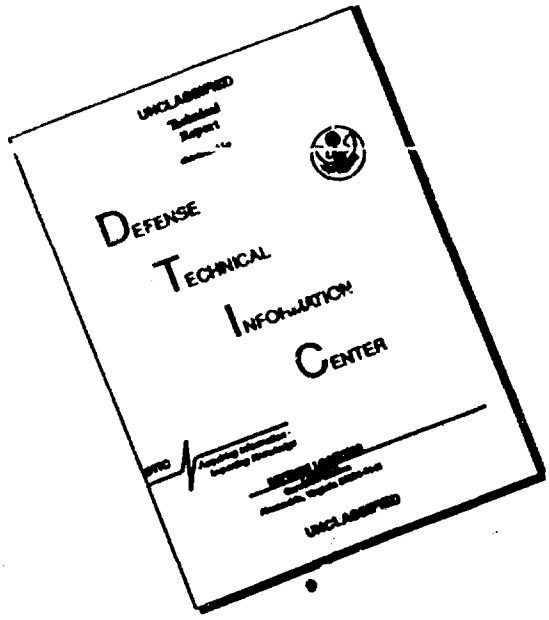
TRANSLATION NO. 96

DATE: July 25, 1949

DEPARTMENT OF THE ARMY
Fort Detrick
Frederick, Maryland

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

From Soviet Agron 7(9):75-79, 1949 #96

IMPLUENCE OF RADIOACTIVE ELEMENTS UPON THE LIVES OF PLANTS

By A.A. Drobkow

Science has been constantly centering its attention on the problem of ascertaining what chemical elements enter into the composition of living organisms and what part various elements play in the lives of these organisms.

Close studies have shown that 99-99.5% of the live weight of animal and vegetal organisms are composed of 10 chemical elements-carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, magnesium, sulphur and iron. The other chemical elements were found to form less than 1%. From this fact the conclusion was drawn, that a limited number of chemical elements is needed for animal and vegetal organisms, all in all 10 or 15, only. These elements were called macro-elements, all other elements were classified as accidental foreign-matter.

At first, this deduction was universally acknowledged but subsequent experiments performed by various scientists did not corroborate this theory. It has been shown that, by adding to essential nutritive substances small amounts of boron, manganese, copper as well as other elements (called micro-elements because of the extremely minute quantities in which they are to be found in living organisms), plants would thrive better and yield a better crop. Futhermore, accurate physiological experiments have shown that when boron, sins, copper, manganses, molybdenum etc. are completely excluded from the nutritive mixture plants cannot develop normally, even though when present these elements are never found in quantities exceeding 0.001 or 0.0001% of the live weight.

Certain diseaes are caused by the insufficiency of some micro-elements in living organism. For instance, goiter in man and animal is due to an iodine insufficiency. His experiments lead Prof. A.P. Vinogradov to the following conclusions: "We are of the opinion that there is no reason to deny the physiological role of either one of the 92 chemical elements with regard to various organisms, especially when a given element is continuously found in a given organism."

In 1896, the French scientist Becquerel discovered Radioactivity. The importance of this phenomenon is that the atoms of certain elements-uranium, radium, thorium, actimium, potassium, rubidium, etc., called radioactive elements are enormous quantities of energy in the form of alpha, beta and gemma rays. This process of emnation is spontaneous, it cannot be disturbed even by the most powerful sources of energy. This process takes place wherever radioactive elements are found in the earth crust, atmosphere, hydrosphere, in animal and vegetal organisms.

The discovery of radioactivity attracted wide interest in world science. In a very short time it radioally changed our conception of matter and its energy. The ancient theory of the indivisibillity of the atom was shaken to its rest. It became apparent that emormous quantities of energy are concentrated within the atoms, quantities several million times greater than the energy obtainable from a equal amount of matter undergoing know chemical reactions.

As a result of the artificial disintegration of the atomic nucleus of the atomic nucleus of uranium, modern science has already found practical means of using the intra-atomic energy of radioactive elements.

The discovery of the phenomenon of radioactivity created a new important problem for the biologist, namely the influence of radioactive radiations (alpha beta, and gamma rays) upon animal organisms plants, and mircro-organisms. Many experiments have been made in thes direction and a great amount of literature has been gathered. We do not have the possibility to discuss this in details here. We shall limit ourselves to the most important results only.

It has been noted that the action of radioactive element radiations on the living cells of the body causes a local inflammatory process, similar to burns and difficult to cure. After a prolonged work involving radioactive elements, a finger affection is observed, affection very similar to frost-bite, the growhh of nails is impaired, etc. Increased stimulation in the central nervous system is observed when the submitted to the action of radi .

Subsequently it was found that negative results from the action of radioactive elements are observed only when applied in high dosage, while a low dosage, on the coutrary, has beneficiary results. For instance when moderate concentrates of radium emenations are introduce into the stomach area, carbo-hydrate matbolism is improved withen the organism, Intensified radioactive radiations have been applied in the cure of skin tumors and the results obtained were positive. At present, medicine is widely using these results in its fight against cancer.

There is a certain similarity between vegetal and animal organisms is merely the fact that plants manufacture their own organic matter from mineral combinations which they find in the soil and air around them, while animals obtain their nutritive matter exclusively at the plants expense.

According to their respective quantity contained in living organisms, radioactive elements belong to the macro-(potassium) micro- and ultra-micro elements. But their main difference, setting them apart from any other chemical element is due to the fact that in addition to chemical energy, they continuously emanate intro-atomic energy as a result of the radioactive disintegration of the atoms.

Many a work has been written on the action of radioactive elements upon the growth of plants. Experiments were conducted in two directions: the action of radioactive radiations upon the growth of plants and germination of grains and moreover field experiments were conducted in order to study the actions of radioactive elements on the yield of crops.

At first, the majority of experiments pointed to a negative action of radioactive radiations: it retarded the growth of plants, accelerated

wilting and the fall of leaves, and stopped seed germénation.

However, it became later apparent that these negative results were mainly due to exceedingly high dosage. When moderate dosage were used, the radioactive radiations had a benificiary action on the plants. As a rule, a plant submitted to radiations, developed better and the seed germénation increased was accelerated. Futhermore Professor Molish of University of Vienna proved tha under the action of radioactive radiation the winter slumber of flower buds could be disturbed. In his experiments, lilacs, chestnuts and tulips bloomed in wintertime. In another experiments he noted that plants reacted to radioactive radtion in the same way they react to sun-rays i.e. plants turn toward the source of radioactive radiation. In science this phenomenon is called positive tropism (from the Greek word tropostential increase in the yield of crops was observed: for instance, in the experimental station of Columbia University minute quantities of radium were added to the soil, and the yield of crop in cucumbers increased up to 35%, corn up to 50%, radishes up to 70%, and melons up to 5%.

Due to these experiments, interests toward radioactive elements became so great that, already in 1910, seversl countries put the first radioactive fertilizers on the market. However, they did not become very popular, as the increase in crops did not always justify the high cost of theis kind of fertilizers. Futhermore, cases have been published whare radioactive fertilizer had no effect on the crop and in some cases even reduced the harvest.

These unsuccissful experiments in the practical use of radioactive elements in agriculture and in other sectors of biology should be considered as a result of insufficient studies of the intire problem. At that time, very little was known about the fact that radioactive elements are quite often present in nature and especially in living organisms. Only subsequent works have shown that, as a rule all vegetal and animal organisms contain in their matter some radioactive elements, futhermore they concentrate these radioactive elements in specific organs. Thus kern observed that the human brain contains a greater quantity of radium than other parts of the body. Soviet scientists, Brunovski and Kunasehova discovered that the water plant duckweed concentrated a hundred times more radium that is contained in water.

Radioactive elements are to be found in all types of natural waters and in all types of soils, wherever concentrations of uranium and water, while the animal organisms obtain elements from vegetal food.

In the U.S.S.R., the degree in which radioactive elements are necessary to plants and the specifec action of these elements upon the plants growth have been studied in the Vornadoky Geo-Chemical Laboratory of the Academy of Sciences of the U.S.S.R. We shall give, below a short description of these expriments.

It should be noted that the study of these question encounter great difficulties, becouse the present livel of our knowledge does not permit to create medium where the radioactive influence would be completely non-existent. One of the main obstacles is that such an important radioactive element as potassium can not be excluded from nutritive mixtures. It is a known fact that plants perish for lack of potassium. Potassium cannot be replaced by another element. There is no non-radioactive potassium in nature. Potassium emits beta-rays together with a small amount of gamma-rays as a result of radioactive disintegration of the atom. The radioactivety of potassium is a thousand times smaller than the activity of uranium.

This feeble radioactivity of potassium explains the fact that potassium has no ill effects on plants even when present in big quantities, while even insignificantly small concentrations of strong radioactive elements have a harmful effect on plants. In our experiments, when 10-6g. of radium has been mexed with 1 kg. of soil, flower buds of the rose-plants withered, while a concentrations of a 1000 times smaller concentrations improved the growth of plant and plant accelerated their blooming (Fig. 2).

In the life of plants the radioactive properties of potassium play an especially important role.

In vegetative experiments we studied the action of uranium X1 (one of the uranium isotopes) on sugar beets and its sugar content. X1 emits beta-rays similar to those emitted by potassium. These experiments have proved that uranium X1 has the same physiological action on plants as potassium namely by incorportion infinitely small quantities of uranium X1-10-14 to 8 kg. of the sand equal in radioactivity to a normal amount of potassium in a nutritive mixture) the sugar-beet crop as well as its sugar content would increase sharply.

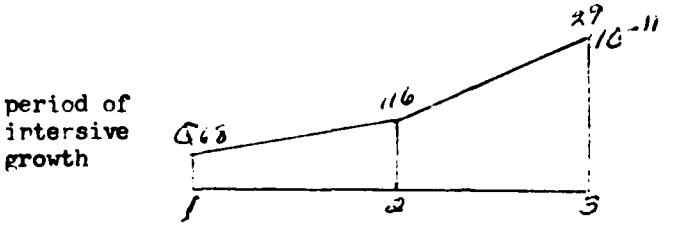
With the help of an electronic counter, we were able to determine that uranium X1 and potassium are concentrated in the young organs of the plants.

In order to observe the degree of need for radioactive elements in plants vegetative experiments were conducted with water cultures, all reagents having been carefully purified and only distilled water used. The results showed that of full nutritive mixture without any additions of radium, uranium, or thorium plants were noticeably retarded in their growth and flower buds did not appear (Fig. 1, 2, 3, 5, and 6). This reaction shows that radioactive elements are needed by the plants in the same way as other nutritive matters in order to develop normally. If in the absence of radioactive elements plants do thrive normally, this can be explained by the presence of impurities in the medium (Fig. 10).

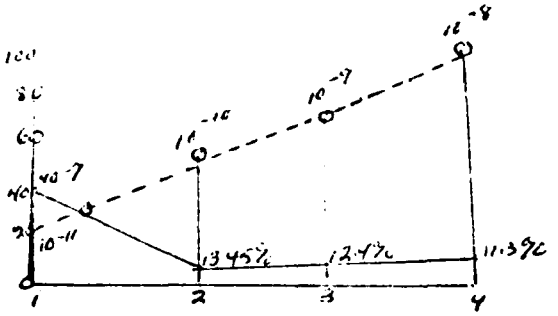
As shown by experiments plants, assimilate radioactive elements during all the vegetative period. But it has to be taken into consideration that the assimilation is not uniform; plants need a greater amount of radium and uranium during their blooming and ripening periods (see diagram). Figures show the content of radium to be 10-11% of the live weight.

We also verified the manner in which plants use radioactive elements present in arious concentrations. It has been observed that, when the dosages in nutritive mixture is increased, the contedt of radioactive elements in the plants increases. But the plants take most of the uranium and radium, in those cases where the concentrations were the lowest (see diagram on next page). In all the examined radioactive element concentrations in plants, it was noticed that, when figuring the percentage in relation to the live weight, the concen-

trations was high then the one in the nutritive medium. Thus, the content of radium in peas was 16 times greater the content of actinium 160 greater than in the nutritive medium. The best dosage for plant growing in water and sandy soils were found to 10(-9)-10(11g.) radium and 10-4 and 10-5 thorium per liter of the nutritive solution or per kg. of sand



Introduction of radium into the plant in the differert period of growth. Surface organs of peas - water cultures.



Use of radium corcentrations by plants (Vegetative experiments, pea plants).
- - - - radium introduced per g. of
percentage of radium assimilated from the corcentratiors introduced.

In our experiments, uranium radium and thorium gave a similar physiological action. Prof. V.I. Baranov thinks that the optimum concentration of separate radioactive elements for the plants are equiradioactive, that is they correspond to approximately the same amount of atoms disintegrating in a given unit of time.

The positive action of radioactive elements is shown by an increasing yeeld of fruit. An increase and acceleration of blooming and ripening of the plant (Fig. 8.) 1, and sugar cane in the roots of sugar beets and ordinary beets, carrots, cucumbers and other plants. On the eccsaguise the action of the radioactive elements is shown by the increase of crops in roots and the increase in their content of rubber (Fig. 11) as shown by experiments the imcrease of carbohydrated is linked very closely to the increase in activity of the invertas fermentation in cells of the plants under the influence of radioactive elements.

When used in correct dosage, radioactive elements have a benefical action on plants, not only on those growing in water and sand but on those growing in soil as well. In 1952, we made some field experiments with sugar-beets. In these experiments radium was introduced as a concentrate of radioactive ore compound with a complete fertillizer. On the controlled lots (complete fertillzer without radium) a harvest

of 155 centners per hectare of root with a 14% sugar. Content was obtained. By introding radium the crop of sugar-beet roots increased but slightly only 175 centner per hectar, but the percentage of the sugar content increased up to 20.1%. Similar results were obtained in vegative experiments open a great future for the practical use of radioactive elements in agriculture.

The infleuence of radioactive elements on plants may be compared to the action caused by vitamins necessary to living organisms for their normal development. Vetamins do not replace nutritive matters but a lack of vitamins in foods may cause seróous disease in mankind (such, as scury, rickets, etc.) However with a sufficient content of vitamins in food products, even the use of concentrated vitamin preparations will not cause any positive action.

Similar phenomena may be oberved in agriculture. Crops and qualities of plants in natural conditions are determained not only byl a sufficient content of macro-elements nitrogen, phosphorus, calcium, manganese, iron) in the soil but in the amounts of micro-or ultramicroscopic elements, i.e. elements contained in extremely minute quantities, among these radium and uranium, etc. This fact quite often is not sufficiently taken into consideration and thus causes tremendous unproductive expense. Quit often, large dosage of nitrovenous, phoshorous and other fertilizers are used, while in order to obtain a hégh and stable crop, the only things needed, is an extremely small quantity of micro-elements.

Radioactive elements play a great part, not only in the lives of plants, but also in the lives of bacterias which usually develop in the absence of the sun light. In our experiments with peas and beans we noticed that tubercules,with the help of which leguminous plants assimilate the atmospheric nitrogen of air, do not form on the roots of plants in absence of radioactive elements. On the other hand, in containers with radium the tubercules develop with a great intensity and assimilate in addition almost as much of the atmospheric nitrogen as there hand been added to the nutrutive mixture (Fig. 9.).

What is there essince of the actiçn caused by radioactive elemeuts?

Their action cosists primarily in the invésible energy which is continuously being emanated by them as a result of an uninterruped radioactive disintegration process. It is this hidden energy, together with the energy of the sun, that plays an impottant part in the synthesis of complex organix combinations-of carbo-hydrates, albumines, and others inside the living cells.

In referenoe to this question the academician V. I. Vernadak writes as follwws: "Life in the bio-spher emanated from two basic sources of energy". According to Prof. V. I. Vernadsky, only three radioactive elements uranium, thouium and potassium develop in the earth-crust, such a tremendous quantity of heat, many thousand times greater than the energy obtained from the sun itself. It is known á fact that in the earth-crust uranium and thorium are found to be in the following quantities: n. 10-3% and potassium 2.4%.

Quite often biologist are of the erroneous opinion that the radioactive energy, emanating from the radioactive elements present in living organisms and the disintegration products, is unsignificant. This opinion is based on the inaccurate calculation of radioactive energy. Usually, only the energy manifestion itself as heat is taken into consideration (for instance on gram of radium in one hour yields 136 calories) while kinetic energy related to electrical phenomena is not taken into consideration.

The radioactive rays (alpha beta and gamma rays) when passing through gases ionize them, i.e. they break the electrically neutral molecules of gases into particles with opposite electrical charges as a result such gases become conducive of electricity. During this process a single alpha particle ionizes, while the particle is itself transformed into an atom of helium. When under going the transformation of radium into radon, one of the disintegration products of radium there is an emanation of one and a half million times more energy in comparision with the energy obtained from the formation of water from the fire-damp gas combinations of oxugen and hydrogen (during this reaction there is a formation of 137 calories.)

Under the influence of radioactive elements there may take place in live cells not only chemical but also nuclear reactions, similar to those creating artificial radioactivity. It is under this action of alpha particles upon light elements that there occurs disintegration of their atoms with a further transformation into different elements. Thus nitrogen becomes one of the isotopes of oxygen with an atomic weight of 17, etc.

At the present-time, science does not yet possess a sufficient amount of facts to have a more complete estimate of the manifold importance of atomis energy and vegetal organisms. But one thing is sure, and this is, that the radioactive elements in living organisims are first of all continous sources of enormous kinetic energy, which together with solar energy, plays an important role in the flow of the complex bio-chemical processes.