Radiation Research with Pigeonpeas (*Cajanus cajan*): Results on X_3 and X_4 Generations

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INTRODUCTION

During the past several years numerous experiments have been conducted to induce mutations for the improvement of cultivated plants by means of "mutation breeding." It is by now evident that induced mutations can increase the yielding capacity of a variety, or improve special qualities of importance, such as earliness and lateness in maturity, stiffness of straw, grain size, disease resistance and other attributes.

Gustafsson and MacKey (*4*)[2] and Muntzing (*7*) have used radiations to produce mutations for earliness, lateness, and better straw strength in the cereals. Frey (*2*, *3*) reported mutants in oats with shorter, stronger straw, earlier and later maturity, different bushel weight and yield, and field resistance to the prevalent races of crown and stem rust.

According to Gustafsson and Tedin (*5*) radiation has been used to induce mutations for straw stiffness, earliness, protein content, baking quality, fiber-strength, and grain-size in the cereals and comparable mutations in peas, lupines, flax, and tomatoes. Merten and Burdick (*6*) produced two lines of tomatoes that were earlier than the control.

This paper reports some preliminary results from investigations concerning the induction, by means of ionizing radiations, namely, γ rays and neutrons, of mutations in the X_3 and X_4 generations of pigeonpeas, (*Cajanus cajan*).

MATERIALS AND METHODS

Two hundred fourteen lines of pigeonpeas from the X_2 plant population were used in the X_3 generation. These lines were selected on the basis of the data recorded from the X_2 generation by Abrams and Vélez Fortuño (*1*), *i.e.*, early-, intermediate-, and late-flowering mutants, tall, vigorous types, and lines with general desirable agronomic qualities for this particular crop. The radiation lines plus the parent variety Kaki and late variety Saragateado were planted in a 6 x 6 x 6 cubic lattice design with three replications. Each plot consisted of a single row, 56 feet long and 8 feet between plots. The seed in each entry were spaced 4 feet apart and planted at a

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[2] Italic numbers in parentheses refer to Literature Cited, p. 42.

heavy rate and thinned at random to one plant per hill. A perfect stand would have given 14 plants per entry per replicate. Data were recorded on flowering date and yield of shelled dry peas.

A total of 86 lines (approximately 40 percent) was selected from the X_3-generation experiment and, together with 12 early F_5 hybrids from a cross between Kaki x Florido, plus commercial varieties Kaki and Saragateado as controls, were arranged in a 10 x 10 triple lattice design with three replicates during 1959–60 at the Isabela Experiment Substation. A plot consisted of two rows, 8 feet apart and 30 feet long, with the seed spaced 3 feet apart and thinned to one plant per hill, making a total of 20 plants per entry per replicate for a perfect stand. Date of flowering and yield of green pods were determined on a plot basis.

TABLE 1.—*Analyses of variance for number of days to flower and yield of dry shelled pigeonpeas from 214 X_3 lines, parent variety Kaki and late variety Saragateado grown in 1959*

Source of variation	d.f.	Mean squares[1]	
		Days to flower	Yield
Replications	2	13.10	79.21
Blocks (eliminating lines)	105	33.16	4.34
Lines (ignoring blocks)	215	115.55**	2.70**
Error (intrablock)	325	5.89	.97

[1] ** Denotes significance at the 1-percent level.

EXPERIMENTAL RESULTS

X_3 GENERATION

The analyses of variance are shown in table 1 for each of the characters studied in the X_3 generation. There were highly significant differences among lines for all characters; however, this was expected because of the large character differences among lines caused by irradiation in the X_2 generation. A considerable degree of accuracy in the measurement of each character was indicated by the relatively small experimental errors.

Frequency distributions for the X_3 generation, together with the check varieties, are presented in the form of graphs for flowering dates and yield of dried shelled peas.

Figure 1 presents the frequency distribution for mean flowering date of X_3's and the control-treatment means. The distribution appeared to be normal for this attribute. As in the previous generations the range exceeded that of the parent variety Kaki in both directions, *i.e.*, earlier and later maturing lines with a higher frequency of intermediate types; however, no particular line exceeded the late commercial variety Saragateado. The range for the X_3 generation lines was from 112 to 142 days to flower with means of 119, 123, and 152 days for parent variety Kaki, X_3 lines, and late variety Saragateado, respectively.

Frequency distributions for yield of dry shelled peas for X_3 lines, Kaki, and Saragateado varieties, are presented in figure 2. High variability was observed in the yield of the X_3 generation. Yield ranged from a low of 145 to a high of 679 pounds per acre, with means of 246, 435, and 439 pounds

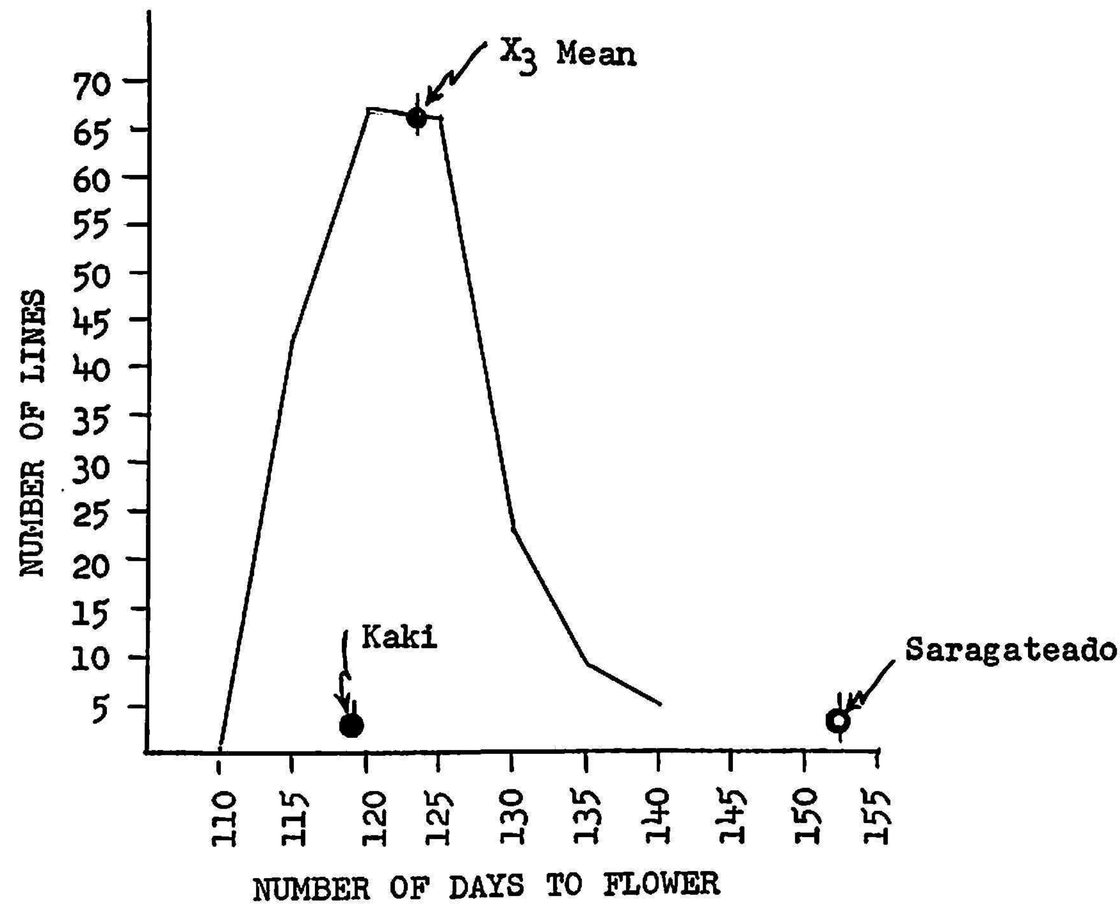

FIG. 1.—Frequency distributions of the X_3 generation and the mean of the parent variety Kaki and late variety Saragateado pigeonpeas for number of days to flower.

for Saragateado, Kaki, and X_3 lines, respectively. Low-yielding X_3 lines can be explained on the basis of partial sterility caused by radiation treatments; nevertheless, it is of interest to observe that a good number of lines exceeded the parent variety for this attribute. Late variety Saragateado has been always a lower yielder than Kaki and more so in regard to dry shelled peas than on a green-weight basis, according to field observations.

X_4 GENERATION

The analyses of variance for number of days to flower and yield of green pods are presented in table 2. There were highly significant differences for

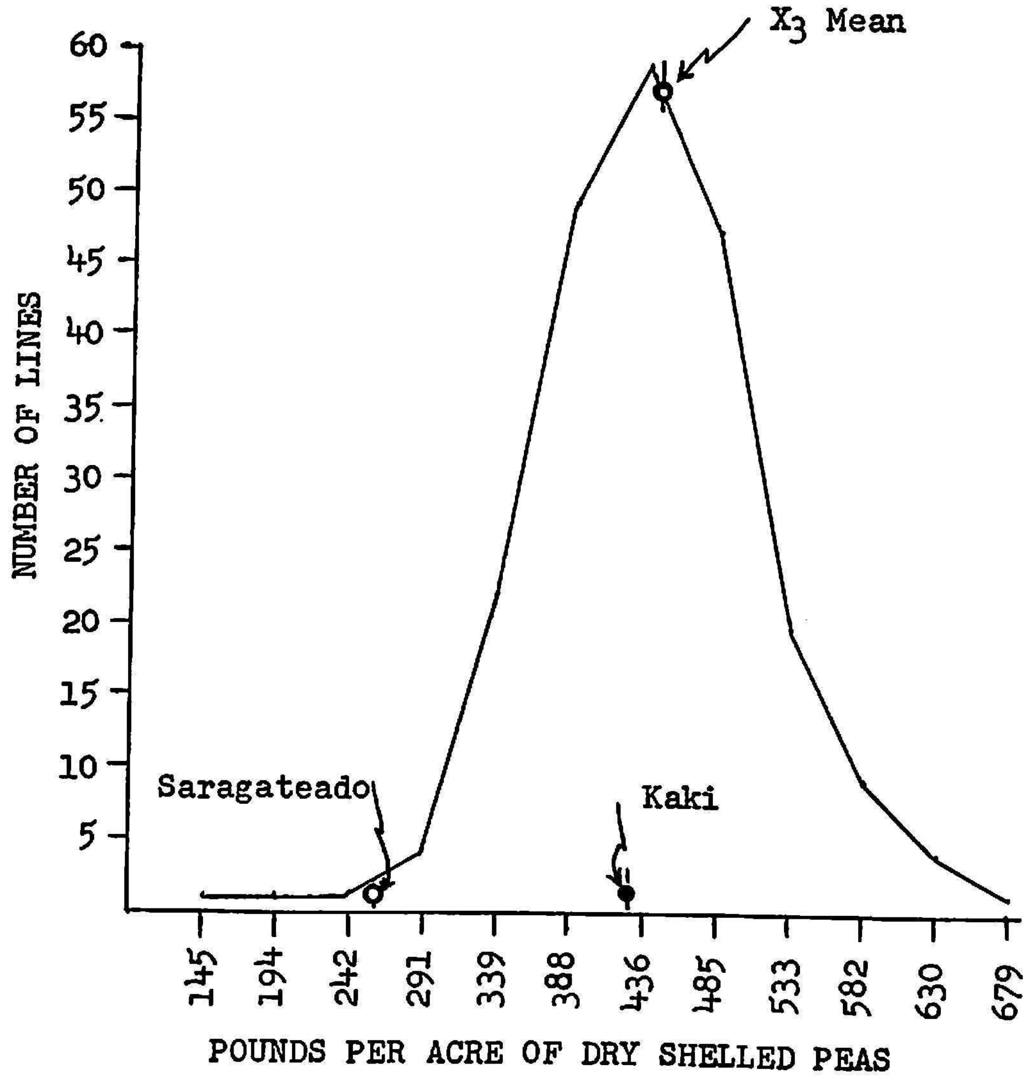

FIG. 2.—Frequency distributions of the X_3 generation and the mean of the paren variety Kaki and late variety Saragateado for yield, in pounds per acre of dry shelled pigeonpeas.

TABLE 2.—*Analyses of variance for number of days to flower and yield of green pods from 86 X_4 lines, 12 F_5 hybrids, and varieties Kaki and Saragateado of pigeonpeas grown in 1960*

Source of variation	d.f.	Mean squares[1]	
		Days to flower	Yield
Replications	2	53.75	1,048.16
Blocks (eliminating lines)	27	35.89	84.17
Lines (ignoring blocks)	99	372.93**	219.98**
Error (intrablock)	171	1.91	35.60

[1] ** Denotes significance at the 1-percent level.

the attributes studied, following a pattern similar to the one obtained in the X_3 generation.

Frequency distributions for number of days to flower are shown in figure 3 for 86 X_4 lines, 12 F_5 hybrids, and varieties Kaki and Saragateado. The F_5 hybrids showed a trend toward earliness with a range of 111 to 123 days and mean of 118 days; the X_4 lines ranged from 126 to 163 days with mean

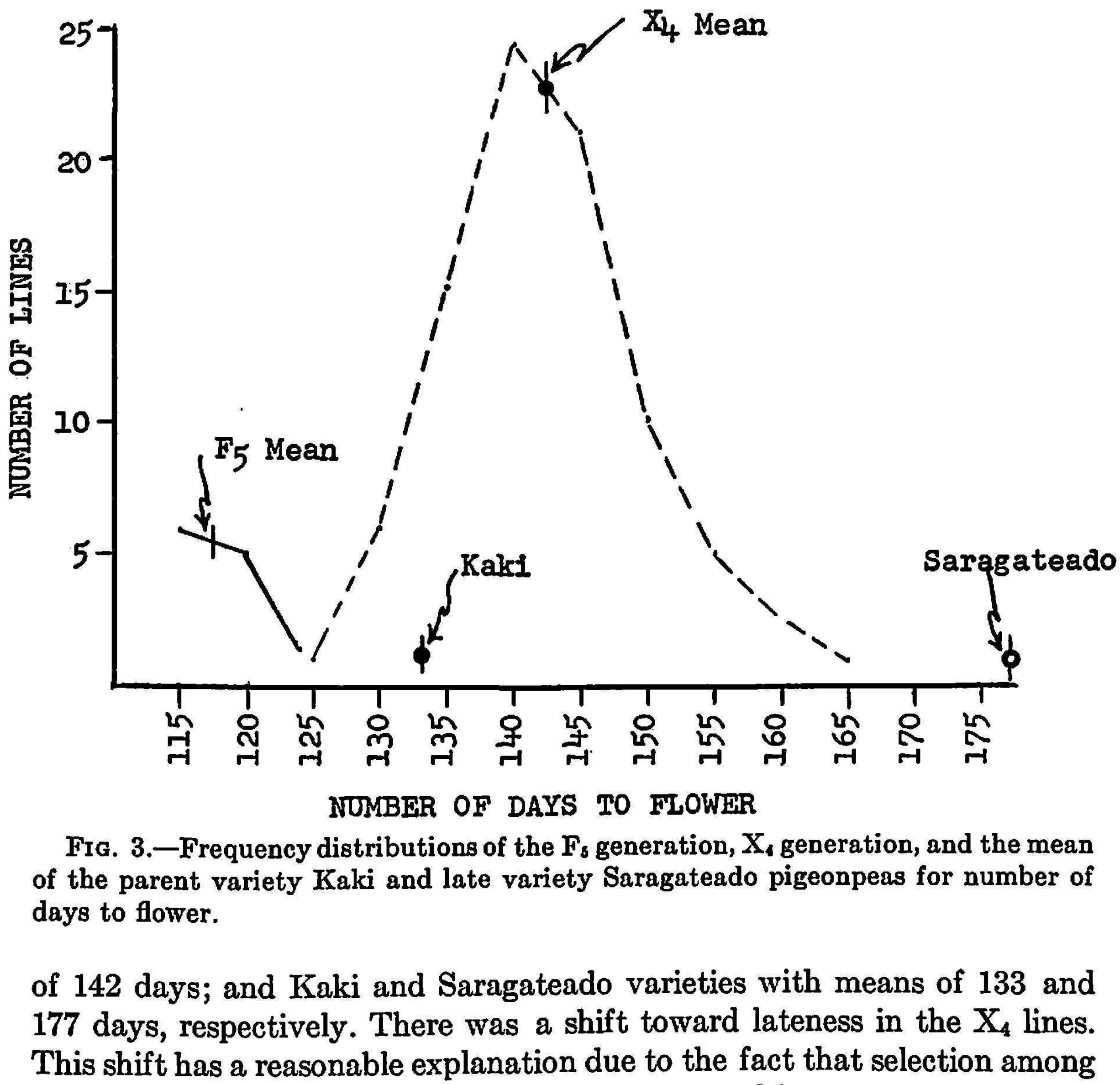

FIG. 3.—Frequency distributions of the F_5 generation, X_4 generation, and the mean of the parent variety Kaki and late variety Saragateado pigeonpeas for number of days to flower.

of 142 days; and Kaki and Saragateado varieties with means of 133 and 177 days, respectively. There was a shift toward lateness in the X_4 lines. This shift has a reasonable explanation due to the fact that selection among lines since the X_2 generation has been for early and late types, with a predominance of lines for a late-flowering date. Difference in planting dates plus seasonal effects must also have contributed to this shift, as indicated by the differences in the two seasons for the Kaki and Saragateado.

Frequency distributions for yield of green pods are presented in figure 4. The F_5 hybrids showed the lowest yields with a range of 630 to 1,748 pounds per acre, with a mean of 1,156 pounds; X_4 lines ranged from 1,687 to 4,280 pounds per acre, with a mean of 2,795 pounds, and Kaki and Saragateado varieties had means of 3,050 and 1,284 pounds per acre, respectively. This distribution follows a pattern similar to the one obtained in the X_3 generation in regard to yield, *i.e.*, X_3 lines lower and higher yielders than parent variety Kaki and Saragateado lower yielder than Kaki. The F_5 hybrids group, in general, were lower yielders. A possible explanation for this is a

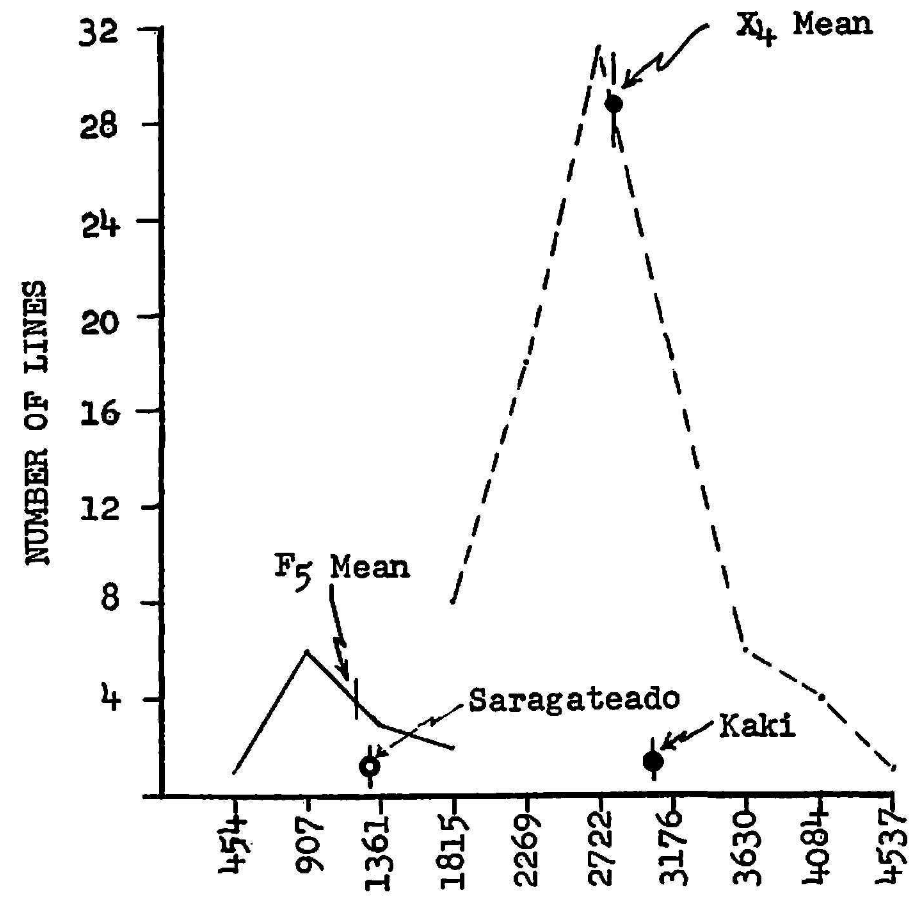

FIG. 4.—Frequency distributions of the F_5 generation, X_4 generation, and the mean of the parent variety Kaki and late variety Saragateado pigeonpeas for yield of green pods in pounds per acre.

reduced pod set. It was observed that these hybrids flowered early and profusely, but most of their flowers dropped without having a normal pod set. This condition was not observed in any of the other treatment plots.

In table 3 data are given for several families[3] of radiation derived lines. The data presented herein are from only a portion of the mutant strains selected from the irradiated Kaki material. However, they are representative. Line 30-26 is an early derived line, while the rest of the 15 lines are

[3] A family was derived from 1 γ-ray- or neutron-treated seed.

intermediate to late in date of flowering. Of special interest is the fact that lines selected for earliness and lateness have been consistently such since the X_2 generation. Differences in the mean number of days to flower between the 1959 and 1960 crops may be attributed to the effect of selection, and to the different dates of planting and season. The 1959 crop was planted in August while the 1960 crop was planted in July. Several of the

TABLE 3.—*Mean agronomic performance of X_3 and X_4 pigeonpea selections from families of irradiated Kaki variety material*

Selection	Yield		Flowering date			
	1959[1]	1960[2]	1959[3]	Delay in anthesis	1960[4]	Delay in anthesis
	Lb./A.	*Lb./A.*	*Days*	*Days*	*Days*	*Days*
30-26	446	3,092	113	−7	126	−7
86-21	474	3,956	126	+6	140	+7
127-10	560	4,095	127	+7	141	+8
106-21	506	3,753	127	+7	143	+10
106-9	481	4,281	128	+8	144	+11
106-24	481	3,749	125	+5	145	+12
27-24	624	3,989	127	+7	145	+12
106-26	631	3,890	127	+7	145	+12
106-16	558	3,174	127	+7	145	+12
106-22	551	3,035	133	+13	148	+15
70-38	397	3,052	139	+19	152	+19
70-37	374	2,750	140	+20	154	+21
166-40	602	2,443	134	+14	159	+26
116-5	432	2,209	133	+13	159	+26
70-39	376	2,411	140	+20	163	+30
Kaki	435	3,050	120	—	133	—
Saragateado	246	1,284	152	+32	177	+44

[1] Yield on basis of dry shelled peas.
[2] Yield on basis of green pods.
[3] Planted in August 1958.
[4] Planted in July 1959.

lines were higher yielders than the parent variety during the X_3 and X_4 generations, indicating the possibility of improving this attribute by means of irradiation.

DISCUSSION

The agronomic mutations obtained from γ-ray and neutron-treated Kaki pigeonpea seed permit optimism concerning the possibilities of "mutation breeding" in this crop. Probably the most desirable agronomic mutation found was that for earliness and lateness in flowering date, which, in turn, makes it possible to increase the production season of pigeonpeas in Puerto Rico and consequently would result in an increase in total production and larger output for the canning factories.

Apparently flowering date is a characteristic with a high heritability, since the attribute has been expressed consistently in the selected lines from X_2 up to X_4 generations.

Several of the lines yielded more than the parent variety, Kaki, especially the early- and intermediate-flowering ones. In general, the later varieties tended to yield less, however, their yield was superior to that of the late commercial variety Saragateado, making them very desirable.

These results from the X_3 and X_4 generations indicate that: 1, Irradiation resulted in mutations which conditioned a yield increase in selected pigeonpea lines; 2, mutation effect in yield was large enough to be detected with the standard testing procedures; and 3, it is possible to fix some of the genetic variability in the irradiated families by repeated single plant selections, as in the case of flowering date.

Further testing and purification of the lines will be undertaken to determine their stability and possible use of these lines for commercial production or as a source of germ plasm for our breeding program.

SUMMARY

A number of agronomically desirable mutant strains of pigeonpeas were isolated from seed of Kaki variety irradiated with γ rays and neutrons. Some were earlier than the parent variety while others were later in date of flowering during the X_3 and X_4 generations tests. Many of the mutant lines also yielded better than the parent variety and late commercial variety Saragateado.

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RESUMEN

Se seleccionó un número de líneas de gandur de la segunda generación de un material previamente tratado con rayos gamma y neutrones. Estas líneas se incluyeron en ensayos experimentales en su tercera y cuarta generación. Se observaron los siguientes resultados:

1. Algunas de estas líneas fueron más tempranas y otras más tardías en producción que la variedad madre, Kaki.

2. Hubo líneas de mejor producción que la variedad madre y que la variedad tardía Saragateado.

Los resultados de las generaciones X_3 y X_4 indican 1, que la irradiación causó mutaciones que condicionaron un aumento en rendimiento en líneas selectas de gandur; 2, que el efecto de las mutaciones sobre el rendimiento fué suficientemente grande para poderse medir con los procedimientos usuales de prueba; y 3, que es posible fijar alguna variabilidad genética en las familias irradiadas mediante una continua selección de plantas individuales, como en el caso de la época de florecida.

Se continuará el estudio y purificación de estas líneas para determinar su estabilidad genética y valor comercial, o como fuente de germoplasma para futuros trabajos de mejoramiento.

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