PHYSIOLOGICAL STUDIES ON GAMMA IRRADIATED SOYBEAN PLANTS

By

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The effects of ionizing radiation on plants has been closely tied to the discovery of X-rays by Rontgen in 1895, natural radioactivity by Becqurel in 1896 and induced radioactivity by Curie and Joliot in 1934. More recently, the many advancements research associated with the greater availablity of radiation source for peaceful utilization of atomic energy and successful efforts for nuclear energy programs, have all stimulated the investigation of the biological effects of ionizing radiation.

The most efficient use of ionizing radiations in the field of plant physiology is pre-sowing seed irradiation to stimulate growth and improve the yield. However, application of ionizing radiation in this field requires a through understanding of plant radiobiology. Moreover, it seems not only appropriate but urgent that a certain amount of effort should be devoted for elucidating fundamental problems concerned with the morphological, physiological and cytogenetic effects of ionizing radiations and their possible significance with respect to practical applications.

The present work was carried out to evaluate

The applicability of pre-sowing seed irradiation with low doses of gamma rays, emitted from cobalt-60 source, in stimulating growth and increasing plant productivity of soybean plants which is considered as one of the important field crops in the world. In addition, the application of biochemical parameters as an indicator of radiation effect was also included in the present work.

REVIEW OF LITERATURES

Stimulation of the physiological functions in seeds and plants as a result of radioactive treatment has been reviewed by Sax in 1955. Such review can be separated into three categories, based on findings or techniques, i.e. a) stimulation reported but not statistically demonstrated, b) effects usually deleterious, and c) stimulation statistically demonstrated. On the other hand, the variabilities in plant responses to ionizing radiation whether in different plant species or in different varieties within a species prompted the following for the review of literature on the subject :

I- Effect of ionizing radiation on growth characters,
II- Effect of ionizing radiation on the yield, and
III- Physiological and biochemical effects.

I- Effect of ionizing radiation on growth characters :

Exposure of seeds or plants to an appropriate dose of ionizing radiation can induce cytological, morphological, genetical and physiological changes in cells and tissues. Such treatment showed remarkable changes during growth and development of every part in the plant.

Bersa (1926), stated that both <u>Vicia faba</u> and <u>Sinapis alba</u> grown either in the green houses or out-of-doors, showed an increase in sprout growth as a result of exposure to relatively weak doses of X-rays only in certain cases. The duration of inhibition was inversely proportional to the strength of dose of the X-ray.

Ancel (1927), pointed out that the growth of lentil seedling having roots about 2 - 15 cm long were retarded when exposed to various doses of X-rays. A marked decrease of the effect of the rays was noted when the period of irradiation was lengthened and the intensity was lowered. In 1928, he reported that when X-ray dose was divided between two exposures, there was less injury than when an equivalent dose was given at one exposure.

Mac Arthur (1934), irradiated tomato seeds with various doses of X-ray using a maximum of approximately 20.000 R units, observed a morphological changes including potato-leaf shaped leaves, narrow dissected leaflets of early leaves and killing of the growing tips.

Johnson (1936), reported that exposure of Nemophila and Zinnia seedlings to 2500 R unit was lethal to both varieties. However, growth of both varieties showed a difinite relation between the amount of X-rays dosage and the effect produced with respect to average height at various periods. Working on dry and soaked X-rayed wheat seeds he stated in 1939 that, at maturity, the plants from dry 1000 and 5000 R groups were taller than the controls; seedling from soaked grains, however, made less growth in plant height than did the controls. Later on, in 1948, he found that Kalanchöe seeds irradiated with low doses of X-rays produced higher plants than the controls.

Bless (1937), noted that when seeds of corn were subjected to five doses of X-rays, each of five wave lengths, the effects depended on the energy absorbed. The longer exposures produced temporary inhibitive effects and the optimum dosage depended on the stage of growth.

Wort (1941), obtained a stimulation effect in plant size in wheat after the seeds were exposed to low doses of X-rays.

A number of leaf anomalies took place for different ionizing radiation doses (Brody, 1953) and included mainly :

i) change in shape, size, margin and apex, ii) distored veination, iii) fission and fusion of leaves to various depth, iv) irregular development of chlorophyll and thereby given a mosaic-like appearance, v) development of funnel or cup-chaped leaves (a scidia) and vi) development of shrinked leaves.

Sax (1955), pointed out that, applying 3000 R of X-rays to dormant seeds of lettuce, cabbage and carrot, seemed to stimulate the growth, but more critical tests showed no significant effect of the irradiation.

Kankis and Webster (1956), found no growth stimulation by irradiation of Sorghum seeds with thermal neutrons at various doses.

Spencer and Cabanillas (1956), found that exposing the seeds of trailing indigo (Indigofera endecophylla Jacp.) to various doses of X-rays and thermal neutrons, induced a slight non significant increase in height and weight after four weeks for plants arised from seeds exposed to 20.000 R.

Oka et al. (1958), observed that a pure line of rice (Oryza sativa L.) X-rayed with two doses of 6000 and

12,000 R gave approximately the same mean for plant height as the controls but differed in their variability. The largest variation due to the treatment of 6000 R was intermediate compared to the controls which showed the smallest variation.

Rawling <u>et</u> <u>al</u>. (1958), working on the R_2 generation of some soybean varieties concluded that the variability for the plant height was significant in all treatments of radiation used.

Sopiano (1959), reported that growth inhibition occurred in rice seedlings height after X-ray treatment of rice grains, and such difference in growth was disappeared at maturity. He concluded that growth inhibition was possibly effective at the early stage only or might be eleminated in the process of development.

Osborn and Bacon (1960), pointed out after testing [illegible]ious species, that no stimulation of seedlings gro[illegible] following seed irradiation at doses of 500 to 10[illegible],000 R was occurred except in one of the eighteen tests [illegible]

Natarajan and Maric (1961), working on dry barley and heterozygous maize seeds, found a significant difference in seedling height when the seeds were sown immediately after chronically or acutely gamma radiation. Thus, results indicated that lower dose rate of cobalt-60 was more effective in retarding growth than was the higher dose rate.

Treating the diploid Saia and the hexaploid Minhafer varieties of oats with X-rays and thermal neutrons, Koo (1962), pointed out that in X_1 generation the coefficient of variation indicated that Saia had a greater variability in plant height than Minhafer, the controls and the irradiated series. He stated that the variability increased as the reduction in plant height of a variety became greater.

Plummer (1962), working on some species of Trifolium pointed out that all the species showed obvious growth inhibition from 43 KR gamma radiation or more during the first 60 days. Later, certain undetermined recovery brought those plants to normal growth characteristics after four months. Many seeds exposed to 93 KR were capable of producing mature plants with apparently normal characteristics after four months of growth. Exposure of 140 KR was a severe treatment from which shoots will develop but no favourable recovery could be expected. Shoots would not be expected to develop from seeds exposed to 280 KR.

Bianchi *et al*. (1963), reported that when the seeds of some tomato varieties were exposed to the doses 7, 14 and 21 KR, there was a fairly delay in seedling sprouting which was the first indication of physiological damage. They concluded that this damage was also reflected in seedling height which might result in differential responses of the various treated varieties.

Constantin (1964), exposed the dormant seeds of three American Upland cotton varieties to 5 - 40 KR gamma doses and stated that the 50 per cent growth reduction dose for all the three varieties was approximately 38 KR.

Donini and Scarascia (1964), reported an increase in the mean number of culms per plant and an increase in the mean weight per mature plant after exposure to daily chronic gamma radiation of 148 and 72 R per day with or without a recovery period. In both durum and bread wheat they also reported that the strongest tillering reaction was typical of the late varieties.

Selim *et al*. (1964), stated that low cobalt 60 doses had a stimulating effect on both seedling and mature plant height of Ashmouni and Giza 45 varieties of Egyptian cotton, while high doses were inhibitive. They suggested that the stimulation observed due to low doses was initiated in the first stages of growth.

Suess and Haisch (1964), reported significant variations in fresh and dry weights of shoots of wheat and barley when they were treated with small dose irradiation at early stages of development. They also reported that the effective doses were between 0.5 R and 100 R while doses of more than 200 R were harmful to growth.

El-Hamidi *et al*. (1965), pointed out that the weight of leaves of *Datura stramonium*, cv. (inermis) of seeds irradiated with gamma radiation were less than the control.

Paiziev *et al*. (1965), reported that irradiation doses from 0.5 - 1.0 KR stimulated the growth of cotton plants during the stage of 3 - 4 real leaves and budding.

Mathur (1966), stated that irradiation of seeds of peanut with ^{60}Co gamma rays stimulated the growth of germinating peanut and the maximum was at 500 R.

Matsumura (1966), pointed out that treating Triticum monococcum seeds with ^{137}Cs gamma-rays resulted in delaying the growth of the seedlings.

van Huystee and Cherry (1967), recorded that the dose of 250 and 500 KR of X-rays inhibited seedling growth of peanut by about 60 %. Radiation of 759 KR and higher levels completely inhibited seed germination.

Abrol et al. (1969), reported that treating the seeds of Triticum vulgare cv. (Sonora 64) with gamma-rays (^{60}Co as source) showed progressive inhibition in root and shoot growth at 40 KR.

Abdel-Halim et al. (1970), found that low doses of 1 KR treatment stimulated the growth and production of broad bean, whereas, high doses above 10 KR were deleterious and sometimes lethal.

Bajaj et al. (1970), stated that seeds of