แหล่งกัมมันตภาพรังสีสำหรับอาบรังสีในอัตราปานกลางให้กับพืชที่กำลังเติบโต

Radiation Sources for Semi-Acute Irradiation of Growing Plants

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More than 40 years ago Muller (3) and Stadler (5) have demonstrated that X-rays can induce genetic changes and produce mutations in Drosophila and in corn respectively. Since then there was considerable interest in the production of mutations by irradiation. Gustafsson (1,2) and his co-workers in Sweden started work along these lines as early as 1928 using X-rays have succeeded in producing higher yielding crop plants and other valuable characteristics in economic plants through X-ray induced mutations.

After World War II when radioisotopes became common and could be obtained quite easily and cheaply, there were increasing uses of radioisotopes such as cobalt 60 and cesium 137 as radiation sources in the induction of mutations in plants. These two radioisotopes emit gamma rays. The Co^{60} emits a rather emergetic gamma rays of about 1.25 Mev. and has a half life of 5.3 years, while the Cs^{137} gives off gamma rays of about 0.30 Mev. and has a half life of 30 years.

The author had the opportunity of visiting and working at the Brookhaven National Laboratory in 1957 and had observed several radioactive Co^{60} sources ranging from about 10 c installed in a greenhouse to the 1800 c Co^{60} source installed in the Brookhaven gamma field. These gamma-ray sources are very handy in treating growing plants for a short period as well as over a long period of time.

KASETSART RADIATION GREENHOUSE

Some time after the author's return from his scientific tour in the United States, the radiation facility at Kasetsart University was designed. This consists of a rectangular 8×10 meters concrete room and 8×13m. connecting nursery–all in the same building. It is called the *Rukka Rangsee* Greenhouse, (rukka = plants; rangsee = radiation). The whole building has a glass roof so that the entering light is sufficient for proper plant growth. The construction of this irradiation building which is situated right in the middle of the campus, was finished in 1961.

In January 1962 a 16 curie cobalt 60 irradiation source was installed in the concrete room. The source was located at 4 meters equidistant from the side walls, 3.35 meters from the back wall and 6.65 meters from the front wall. The walls have the calculated thicknesses to contain the gamma rays and have sufficient heights to prevent any direct radiation from reaching an adjacent building containing offices and lecture rooms. Gamma radiation emerging from the top of the irradiation cell will be scattered by the air, the roof, and supporting structures above the cell. This scattered radiation is generally known as skyshine and its effect is negligible.

The Co^{60} cell is attached to 6 x 18 cm. lead plug and contained within a long hollow tube about 7 cm. in diameter. One part of the tubes is an iron pipe sunk 2.5 meters into the earth, the other connecting part protruded above the concrete floor is an aluminum tube.

In July 1965, a 100 curie cesium 137 source was purchased from the Radiochemical Centre (also the supplier of our cobalt 60 source), England, and installed to replace the weaker Co^{60} source. With a half life of 30 years the cesium 137 source is expected to be in good useability for a much longer time than the cobalt 60 which has a 5.3 years half life. After taking out the Co^{60} source, the Cs^{137} source was put in place in the same position. The Cs^{137} cell is again attached to a lead plug and contained in the same tubes, but this time the underground part of the tubes are 2 pipes, the inner one is a 3-in stainless steel pipe standing inside a 4-in flint coated outer iron pipe. Both pipes were carefully welded and sealed at the bottom ends to prevent water from getting in.

Figure 1 show a cross-section drawing of the radiation room.

OPERATING PROCEDURE

The lead plug with the attached radioactive source is raised and lowered within the tube by means of a metal wire. When the Cs^{137} cell is about 2.5 meters below the ground level no radiation could be monitored above the concrete floor. The above ground part of the tube is of aluminum. When in use the Cs^{137} cell is raised in the aluminum tube to about 52 centimeters above the floor. Plants placed at various distances around the source will be affected by gamma rays from the Cs^{137} source.

The raising and lowering of the Cs^{137} source is electrically operated (or can be manually operated in case of electrical failure). The source is at present used 17 hours per day. When not in use the source is kept down 2.5 meters underground.

The gamma room is always locked when radiation is present, i.e., when the source is raised. To enter the room, after unlocking the door, there is an order that one must first take a reading on the radiation survey meter and note the amount of radiation present while the source is still in the raised position. This come to about 2 mr/hr. This range is below the maximum permissible average rate of occupational exposure to gamma radiation for the whole body.

Safety mechanisms have been incorporated into the construction of the gamma building. A red warning light above the locked door of the gamma room goes on when the source is up. Should the door be opened when the red light is on, an alarm siren will be set off, and the Cs^{137} source will be automatically lowered.

COST OF THE KASETSART RADIATION GREENHOUSE

The cobalt 60 source and the cesium 137 source are the properties of Kasetsart University. Both radioactive sources were purchased from the Radiochemical Centre of England. The cobalt 60 was purchased by the Atomic Energy Laboratory of Kasetsart University while the cesium 137 was given by the International Atomic Energy Agency. Items of expense in the construction of the radiation greenhouse are shown in Table 1.

IRRADIATION EXPERIMENTS WITH PLANTS

Both the Co^{60} source and the Cs^{137} source in the gamma house are used primarily to provide radiation for growing plants, treating vegetative parts of the plants such as buds, cuttings, etc. The radiation is also used for treating seeds and other biological materials. A good number of the field crop seeds could be irradiated favorably at close range–up to 4 to 5 centimeters from the source. For example at 5 cm. the radiation dosage from the Cs^{137} source is approximately 11,400 r/hr., a fairly good dose for most seeds in one hour time. Field and horticultural seeds such as rice, cotton, tobacco, beans, rubber seeds, and other kinds of seeds and plant materials have been irradiated successfully in this gamma house.

The usual procedure is to place the seeds within a few centimeters or close to the aluminum tube at the level where the source cell is located. Table 2 shows the doses actually measured at 5 distances at the level from the center of the aluminum tube housing the Cs^{137} source. Table 3 shows the calculated doses received by materials placed at different distances from the source.

After a few years of operation using gamma rays from the Co^{60} source to induce changes in plants, several mutant forms were created in some ornamental plants. For example, in canna (Canna sp.) it was found that appropriate radiation dosages induced a great many floral color changes and other characters. The desired mutants were propagated asexually and several of their new forms persisted to the present time.

Treatment of growing plants, both for acute and chronic radiation are being done using gamma source from both the Co^{60} and the Cs^{137}. Plants must be grown in their own containers, usually in earthen pots of various sizes, and placed at desired distance or in concentric rings around the gamma source. All plants are watered and fertillized adequately. Response and sensitivity to radiation of several species of plants have been learned through the use of these radioactive sources.

CONCLUDING REMARKS

This paper describes the Kasetsart University Rukka Rangsee greenhouse –a simple, economical and effective gamma radiation facility, using first the

Co^{60} and later the Cs^{137} as sources. The new 100 curie Cs^{137} installed in 1965 is expected to give usefull service for long time to come, since at the end of 30 years it will still be operating at one-half of its original strength. The thick concrete walls surrounded the source adequately contain radiation within the 8×10 m. irradiating room.

The facility is proving very satisfactory for its intended purpose of studying the radiation effects on growing plants and inducing mutations in plants. It has also been used for experimental treatments of seeds, nursery stocks, fruits, several bulbous and woody plant materials. In addition, this ideal radiation sources has provided radiation treatments of forest tree seeds, fish fingerlings, insects, and many other experiments carried on by various departments and organization desiring radiation for their research purposes.

Table 1. *Expenses involved in construction of radiation greenhouse, costs of radioactive sources, and installation of sources*

Items	Cost (baht)
Gamma irradiation buildings, (a 8×10×2.5 m. concrete room, a 8×13 m. connecting nursery, a seperate 6×6 m. brick shed, hole for source, parings, etc.)	251,500
Cobalt 60, 20 curie source including shipment from England	5,800
Installation of cobalt source, electrical mechanisms alarm systems, etc.	14,000
Aluminum awnings	1,200
Signs	400
Cesium 137, 100 curie source	13,400
Container and shipment from England	12,600
Removal of cobalt 60 source and installation of cesium 137	1,700
Fence, wooden fence with gates	2,000
Miscellaneous	700
Total	303,300

Note: Rate of exchange, 20 baht = U.S. $ 1 approximately.

Table 2. *Radiation levels at different distances from 100 c. cesium 137 source. Measurements made August 3, 1965**

Distance from source (meters)	Radiation (approximate) r/hr
0.5	116.3
1.0	27.9
2 0	7.1
3.0	3.23
4.0	1.81

*Measurements by the Health Physics Section of the Thai AEC.

Table 3. *Calculated radiation doses at different distances from 100 c. cesium source*

Distance from source (meters)	Radiation as of August 1965 r/hr (approximate)
.04	17,925
.05	11,472
.07	5,853
.10	2,868
.20	717
.30	318
.50	114.7
1.00	28.7
1.50	12.7
2.00	7.2
2-50	4.6
3.00	3.2
3.50	2.3
4.00	1.8
4.50	1.4
5.00	1.14
5.50	0.95
6.00	0.80

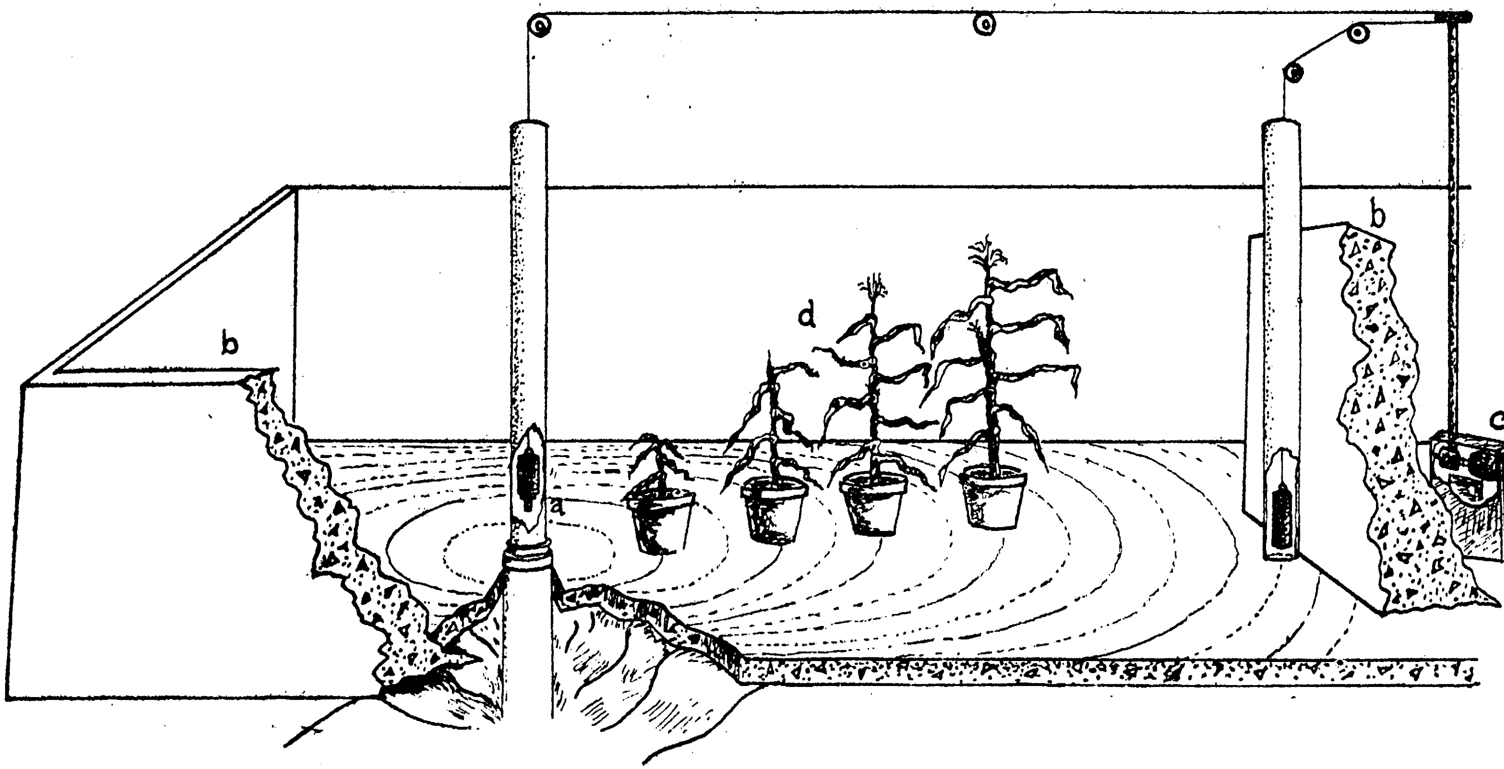

Fig. 1. Cutaway schematic drawing of radiation room, showing cesium 137 source in raised position (a). Plants (d) placed in circles around source will be affected by varying intensity of gamma rays source. Electric machine (c) operates the raising and lowering of source. Concrete walls (b) protect workers outside room from gamma radiation.

สรุป

บทความเรื่องนี้ได้บรรรยายลักษณะและการใช้ประโยชน์ของเรือนรุกขรังสีของมหาวิทยาลัยเกษตรศาสตร์ ซึ่งเป็นอาคารวิจัยเกี่ยวด้วยการฉายรังสีแกมมาที่ได้ผลดีสิ้นค่าใช้จ่ายพอประมาณ และไม่ยุ่งยากซับซ้อน ในระยะเริ่มแรกใช้โคบอลท์ 60 เป็นแหล่งกัมมันตภาพรังสี แล้วต่อมาเปลี่ยนเป็นซีเซียม 137 ซีเซียม 137 กำลัง 100 คูรีนี้ได้ติดตั้งในปี พ.ศ. 2508 และคาดว่าจะให้ประโยชน์เต็มที่เป็นเวลานานทีเดียว เพราะต่อจากนี้ไปอีก 30 ปี ก็คงจะยังมีกำลังเหลืออยู่ครึ่งหนึ่งของกำลังปัจจุบัน กำแพงคอนกรีตอย่างหนาซึ่งล้อมรอบแหล่งกัมมันตภาพรังสีนี้สามารถกักกันการกระจายรังสีให้อยู่แต่ภายในห้องฉายรังสีขนาด 8×10 เมตร ได้อย่างเพียงพอ

อุปกรณ์วิจัยชิ้นนี้ ใช้งานได้อย่างน่าพึงพอใจตามที่วางแผนไว้ ได้ใช้ศึกษาผลของรังสีต่อพืชที่กำลังเติบโต และชักนำให้เกิดการเปลี่ยนแปลงทางกรรมพันธุ์ในพืช และยังใช้ในการทดลองเกี่ยวกับเมล็ดพันธุ์ ต้นตอขยายพันธุ์ ผลไม้พืชมีหัว และไม้ยืนต้นต่าง ๆ นอกจากนั้นก็ได้ใช้ในการทดลองรังสีแก่เมล็ดไม้ป่า ลูกปลา แมลง และงานวิจัยอีกหลายโครงการที่แผนกวิชา และหน่วยงานต่าง ๆ ดำเนินการอยู่

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