

Genetics of a high-selfing trait in pigeonpea

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Summary

A true-breeding line characterized by free filaments of anthers and modified keel petal was derived from F₂ population of an intergeneric cross between *Cajanus cajan* (L.) Millsp. and *Atylosia lineata* W. & A. This variant, designated as 'partial cleistogamy', favours a high level of self-fertilization. The inheritance of this trait was studied in the F₁, F₂, F₃, and BC₁F₁ generations of three crosses. The results suggest that the partial cleistogamy trait is governed by a single recessive gene, designated as *pc1*.

Introduction

Pigeonpea is unique among leguminous crops because, despite having a floral structure designed for self-fertilization, it permits a considerable degree of natural out-crossing. Early pollen shedding (Onim, 1981) and slow pollen tube growth (Dutta & Deb, 1970) have been reported to encourage cross-fertilization in preference to self-fertilization. Ariyanayagam & Adu-Gyamfi (1988) reported that pigeonpea was protandrous and that, by the time the stigma attains receptivity, the viability of the self-pollen was on the decline and hence foreign pollen succeeds. Although a number of insect species have been found to forage on pigeonpea at ICRISAT Center, only *Megachile* spp. and *Apis dorsata* are responsible for cross-pollination (Williams, 1977). Howard et al. (1919) were the first to report 14% natural out-crossing in pigeonpea and, subsequently, a large variation in the extent of natural out-crossing has been reported from various countries or locations within a country (Saxena et al., 1990a). As a result of natural out-crossing, pigeonpea cultivars deteriorate rapidly in genetic

purity and, in addition, it influences the effectiveness of pure-line breeding programs. An easily identifiable trait that ensures total or near self-fertilization would be of immense value to the breeders. This paper describes a floral variant, designated as 'partial cleistogamy', which ensures a high level of self-pollination in pigeonpea (Saxena et al., 1990b), and reports its inheritance in three crosses.

Origin and description

A true-breeding plant with flowers grossly differing from the normal pigeonpea flowers was isolated from F₂ population of an intergeneric cross between *Cajanus cajan* (L.) Millsp. (cv. T.21) and *Atylosia lineata* W. & A. (Reddy, 1973). In this line, the filaments, instead of assuming the diadelphous (9 + 1) status of the normal genotypes, are all free arising individually from a basal pad. This floral modification alters the shape and structure of flower buds. Often they are elongated and grooved ventrally. The keel petals usually surround parts of



Fig. 1.

the standard and the wing petals (Fig. 1). This causes a considerable delay in the opening of such buds. Eventually, in an open flower the standard unwraps itself but the wings still remain enclosed within the keel. This condition is designated as

'partial cleistogamy' and is similar to the 'pre-anthesis cleistogamy' of Lord's (1981) terminology. This partial cleistogamy results in almost complete self-fertilization. The exact mechanism that leads to a high level of self-fertilization in this variant,

Table 1. Segregation for normal and partial cleistogamy in various generations of three crosses in pigeonpea

Cross/generation	Normal	Partial cleistogamy	Expected ratio	Probability
Cross 1 (Mutant × ICPL 87)				
F ₁	50	0		
F ₂	172	57	3:1	1.00
Mutant × F ₁	13	17	1:1	0.25-0.50
F ₁ ^a (44 prog.)	1932	602	3:1	0.10-0.25
Cross 2 (Mutant × ICPL 1)				
F ₁	25	0		
F ₂	126	54	3:1	0.10-0.25
F ₁ ^a (28 prog.)	1497	453	3:1	0.05-0.25
Cross 3 (Mutant × ICPL 85076)				
F ₁	2	0		
F ₂	66	18	3:1	0.25-0.50
F ₁ ^a (7 prog.)	359	107	3:1	0.25-0.50

^aPooled data from segregating normal flower progenies.

however, is not fully understood. It may be presumed that a delay in the unfolding of petals fail to attract the pollinating insects in the initial stages and by that time self-fertilization is completed.

Inheritance study

The partial cleistogamy line was crossed to three short-duration cultivars: ICPL 87 (cross 1), ICPL 1 (cross 2), and ICPL 85076 (cross 3) in 1985. A part of the F_1 seed from all the three crosses was sown in the 1986 rainy season for generation advance and also to make backcrosses with the partial cleistogamy parent. Seed-set in the backcrosses was affected by pod borer attack and only in cross 1 could some seeds be harvested. In the 1987 rainy season, F_1 , F_2 , and BC_1F_1 seeds were grown together with the parents in Alfisols. At flowering stage, counts of normal and partial cleistogamy were made. A proportion of the F_2 population died soon after flowering due to wilt disease caused by *Fusarium udum* Butler. In the remaining population the plants with normal flowers were selfed using muslin cloth bags for studying the segregation pattern in F_3 generation.

The partial cleistogamy parent showed no variation in its floral morphology over years. The F_1 progenies of all the three crosses had normal flowers (Table 1). In the F_2 generation of cross 1, 57 of 229 plants had partially cleistogamous flowers. Similarly in cross 2, 54 of 180 plants and in cross 3, 18 of 84 plants had partial cleistogamy. Chi-square tests indicated that the segregation in F_2 progenies fitted a ratio of 3 normal : 1 partial cleistogamy, indicating that the latter character is governed by a single recessive gene. The backcross progenies of cross 1, though limited in size, also fitted an expected ratio of 1:1 for segregation of a single recessive gene. In F_3 , 44 progenies out of 78 in cross 1, 28 out of 47 in cross 2, and 7 out of 12 in cross 3 segregated for flower type and the remaining bred true for normal flowers. The ratio of segregating to non-segregating progenies did not fit the expected ratio

of 2:1, perhaps due to inadequate sampling caused by mortality among F_2 plants. A ratio of 3 normal : 1 partial cleistogamy was observed in most segregating F_3 progenies with probability values between 0.02 to 1.0. In each cross the pooled segregation in such F_3 progenies fitted to a 3:1 ratio (Table 1) confirming the conclusions drawn from the F_2 and backcross generations. These results suggest that the partial cleistogamy trait is governed by a single recessive gene, designated as *pct*.

Pigeonpea is a perennial shrub and belongs to a monotypic genus. It is normally indeterminate and natural out-crossing is often high. The identification of a partially cleistogamous floral variant raises the question whether domestication and adaptation to narrowing environmental situations is forcing its evolution towards autogamy.

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