NEWS

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Radiation Increases Frequency of Plant Aberrations

Brookhaven research into effects of gamma rays on plants shows no new abnormalities

BROOKHAVEN, N. Y.—Radiation has not caused any abnormal plant growths that are not also known to occur in nature. What radiation can do is to increase the incidence and severity of these aberrations tremendously. This seemed to be the consensus of opinion at the 4th annual summer conference sponsored by the biology department of Brookhaven National Laboratory from Aug. 3 to 5. This year the conference took the form of a Symposium on Abnormal and Pathological Plant Growth.

The radiosensitivity of the individual plants, the dosage level, the age of the plant parts irradiated, and the physiological condition of the plant are all variables which will affect the morphological response of irradiated plants, reported J. E. Gunckel of Rutgers University. Dr. Gunckel, working with Arnold H. Sparrow of the Brookhaven biology department, used the Brookhaven "gamma field" to determine the effects of gamma radiation on various types of plants.

The gamma field, about eight to 10 acres, has a small cylindrical piece of cobalt-60 of approximately 2000 curies as the source of gamma radiation. The field "operates" 20 hours per day, the remaining four hours being used for cultivation and observation of results. When in operation, the source is suspended a short distance above ground level by a cable. To make it possible for investigators to enter the field, the source is lowered into a lead cylinder buried in the ground, and is covered with a snugly fitting lead stopper. Elaborate safety precautions are taken to make sure that no one is in the field while the source is up.

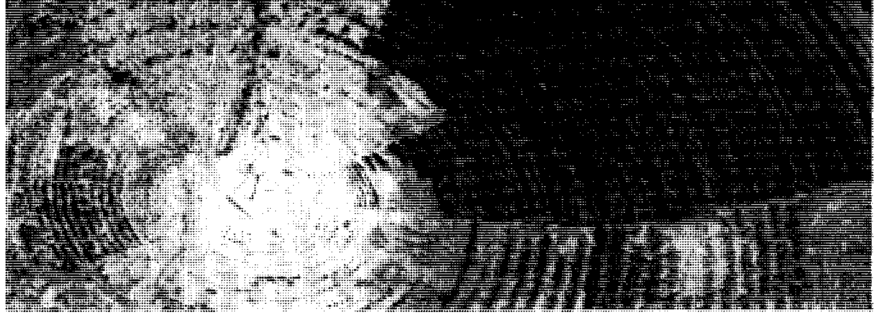
Dosage rates in the field vary from 8000 Roentgens per 20 hour day, as near to the source as is practical for planting, to one Roentgen per 20 hour day at the edge of the field. The source is placed off-center in the rectangular field, so that low dosage rates can be obtained. Gladioli, broccoli, lettuce, potatoes, snapdragons, tomatoes, and tobacco are among the plants cultivated in the field. Many of the Brookhaven personnel use the field for their studies. For instance, S. Shapiro is attempting to produce useful mutations in woody plants.

Radiation Effects. Radiation responses may range from death or complete growth inhibition to marked proliferation, resulting in deformed plant parts. Drs. Gunckel and Sparrow, who found *Tradescantia* well suited to their purposes, grew this plant at a dose level of 50 Roentgens per day for three months. An initial expansion of the axillary buds was noted, but then growth was arrested. When the gamma radiation was removed, the numerous inhibited adventitious buds produce a bushy outgrowth not commonly found on control plants. Dwarfing results from destruction or inhibition of the terminal meristems and failure of the internodes to elongate. This is a characteristic stem response to irradiation, due, perhaps, to auxin destruction, which also occurs with x-rays. Radiation may also act on the mechanism of assimilation, said Dr. Gunckel, and both x-rays and gamma radiation can cause fasciation.

The initial response to gamma irradiation was a twisting and swelling of the stem. Chronic gamma rays, between 13 and 37 Roentgens per day, produced aberrant multiple shoots or single shoots with very short internodes and a mass of fused or dissected leaves on the axillary buds. Cuttings from these *Tradescantia* eventually grew normally, indicating that the abnormalities are due to physiological disturbances rather than mutations, declared Dr. Gunckel.

Irradiation of leaves with x-rays, radium, and cobalt-60 all caused dwarfing, changes in form and texture, thickening, puckering, curling, failure to develop, distorted venation, fusions, abnormal curvatures, and mosaic appear-

The "gamma field" at Brookhaven National Laboratory, where effects of radiation on plant growth can be studied. In the lower left corner of the field is the gamma radiation source, a 2000-curie piece of cobalt-60



C. D LaRue of the University of Michigan explains a point in his paper on the in vitro culture of gametophytes, embryos, and endosperms

ance. Cell proliferation, pulling apart, and enlargement contribute to the leaf thickening. Portable beta ray sources and radioactive trace elements have also caused leaf anomalies. Extremely irregular epidermal cells and virtual disappearance of a recognizable palisade layer result from leaf irradiation.

A common abnormality in irradiated plants is uneven distribution of chlorophyll. After two months exposure in the gamma field at 122 Roentgens per day, Sedum leaves were all green. At 500 Roentgens per day, the bottom half of each leaf was green and the top pink: at 5100 Roentgens the whole leaf was pink. Plants showing this color change died the following week.

Radiation Sensitivity. The most radiation sensitive sections of a plant are the cells of the growing tip. Dr. Gunckel said that this might be explained on the basis of the greater radiation sensitivity of nuclei in prophase and metaphase stages as compared to those in interphase. Plants with large chromosomes have a high radiation sensitivity.

The effects of radiation on plants are usually only quantitatively, not qualitatively, different from abnormalities in the development of nonirradiated plants, declared Dr. Gunckel.

Normal vs. Abnormal Growth. The boundary between the normal and the abnormal in plants is indistinct, declared R. Bloch of the University of Pennsylvania. Humidity and light are only two of the many factors capable of modifying plants. Many plant cells are not stably determined and remain interconvertible, said Dr. Bloch, and difference is often a matter of degree.

Dr. Bloch described three general divisions of abnormal growth. The first, amorphous histological changes and disorganizations, includes wound tissues, tumors and galls, and tissue cultures.

The second general division of abnormal growth, abnormal organ development, can alter the form, distribution, and number of organs. It may be caused by injury, irradiation, parasitic infection, and general physiological and nutritional disturbances. Organoid galls and fasciations are two examples of this division.

Insect-caused prosoplasmic galls are examples of the third general division of abnormal growth. Harmonious histological reorganizations, are entirely specific, declared Dr. Bloch. Their growth is of a determinate nature, resulting in constant form and size, qualitative alteration of the histological pattern involving orderly reorganization of cells and cell layers, and a degree of differentiation not below the level of the host.

Desirable Hypertrophies. Because of symbiotic nitrogen fixation by the causative rhizobic bacteria, leguminous root nodules are one type of abnormal plant growth that have a definite economic value. As a matter of fact, declared O. N. Allen of the University of Wisconsin, $4 million are spent annually to encourage nodule formation and consequent nitrogen fixation. At the last count, 17 companies were in the field.

Answers to the question of why rhizobia produce nodules only on leguminous plants are still speculative. Compatibility of bacterial and plant proteins, the existence of an enzyme in legumes which enables the plant to select, entrap, and use bacterial nitrogen, and the role of the calcium fraction, which is three to five times greater in leguminous plants than it is in nonleguminous, are some of the suggestions which have been advanced.

Two general physiological relationships between the bacteria and the host plant were outlined by Dr. Allen: first, infectiveness, or the ability to cause the formation of nodules on certain leguminous species; and second, effectiveness, or the ability to aid the plant by nitrogen fixation.

Infection is normally accomplished through the root hairs, although entrance may be gained through epidermal and cortical cells, and ruptured tissue at the site of the lateral rootlet emergence. The exact site of entry may be a bright refractive spot near the tip or side of the root hair.

A small colony of rhizobia forms near the apex of the hair, causing the hair to curl in the form of a shepherds crook. The rhizobia enter through this deformity. A hyphal-like thread, which proceeds directly toward the base of the hair, is formed almost immediately after the root hair is invaded. The directness of the course of the thread suggests a chemotatic attraction by the basal cells, said Dr. Allen. The infection thread, composed of bacteria,

Leguminous root nodules are not to be considered normal growths, declared O. N. Allen of the University of Wisconsin

branches out as soon as it enters the root cortex.

The age and species of the plant will affect the distance to which the threads penetrate the cortex, but neither root endodermis nor the pericycle is penetrated at any time. The threads head toward the host cell nuclei, which show signs of the hypertrophy of the entire cell when the rhizobia are released into the cytoplasm.

Bacterial Release. The rhizobia are released by discharge from the tip of the thread as it pushes forward, bursting of the blister-like swellings along the sides of the young threads (before they are sheathed in cellulose in an apparent effort at self-protection by the host plant), or through rupture of the threads during cell enlargement or division. Release may also occur by cleavage of the beadlike swellings in the multibranched infection filaments, resulting in the liberation of microcolonies.

The invading rhizobia, which may eventually fill the entire cell, settle in the peripheral cytoplasmic layer around the vacuoles of the host cell as they are released. The host cells and the adjacent noninfected cells undergo rapid cell division and nuclear enlargement almost immediately after the release of the bacteria. "Although auxins, which may be produced by the rhizobia, play a role in nodule formation, the key mechanism remains to be found," declared Dr. Allen.

Dr. Allen described two unique features of the bacteroid zone of effective nodules. First, the nodule is the seat of the symbiotic nitrogen fixation process, and second, effective nodules contain four well defined pigments.

Nodule Pigments. Leghemoglobin, a red pigment, is very similar to the hemoglobin found in animal blood, and this is the first reported occurrence of hemoglobin in the plant kingdom. Neither plants nor rhizobia produce hemoglobin independently, and it is only present during the effective stage of symbiosis.

The other pigments found in the nodule are legcholeglobin, a green pigment; and legmethemoglobin and coproporphyrin, both browns. These last three are considered to be breakdown products of the first. Hemoglobin is thought to be indispensible to the fixation process. When the bacteroid zone changes from red to green, the effective nodule is approaching senility.

Many factors, such as inadequate photosynthesis, clipping of plant tops, drought or excessive moisture, fruition, and attack by certain insects or fungi, may lead to loss of nodules. Some nodules may last as long as six years, others are fragile structures designed for short, seasonal periods. Microscopic evidence of senility is loss in turbidity, brownish color, wrinkled surface, or spongy texture.

A mottled condition in the bacteroid area, due to clumping of rhizobia in the innermost bacteroid cells is histological evidence of nodule senility. "Many minute vacuoles are formed, and the rhizobia and cell nuclei lose their ability to stain," reported Dr. Allen. The bacteria may invade the intercellular spaces by attacking the host cell walls. Nuclei disintegrate, walls collapse, and cell contents disappear. "Potent rhizophages" may be active at this time. Finally the nodule is sloughed from the root.

More Research on Wood Wastes Asked at Stockholm

A call for more efficient utilization of our wood resources was the theme of the plenary lecture delivered before the symposium on the chemistry of wood and wood wastes at the 13th International Congress of Pure and Applied Chemistry in Stockholm recently. The plea was made by Harry F. Lewis of the Institute of Pulp and Paper Chemistry, Appleton, Wis. The International Congress was held in conjunction with the 17th Conference of the International Union of Pure and Applied Chemistry.

The pulp and lumber industry would prefer to make low grade pulp from wood waste and evaporate and burn the liquors than get into the business of making alcohol, yeast, lignin ethers, or vanillin, Lewis declared. However, he feels, the industry must break with tradition sooner or later and enter new fields.

He emphasized that any chemical industry derived from wood must face competition from an alert synthetic chemical industry accustomed to spending a sizable portion of its sales income on both fundamental and applied research. He remarked that a few companies in the pulp and paper industries spend only 1 to 1.5% on research while the chemical industry has been estimated to spend about 3.5% of its net sales dollar for research.

He made the point that just because conventional wood distillation plants are no longer operating, wood distillation as a process for converting wood substances to chemicals is not necessarily finished. Application of the fluidizing process, used by the petroleum industry, to destructive distillation of sawdust might make possible the recovery of some intermediate products of pyrolysis in high yield; these in turn may be susceptible to catalytic oxidation with subsequent production of valuable chemicals.

Our comparative ignorance of the physical and chemical constituents of wood is another handicap for the industry, said Lewis. "We know only in part what lignin is; if we knew its chemical structure we might not even then be able to convert the enormous amounts of lignin available in all of our wastes to a chemical asset, but at least we would work more intelligently toward the ultimate goal, which is to make a material useful to something else besides the particular plant in which it is formed."

Industry

Mrs. Tucker's Foods Opens Plant in Illinois

Mrs. Tucker's Foods new plant at Jacksonville, Ill., was dedicated Aug. 13 at ceremonies attended by the Governor of Illinois, William Stratton. The occasion was marked by a civic holiday for the citizens of Jacksonville.

According to the company, the new plant has one of the largest capacities for refining and processing vegetable oils in the world. Construction has taken three years. Among the plant's facilities are storage tank facilities capable of handling more than 600 railroad tank cars at a time, a vegetable oil refinery, a hydrogen production plant, packaging lines for shortenings, margarines, salad and cooking oils, refrigeration plant, warehouse and maintenance facilities, office space, and a cafeteria. Between 400 and 500 employees will ultimately be required for operating the plant.

Products to be made in the plant include shortening, margarine, and salad oil for retail markets and Velvet, Gleam, Southern Queen, and Kerba shortenings and cooking oils for institutional users.

Mrs. Tucker's was founded in 1913 and became a part of Anderson, Clayton & Co. last year.

Columbia-Southern to Produce Ammonia at Natrium

Columbia-Southern Chemical Corp. has announced that it will enter the ammonia production field with a new plant to be built at Natrium, W. Va. The hydrogen by-product from Columbia-Southern's chlorine-caustic plant at Natrium will be utilized in the ammonia process. The hydrogen is now being burned for fuel.

Agricultural outlets are expected to account for about 50% of the plant's output. The company has not disclosed the plant's planned capacity or the cost of building it. Contracts are to be let in the near future and production is expected to begin late next year.

New plant of Mrs. Tucker's Foods at Jacksonville, Ill. Dedication on Aug. 13 was attended by the governor of Illinois. Facilities at plant include storage tank facilities capable of handling 600 railroad tank cars at a time, vegetable oil refining unit, and a hydrogen production plant