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Radiation Research with Pigeonpeas (*Cajanus cajan*): Results on X_1 and X_2 Generations

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INTRODUCTION

It is a well-known fact that ionizing radiations affect germination, plant growth, fertility, and time of anthesis (*1, 3, 6, 9*)[2], among other characters in the higher plants. Different sources of radiation may affect these factors in different manners (*4, 10*).

Not all mutants induced by radiations are deleterious; many of them have useful agricultural properties. Important European radiation-derived varieties include the "Stralart" Ray Pea (*7, 8, 11*) and Primex white mustard (*2, 7, 11*).

In the United States, Down and Anderson (*5*) produced the bush-type bean variety Sanilac by radiating the Michelite variety. The bush character greatly aids mechanical harvesting, keeps the pods off the ground, and minimizes the effects of wet, humid weather during harvest. It had never been possible previously to produce a bush-type field bean with a smooth seedcoat. Under the name "NC 4X" Gregory released a radiation-derived peanut variety which appeared superior for several agronomic characters to the varieties previously recommended for North Carolina. A radiation-derived oat variety with superior crown rust resistance has been released recently in Florida.

This paper is based on investigations carried out during 1956 to 1958 at the Isabela Agricultural Experiment Substation. The objective was to explore the use of gamma rays and neutron radiation as a tool in practical plant-breeding work with pigeonpeas (*Cajanus cajan*). In the present study the effects of γ rays and neutrons on germination, plant growth, and time of anthesis in the X_1 and X_2 generations of pigeonpeas are reported.

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[2] Italic numbers in parentheses refer to Literature Cited, p. 204.

MATERIALS AND METHODS

In the spring of 1956 dormant seed of pigeonpea variety Kaki, were sent to the UT-AEC Agricultural Research Program at Oak Ridge, Tenn., for radiation treatment. The following gamma-ray and neutron treatments were given to the seed.

Gamma rays(r)	*Neutrons (hours)*
0	0
4,000	0.5
8,000	1
16,000	2
32,000	3
64,000	6

Twenty-five seed from each treatment were planted in plant bands at the greenhouse in order to protect the small plants during the early growing stage. After 30 days the surviving plants were transplanted to the field at the Isabela Agricultural Experiment Substation Farm.

Germination percentages were determined 8 days after planting and measurements of plant height in feet were made every month. A record was also kept on the flowering date of each individual plant in the X_1 generation.

The X_1 plants in the field in 1956 were harvested and threshed individually. X_2 plant rows of 50 seed each from individual plants of the X_1 generation were planted at the Isabela Substation Farm in 1957. The X_2 plants were grown at 4-foot spacings in rows 8 feet apart, making a population of approximately 12,000 plants in the X_2 generation. The mother variety Kaki was included for comparison in every tenth row. Data were recorded on plant height, flowering date, general agronomic characteristics, and detectable mutants in the X_2 generation.

RESULTS AND DISCUSSION

X_1 GENERATION

Both gamma rays and neutrons caused a reduction in germination with the highest dosages as shown in table 1. A dose of 64,000 r of gamma rays or a neutron exposure for 6 hours impaired germination of the seed so much that no plants survived. A reduction in germination of 30 and 15 percent was caused by a dose of 32,000 r of gamma rays and 3 hours exposure to neutrons, respectively.

Plant height was also affected by the higher dosages of both sources of radiation as shown in table 1 and figure 1.

Of particular interest were the results observed on the effect of both sources of radiation on flowering date, both tending to stimulate early- and late-flowering-type plants. Under one of the treatments with 16,000 r of gamma rays, one particular plant flowered 28 days later than the mother variety.

X_2 GENERATION

The frequency distributions for plant height in the mother variety and the X_2 generation of pigeonpea variety Kaki are presented in table 2 and figure 2. An examination of the X_2 frequency distributions shows individuals shorter and taller than the mother variety, indicating an increase in genetic variability for this attribute caused by the radiation treatments.

TABLE 1.—*Effect of gamma rays and neutrons on the germination percentage, plant height, and time of anthesis in the X_1 generation of pigeonpeas,* (**Cajanus cajan**)

Treatment	Germination	Plant height	Mean days to flower	Delay in anthesis
	Percent	*Feet*	*Number*	*Days*
Untreated	100	3.97	115	
Gamma rays				
4,000 r	96	3.95	105	−10
8,000 r	100	3.77	105	−10
16,000 r	96	4.18	131	+16
32,000 r	70	3.73	132	+17
64,000 r	0	—	—	—
Neutrons				
30 minutes	100	3.83	107	−8
1 hour	100	3.60	110	−5
2 hours	100	3.89	113	−2
3 hours	85	3.08	119	+4
6 hours	0	—	—	—

The mean plant heights for the radiated population and the mother variety were 5.15 and 4.97 feet, respectively, indicating a tendency toward higher plants by the radiation treatments.

The higher values for the standard deviations and coefficient of variability of the X_2 generation as compared with that of the mother variety give evidence of the increased genetic variability in plant height caused by the radiation treatments.

Data on flowering date for the mother variety and the X_2 generation of pigeonpea variety Kaki are shown in table 3 and figure 3. The mother variety ranged from 125 to 135 days to flower, with a mean of 131.66 days, while the X_2 population ranged from 115 to 165 days, with a mean of 133.52 days.

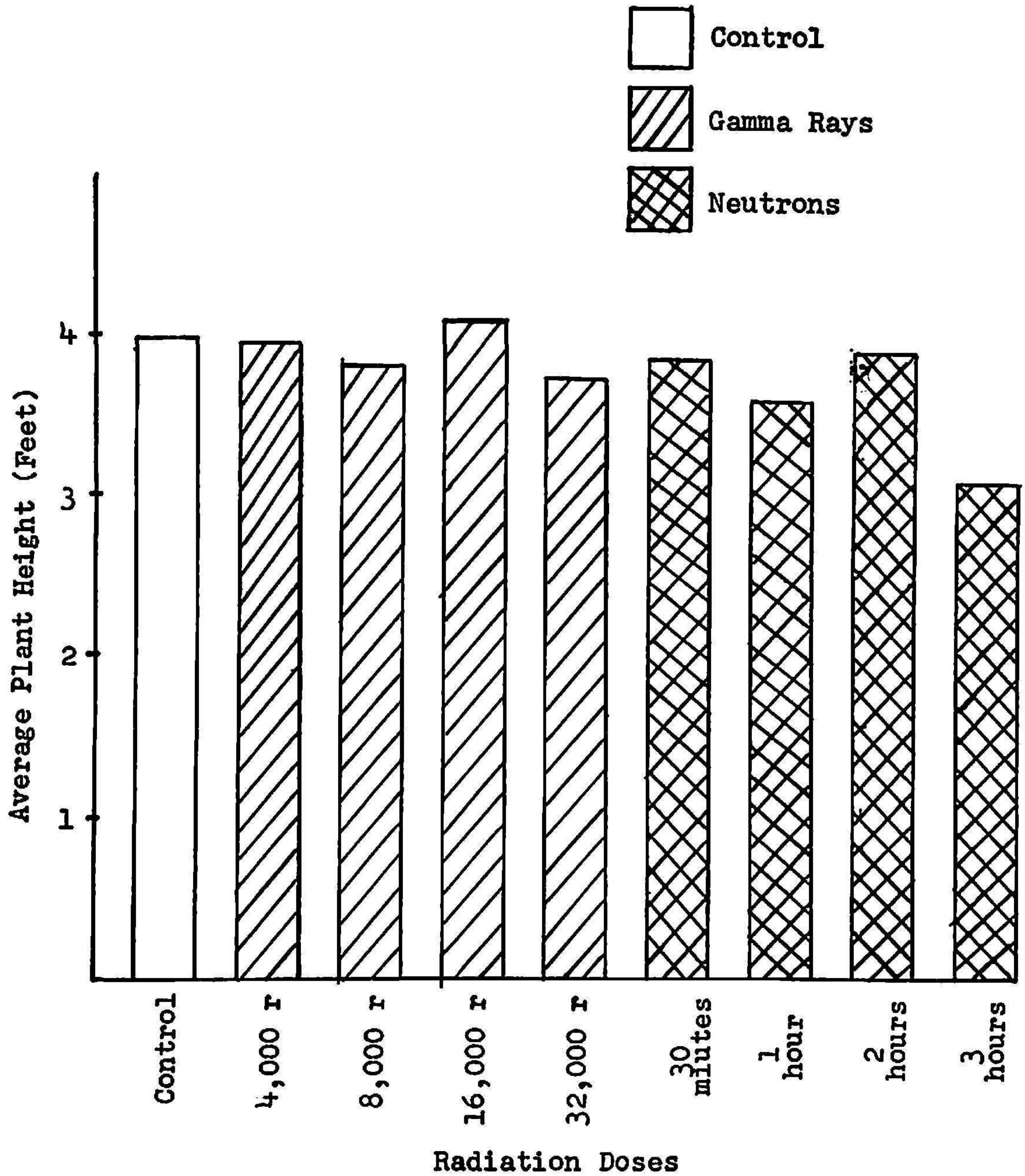

FIG. 1.—Effects of different doses of gamma rays and neutrons on plant height of pigeonpea variety Kaki in the X_1 generation.

TABLE 2.—*Frequency distributions for plant height in the mother variety and X_2 generation of pigeonpea variety Kaki*

Generation	Data for class centers in feet										n	X	S.D.	C.V.
	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75	6.00	6.25				
Parent	—	—	2	5	2	1	2	1	—	—	13	4.97	0.4	3
X_2	6	10	31	42	27	14	15	10	4	3	162	5.15	1.67	30

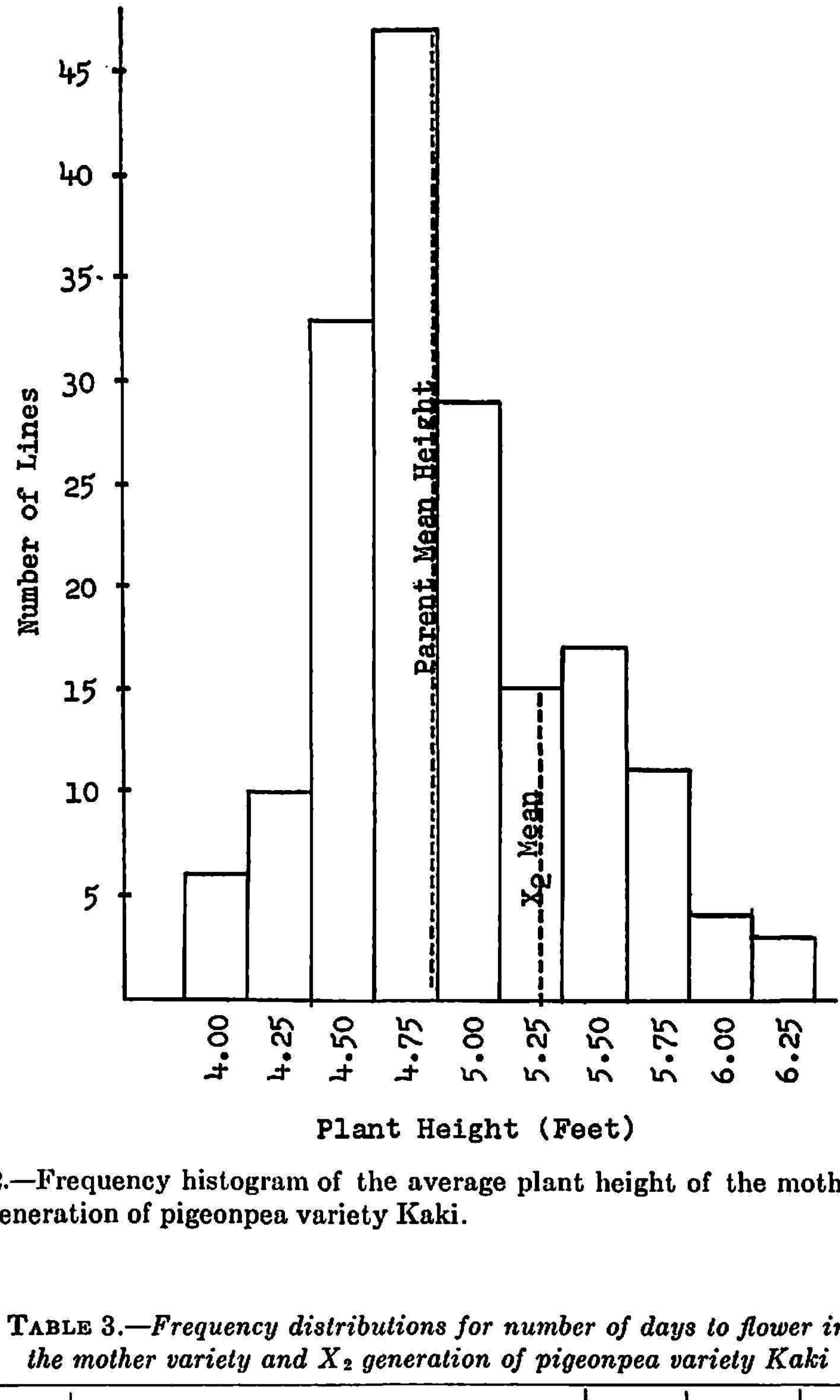

FIG. 2.—Frequency histogram of the average plant height of the mother variety and X_2 generation of pigeonpea variety Kaki.

TABLE 3.—*Frequency distributions for number of days to flower in the mother variety and X_2 generation of pigeonpea variety Kaki*

Generation	Data for class centers in days											*n*	*X*	S.D.	C.V.
	115	120	125	130	135	140	145	150	155	160	165				
Parent	—	—	3	4	6	—	—	—	—	—	—	13	131.66	4.46	3.40
X_2	1	6	34	49	32	16	9	7	5	2	1	162	133.52	9.00	7.00

The data indicate a great variability in the radiated population for flowering date, with lines flowering earlier and later than the mother variety. This fact is substantiated by the standard deviation and coefficient of

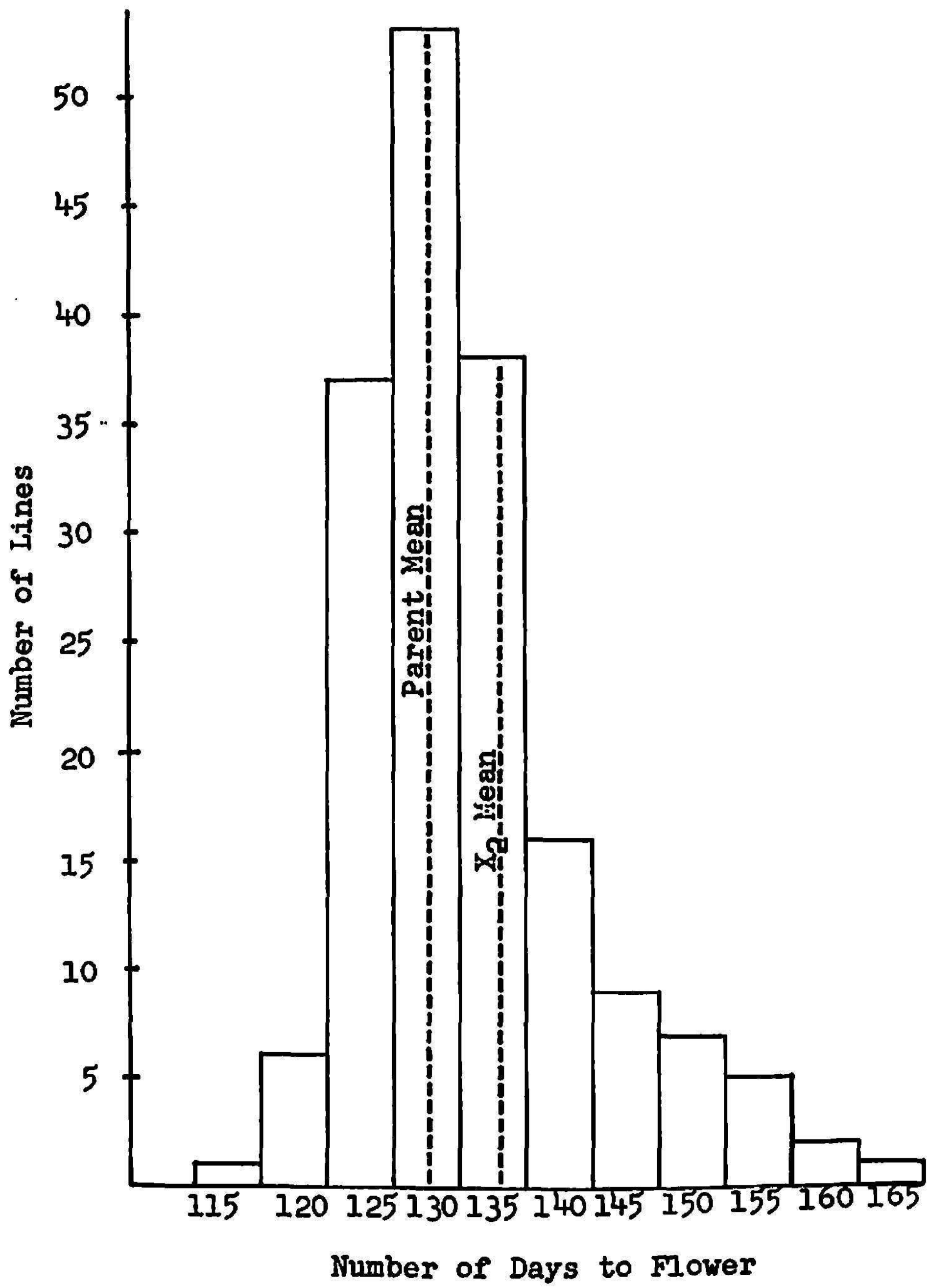

FIG. 3.—Frequency histogram of the average number of days to flower for the mother variety and X_2 generation of pigeonpea variety Kaki.

variability of the radiated population that is higher than that of the mother variety.

These data present some interesting aspects: First that segregating generations from irradiated populations could be as vigorous as, or more vigorous than the mother variety, as expressed by the mean plant height of the radiated population in the X_2 generation. Secondly, that the commercial production of pigeonpeas can be extended considerably as indicated by the wide range in number of days to flower in the radiated population. In other words, radiation has induced great genetic variability in pigeonpeas for plant height and early- and late-flowering-type lines. These attributes are very desirable in the breeding program of this crop in Puerto Rico, since they will permit the selection of vigorous early- and late-type plants.

It seems possible that, with this new source of germ plasm, pigeonpea varieties can be selected with desirable agricultural characteristics such as early- and late-flowering varieties, that will permit a considerable increase in the production season of pigeonpeas in Puerto Rico, which, in turn, would result in an increase in production and larger output for the canning factories.

Further studies with selections from subsequent generations are underway at present.

SUMMARY

Seed of pigeonpea variety Kaki were irradiated at Oak Ridge National Laboratories with different doses of gamma rays and neutrons. The effects of both sources of radiation were studied on seed germination, plant growth, and flowering date during the X_1 generation, and plant height and number of days to flower on the X_2 generation. The results indicate that both sources of radiation reduced seed germination, and plant height, and induced both earliness and lateness in number of days to flower during the X_1 generation. Genetic variability for plant height and early- and late-flowering lines was increased considerably in the X_2 generation in the radiated population. With the new source of germ plasm located it appears that pigeonpea varieties can now be selected with more desirable characteristics, thus permitting a considerable increase in production in Puerto Rico.

RESUMEN

Semillas de gandur de la variedad Kaki fueron sometidas a diferentes dosis de rayos gamma y neutrones en los Laboratorios Nacionales en Oak Ridge, Tennessee. Se observaron los siguientes resultados en las semillas y plantas de la generación X_1 y X_2.

1. Las dosis más altas de rayos gamma y neutrones disminuyeron el porcentaje de germinación de las semillas. En ambas fuentes de irradiación, la dosis más alta resultó letal para las semillas.

2. Los aumentos progresivos en las dosis de irradiación redujeron el ritmo normal del crecimiento de las plantas.

3. La variabilidad genética en cuanto a la altura de las plantas y la fecha

de floración aumentó considerablemente en la generación X_2, ofreciendo oportunidad para seleccionar aquellas plantas tempranas y tardías con buen vigor.

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