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STEM TERMINATION GENETICS IN PIGEONPEA VARIANTS (*CAJANUS CAJAN* (L.) MILLSP)

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ABSTRACT

In pigeonpea, there are three distinct growth habits of plants types which differ in the morphology of the inflorescence, that are determinate (DT), semidetermInte (SDT) and indeterminate (IDT). Growth habit is useful trait because of short stature of the determinate plant types makes them amenable to efficient crop management practices, such as foliar insecticide application and mechanized crop production. Indeterminate plants, on the other hand, grow taller; hence, efficient management and mechanization become difficult. But indeterminate genotypes yielded more than determinate genotype in semiarid environment. Indeterminate plants produce flowers throughout the growing season whenever sufficient moisture is available. This is not possible in case of determinate genotypes. While semideterminate growth habit was rarely observed in pigeonpea germplasm. Inheritance studies of growth habit, indeterminate Vs determinate and indeterminate Vs semideterminate growth habit was studied with seven populations (parents, F_1, reciprocal, F_2 and both back cross) of eight and two crosses with respective characters. Data analysis of segregating populations (F_2s and test crosses) was carried out with the help of chi-square test. Present studies showed that indeterminate growth habit was completely dominant over determinate plant type and indeterminate trait was governed by single gene as all F_2 and their test cross progenies segregated and well fitted for 3:1 and 1:1 ratio in cross IDT Vs DT. Inheritance study of indeterminate Vs semideterminate growth habit showed dominant epistatic ratio for two loci of 12:3:1, IDT/ SDT/DT in F_2 population. This result confirmed with test cross and back cross with dominant parents. From present study of IDT Vs SDT, it was concluded that indeterminate growth habit was governed by Dt_1/dt_2s and semideterminate as dt_1/Dt_{2s}. The presence of Dt_1 allele completely masked the expression of Dt_2s allele. The presences of the recessive allele of these genes in homozygous state (dt_1 dt_1, dt_2s dt_2s) result in determinate growth habits. While no reciprocal differences were observed in inheritance pattern of IDT Vs DT and IDT Vs SDT, indicating no maternal effect to govern the traits.

INTRODUCTION

In pigeonpea, there are three distinct growth habits of plants types which differ in the morphology of the inflorescence, that are determinate, semidetermInte and indeterminate. In plants with determinate growth habit, the inflorescence is short, the apical buds develop into the flower and the sequence of inflorescence production is basipetal such plants are compact and have moderate height and their flowering duration is comparatively short (Sheldrake, 1984). In the semideterminate plants, the inflorescence in plant after initiation of reproductive growth, grow as in indeterminate plants, resulting in elongated flowering or fruiting branches terminating with a flower as in the plants with determinate growth habit. In the indeterminate plants, the flowers are scattered. New vegetative buds and leaves are produced even after initiation of reproductive growth, plants grow tall and flower duration is comparatively long.

Among the many traits, growth habit has been found to be useful markers. For example short stature of the determinate plant types makes them amenable to efficient crop management practices, such as foliar insecticide application and mechanized crop production. Indeterminate plants, on the other hand, grow taller; hence, efficient management and mechanization become difficult. Most of the traditional medium (maturing in 150-200 days) and long-duration (maturing in >200 days) pigeonpea cultivars are tall indeterminates, resulting in low productivity, mainly because of inefficient pest (mainly *Helicoverpa armigera* pod borer) control (Gupta & Kappor 1991). Some benefit of indeterminate plant type reported by Quisenberry and Roark in 1976. They found that indeterminate genotypes yielded more than determinate genotype in semiarid environment. Indeterminate plants produce flowers throughout the growing season whenever sufficient moisture is available. This is not possible in case of determinate genotypes. While semideterminate growth habit was rarely observed in pigeonpea germplasm.

Information on the genetics on stem termination in pigeonpea genotypes is limited and contradictory (Waldia and Singh 1987). Very few studies have been reported on inheritance pattern of indeterminate or determinate growth habit in pigeonpea. To our knowledge only one study on semideterminate growth habit was carried out by Gupta and Kapoor in 1991. Inheritance of semideterminate growth habit was first time reported by using parent gigas leaf variant. This paper gives an additional data on the inheritance of indeterminate, semideterminate and determinate growth habit in pigeonpea.

MATERIALS AND METHODS

Five pigeonpea variants used as male parents i.e four height variants (Dwarf 30, Dwarf 45 white seed, Dwarf 45 brown seed and Dwarf 60) were determinate growth habit and one leaf variant (Gigas leaf variant) having semideterminate growth habit. Two commercially released varieties of pigeonpea i.e AKT-8811 and TAT-10 were used as female lines both having indeterminate growth habit. All male crossed with each female in kharif 2009. Five populations F_1s, reciprocals, F_2s, back crosses and test crosses were developed from respective crosses. All these populations were grown on 12th July 2011 at spacing 60 × 20 cm sufficiently for inheritance studies. At flowering stage the number of determinate, semideterminate and indeterminate plants of each population was recorded. Chi-square analysis was used to test the significance of deviation from expected segregation.

RESULTS AND DISCUSSION

All seven parents used in present study bred true for growth habit. All parents not showed segregation after selfing in future generation, suggesting that all parents used for present studies are genetically pure.

Indeterminate × Determinate

All the F_1s and reciprocals plants in the crosses involving IDT × DT parents and BC_1 F_1 plants with indeterminate parents were of IDT type for all four crosses, indicating the dominance of gene or genes governing IDT growth habit over those for DT growth habit. The F_2 progeny of each cross showed a 3:1

Table 1: Segregation for indeterminate and determinate growth habit in different population of pigeonpea variants

Generation & Cross	Number of plants					Ratio	X^2	P
	Total	Observed		Expected				
		IDT	DT	IDT	DT			
1) AKT-8811 × Dwarf 30								
F_1 & Reciprocal	30	30	-	All IDT	-	-	-	-
F_2	580	453	127	435	145	3:1	2.81	0.09
F_1 × Dwarf 30	99	54	45	49.5	49.5	1:1	0.61	0.42
F_1 × AKT-8811	98	98	-	All IDT	-	-	-	-
2) TAT-10 × Dwarf 30								
F_1 & Reciprocal	30	30	-	All IDT	-	-	-	-
F_2	515	390	125	386.25	128.75	3:1	0.10	0.75
F_1 × Dwarf 30	90	46	44	45	45	1:1	0.01	0.92
F_1 × TAT-10	90	90	-	All IDT	-	-	-	-
3) AKT-8811 × Dwarf 45 white seed								
F_1 & Reciprocal	30	30	-	All IDT	-	-	-	-
F_2	343	254	89	257.25	85.75	3:1	0.11	0.74
F_1 × Dwarf 45 white seed	48	25	23	24	24	1:1	0.02	0.88
F_1 × AKT-8811	97	97	-	All IDT	-	-	-	-
4) TAT-10 × Dwarf 45 white seed								
F_1 & Reciprocal	30	30	-	All IDT	-	-	-	-
F_2	281	216	65	210.75	70.25	3:1	0.42	0.51
F_1 × Dwarf 45 white seed	46	26	20	23	23	1:1	0.51	0.47
F_1 × TAT-10	85	85	-	All IDT	-	-	-	-
5) AKT-8811 × Dwarf 45 brown seed								
F_1 & Reciprocal	30	30	-	All IDT	-	-	-	-
F_2	294	215	79	220.5	73.5	3:1	0.45	0.50
F_1 × Dwarf 45 brown seed	65	38	27	32.5	32.5	1:1	1.53	0.21
F_1 × AKT-8811	81	81	-	All IDT	-	-	-	-
6) TAT-10 × Dwarf 45 brown seed								
F_1 & Reciprocal	30	30	-	All IDT	-	-	-	-
F_2	268	198	70	201	67	3:1	0.12	0.72
F_1 × Dwarf 45 brown seed	54	29	25	27	27	1:1	0.16	
F_1 × TAT-10	72	72	-	All IDT	-	-	-	-
7) AKT-8811 × Dwarf 60								
F_1 & Reciprocal	30	30	-	All IDT	-	-	-	-
F_2	421	323	98	315.75	105.25	3:1	0.57	0.44
F_1 × Dwarf 60	88	48	40	44	44	1:1	0.55	0.45
F_1 × AKT-8811	78	78	-	All IDT	-	-	-	-
8) TAT-10 × Dwarf 60								
F_1 & Reciprocal	30	30	-	All IDT	-	-	-	-
F_2	265	195	70	198.5	66.25	3:1	0.21	0.64
F_1 × Dwarf 60	54	29	25	27	27	1:1	0.16	0.68
F_1 × TAT-10	74	74	-	All IDT	-	-	-	-
Pooled (IDT × DT crosses)								
F_1 & Reciprocal	240	-	-	All IDT	-	-	-	-
F_2	2967	2244	723	2225.25	741.75	3:1	0.59	0.44
F_1 × DT (Parent)	544	295	249	272	272	1:1	3.72	0.053
F_1 × IDT (Parent)	675	675	-	All IDT	-	-	-	-

Table 2: Segregation for indeterminate and semideterminate growth habit in different population of pigeonpea variants

Generation & Cross	Number of plants							Ratio	X^2	P
	Total	Observed			Expected					
		IDT	SDT	DT	IDT	SDT	DT			
1) AKT-8811 × Gigas leaf variant										
F_1 & Reciprocal	30	30	-	-	All IDT	-	-	-	-	-
F_2	615	459	105	51	416.25	115.32	38.43	12:3:1	5.03	0.08
F_1 × Gigas leaf variant	135	77	58	-	67.50	67.50	-	1:1	2.40	0.12
F_1 × AKT-8811	75	75	-	-	All IDT	-	-	-	-	-
2) TAT-10 × Gigas leaf variant										
F_1 & Reciprocal	30	30	-	-	All IDT	-	-	-	-	-
F_2	483	363	85	35	362.5	90.56	30.18	12:3:1	1.11	0.57
F_1 × Gigas leaf variant	113	61	52	-	56.5	56.5	-	1:1	0.56	0.45
F_1 × TAT-10	73	73	-	-	All IDT	-	-	-	-	-
Pooled (IDT × SDT crosses)										
F_1 & Reciprocal	60	60	-	-	All IDT	-	-	-	-	-
F_2	1098	8202	190	86	823.5	205.87	68.62	12:3:1	5.62	0.06
F_1 × SDT (Parent)	248	138	110	-	124	124	-	1:1	2.93	0.08
F_1 × IDT (Parent)	148	148	-	-	All IDT	-	-	-	-	-

segregation ratio of IDT and DT types. The same segregation ratio was found in the pooled data of these four crosses (heterogeneity X^2 was non significant), indicating that the indeterminate character is controlled by single dominant gene. Test cross progenies of all four crosses segregated as 1:1 (IDT/DT) ratio. Pooled analysis of all test cross progenies showed same results and back cross with dominant parent produced only IDT plants. The pooled data also showed same segregation as with individual back crosses, confirming the control of IDT character by a single dominant gene (Table 1). These results are in conformity with those already reported by, Reddy and Rao (1974) 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_1, F_2, and BC_1F_1 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.

Indeterminate × Semideterminate

AKT-8811 x Gigas leaf variants

In the present cross, the female parent AKT-8811 had indeterminate growth habit, and male parent, Gigas leaf variant had semideterminate growth habit. All plants in F_1, its reciprocal and back cross with indeterminate parent generations were observed as indeterminate growth habit indicating dominance of indeterminate growth habit over semideterminate and no cytoplasmic gene effect to govern the traits growth habit.Out of total 615 plants were observed in F_2 population, 459 plants were found to be indeterminate, 105 plants were semideterminate while 51 plants were determinate. Chi-square test (5.03) of F_2 population gave a well fit to a dominant epistatic ratio for two loci of 12:3:1, indeterminate/ semideterminate/ determinate. This indicated that semideterminate and indeterminate growth habit was governed by two non-allelic genes with dominant epistatic action.135 test cross progenies were studied and they segregated in 77 indeterminate and 58 semideterminate. The chi- square test (2.40) showed well fit to 1:1 ratio (Table 2). These result confirmed the segregation pattern in F_2 population (Table 2).

TAT-10 x Gigas leaf variants

In this cross female parent (TAT-10) had indeterminate growth habit and male parent (Gigas leaf variant) had determinate growth habit. Their F1, reciprocals and back cross with dominant parent's generation produces all indeterminate plant type. It showed that, indeterminate growth habit was dominant over semideterminate growth habit and governed by nuclear gene action. In F_2 population, 363 indeterminate, 85 determinate and 35 semideterminate plants were observed. Chi-square test (0.57) of F_2 population gave a well fit to a dominant epistatic ratio for two loci of 12:3:1. Total 113 test cross progenies were studied and they segregated 61 indeterminate and 52 semideterminate plants. The chi- square test (0.45) showed well fit to 1:1 ratio (Table 2). These result confirmed the segregation pattern in F_2 population (Table 2).

Pooled analysis of both crosses

Pooled analysis of both crosses (AKT-8811 x Gigas leaf variants and TAT-10 x Gigas leaf variants) gave same type of inheritance pattern, which was observed individualy in both crosses. Pooled analysis again confirmed the results of dominant episttic interaction for semideterminate growth habit (Table 2).

From present study it was concluded that, growth habit was governed by two epistatic genes in mention above crosses. This indeterminate condition designated as Dt_1/dt_2s and semideterminate as dt_1/ Dt_{2s}. The presence of Dt_1 allele completely masked the expression of Dt_2s allele. The presences of the recessive allele of these genes in homozygous state (dt_1 dt_1, dt_2s dt_2s) result in determinate growth habits.

Present results are in agreement with the findings of Gupta and Kapoor (1991) in pigeonpea crop. They found that, F_2 population of the cross between indeterminate and semideterminate parents segregated in the ratio of 12 indeterminate: 3 semideterminate: 1 determinate, suggesting the expression of the semideterminate allele (Dt_{2s}) masked by the presence of indeterminate allele (Dt_1) and that the homozygous recessive genotype for both genes (dt_1 dt_1 dt_{2s} dt_{2s}) has the determinate phenotype. The results obtained in BC_1F_1 with both parents also supported the F_2 data. Similar finding also reported in other crops by Bernard (1972), he observed digenic inheritance of determinate, indeterminate and semideterminate growth habit in soybean crop. Yonatan Elkind (1991) studied inheritance of growth habit in tomato, they made the cross between semideterminate and indeterminate types and the results indicated control by two genes, sp and sdt, with the sp+ indeterminate type epistatic over semideterminate. The goodness of-fit to this model was 70% and 82% for F_2 and backcross generations, respectively.

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