₁, S_{AI}, S₁ act as S₁ and S₂ act as S_{AI}. These different genetic ratios of direct and reciprocal cross is due to characters that were governed by duplicate genes,

multiple alleles, genetic and cytoplasmic effects, maternal effects and their interactions.

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