# INCORPORATION OF TRITIUM DUE TO FOLIAR EXPOSURE IN CERTAIN VEGETATION*

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ABSTRACT

Tritium uptake, release and incorporation patterns through the foliage of seedlings of certain edible vegetation were investigated, for exposure periods ranging from an hour to about 20 hours. A large number of plants belonging to the family of lettuce (*Lactuca sativa* L.), cabbage (*Brassica oleracea* L.) and capsicum (*Capsicum fruitescens* L.) were exposed to tritiated air under dynamic and static conditions. The half times for tissue-free-water-titrium (TFWT) were found to be about 46 and 32 *minutes for capsicum* and lettuce and 45 minutes for cabbage.

Tissue-bound-tritium (TBT) in the seedlings and the grown plants showed different incorporation rates as a result of foliar exposure. The relative concentration factors were larger by a factor of ten for TFWT in the leaves of the grown plants than in the shoots of the seedlings. However, tissue-bound-tritium concentration values in the shoots/stems of the young and grown plants were of the same order, as related to the tissue-free-water-tritium concentrations. Thus the study indicates a larger translocation of tritium from aqueous to organic phase in the leaves of the grown plants than in the shoots of young seedlings.

## INTRODUCTION

BECAUSE of the close relationship among the soil moisture, plant-water and atmospheric humidity and temperature conditions the transfer of water and hence tritium is intimately related to the ecological and meetorological factors. The soil-plant tritium movements have been extensively studied by many workers. The uptake and release pattern of tritium in the plants through foliage has been studied by Vaadia and Waisel[1], Koranda and Martin[2], McFarlane[3] and Krishnamoorthy *et al.*[4].

It is reported that when the water falls on the vegetation it will be absorbed by the leaves and stems of the plant. If it is tritiated, there may be $^3H$ incorporation in the transpirational stream and swept out with the larger flux of water transpired each day. Alternatively, it can be involved in the photosynthesis and fixed in the organic compounds which may be translocated to other parts of the plant.

Absorption through aerial organs has been reported for zero-time concentrations and short term exposures. The present study summarises a series of experiments under different modes of tritium exposure conditions and release patterns in the plant's natural environment, using a number of potted plants belonging to the species *Capsicum fruitescens*, L., *Lactuca sativa*, L. and *Brassica oleracea*, L.

## EXPERIMENTAL DETAILS

The experiments consisted of exposure of a number of naturally grown potted plants of different age groups from 2 weeks to 5 months, to tritiated atmospheres of very nearly 100% relative humidity, whenever the outside relative humidity values are also very nearly the same. In all the cases of exposure conditions, there was rain in the neighbourhood of the plants. During irradiation, potted plants were kept in a polythene chamber of volume 200 l, away from the rain. These plants were grown under natural environment in the respective pots to avoid transplantation shocks, as they were very young.

The tritium active atmospheres were generated each time by bubbling dry air through two bubblers at fixed flow rates. The bubblers contained the active tritiated water samples.

In the case of exposures which involved night periods, fluorescent lighting was provided above the plants. The polythene chamber was provided with a transparent top cover so that light was allowed to pass through while the activity could be contained effectively during the period of interest. Fig. 1 shows the schematics of experimental arrangements.

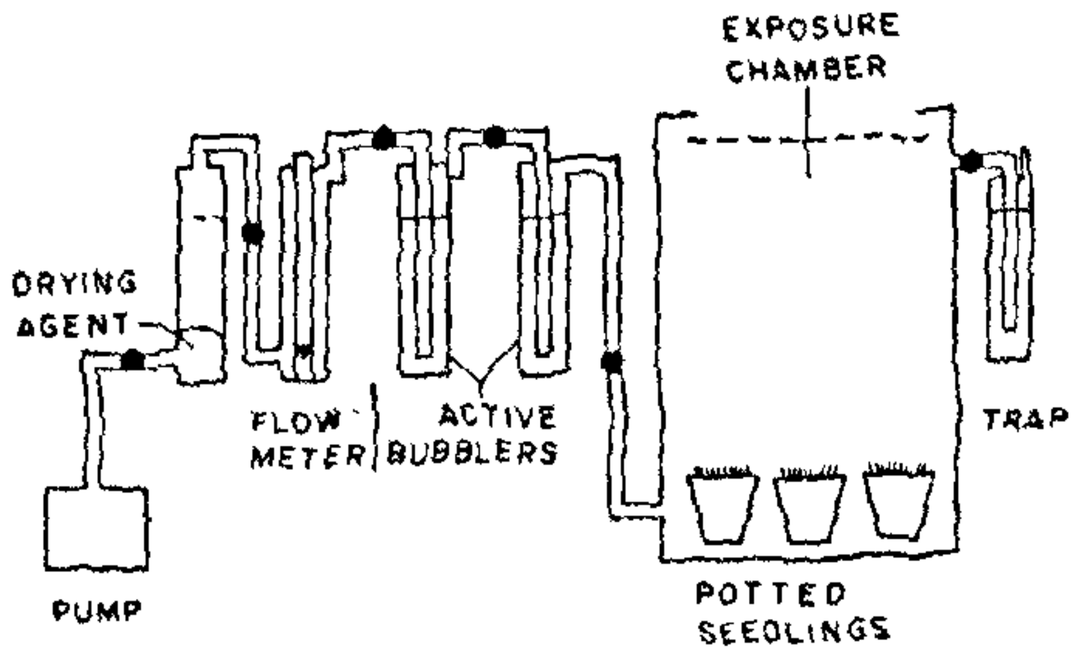


FIG. 1. Schematic arrangement for foliar exposure experiments.

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The samples were collected at different periods of exposure timings. The whole plant was carefully removed from the pot each time, entirely along with the roots. The sampling schedules are explained below.

*Tritiated Water Vapour Exposure Schedule*

The uptake of tritiated water vapour by the plant foliage of the common sunflower plant *Helianthus annua*, L. has been studied for time-zero conditions by Vaadia and Waisel[1]. Koranda and Martin have reported a series of ecological experiments conducted at Lawrence Livermore Laboratory, in which a number of field grown plants were exposed to tritiated water vapour and the detailed information on the retention of tritium by these plants has been well documented[2].

In the present work a series of potted plants and seedlings (nearly 100 nos.) belonging to the species capsicum, cabbage and lettuce were exposed to tritiated water vapour for various periods of time, in an enclosed atmosphere as explained earlier. The exposure schedules are divided into three modes as given below :—

(i) *Active environment (dynamic)* : The dry air bubbled through tritiated water of known specific activity was allowed to pass through the chamber at a low rate of flow initially (0·5 l/m) and increased to a faster rate (3 l/m) later. Flow rates beyond this were not achievable in the set-up used, because of spray of active water along the line. The temperatures of the air inside as well as outside were monitored. The relative humidity values were the same inside and outside the chamber.

(ii) *Active environment (static)* : In this case the plants were kept in a static atmosphere for a fixed length of time in the active environment with no air flow.

(iii) *Inactive environment (dynamic)* : The potted plants were kept in the natural environment before and after exposure. The periods involved were varied under each one of the combinations mentioned above. In addition to zero-time samples, corresponding to each of the exposure mode combinations, periodic samplings at 15 min intervals were continued.

The exposure schedule for the plant clusters handled are mentioned in Table I.

*Soil Samples*

The surface soils from the different pots exposed as per the above schedules were analysed for tritium content to account for any possible interference. The soil moisture was extracted using vacuum freeze drying technique. The different values obtained during the sampling schedules were more or less constant, indicating that the results refer only to foliar exposure. The soil sampling was continued in the natural environment for a few days and the values are plotted in Fig. 2. It can be seen that the soil moisture has a tritium mean residence time of 2·45 days, which is very much longer than those for the plants.

*Processing of Samples*

The plant as a whole was removed each time for sampling. In the case of grown plants they were cut into three parts, *viz.*, leaves, stem and roots. In the case of very young plants (particularly seedlings) the weights involved were very small for analysis and hence the entire shoot was analysed as a whole. All parts were separately analysed for TFWT and TBT by the conventional methods of analysis. A Packard Liquid Scintillation Spectrometer (Model 3255) was used for determining tritium activity. Depending upon the type and amount of quenching the necessary corrections were made using the channels ratio technique, automatic external standardisation method or internal spike method.

TABLE I

*Exposure schedules*

| Plant species | Active environment exposure time min | Time in inactive environment | | No. of plant clusters sacrificed |
|---|---|---|---|---|
| | | Short term min | Long term min | |
| Cabbage | 85 | 15 to 90 | 1100–1200 | 58 |
| | 120 | ,, | ,, | |
| | 175 | ,, | ,, | |
| Lettuce | 85 | ,, | ,, | 38 |
| | 175 | ,, | ,, | |
| Capsicum | 165 | 30–500 | — | 12 |
| | 195 | 0–100 | — | |

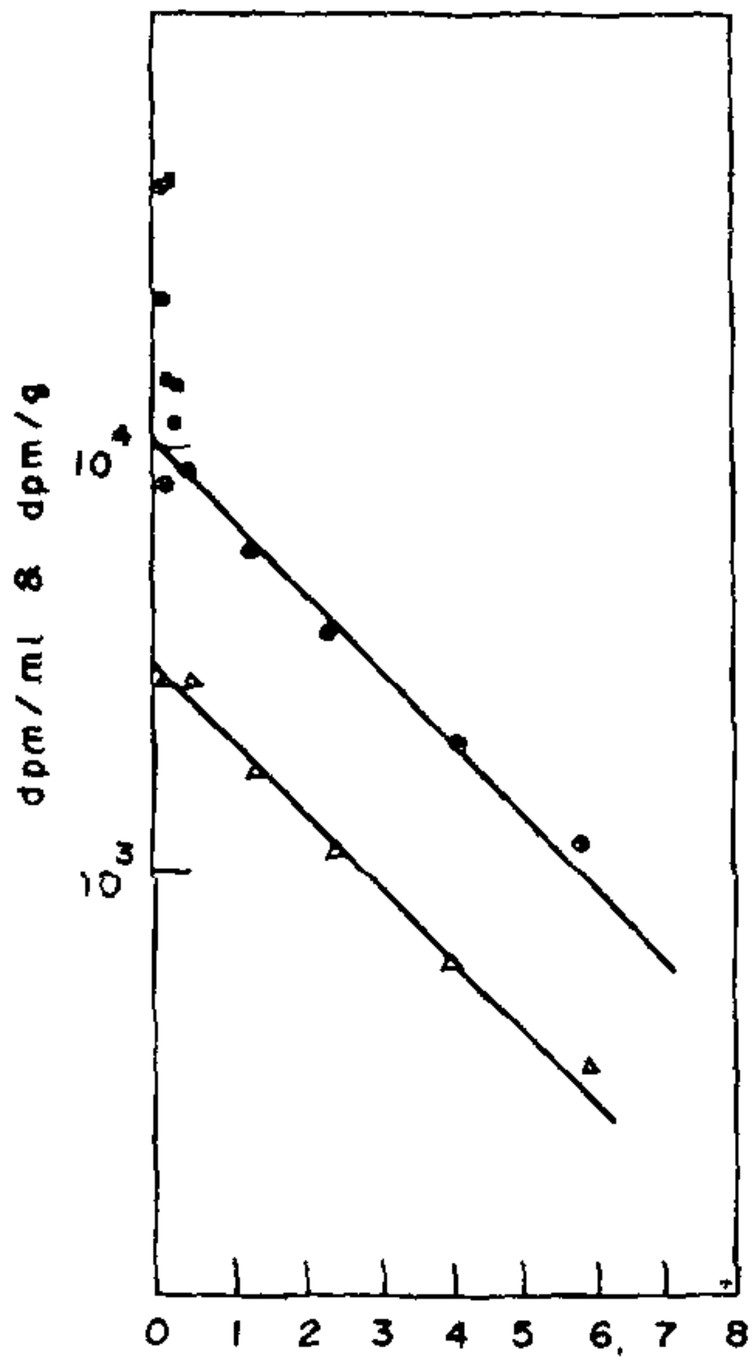


FIG. 2. Subsoil tritium activity.

## RESULTS AND DISCUSSION

The mean residence time of the plants was determined both as individual seedlings and as clusters. In Table II, the rate constants for each exposed group of plants are given. Fig. 3 gives the $^3H$ release rate for capsicum plant for leaves and stem separately. The TBT values for leaves are also given in this figure. Fig. 4 gives similar values for the fresh shoots of cabbage and lettuce seedlings. The plants were taken up together for a single tritium release rate. In the case of *Capsicum fruitescens*, L. the shoots and roots showed half residence time values ($T_{\frac{1}{2}}$) of 46 min. and 65 min corresponding to a least square approximation. For the lettuce the value was found to be 32 min and the cabbage 45 min.

In addition to the above mode of analysis each plant was considered individually and from the exposure periods and the activity measured, the decay constants governing the tritium release rates from roots and shoots were determined (Table II). For this, the zero time activity was assumed as the Y intercept value obtained from the least square fit. In the case of short-term exposure schedules the available number of plants was grouped into two sets, *viz.*, those in equilibrium with the medium and those which are allowed to release tritium in an active environment under natural conditions. The concentration factors expressed as the ratio of tritium concentration in the plant moisture to that in the exposure chamber expressed as percentages were determined for the different groups of plants (Table III). It can be seen that fresh offshoots have much lower values than the grown plants due to larger uptake by the leaves.

TABLE II

*Rate constants of tritium release*

| Species | Rate constant $min^{-1}$ | Half time min | Mean residence time, min |
|---|---|---|---|
| Lettuce shoots | $2{\cdot}2 \times 10^{-2}$ | 31·65 | 45·5 |
| Capsicum shoots | $1{\cdot}52 \times 10^{-2}$ | 46·3 | 66·7 |
| Capsicum roots | $(1{\cdot}07 \times 10^{-2})$ | (64·95) | (93·45) |
| Cabbage shoots | $1{\cdot}54 \times 10^{-2}$ | 45·1 | 64·9 |

The tissue-bound tritium was analysed for all the different plants and their individual parts (Figs. 3 and 4). The ratios of the $^3H$ values of organic fractions to that of aqueous values can be compared by expressing them in terms of the relative specific

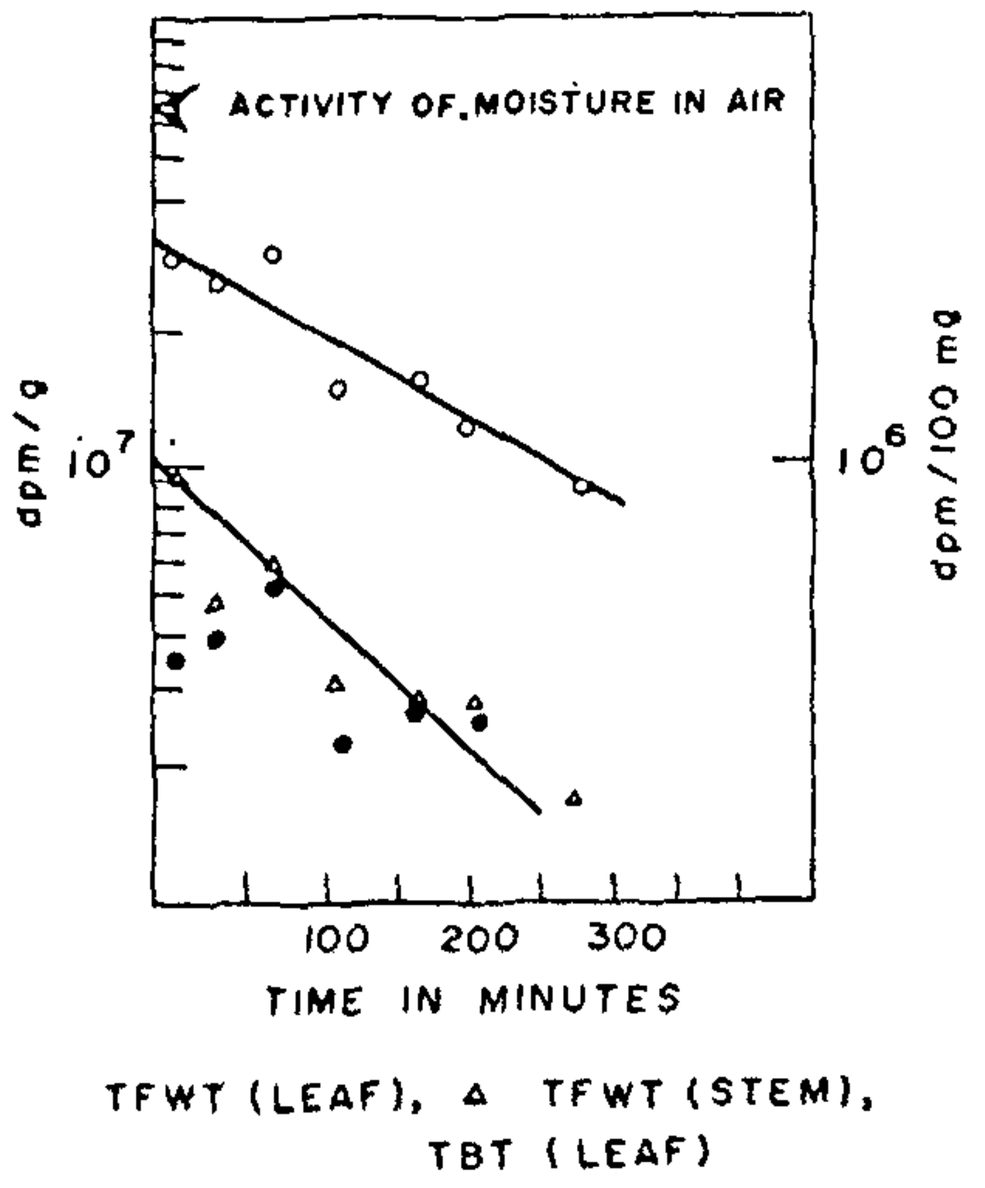


FIG. 3. Tritium release pattern in capsicum (leaf and stem).

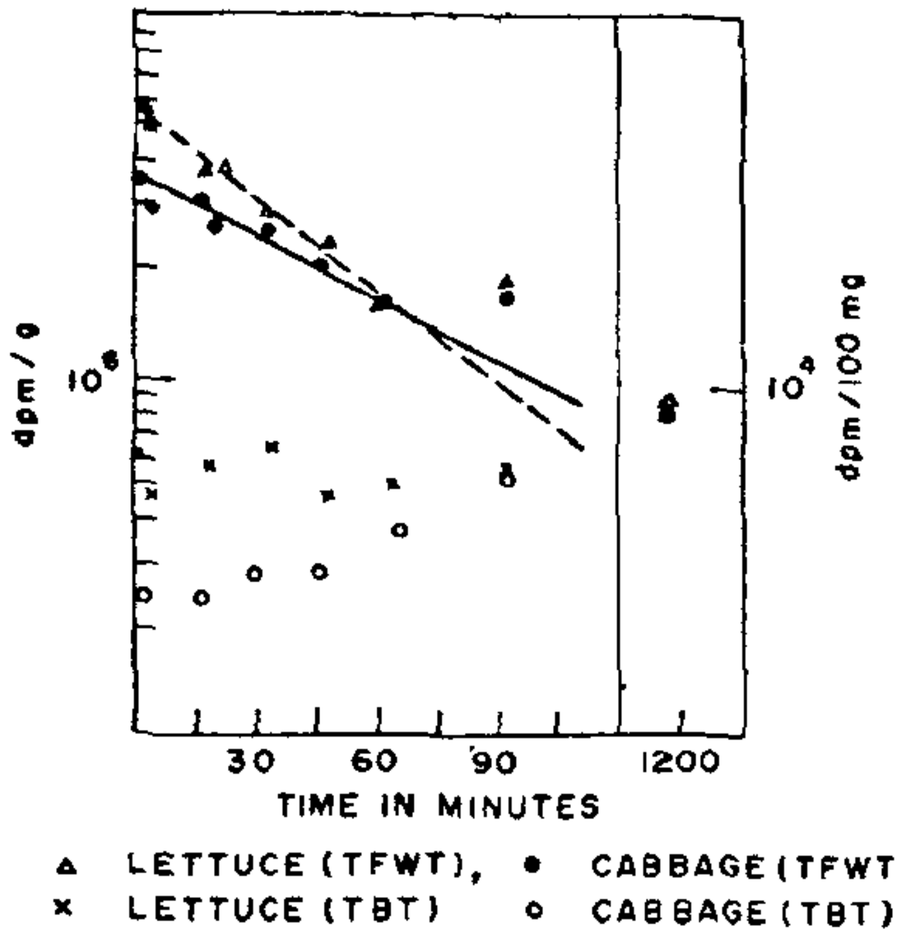


FIG. 4. Tritium release Pattern in cabbage and lettuce (fresh Shoots).

activity ratios, the specific activity itself being expressed as dpm/g of hydrogen. The hydrogen content of lyophilised tissue was estimated by burning the sample and absorbing the steam in $MgClO_4$ using conventional chemical apparatus.

It can be seen that the incorporation of TBT is around $4{\cdot}2 \pm 0{\cdot}83\%$ for cabbage, $4{\cdot}42 \pm 0{\cdot}97$ for lettuce and $6{\cdot}69 \pm 0{\cdot}59\%$ for capsicum (Table IV).

The zero time fixation rate as reported by Vaadia and Waisel shows a very low value compared to that reported by Koranda and Martin[2]. Our study shows that the uptake coefficient (defined as the ratio of specific activity of tissue water of plant and that of the water moisture in the chamber) is very near to that reported by Koranda and Martin. For the young plants *Capsicum fruitescens*, L. the value is found to be 0·42 as against 0·49 obtained for young plants of *Helianthus annua* by Koranda and Martin.

TABLE III

*Concentration factors for TFWT*

| Species | | Concentration factors % |
|---|---|---|
| Capsicum | leaf | $42{\cdot}4 \pm 0{\cdot}19$ |
| Capsicum | stem | $10{\cdot}2 \pm 1{\cdot}4$ |
| *Lettuce* | shoot | $4{\cdot}44 \pm 0{\cdot}14$ |
| Cabbage | shoot | $3\,8 \pm 0{\cdot}9$ |

TABLE IV

*Ratio of organic to aqueous fractions*

| Spec'es | . Relative specific activity ratio as % (organic to aqueous components) |
|---|---|
| Cabbage | $4{\cdot}2 \pm 0{\cdot}83$ |
| Lettuce | $4{\cdot}42 \pm 0{\cdot}97$ |
| Capsicum | $6{\cdot}69 \pm 0{\cdot}59$ |

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