Agricultural Applications of the Puerto Rico Nuclear Center

Co\textsuperscript{60} Gamma Irradiation Facility

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The Co\textsuperscript{60} Gamma Irradiation Facility for the Puerto Rico Nuclear Center has been in use since May 1963. It is housed in a laboratory room in the Nuclear Center Building at Mayaguez. It is operated by the Agricultural Bio-Sciences Division. The facilities have met the requirements of the biologists and agricultural experimenters.

Description of Source:

The Co\textsuperscript{60} gamma irradiation facility consists of a pool nine feet by eight feet that is fourteen feet deep. The facility uses water as the shielding material.

A portable steel bridge goes across the top of the pool and serves as the base for the operator conducting the irradiations.

A platform three feet by eight feet is located ten feet below the water surface. This platform holds the variable geometry irradiator. All irradiations are performed on this platform. The ten feet depth is sufficient to reduce the radiation level at the surface to less than 0.2 mr/hr. It allows observation of all operations in the pool without difficulty.

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The $^{60}$Co is contained in twelve pencil type capsules each containing approximately 200 curies. The capsules are held in a hollow cylinder variable geometry irradiator. This variable geometry irradiator can be adjusted to simulate a radiation chamber from three centimeters to twenty centimeters in radius formed with the capsules. A symmetrical field can be obtained by using three, six or twelve capsules.

Irradiations have been conducted using all possible geometries (3, 5, 10, 15, 20 cm). Any dose can be obtained by changing the geometry of the holder or by using three, six or twelve capsules. The ten centimeters position with a dose rate of 2,000 r per minute is the most useful for biologists.

Most of the samples to be irradiated are placed in an aluminum container which is weighted to overcome flotation. This container has a screw top and a solid aluminum rod attached to the top for underwater handling. The top of the container also has two hose connections either for air, or for oxygen or nitrogen, allowing irradiations to be conducted in different atmospheres.

Other biological samples are placed in plastic bags and weighted, then are lowered in the radiation field by means of a cord.
Following is a brief account of some of the experiments conducted so far in the field of biology and agriculture using the facilities. A big group of the experiments conducted are from different agencies using the cooperative irradiation service from the Puerto Rico Nuclear Center.

Insect sterilization studies are in progress now by irradiating the insect in different stages of the life cycle. The studies are with the sugar cane borer, *Diatraea saccharalis*. The primary objective of this experiment is to determine if *D. saccharalis* can be rendered sterile by subjecting it to gamma radiation from a Co$^{60}$ source. The preliminary work indicates that the larval stage and the early pupal period cannot be used for gamma irradiation since mortality dosage and sterility dosage are practically equal at these stages. Irradiations of newly emerged adults shows some promise and the dosage for sterility appear to be in excess of 8,000 roentgens. According to the preliminary works seems to be easier to irradiate the females and release them than the males.

Unripe banana fruit of Johnson and Monte Cristo variety has been exposed to gamma radiation and stored at room temperature. The objective of this experiment was to study the radiation effects on the ripening of the fruit. The fruits are placed on sealed plastic bags and are lowered down in the radia-
tion field. Ordinarily such fruit ripen in six to ten days. At doses of 25 Kr. the ripening of both varieties was retarded by ten days or more with little, if any, effect on flavor. Higher doses caused more rapid ripening and early blackening of the skin.

Rice seeds (*Oriza sativa*) have been treated with gamma radiation and with 5 BUDR to see if this chemical can modify the gamma radiation effects on seedling height. The purpose is to establish a mutant stock and induce backmutation in the somatic tissue. Seedling pigment deficiency mutants have been observed at 8,000 r and at 12,000 r.

Mutation studies have been conducted by irradiating maize tassels and maize seeds. The tassels have been exposed to a wide dose range (varies from 0 to 20,000 r). A suitable dose range has been obtained for the full development of kernels in the cob. Also radiation effects on the germination ability of the seeds and the germination rate have been observed.

Corn seeds have been exposed to gamma radiation to study the radiation effects on the absorption of calcium and strontium on corn plants.

Bacterial cultures have also been irradiated to study radiosensitivity, threshold dose, and to obtain a dose-response curve. This irradiation was done as a cooperative service for
the radiobiology courses given by the Biology Department in the CAAM. Also backmutation studies are conducted in the present by exposing bacterial cultures to gamma radiation.

Vegetative cuttings of bananas and guava have been exposed to gamma radiation to study the growth of these cuttings after treatment. The guava also includes rooted cuttings from several varieties. After exposure they are transplanted to a nursery plot. Radiation effects have been observed in the growth of these cuttings.

Seedlings from ornamental trees have been exposed to gamma radiation and grown in a nursery plot. *Muntigia calabura* seedlings (Panamá berry) were used for this experiment. The objective was to cause partial or complete sterility to the tree. 600 seedlings were treated with a dose ranging from 0 - 100 Kr. Only 90 seedling reached maturity. No survivals were obtained over 60 Kr. From the observations, it appears that this material was very sensitive in the vegetative state, to gamma rays. Radiation failed to cause sterility in this material. Also seeds from the same ornamental trees were exposed to ionizing radiation. Radiation effects on the germination ability of the seeds was observed.

The effects of gamma radiation upon the phenol level in the leaves has also been studied. Velvet bean plants, *Stizolobium deeringgranum*, four weeks old were used for the experiment. The
leaves were irradiated with five dosages of gamma rays ranging from 15 to 100 Kr. Extraction and assay of phenolic compound using the Folin-Denis calorimetric procedures were done following each irradiation. The data obtained indicated that the most significant change in phenolic content of irradiated leaves occurs at about 15 Kr.

Indigophora cuttings have also been irradiated trying to get toxin-free mutants from this plant. The cuttings after being exposed to gamma radiation are planted in the greenhouse. No survivals have been obtained over a 3,000 r exposure.

Mangoes from several varieties including the native have been exposed to gamma radiation. The fruits are selected green, almost ripe, and ripe and are exposed to the same dose range. Radiation effects and post-irradiation treatments have been observed for the varieties.

The field of induced mutations has received considerable interest, and some high school science teachers and their students have asked for information and for irradiation services. Material which has been irradiated for them include: small plants, seeds, and chicken embryos.

Visitors from foreign countries have shown great interest in the design and the diverse uses of the Puerto Rico Nuclear Cer. er Co60 gamma irradiation facilities.
The facility has been successfully used by researchers from various fields of science. The accuracy of the dose delivered, the visual observations of the material during the irradiations and the safety in conducting the irradiations has made the Co$^{60}$ gamma irradiation facility a great tool for researchers.

The supervisor of the facilities is able to give all possible help in the irradiation services to all experimenters interested in using the facilities. All services given are free, and valuable information is given to those who ask for it.

Recommendations such as: dose range to be used, dose rate, suitable geometry, number of capsules to use, and safety precautions involved in conducting the irradiation are given by the supervisor prior to any irradiation process.

The Puerto Rico Nuclear Center also has a research reactor which operates at 1000 kilowatts. The combustible elements contains Uranium oxide enriched at 20% in Uranium-235.

It is a pool type reactor. The pool is 49 feet long, 23 feet wide by 32 feet deep. At 1000 kilowatts, a flux of $5 \times 10^{12}$ neutrons per square centimeter per second is obtained.

Biological material which have been exposed to neutron irradiation include: pieces of sugar cane variety PR980, and seeds.