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The Study of the Fertilizers induced radiological impact on Plants

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Abstract

All fertilizers used for plantation consist of some naturally radionuclides with their daughter decay products. The radiological impact of the use of fertilizers for plantation is due to internal irradiation of the lung by the alpha particles, short lived radon-thoron progeny and the external irradiation of the body by gamma ray emitted from the radionuclides. The aim of this study is to estimate the enhanced of alpha radioactivity in different parts of spinach plants due to different fertilizers. In the present work a control study has been carried out on this plant using different fertilizers.

Keywords: *Natural Radioactivity, LR-115, Fertilizer, Soil, Plants, Alpha track densities*

1. Introduction

The human population is exposed to a natural background radiation level that is contributed by three components viz., cosmic rays, terrestrial radioactivity and internal radioactivity. Plants are the major source of food for human beings. In addition to these natural sources, the level of background radiation in a region is affected from man-made sources such as those from nuclear activities and accidents (UNSCEAR, 2000). Components of natural environments such as soils, rocks, sediments, vegetation, air and water include some naturally occurring radioactive materials (NORM). Besides the well known 16 essential elements for the growth and reproduction of vegetation, a number of other natural radioactive elements like uranium, thorium and their progenies, cosmogenic radionuclides such as ^{7}Be and artificial radionuclides such as ^{137}Cs and ^{90}Sr are known to be present in plants in varied concentrations. Natural background radiation is the most important source of human exposure and a significant component of the background radiation generates from the natural radionuclides in the soil.

Soil plays an important role in the productivity and stability of terrestrial ecosystems because it is the source of nutrients and water for plants (Peth & Horn 2006). The soil radioactivity is usually important for the purposes of establishing baseline data for the future radiation impact assessment, radiation protection and exploration (Ramli, Wahab, Hussein, & Khalik, 2005). Radon is an radioactive inert gas can diffuse through the soil and enter the earth atmosphere. Radon exposure is associated with the risk of leukemia and certain other cancers of kidney and prostate (Henshaw, Eotough, & Richarbson, 1990). Leafy vegetables are the least expensive sources of a number of protective nutrients. They are readily available throughout the year, and are grown in sufficient quantities throughout the India. Consumption of locally available green leafy vegetables is an important means to overcome deficiencies (Khader, 2003). Leafy vegetables are good source of vitamins and minerals. Vegetables are generally high in carbohydrates and especially low in proteins. However their nutrient value in part on the soil and climate in which they are grown (Luke, 1984). There are different kinds of vegetables. They may be edible roots, stems, leaves, fruits or seeds. Each group contributes to the diet in its own way (Robinson, 1990). Vegetables contribute minerals, vitamins and fibre to the diet.

The decay of uranium in the soil and presence of fertilizers in the fields, leads to ^{226}Ra which further decays to ^{222}Rn along with the emission of alpha radiation. Fertilizers are chemical compounds that provide necessary chemical elements and nutrients to the plants. In the present work, the estimation of alpha activity in leaves of spinach plants grown using different types of fertilizers like diammonium phosphate (DAP), NPK, single super phosphate (SSP), urea, zinc sulphate (ZnS), potash, ammonium sulphate and organic fertilizer in same amounts before the plantation of the seedlings, has been made and reported.

2. Experimental Details

The tracks etch technique which is the simplest, economical, and feasible and an efficient passive method has been used to determine alpha activity in leaves of plants like round gourd. Alpha sensitive plastic track detectors L-R 115 type-II (Kodak- Pathe: Cellulose Nitrate type II, Vincennes, France), as the solid state nuclear track detectors (SSNTDs) has been used. These are widely applied for the detection of alpha particles. It is 10µm thick film red dyed cellulose nitrate emulsion coated on inert polyester base of 100µm thickness and has maximum sensitivity for alpha particles. Also these have low sensitivity to beta and gamma radiations and hence suitable for detection of alpha particles in mixed radiation fields. The plants were grown by planting the seeds in earthen pots having equal amounts of (12kg) of same type of soil. Different amounts (varying from 10 to 50gm) of fertilizers like D.A.P. (Diammonium Phosphate), NPK (nitrogen, phosphorus and potassium), potash, single super phosphate (SSP) and zinc sulphate ($ZnSO_4$) were added to the soil just before the plantation of the seeds of plants in the pots. The healthy leaves from different samples of plant at regular interval of time (after 70 and 90 days) were plucked, dried in an oven at 40 °C and then sandwiched between two plastic track detectors each of same size (1 cm x 1cm**)** by wrapping a cello tape tightly to record the tracks for alpha radiations emitted from both upper and bottom faces of the leaves. The exposure time of the detectors was 60 days. At the end of exposure time, the detectors were removed and subjected to a chemical etching process in 2.5 NaOH solution at 60 °C for one and half hour. The detectors were washed, dried and after that, the tracks caused by alpha radiations emitted from the leaves were counted using optical Olympus microscopes using CCTV camera and a monitor at magnification 400 X.

3. Results and discussion

For the present control study on spinach plants using different fertilizers, alpha track densities for various samples taken as leaves collected after 70 and 90 days of plantation have been measured. For leaves plucked from the plants after 70 days of plantation of the seeds, it has been found that the alpha track densities on the top face of the leaves varied from 99 to 265 T cm^{-2} while at the bottom face these varied from 116 to 297 T cm^{-2} with an average variation of 107±8.5 to 281±16 as shown in Table-1.

Table 1: Alpha track densities measured in the leaves of Spinach plants after 70 days of plantation

Sr. No.	Fertilizer Used	Tracks/cm^2 on Leaves		AM±SE*	Tcm^{-2}d^{-1}
		Top face	Bottom face		
1.	WF	133	133	133±0.0	2.2
2.	CDM	149	165	157±7.9	2.6
3.	DAP	265	297	281±16	4.7
4.	NPK	165	182	174±8.5	2.9
5.	SSP	232	248	240±7.9	4.0
6.	PF	248	281	265±16	4.4
7.	$ZnSO_4$	215	248	232±16	3.8
8.	URA	182	215	198±16	3.3
9.	OF	99	116	107±8.5	1.8

These variations are on higher side as compared to the plants grown without any use of chemical fertilizers. Similarly, for leaves plucked from the plants spinach after 90 days of plantation of the seedlings, it was found that the alpha track densities on the top face of the leaves varied from 133 to 281 T cm-2 while at the bottom face these varied from 149 to 314 T cm-2 with an average variation of 141±7.9 to 297±16 as shown in Table 2. The track density was higher in case of D.A.P. (Diammonium Phosphate), SSP, zinc sulfate (ZnSO4) and potash fertilizer (PF) as compared to other fertilizers.

Table 2: Alpha track densities measured in the leaves of Spinach plants after 90 days of plantation

Sr. No.	Fertilizer Used	Tracks/cm^2 on Leaves		AM±SE*	Tcm^{-2}d^{-1}
		Top face	Bottom face		
1.	WF	133	149	141±7.9	2.4
2.	CDM	149	165	157±7.9	2.6
3.	DAP	281	314	297±16	4.9
4.	NPK	198	248	223±25	3.7
5.	SSP	232	265	248±16	4.2
6.	PF	265	297	281±16	4.7
7.	$ZnSO_4$	232	265	248±16	4.2
8.	URA	182	215	198±16	3.3
9.	OF	149	165	157±7.9	2.6

A positive correlation (R2 = 0.8764) was observed between alpha track densities of fertilized soil and leaves of spinach plants after 90 days of plantation.
It is found to be higher on its bottom face as compared to that on the upper face which may be due to the presence of large number of trichomes at the lower face to which dust particle from environment with the radon daughter attached, and get stuck. In similar studies, Nain et al., 2008 have found the effect of chemical fertilizers on radioactivity of tobacco plants.

4. Conclusion

From present investigation we can conclude that:
1. The alpha track densities vary with the nature of fertilizers added to the soil for the growth of plants. The variation in alpha radioactivity with the passage of time of growth due to large absorption of fertilizers by plants and hence more uptake of radio-nuclides with the passage of time.

2. The alpha activity was found to be more in case of fertilizer potash, D.A.P. and zinc sulphate used in plants. This may be due to the fact that the rock mineral apatite, from which phosphate is derived, is rich in uranium and its decay products.
3. The excessive use of phosphate fertilizers had shown retardation in the growth of the plants. At initial stage the growth of plants was accelerated with increase in amount of fertilizers while it was retarded for higher amount of fertilizers added. The growth observed was better in case of DAP, OF and NPK fertilizers when added before plantation and in case of URA when added few days after the plantation, compared with other fertilizers. Therefore, for healthy growth and reduced level of radioactivity in plants, optimum use of phosphate fertilizers may be made and use of organic fertilizers should be encouraged.

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