Inheritance of Some Quantitative Characters in Pigeonpeas (*Cajanus cajan* (L.) Mill sp.)[1]

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INTRODUCTION

Progress in plant breeding apparently is conditioned in a general way by the nature, magnitude, and interrelationships of genetic and nongenetic variation in various significant characters. One of the most difficult problems a plant breeder is forced to face is the identification of a desirable plant with a potentially high yield from a segregating population. Most commercial agronomic attributes are inherited quantitatively and these consequently are highly influenced by the environment in which the plants are grown. It is very difficult to judge whether observed variabilities are heritable—or due to environment. The importance of partitioning overall variability of plants into their heritable and non-heritable components is thus suggested so such information can be put to use in a plant breeding program. Knowledge of heritability may be useful in increasing the efficiency of breeding methods, because such knowledge is a measure of success in separating genotypes by selection. Association of plant characters with yield can also be of great value for the selection of desirable strains.

Pigeonpeas constitute an important part of the diet in Puerto Rico; not only because of consumer preference but also because of their high protein content. They also are of importance to the economy; the farm value of the pigeonpea crop is estimated at approximately $2 million annually with good potential for future increase.

The present investigation was undertaken to determine heritability of quantitative characters such as date of flowering, plant height, and seed weight in different populations of pigeonpeas, and to find out the degree of association, if any, between these attributes.

REVIEW OF LITERATURE

According to Warner (*19*)[3], the study of hereditary and environmental components of variation began with Johannsen and Nilsson-Ehle in 1909, and East in 1916. Techniques for partitioning phenotypic variance into

components were described by Mather (13). Lush (11) classified heritability percentages into two categories: (a) broad, or the ratio of genotypic to total variance, and (b) narrow, or the ratio of additive genetic to total variance. Grafius et al. (9) and Bartley and Weber (1) suggested that the magnitude of heritability value would indicate the characters for which selection would be successful and the generation when selection could be profitably practiced. Burton (4) suggested the use of both heritabilities and genetic coefficients of variation to show the progress expected from selection.

Frey and Horner (8) using the standard unit method found the heritability for heading date in 22 oat crosses to be 62, 63, and 68 percent for the F_2-F_3, F_3-F_4, and F_4-F_5 comparisons, respectively. Mahmud and Kramer (12) found heritabilities of 41 and 43 percent for height and yield, respectively, in soybeans. Fiuzat et al. (5) found heritability percentages of 86 and 90.9 percent in the F_2 generation of barley for maturity date and heading date; they therefore concluded that individual plant selection in the F_2 generation should be very effective for these characters. Swarup and Sharma (16) found heritability estimates of 37 percent for gross weight of head and 80 percent for maturity in cabbage. Wallace et al. (18) used genotypic variances and covariances to estimate the relationship between height and weight per seed with yield in oats.

The most commonly applied methods for calculating heritability percentages are parent-progeny regressions and two variance components procedures. Frey and Horner (7) concluded from their work with barley selections that (a) the heritability values as calculated by the components of variance method in the F_4 and F_5 generations are realistic and reliable; (b) the close agreement between the expected and actual gains in performance in six of the seven comparisons suggests that the gene action involved in the F_4 and F_5 generations is largely additive; (c) of the two methods of calculating heritability percentages, namely, parent-progeny regressions and components of variance, the latter gives closer agreement between predicted and actual gains in selection experiments; and (d) the parent-progeny regression method tends to under-estimate the true heritability percentages.

Robinson et al. (15) using variance components computed a selection index for corn. The analysis of variance for estimating heritability percentages was applied by Burton (3) in pearl millet, and by Robinson et al. (14) in corn.

Brim et al. (2) noted that dominance is of minor importance in self-fertilizing species. In his study with soybeans the additive component of variance was indicated to be the principal component for all characters studied. Grafius et al. (9) have shown that by the fourth generation after a

cross in self-pollinated crops, the non-additive gene effects have nearly disappeared as a cause of variability between lines.

Thomas and Kernkamp (17) found heritability ratios more convenient and useful as an aid to selection than correlation between parent and progeny.

It has been shown that the expected variance of any non-segregating population is environmental variance; thus, total variance of a segregating population would be genotypic variance plus environmental variance. Weber and Moorthy (20) used parental and F_1 values to estimate the magnitude of the environmental variation in their work with quantitative characters of soybeans.

MATERIALS AND METHODS

Three varieties and an irradiation-derived line of pigeonpeas were used as parents in five crosses as follows: P.I. 5690 (plant introduction from Trinidad) X Kaki, P.I. 5690 X Saragateado, P.I. 5690 X 526, Saragateado X 526 and Kaki X 526. The parents were chosen on the basis of previous data to contrast for earliness, yield, plant height, and weight per 100 seeds. Each variety was considered homozygous.

The F_2, F_3, and parents of each cross were planted in the field at the Isabela Substation during 1966–67 in a randomized block design with three replicates. Cross 526 X Saragateado, however, consisted of two replicates. Planting distance was 8 feet between rows and 4 feet in the row. The F_2 and F_3 populations consisted of 200 seeds per replicate with the same spacing and row length as the non-segregating generations.

The following data were recorded for each plant in the F_2, F_3, and parental progenies: Flowering date, recorded as number of days from planting to first flowers on plants; plant height, measured to the nearest tenth of a foot at harvesting time; and seed weight, recorded in grams per 100 dry seeds.

The sums of squares were calculated separately for each replication. The resulting F_2 and F_3 pooled variance contained two parts, namely, the genotypic fraction due to additive gene action including dominance and epistasis, and the fraction due to environment. The environmental variances and covariances were calculated from parental values. The F_2 and F_3 genotypic variances were determined by substracting the environmental variances from the total F_2 and F_3 variances, respectively. The same method was used in calculating the covariances. Estimates of heritability were obtained by the following formula, estimating environmental variance by the parental variance.

$$H = \frac{\sigma^2_{F_2} - \sigma^2_P}{\sigma^2_{F_2}}$$

H is the estimate of heritability, where $\sigma_{F_2}^2$ is the F_2 variance and $\sigma_P{}^2$ the joint mean square of parental lines. Both $\sigma_{F_2}^2$ and $\sigma_P{}^2$ were calculated after removing the block effect. The same procedure was used for estimating $\sigma_{F_3}^2$. The estimate of genetic correlation was calculated for each pair of the characters measured by the following formula:

TABLE 1.—*Mean and range for flowering date, plant height, seed weight, and number of seeds per pod of parental, F_2, and F_3 generation of five pigeonpea crosses*

Parent or generation	Flowering date (days)		Plant height (feet)		Seed weight (grams)		Average seeds per pod (number)	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
P.I. 5690	123.7	105–130	4.1	3.4–4.7	13.9	11–17	3.6	2.6–4.2
Kaki	153.8	137–166	6.5	5.9–7.8	23.8	20–26	3.8	3.8–4.4
F_2	139.1	103–159	5.8	3.8–7.8	19.2	11–28	3.7	2.3–5.1
F_3	143.7	105–173	5.9	3.2–8.4	18.0	11–23	3.8	2.0–5.1
P.I. 5690	123.7	105–130	4.1	3.4–4.7	13.9	11–17	3.6	2.6–4.2
Saragateado	204.2	186–215	7.0	5.6–8.5	17.6	14–21	3.8	3.6–4.2
F_2	152.4	110–190	6.2	3.5–9.0	19.2	12–24	3.8	2.0–5.3
F_3	154.1	110–190	5.9	3.3–7.9	18.0	10–24	3.6	2.1–5.7
Kaki	153.8	137–166	6.5	5.9–7.8	23.8	20–25	3.8	3.8–4.4
526	192.9	167–215	7.0	5.7–8.4	16.3	12–20	3.5	3.1–4.8
F_2	163.2	144–187	7.0	4.0–8.8	21.7	15–26	3.7	3.0–4.8
F_3	156.4	138–187	7.0	4.5–9.3	20.4	12–25	3.9	2.7–5.4
P.I. 5690	123.7	105–130	4.1	3.4–4.7	13.9	11–17	3.6	2.6–4.2
526	192.9	167–215	7.0	5.7–8.4	16.3	12–20	3.5	3.1–4.8
F_2	158.8	116–210	5.8	3.8–7.7	16.2	11–23	3.8	2.1–5.5
F_3	161.1	110–210	6.0	3.8–8.1	15.4	10–23	3.7	2.2–4.9
Saragateado	204.2	186–215	7.0	5.6–8.5	17.6	14–21	3.8	3.6–4.2
526	192.9	167–215	7.0	5.7–8.4	16.3	12–20	3.5	3.1–4.8
F_2	192.6	151–224	6.5	5.2–8.4	18.3	12–22	3.8	2.2–4.4
F_3	173.8	145–215	6.5	4.1–8.9	18.4	14–23	3.4	2.3–5.1

$$\text{Genotypic } r_{xy} = \frac{\text{COV}_{xy_g}}{\sqrt{\sigma_{x_g}^2 \cdot \sigma_{y_g}^2}}$$

where

COV_{xy_g} = genotypic portion of the covariance between the characters X and Y.

$\sigma_{x_g}^2$ and $\sigma_{y_g}^2$ = genotypic portion of the variance in the expression of the characters X and Y.

Frequency distributions were prepared for plant height, flowering date, and seed weight for both F_2 and F_3 generations together with parental means for all crosses.
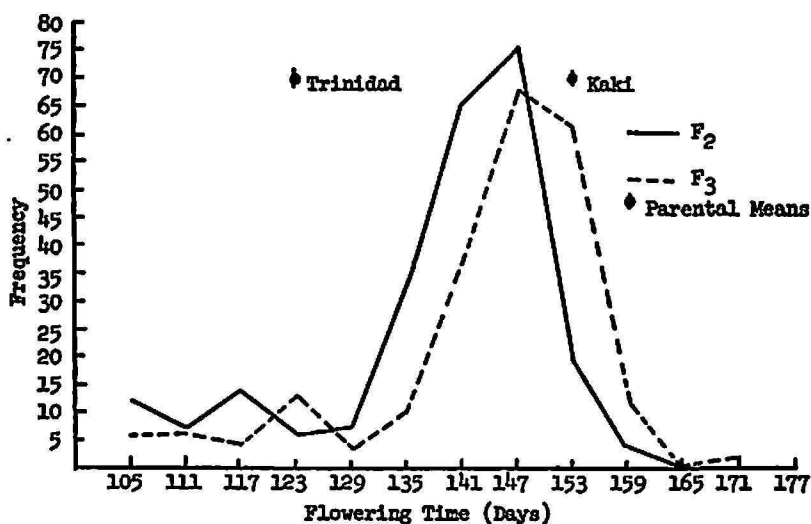

FIG. 1.—Frequency distribution of the F_2 and F_3 generations, and the parental means for date of flowering in the cross P.I. 5690 X Kaki.
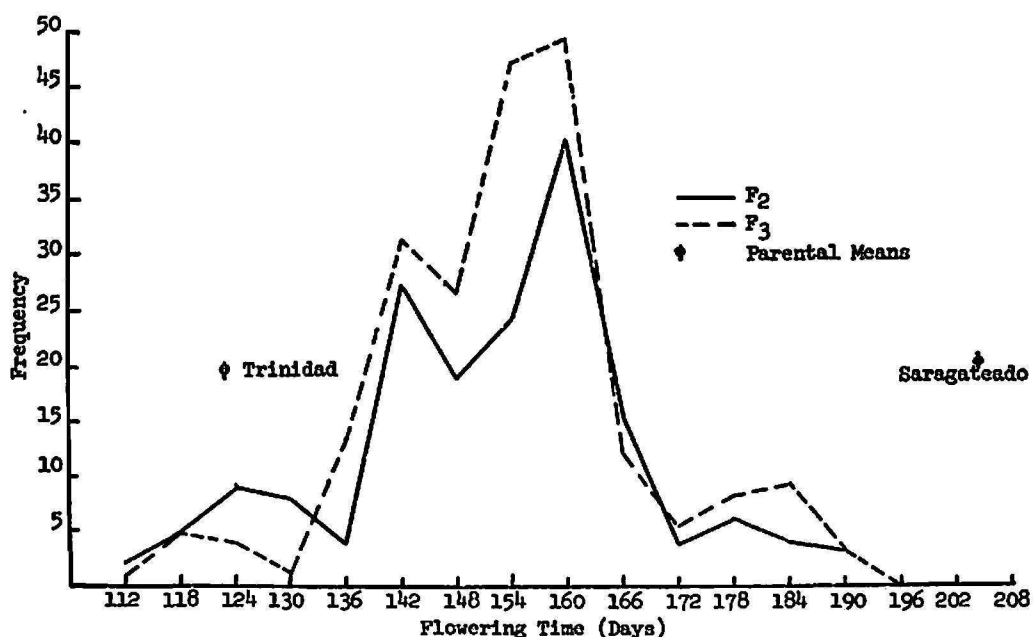

FIG. 2.—Frequency distribution of the F_2 and F_3 generations, and the parental means for date of flowering in the cross P.I. 5690 X Saragateado.

RESULTS

The mean and range for date of flowering, plant height, seed weight, and number of seeds per pod of parental, F_2, and F_3 generations of five pigeon-pea crosses are presented in table 1. For all characters studied the range of variability was greater in F_2 and F_3 generations with increasing contrast

in parents characteristics. The number of seeds per pod in segregating generations had a lower range of variability than the other characters studied. This seems to indicate that no appreciable progress in breeding could be
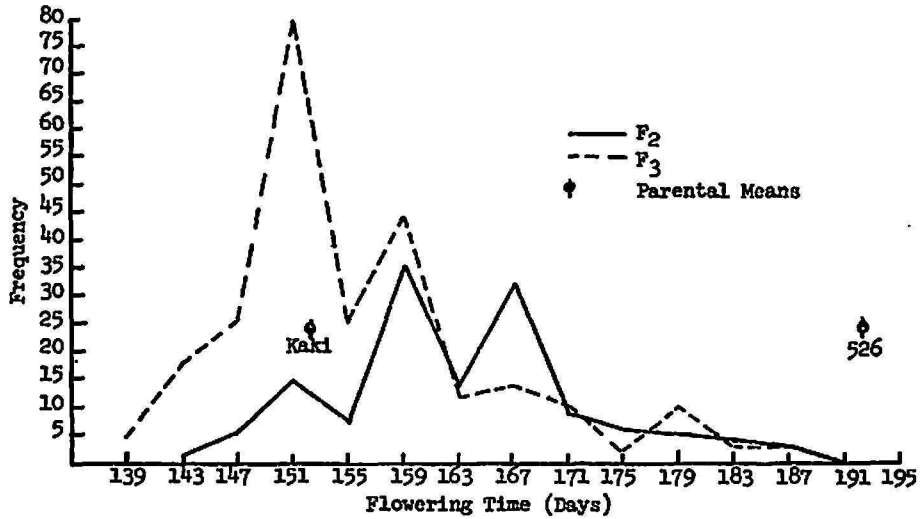

FIG. 3.—Frequency distribution of the F_2 and F_3 generations, and the parental means for date of flowering in the cross Kaki X 526.
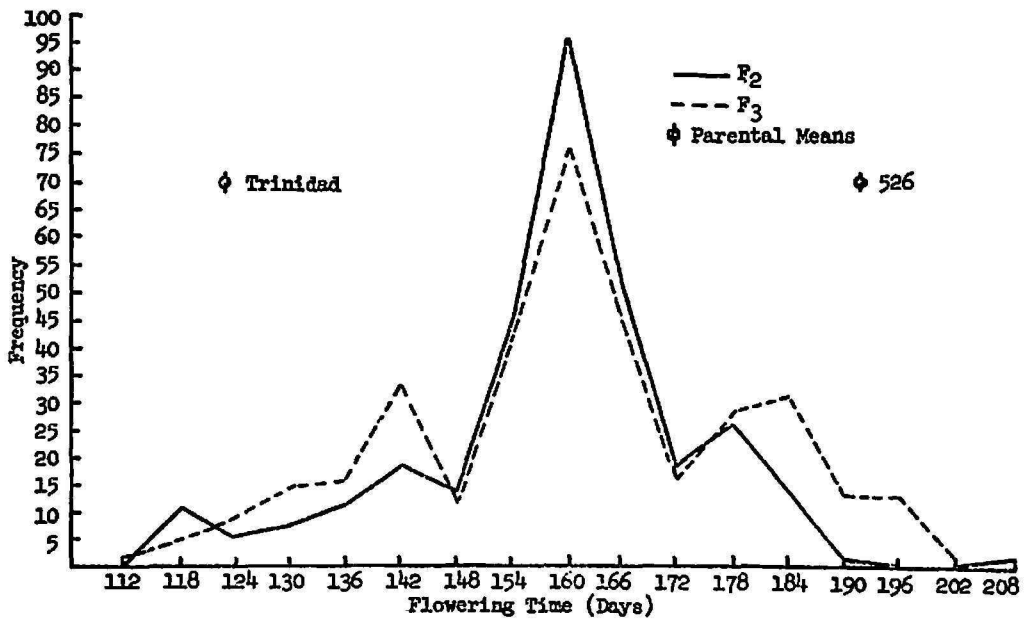

FIG. 4.—Frequency distribution of the F_2 and F_3 generations, and the parental means for date of flowering in the cross 526 X P.I. 5690.

made for this attribute. The means of the five crosses give additional evidence for this conclusion.

Frequency distributions for date of flowering of F_2 and F_3 plants and parental means are shown in figures 1 to 5, inclusive, for the five pigeonpea crosses. Transgressive segregation for earliness and lateness was observed

in crosses P.I. 5690 X Kaki and Saragateado X 526. For all crosses, except Saragateado X 526, the F_2 and F_3 distributions extended over the entire range of the parents. The F_2 and F_3 frequencies were intermediate and somewhat positively skewed toward the earlier bearing parent. This suggests earliness for flowering shows some dominance to lateness; however, because of the negative association of lateness with seed yield, there might be a tendency to select for earlier flowering plants as shown by the particular cross between the two late varieties, Saragateado X 526.

Frequency distributions for plant height are shown in figures 6 to 10, inclusive. This attribute follows a trend somewhat similar to date of flowering, i.e., the F_2 and F_3 plants were distributed over the entire range of the parents and means were intermediate when parents contrasted for this character. In two of the crosses, Saragateado X 526 and Kaki X 526,
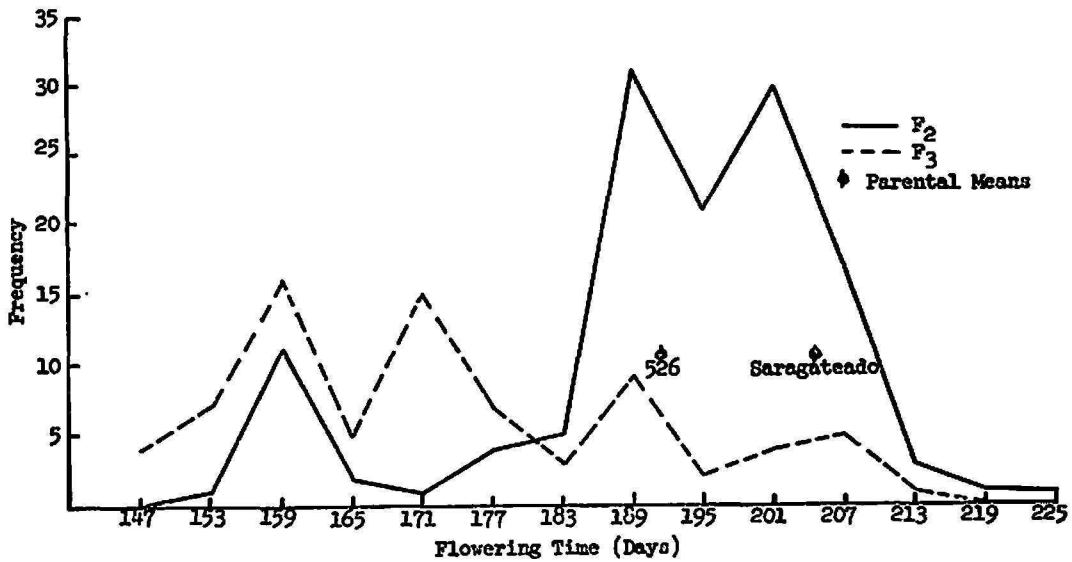

FIG. 5.—Frequency distribution of the F_2 and F_3 generations, and the parental means for date of flowering in the cross 526 X Saragateado.

there was no significant contrast for plant height. The mean height for Kaki, Saragateado, and 526 was 6.5, 7.0, and 7.0 feet, respectively. Apparently, in these three varieties, the ceiling for number of genes for plant height has been attained and the mean remains the same for F_2 and F_3 plants, or the three entries have a similar gene system for plant height.

Figures 11 to 15 show graphically the frequency distribution for seed weight of F_2 and F_3 plants of the five crosses and the parental means. For all crosses the distribution is markedly skewed toward the heavier seed parent. This suggests that for the character seed weight, heavier seeds show some dominance over lighter seeds.

The coefficients of variation (table 2) for flowering date, height, seed weight, and number of seeds per pod were low, with the exception of num-

ber of seeds per pod for cross Saragateado X 526 and 5690 X Saragateado. No known reference exists of previous research work with this crop; thus the degree of precision on the attributes studied cannot be compared.
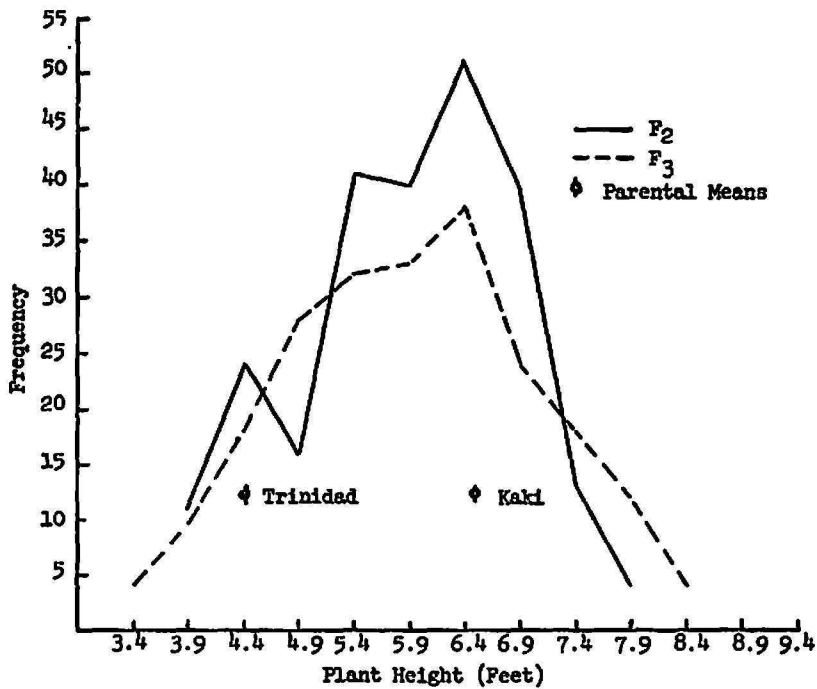
FIG. 6.—Frequency distribution of the F_2 and F_3 generations, and the parental means for plant height in the cross P.I. 5690 X Kaki.
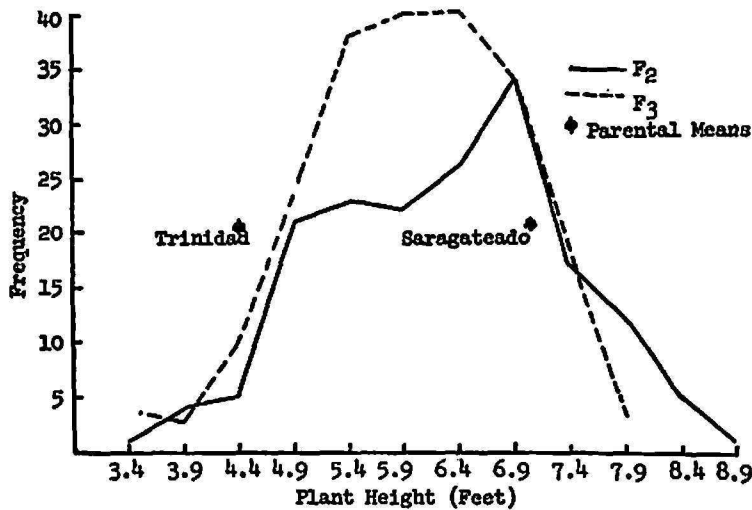
FIG. 7.—Frequency distribution of the F_2 and F_3 generations, and the parental means for plant height in the cross P.I. 5690 X Saragateado.

These low coefficients of variation indicate a good degree of precision for the experiment of the attributes under consideration.

Heritability estimates for the F_2 and F_3 generations for all characters of
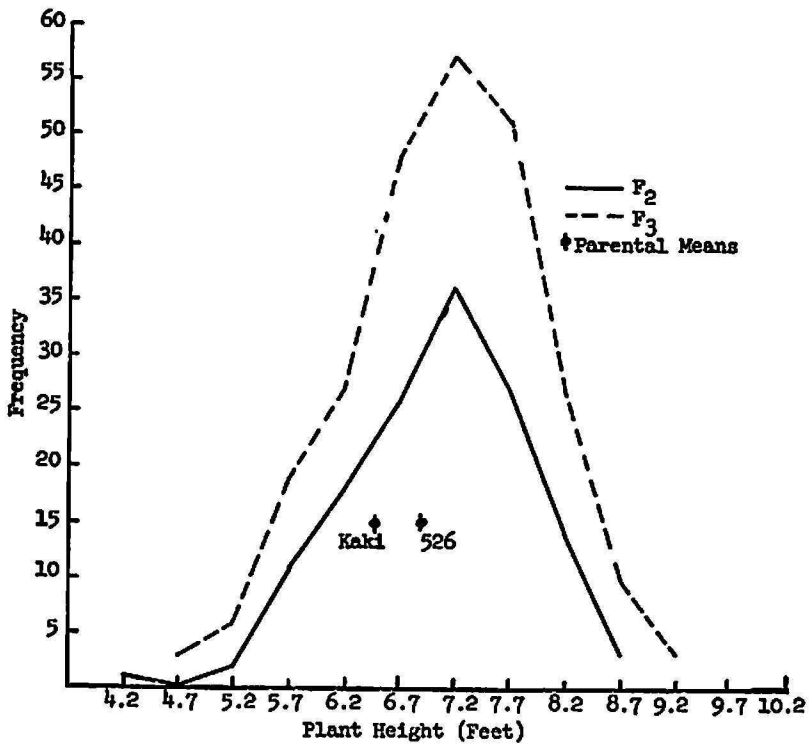
FIG. 8.—Frequency distribution of the F_2 and F_3 generations, and the parental means for plant height, in the cross Kaki X 526.
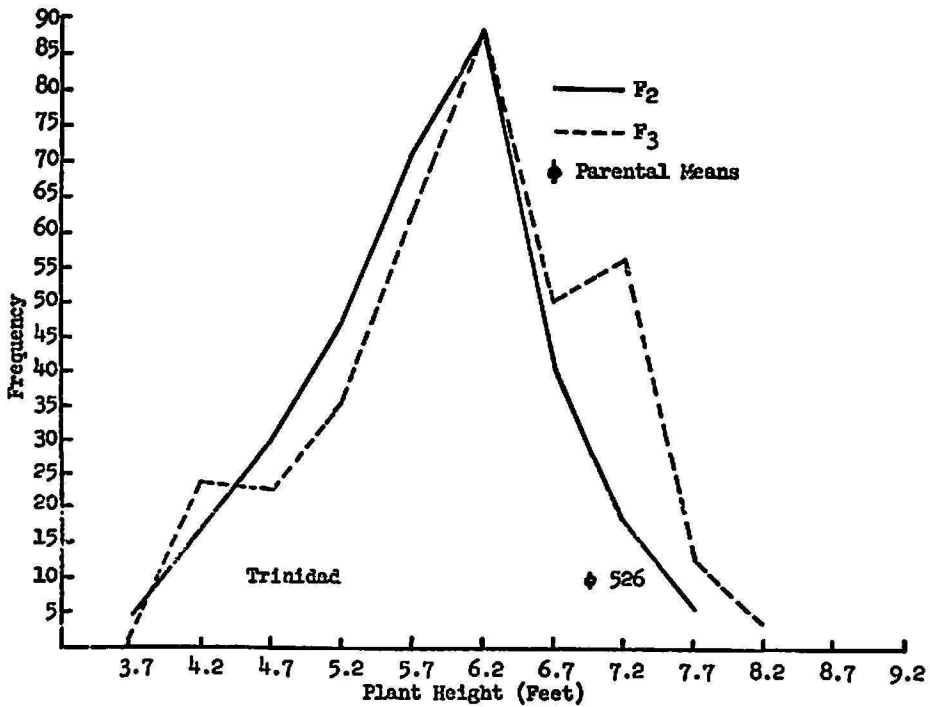

FIG. 9.—Frequency distribution of the F_2 and F_3 generations, and the parental means for plant height in the cross 526 X P.I. 5690.
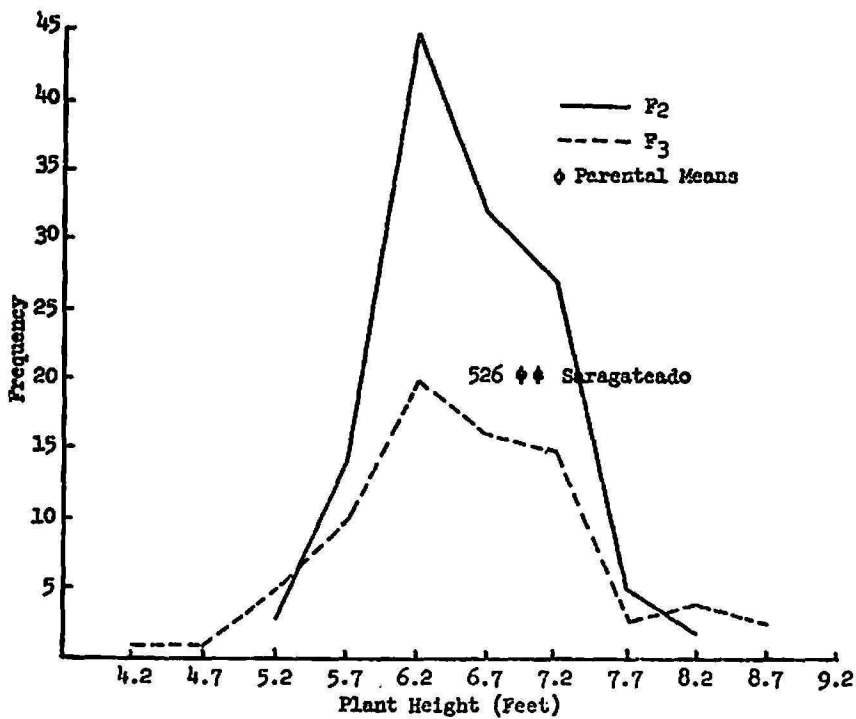
FIG. 10.—Frequency distribution of the F_2 and F_3 generations, and the parental means for plant height in the cross 526 X Saragateado.

FIG. 11.—Frequency distribution of the F_2 and F_3 generations, and the parental means for seed weight in the cross P.I. 5690 X Kaki.

the five pigeonpea crosses are presented in table 3. Heritability values for date of flowering were high and comparable for all crosses.

Estimated heritabilities for plant height in F_2 and F_3 generations were similar in magnitude to those attained for date of flowering except for crosses Kaki X 526 and Saragateado X line 526.

Seed weight, except for crosses Saragateado X 526 and P.I. 5690 X 526 in the F_2 generations, also showed a high heritability percentage and of similar magnitude as flowering and plant height.
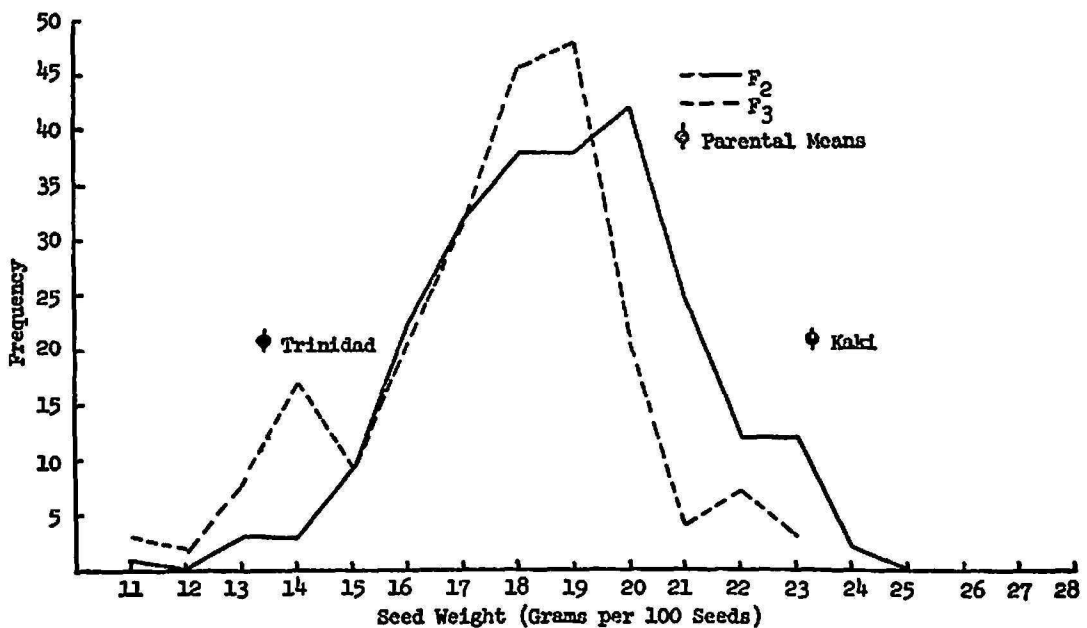

FIG. 12.—Frequency distribution of the F_2 and F_3 generations, and the parental means for seed weight in the cross P.I. 5690 X Saragateado.

FIG. 13.—Frequency distribution of the F_2 and F_3 generations, and the parental means for seed weight in the cross Kaki X 526.

Number of seeds per pod showed the lowest heritability values for all traits of the five crosses. This low heritability for number of seeds per pod can be explained on the basis of a very narrow amount of genetic variation as indicated by the parental means and ranges in table 1.

Heritability values for seed yield and number of pods per plant were estimated for only one of the five crosses, Kaki X P.I. 5690. The heritability estimates for the other four crosses were too erratic because late parent
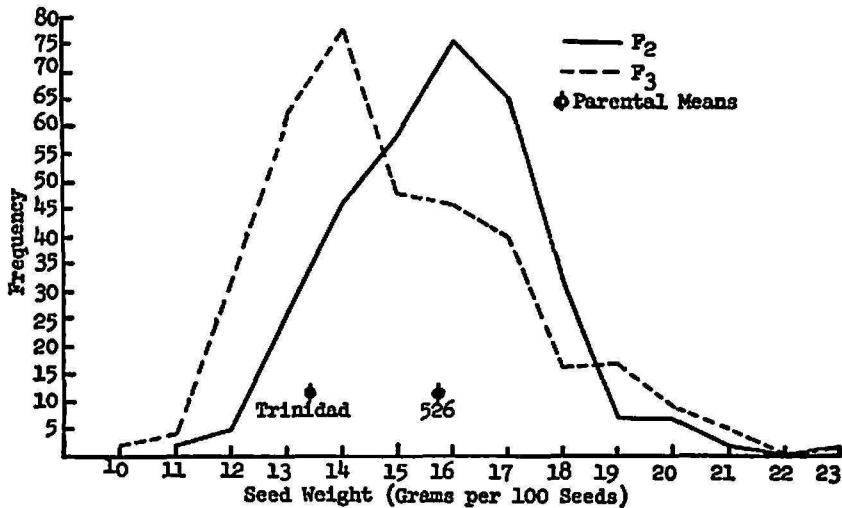
FIG. 14.—Frequency distribution of the F_2 and F_3 generations, and the parental means for seed weight in the cross 526 X P.I. 5690.
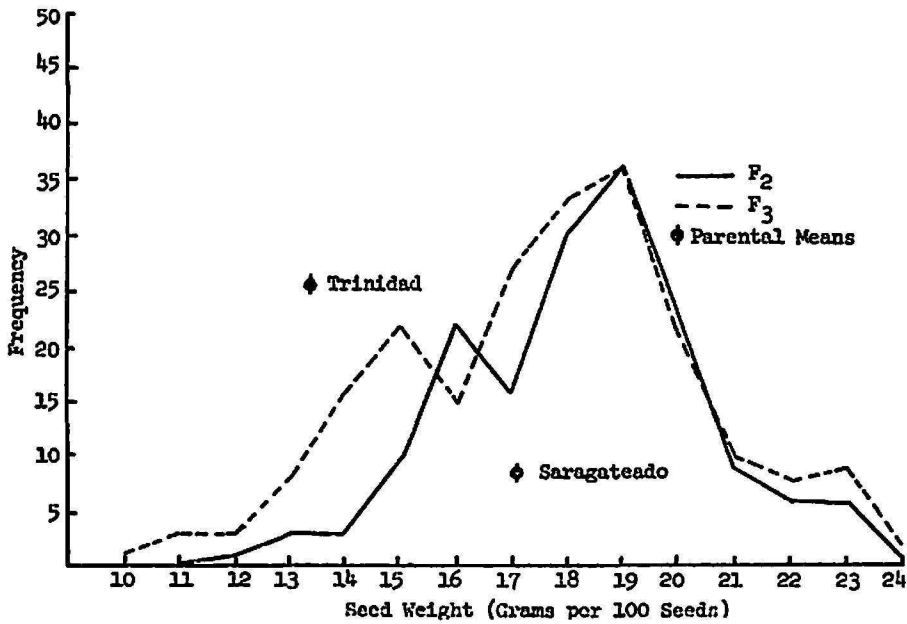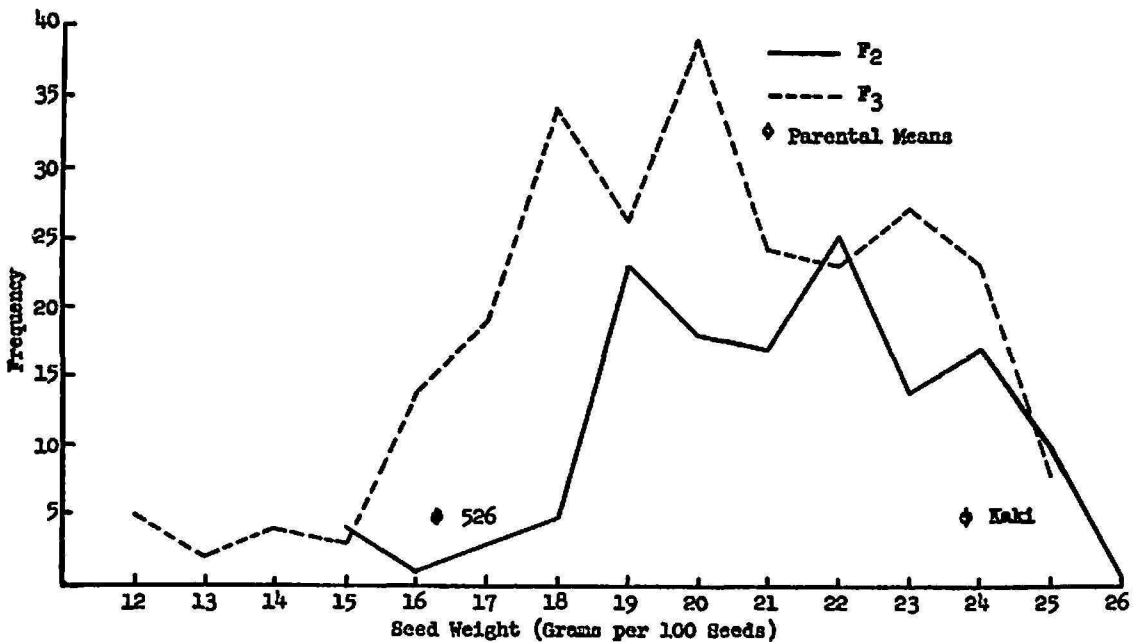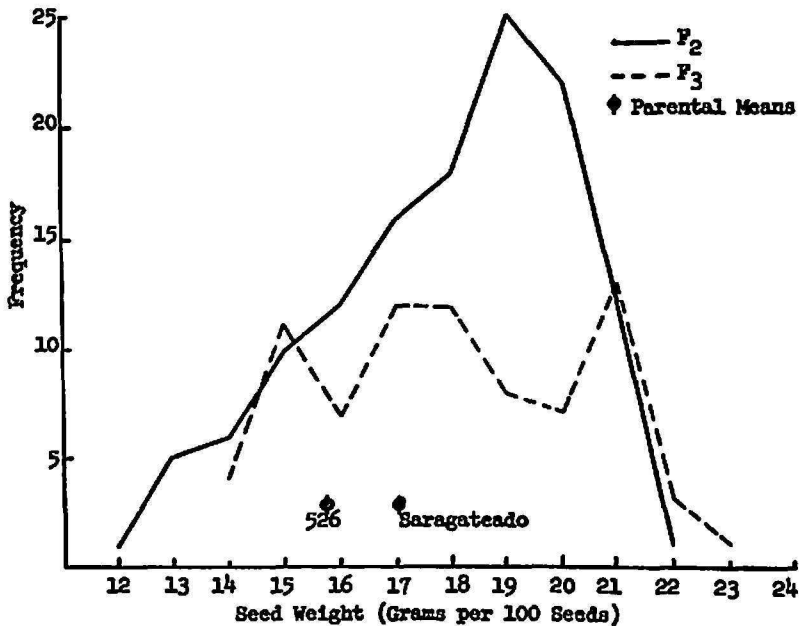

FIG. 15.—Frequency distribution of the F_2 and F_3 generations, and the parental means for seed weight in the cross 526 X Saragateado.

varieties produced low seed yield thus were heavily infested with pod borers. They therefore were excluded from the analyses. Estimates of heritability for F_2 and F_3 generation were 45.1 and 52.1 percent for seed yield and 45.3 and 52.9 for number of pods per plant.

The genetic coefficients of variation are presented in table 4. In general,

the highest coefficients of genetic variation were observed in crosses where the parents contrasted in the attributes under consideration. An exception can be observed in number of seeds per pod in cross Saragateado X 526

TABLE 2.—*Coefficients of variation (percent) for flowering date, plant height, seed weight, and number of seeds per pod of F_2 and F_3 generations of five pigeonpea crosses*

Generation	Flowering date	Plant height	Seed weight	Number of seeds per pod
P.I. 5690 X Kaki				
F_2	8.8	15.8	11.9	11.6
F_3	8.6	16.8	12.7	13.7
P.I. 5690 X Saragateado				
F_2	10.5	14.5	12.1	14.9
F_3	9.2	14.2	15.2	21.5
Kaki X 526				
F_2	5.5	9.3	10.2	11.5
F_3	6.1	9.0	14.2	12.1
P.I. 5690 X 526				
F_2	9.5	13.7	10.6	12.6
F_3	12.1	14.5	14.3	17.2
Saragateado X 526				
F_2	7.6	8.9	12.1	25.6
F_3	10.0	13.2	12.9	13.9

TABLE 3.—*Heritability estimates (percent) for flowering date, plant height, seed weight, and number of seeds per pod in each of five pigeonpea crosses*

Characters	Heritability				
	P.I. 5690 X Kaki	P.I. 5690 X Saragateado	Kaki X 526	P.I. 5690 X 526	Saragateado X 526
Flowering date					
F_2	72.9	81.8	72.5	76.9	60.7
F_3	73.5	76.8	74.7	86.1	72.2
Plant height					
F_2	70.8	75.3	45.1	65.6	36.7
F_3	74.4	71.7	41.8	71.7	38.6
Seed weight					
F_2	75.6	64.4	55.4	35.9	36.3
F_3	75.6	75.9	73.7	61.0	65.3
Number of seeds per pod					
F_2	−37.4	33.3	−6.1	−20.8	55.2
F_3	8.2	64.1	9.6	30.5	64.1

where the genetic coefficient of variation was relatively large. This situation can be explained on the basis of a relatively small plant population, and small population mean, which biased the genetic coefficient of variation.

TABLE 4.—*Genetic coefficient of variability (percent) for flowering date, plant height, seed weight, and number of seeds per pod in F_2 and F_3 generations of five pigeonpea crosses*

	Flowering date	Plant height	Seed weight	Number of seeds per pod
P.I. 5690 X Kaki				
F_2	7.52	13.32	10.36	−7.11
F_3	7.39	14.57	11.06	3.94
P.I. 5690 X Saragateado				
F_2	9.50	12.64	9.72	8.66
F_3	8.06	12.04	13.32	17.26
Kaki X 526				
F_2	3.38	5.84	7.63	−2.86
F_3	3.91	5.38	12.20	3.75
P.I. 5690 X 526				
F_2	8.39	11.10	6.40	5.77
F_3	11.29	12.30	11.22	9.55
Saragateado X 526				
F_2	5.95	5.43	7.29	19.07
F_3	8.54	8.22	8.73	19.19

TABLE 5.—*Genotypic and phenotypic correlations between all pairs of 4 traits measured in the F_2 generations for 5 pigeonpea crosses (genotypic correlations are on the left side of the diagonal, phenotypic on the right)*

Trait	Cross*	Flowering	Height	Seed weight	Seeds per pod
Flowering	1		0.61	0.35	0.22
	2		0.60	−0.08	−0.25
	3		−0.05	−0.07	−0.31
	4		0.46	−0.09	−0.01
	5		−0.24	−0.36	−0.25
Height	1	0.67		0.26	0.36
	2	0.75		0.01	0.06
	3	0.30		0.06	0.24
	4	0.71		0.12	0.37
	5	−0.32		0.18	0.14
Seed weight	1	0.55	0.36		0.21
	2	−0.03	−0.12		0.06
	3	0.01	0.22		−0.06
	4	0.07	0.36		0.06
	5	−0.31	−0.33		0.44
Seeds per pod	1	0.68	0.47	0.22	
	2	−0.27	−0.03	−0.11	
	3	0.97	0.26	1.46	
	4	0.60	0.54	0.03	
	5	−0.35	0.10	0.29	

* 1, 2, 3, 4, 5 denotes P.I. 5690 X Kaki, P.I. 5690 X Saragateado, Kaki X 526, 526 X P.I. 5690 and 526 X Saragateado, respectively.

To study intercharacter associations, correlation coefficients were computed for the four attributes under consideration. Phenotypic and genotypic correlations are presented in tables 5 and 6. In general, the genotypic correlations for any pair of traits seem to be of similar magnitude. Likewise,

TABLE 6.—*Genotypic and phenotypic correlations between all pairs of 4 traits measured in the F_2 generation for 5 pigeonpea crosses (genotypic correlations are on the left side of the diagonal, phenotypic on the right)*

Trait	Cross[1]	Flowering	Height	Seed weight	Seeds per pod
Flowering	1		0.44	0.28	0.06
	2		0.38	−0.23	0.02
	3		−0.01	0.15	−0.30
	4		0.40	−0.20	−0.24
	5		0.17	−0.51	−0.70
Height	1	0.43		0.16	0.48
	2	0.49		−0.11	0.20
	3	0.38		0.11	0.39
	4	0.55		0.03	0.37
	5	−0.14		0.16	0.29
Seed weight	1	0.39	0.22		0.09
	2	−0.23	−0.25		0.05
	3	0.37	0.28		0.06
	4	−0.18	0.09		0.19
	5	−0.60	−0.07		0.41
Seeds per pod	1	0.69	1.56	0.07	
	2	0.16	0.21	−0.02	
	3	0.53	1.09	−0.32	
	4	−0.17	0.53	0.34	
	5	−0.72	0.34	0.29	

[1] 1, 2, 3, 4, 5 denotes P.I. 5690 X Kaki, P.I. 5690 X Saragateado, Kaki X 526, 526 X P.I. 5690, 526 X Saragateado, respectively.

TABLE 7.—*Genotypic and phenotypic correlations of 6 traits measured in the F_2 generation for P.I. 5690 X Saragateado pigeonpea cross (genotypic correlations are on the left side of the diagonal, phenotypic on the right)*

Trait	Yield	Number of pods	Flowering	Height	Seed weight	Number of seeds per pod
Yield		0.90	−0.14	0.25	0.11	0.39
Number of pods	0.91		−0.11	0.20	−0.14	0.31
Flowering	−0.12	−0.08		0.60	−0.08	−0.25
Height	0.25	0.18	0.75		0.01	0.06
Seed weight	0.09	−0.21	−0.03	−0.12		0.06
Number of seeds per pod	0.52	0.30	−0.27	−0.03	−0.11	

the values observed for any two characters are rather similar for the five crosses.

Plant height, in general, is highly positively correlated with late flowering and tends to be negatively correlated with seed weight and number of seeds per pod. As mentioned previously, late flowering plants are subject to more severe attack by pod borers and other insects than early flowering types,

TABLE 8.—*Genotypic and phenotypic correlations between all pairs of 6 traits measured in the F_2 generation for P.I. 5690 X Saragateado pigeonpea cross (genotypic correlations are on the left side of the diagonal, phenotypic on the right)*

Trait	Yield	Number of pods	Flowering	Height	Seed weight	Number of seeds per pod
Yield		0.91	−0.07	0.33	0.29	0.11
Number of pods	0.93		−0.04	0.30	0.10	0.11
Flowering	−0.04	0.03		0.38	−0.23	0.02
Height	0.34	0.31	0.49		−0.11	0.20
Seed weight	0.31	0.10	−0.23	−0.25		0.05
Number of seeds per pod	0.05	−0.01	0.16	0.21	−0.02	

TABLE 9.—*Genotypic and phenotypic correlations of 6 traits measured in the F_2 generation for 526 X P.I. 5690 pigeonpea cross (genotypic correlations are on the left side of the diagonal, phenotypic on the right)*

Trait	Yield	Number of pods	Flowering	Height	Seed weight	Number of seeds per pod
Yield		0.89	−0.03	0.46	0.13	0.52
Number of pods	0.89		0.05	0.42	−0.08	0.40
Flowering	−0.17	0.17		0.46	−0.09	−0.01
Height	0.47	0.39	0.71		0.12	0.37
Seed weight	0.19	−0.10	0.06	0.36		0.06
Number of seeds per pod	0.57	0.35	0.60	0.54	0.03	

because insect populations are greater in numbers later in the season. Late types also are more exposed to environmental stresses such as higher temperature and drought conditions which affect yield and its components adversely.

Genotypic and phenotypic correlations between all six pairs of traits which include yield and yield components are presented in tables 7 to 10. These data were included even though the authors are aware that the number of parental plants is small. Interesting data resulted from two crosses in which the parents showed extreme contrast in most traits. Seed yield is highly positively correlated with number of pods per plant, as expected, in

both crosses. Of particular interest is the negative correlation in both crosses between seed yield and late flowering date. Since pigeonpea is a seasonal crop and very sensitive to photoperiodism, the amount of flower induction apparently is smaller in late flowering types than in early ones. Correlations between other traits followed the same trend as those discussed earlier.

DISCUSSION

There was much greater variation, in general, in seed weight, plant height, and flowering date for all crosses than in number of seeds per pod. The heritable and non-heritable components of variation were estimated with the help of some genetic parameters such as heritability and genetic coefficients of variation.

TABLE 10.—*Genotypic and phenotypic correlations between all pairs of 6 traits measured in the F_2 generation for 526 X P.I. 5690 pigeonpea cross (genotypic correlations are on the left side of the diagonal, phenotypic on the right)*

Trait	Yield	Number of pods	Flowering	Height	Seed weight	Number of seeds per pod
Yield		0.90	−0.18	0.45	0.27	0.62
Number of pods	0.90		−0.07	0.43	0.01	0.45
Flowering	−0.30	−0.02		0.40	−0.20	−0.24
Height	0.46	0.41	0.55		0.03	0.37
Seed weight	0.34	0.04	−0.18	0.09		0.19
Number of seeds per pods	0.83	0.55	−0.17	0.53	0.34	

High heritability values were obtained for some of the characters studied, i.e., flowering date, plant height, and seed weight. The relatively high heritability values for flowering date and plant height might justify the selection for these characters in F_2 and F_3 segregating generations. These traits apparently are not affected largely by environmental factors, thus genetic advances under selection would be expected to be high.

In two particular crosses, namely Saragateado X 526 and Kaki X 526, plant height heritability values obtained were 36.7 and 45.1 for F_2 generation and 38.6 and 41.8 for F_3 generation, respectively. The low values obtained for these two crosses seem to be due to the small genetic variation for this trait in the parents involved. Line 526 is derived from radiation-treated Kaki, with similar mean plant height. We therefore can assume that the gene system for plant height is the same or very similar for both entries. Saragateado is a late-flowering, tall variety with a mean plant height equal to Kaki and line 526. This reasoning could be explained based on the findings that the progenies from the crosses involving these parents have a

mean plant height equal to that of the parents and also a small genetic variance as indicated in tables 1 and 4.

Seed weight heritability was next highest to flowering date and plant height. Seed weight is one of the yield components; therefore, the number of genes responsible for the expression of this trait should be smaller than for total yield and should be less affected by environmental factors. In general, the complexly-inherited characteristics have lower heritability than those inherited simply. The genetic coefficients of variation for seed weight also were relatively large for all crosses, thus, good genetic progress through selection could be made for this trait whenever a good screening technique is employed during the early segregating generations.

Small genetic variation and heritability estimates were obtained for number of seeds per pod. Even though wide ranges were observed for this attribute, the extremes were represented by few plants and the means were practically the same for parental, F_2 and F_3 populations. Not too much progress by selection could be expected for this yield component from the parental material used in this study. All four parents involved in this study had similar or the same number of seeds per pod. Observations made by Abrams[4] in crosses between Florido, a 7 to 8 and Kaki, a 4 to 5 seed-per-pod variety tend to indicate that 1 or 2 more seeds per pod on the average could be incorporated in selected progenies from this particular cross.

Heritability estimates for seed yield and number of pods per plant made for cross P.I. 5690 X Kaki indicated that these characters were influenced by non-heritable effects. These results are in close agreement with the work done by Weber and Moorthy (20) and Mahmud and Kramer (12), in soybeans, another legume crop, for early generation segregating populations, and substantiate the established belief among plant breeders that selection for yield should be based upon progeny test rather than upon individual plant values.

The heritability values in F_3 generation were higher in general than in F_2 for all traits in the five crosses. This trend was expected because both generations were grown in the same year and in the same location, therefore reducing the genotype X year and genotype X location interactions to a minimum. Under these conditions the additive genetic variance would show greater expression in F_3 generation, as expected.

It appears probable that these pigeonpea varieties differ in some genes, conditioning most characters studied. Thus, plus and minus gene effects conditioning an attribute in different parents permitted a complementary type of gene action in F_2 and F_3 segregates. This would explain the indicated transgressive segregation observed in F_2 and F_3 generations for some attributes of the five crosses. The characteristic number of seeds per pod does

4 Unpublished data.

not show this complementary type of gene action in the F_2 and F_3 segregates as shown in table 1. The four parents used in this study apparently have a similar gene system for number of seeds per pod.

With the exception of number of pods per plant, the correlations between seed yield and other traits were not sufficiently great to provide reliable indications for yield. The phenotypic and genotypic correlations between seed yield and number of pods per plant was high, 0.90 and 0.9. We might expect to improve seed yield by selecting for large number per pods. However, its low heritability, 45.3 and 52.1 percent in F_2 and F_3 generations, tends to indicate that not too much progress for seed yield improvement could be expected by selecting for large number of pods per plant. The initial selection should perhaps be directed to seed weight which has a relatively high heritability, postponing selection for number of pods per plant. According to Frey (6) and Jones and Frey (10), heritability of a trait approaches its maximum in successive generations following hybridization, and selection for number of seeds per plant could be based on counts for normal planting rates to avoid the environmental effect associated with spaced plants.

All other genotypic and phenotypic correlations between pair of traits were of too small a magnitude to attain maximum values for a given pair of traits.

SUMMARY

Three varieties and an irradiation-derived line of pigeonpeas were used as parents in five crosses as follows: P.I. 5690 X Kaki, P.I. 5690 X Saragateado, P.I. 5690 X 526, Kaki X 526, and Saragateado X 526.

The F_2, F_3 and parents of each cross were planted in the field at the Isabela Substation during 1966–67 in a randomized block design with three replicates.

Genotypic variability was studied and genotypic and phenotypic correlations were calculated for all the crosses in the F_2 and F_3 generations.

Genetic coefficients of variation and heritability estimates were computed for four traits in five crosses and for six traits in one particular cross. Frequency distributions are shown for date of flowering, plant height, and seed weight.

There was much greater variation for all crosses, in general, in seed weight, plant height, and flowering date than in number of seeds per pod.

With the exception of number of pods per plant the correlations between seed yield and other traits were not great enough to provide reliable indications for yield. The phenotypic and genotypic correlations between seed yield and number of pods per plant were high, above 0.90. However, their low heritability, 45.3 and 52.1 percent in F_2 and F_3 generations, tends to

indicate that not too much progress could be expected for seed yield improvement by selecting for large number of pods per plant.

Good progress by selection could be made by breeders in traits such as flowering date, plant height, and seed weight which showed high heritability values.

RESUMEN

Para este trabajo se cruzaron tres variedades de gandures y una línea obtenida mediante la irradiación de la variedad Kaki, en cinco combinaciones, a saber: P.I. 5690 X Kaki, P.I. 5690 X Saragateado, P.I. 5690 X 526, Kaki X 526 y Saragateado X 526.

Los padres y las generaciones F_2 y F_3 de cada cruce se sembraron en la Subestación de Isabela durante el año 1966–67 en un diseño de bloques distribuidos al azar, con tres repeticiones.

Se estudió la variabilidad genotípica y se calcularon las correlaciones fenotípicas y genotípicas para todos los cruces en la generaciones F_2 y F_3.

Los coeficientes genéticos de variación y los estimados de heredabilidad se calcularon para cuatro caracteres en los cinco cruces y para seis caracteres en un cruce en particular. Se presentan datos sobre la frecuencia de la florecida, altura de las plantas y peso de la semilla.

En general, fue mayor la variación en todos los cruces respecto a la altura de las plantas, florecida y peso de la semilla, que en cuanto al número de semillas por vaina.

Con la excepción del número de vainas por planta, las correlaciones entre la producción y los demás caracteres no fueron lo suficientemente altas como para constituir una indicación confiable respecto a la producción. Las correlaciones genotípicas y fenotípicas entre la producción y el número de vainas por planta fueron altas, excediendo 0.90. Sin embargo, los bajos porcentajes de heredabilidad en las generaciones F_2 y F_3 (45.3 y 52.1, respectivamente) tienden a indicar que no ha de lograrse un aumento en la producción si la selección se hace a base de que las plantas tengan muchas vainas.

En cambio, la selección en las primeras generaciones dará buenos resultados en el caso de tales caracteres como la florecida, altura de las plantas y peso de la semilla, que demostraron altos valores de heredabilidad.

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