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BREEDING FOR YEAR ROUND PRODUCTION IN PIGEON PEAS

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INTRODUCTION

Pigeon pea germplasm is generally day length sensitive and requires 5 to 9 months to produce a crop when planted during the longer days of the year. A cropping system in which the life cycle of pigeon pea could be considerably reduced has been advocated by Spence and Williams (1972). Although useful, the system being centered around short days lacks the flexibility necessary for unrestricted rotational farming. Furthermore, its usefulness as a means of extending the period of productivity is limited to no more than a couple of months.

Significant increases in fresh pea production may be achieved by curtailing the life span of the crop and by eliminating day length requirements for floral induction. The former would enhance production per unit of time and permit two or more crops to be taken where only one was possible previously. The latter would not only favour flexible cropping systems but also spread production year round.

In this paper, the screening procedure for day neutrality and the methods adopted in breeding cultivars capable of year round production are discussed.

MATERIALS AND METHODS

In January, 1974 (short days), 68 cultivars selected from the major pigeon pea producing areas of India, together with 43 obtained from Institute of International Tropical Agriculture - Nigeria, University of the West Indies and Sudan were planted at the U.W.I. Field Station, Trinidad, with the view to (a) screening for flowering responses to day length (b) initiate breeding schemes with suitable photoinsensitive material. Three rows of each cultivar, 8 meters in length, were planted at inter and intra row spacings of 75 cms.

The growth of the germplasm varied from 75 to 90 cm high for determinate forms to 300 to 375 cm for indeterminates. Flowering occurred in 60 to 320 days from the sowing date. In general, cultivars originating from India and Africa bore small-seeded pods whereas those of West Indian origin produced large pods and seeds.

Cultivars that flowered in less than 90 days from sowing were tentatively selected as possible gene sources for year round production. These were crossed to the day length sensitive but large-seeded West Indian germplasm, which having been planting in July of the previous year, were in bloom at that time. approximately 3,500 crosses among 17 parents were attempted but only 3 % succeeded.

In May, 1974 (long days), the parents, together with the F1 progeny, were planted to assess flowering response to long days. In all instances, flowering was delayed. In order to reduce between season variability to a minimum, only the parents in which the difference between seasons was less than 21 days were finally selected.

The f1 progeny of these parents which were in bloom at that time, were then subjected to two breeding procedures :
(a) Modified Diallel Selective Mating on the lines outlined by Jensen (1970) and (b) Pedigree Selection, Allard (1960).

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(a) Modified Diallel Selective Mating

Nine F1 single cross parents and a cultivar were mated in a dialled excluding reciprocals. The resulting double and 3-way crosses were planted in January, 1975, selected for earliness and profuseness of flowering, then mated in a partial diallel. The F1 progeny of these combinations consisting of either 7 or 8 parents were selected for profuse flowering in less than 90 days.

The F2 population was divided into 3 groups. Those flowering under 75 days, between 75 to 90 days and a third group in which days to flowering exceeded 90 days. These 3 groups have from then on been advanced by mass selection for days to flowering and profuseness of blooming. The data presented in this paper is concerned with the first group.

(b) Pedigree Selection

Pedigree selection was done in about 60 crosses each consisting of 1 parent exhibiting early, profuse flowering and comparable vegetative growth year round.

RESULTS AND DISCUSSION

1. Selection of Parents

The mean number of days from sowing to flowering for a cross section of the germplasm screened is shown in Table 1. The data for the short day crop clearly showed that *Cajanus*, contrary to the common belief, is not a qualitative short day species.

Based on the flowering responses in the January planting, the cultivars observed may be classified into four groups :

1.1. Flowering during March (lengthening days) : cultivars 1, 13, 34, 21 etc... are representatives of this group where flowering is essentially early.

1.2. Flowering during April - May (lengthening days) : The codes 1, 20, 17, and 8 belong to this group. Here, flowering is sparce and erratic.

1.3. Flowering during August (shortening days) : cultivar 14

1.4. Flowering after the advent of short days (October - November : Cultivar 47.

The early material in group one, which, from the point of the breeding objective appeared most promising when planted in May (long days) flowered before the onset of short days, indicating genetic potential for year round production of the crop. In contrast, Code 1, only after being induced by short days, flowered approximately 1 1/2 to 2 months later in 137 days.

The apparently day neutral response of the early material, however, was associated with 3 features likely to affect the agronomical and economical aspects of year round production. Firstly, vegetative vigour was noticeably reduced in the short day crop as compared to that of the long day and varietal differences for vigour were present. High variability in a cultivar between seasons would mean differing cultural practices for the two seasons which the farmers may not accept readily. Secondly, the number of days to flower for the two seasons differed widely, it being often delayed in the long day crop. The difference exceeded a month for Cultivar No. 34. The longer the time required to flower, greater would be the vegetative growth and hence cultural operations between seasons would have to be varied. Thirdly, the intensity of flowering which is directly related to productivity varied between seasons and cultivars. The long season crop flowered scantily.

Cultivar origin	Mean number of days to flower (Lat. 11.17)	
	January planting (S.D.)	May Planting (L.D.)
1 India	67	85
13 India	70	90
61 India	62	80
89 I.I.T.A. (Nigeria)	69	91
45 Puerto-Rico	63	81
38 I.I.T.A. (Nigéria)	69	90
34 India	59	90
21 India	63	94
14 India	194	-
47 India	290	-
Code 17 W.I.	81	-
Code 8 W.I.	89	-
Code 20 W.I.	80	-
Code 1 W.I.	84	137

Table 1. Mean number of days from sowing to flowering in short and long days.

Hence, while selecting parents or progenies, between seasonal difference for flowering was restricted to 21 days. Further, high selection pressure was exercised for vegetative vigour during short days while profuseness of flowering was the main factor selected for during the long days.

2. Diallel Selective Mating

The mean number of days to flower and the range of flowering for consecutive generations of few cross combinations of the diallel selective mating planted both during short and long days are shown in Table 2. The pedigree of each combination includes approximately 50 % of West Indian germplasm which as seen from Table 1, flowers during long days considerably later than the germplasm of other origin. The F1 progeny, however, due probably to selection for earliness and the recurrent crossing with combinations consisting of insensitive parents, was relatively early-flowering. The West Indian parents, if planted in July, would have required over 125 days for floral induction.

The flowering range for the F2 generation, despite repeated selection for earliness, was wide. In crosses 1, 5, 6, 7, 10, 11 and 12 the higher values were considerably higher than those normally required by West Indian parents to flower under similar planting conditions. The wide range observed could probably be attributed to the enhanced recombination options provided by the larger gene pool introduced through combining several parents.

The ranges for the third and fourth generations were considerably narrow an account of selection for genotypes flowering in less than 75 days. Further, the ranges for the F3 and F4 generations did not vary much between seasons. In particular, the F4 generation in both seasons showed comparable ranges in most instances, indicating that the selection procedure for seasonal variation was effective. The population means shown in brackets confirm the above assessment.

The mating system, in addition, created large variability for traits such as number of days to flower, growth habit, corolla colour, size of pods and peas, branching, leaf size and pigmentation. Although one of the objectives of the system is to break tight linkages and enhance recombination between linked genes, in this instance, the association between early, profuse flowering and small pods was not appreciably affected. Consequently, only medium sized or short broad pods have been recovered with profusely flowering day neutral genes. Such pods fortunately contain large, green peas. Pod size probably could be improved after genes for profuse, early flowering and narrow seasonal variability are fixed.

PEDIGREE METHOD

The basis of pedigree selection was slightly different from the former method. The between season variation for flowering was restricted not to exceed 15 days. In addition, variation for anthesis within the plant was allowed a maximum of 10 days. Selection for these two parameters was anticipated to generate uniform maturity of the crop. Profuseness of flowering as in the previous method was also taken into consideration.

It is evident from Table 3 that selection for between season variability was very effective. Comparison of the F3 and F6 data further indicates that the selection for earliness was successful.

The extent of variability for earliness as well as other traits, however, was not as large as those produced by the former method. Of 100 single crosses studied only the ones listed in Table 3, showed comparable days to flower in both short and long days, whereas among the diallel combinations, a higher proportion demonstrated the trait. Within crosses, too, the variability was greater for the diallel mating system.

Pedigree		Range and mean number of days to flower from				
		9/7/75	19/1/76	9/7/76	11/1/77	16/3/77
		F1	F2	F3	F4	
1.	45(1x1)(13x8)(61x17)	89	52- 97 (72)°°	68-82 (75)	66-77 (73)	66-74 (70)
2.	(1x1)(48x1)(1x13)(89x1)	85	63- 82 (68)	66-80 (73)	66-74 (70)	60-72 (66)
3.	45(1x1)(1x1)(89x1)	78	59-111 (69)	63-82 (74)	60-78 (69)	58-80 (64)
4.	45(1x1)(13x8)(61x17)	81	67- 79 (67)	61-71 (65)	64-76 (70)	56-84 (70)
5.	(1x1)(43x1)(1x1)(89x1)	89	72- 98 (76)	65-75 (70)	66-80 (73)	- -
6.	(1x1)(61x17)45(1x1)	80	56-102 (68)	63-83 (74)	62-78 (70)	68-80 (74)
7.	45(1x1)(88x8)(89x1)	90	64- 93 (72)	71-73 (72)	71-91 (81)	64-83 (74)
8.	(1x1)(61x17)(1x1)(89x1)	87	59- 78 (67)	73-83 (78)	66-70 (68)	68-76 (72)
9.	45(1x1)(13x8)(61x17)	85	66- 87 (72)	67-82 (75)	66-82 (72)	66-80 (73)
10.	(1x1)(48x1)45(1x1)	87	72-106 (75)	68-89 (79)	59-83 (71)	65-80 (73)
11.	(1x1)(48x1)(1x1)(61x17)	82	73- 99 (75)	59-80 (70)	63-77 (70)	63-85 (74)
12.	(1x1)(61x17)(1x1)(89x1)	83	73- 92 (75)	58-70 (64)	58-73 (66)	66-80 (73)
13.	45(1x17)(13x3)(61x17)	81	58- 80 (71)	70-74 (72)	65-75 (70)	64-83 (74)

Table 2. Mean number of days from sowing to flowering in successive generations of diallel combination of crosses

The within plant variability for anthesis appears to be influenced by environmental factors to a greater extent than the other two traits. All crosses took more than 10 days to bloom completely in both seasons except those marked with asteriks in which during short days complete opening of flowers occured in less than 10 days. This character is influenced by differences in branching patterns between seasons, vegetative vigour of the plants and probably soil fertility and moisture status of the soil.

Selection for profuseness of flowering was effective, but as indicated earlier, the combination of day neutral character and profuseness were associated with medium to short, broad pods.

Workable homozygosity was reached in few pedigrees of 1x88 and 5x20 as early as the F3 selfed generation. These pedigrees, besides flowering profusely, bore peas and pods of acceptable dimensions.

Table 4 shows the number of days from sowing to 50 % flowering of 1x88 (UW17) for each month of the year except April. December to March plantings where, the earliest to flower whereas June was the latest. However, the difference between the earliest to the latest was only 20 days. ICRISAT considers any cultivar reactive to day length and or temperature only if its juvenile phase differs by more than 30 days. By this criterion. UW17 is day neutral in Trinidad.

Table 3 - Mean number of days from sowing to flowering in successive pedigree generations.

Cross	Mean days to flower from			
	31/7/75	31/1/76	6/8/76	16/3/77
	F^3	F^4	F^5	F^6
1x88-3	70	58	60	59
1x88-10	71	69	63	58
13x20-1	72	62	67	62
5x20-10	73	69	68	62
1x16-6	75	64	66	59
61x17-9	73	62	66	59
8x88-10	75	62	67	60

SUMMARY

Evaluation of floral induction during short and long day conditions of Trinidad indicated that none among 101 cultivars tested was day neutral. Variability for sowing to induction period was very wide. The variability could be classified into 4 broad categories of which one produced flowers in both long and short days.In this category, intensity of flowering, vegetative vigour and the difference between seasons for induction, differed considerably. Therefore, these factors were given attention while selecting parents and breeding progenies.

A modified diallel selective mating system and the pedigree method were undertaken to breed for year round cropping. Both methods effectively combined the traits necessary for such cropping. The former method, however, generated greater extent of variability for quantitative traits.

Apparent homozygosity was reached in a few pedigree progenies in the F3 generation. The flowering response of one of these indicated that year round production of peas is possible.

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Month	Days
June	85
July	76
August	79
September	80
October	72
November	70
December	69
January	65
February	66
March	69
April	-
May	-

Table 4. Mean number of days from sowing to flower in monthly plantings of UW 17