

SYSTEMIC BEHAVIOUR AND FATE OF  
C-14 PHOSPHAMIDON IN SPRUCE TREES

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## ABSTRACT

The uptake rate, translocation and fate of the insecticide phosphamidon (2-chloro-N, N-diethyl-3-hydroxycrotonamide dimethylphosphate) in spruce trees, *Picea glauca* (Moench) Voss, has been examined under forest environmental conditions by trunk implantation treatment (TIT), basal bark painting (BBP) and foliar painting (FP) techniques. The direction of migration and accumulation of the substance were investigated by gas-liquid chromatographic (GLC), liquid scintillation counting (LSC) and autoradiographic methods. The chemical was apoplastically accumulated by xylem transport in branches and foliage when injected into the tree trunk. The major route of translocation of radiolabel was acropetal, from the old to the newly flushed foliage. The residue levels were low when the material was brushed on the basal bark and foliage. The translocated phosphamidon in TIT was lost within 34 days possibly by enzymatic breakdown forming polar metabolites some of which became persistent due to their incorporation into the cellular structure of spruce foliage. The mechanism of dissipation of the insecticide from the treated surfaces in FP and probably in BBP techniques appeared due to physical rather than metabolic processes. Consequences arising from the systemic behaviour of the chemical are discussed in relation to practical applicability of the insecticide in forest pest control programs.

## RESUME

La vitesse d'absorption, le déplacement et le devenir de l'insecticide phosphamidon (phosphate de (chloro-2 diéthylcarbamoyl-2 méthyl-1 vinyle) et de diméthyle) dans les épinettes (*Picea glauca* (Moench) Voss) ont été étudiés après injection dans le tronc, badigeonnage de l'écorce à la base et badigeonnage des aiguilles. La direction de la migration et l'accumulation de la substance ont été étudiées par chromatographie de partage gaz-liquide, par comptage par scintillation liquide et par autoradiographie. Le composé injecté dans le tronc s'est accumulé de façon apoplastique dans les branches et les aiguilles par transport dans le xylème. La principale route de déplacement du composé marqué était acropétale, c'est-à-dire des vieilles aiguilles aux nouvelles. Les teneurs en résidus étaient plus faibles lorsque l'insecticide était badigeonné. Dans la méthode d'injection, le phosphamidon déplacé était disparu après 34 jours probablement par dégradation enzymatique pour former des métabolites polaires dont certains sont devenus rémanents, étant donné leur incorporation dans la structure cellulaire des aiguilles. Dans le cas du badigeonnage des aiguilles et peut-être également de l'écorce à la base, la disparition de l'insecticide des surfaces traitées a semblé davantage attribuable à des processus physiques plutôt que métaboliques. Les conséquences du comportement endothérapique du composé sont examinées en vue de son épandage contre les parasites des forêts.

## INTRODUCTION

Many organophosphates are commercial insecticide chemicals used for control of various insect pests in agriculture and forestry. To evaluate the potential hazard from their use, it is necessary to know their fate in and on plants and trees, especially if they have a systemic action or if their use leaves a persistent residue.

One such long-established insecticide extensively used in Canada since 1963 for controlling spruce budworm (*Choristoneura fumiferana Clemens*) is phosphamidon (2-chloro-N, N-diethyl-3-hydroxycrotonamide dimethylphosphate), manufactured and marketed by Ciba-Geigy Ltd., Basle, Switzerland under the trade name Dimecron®. Considerable scientific, technical and chemical information is available on the material (Gunther 1971). Randall (1962) demonstrated effective translocation of phosphamidon in spruce seedlings from the roots to foliage and from a specific foliage site to the remainder of the tree, as measured by mortality to spruce larvae feeding on non-treated parts of the seedlings. Varty and Yule (1976) studied the fate and persistence of the chemical in some components of the forest environment. However, information on uptake, translocation and accumulation of the material in forest trees is not as yet readily available. Recently, sensitive analytical methods have been developed and reported (Sundaram and Davis, 1974, Sundaram 1976) for the determination of the insecticide isomers from forest environmental samples. Because of concern about possible phosphamidon accumulation due to repeated aerial spraying for budworm control, investigations were undertaken to obtain additional information about its systemic behaviour and fate in trees under normal weathering conditions, by choosing white spruce [*Picea glauca* (Moench) Voss] as an indicator species of the tree component of conifer forests of Canada. Areas studied, using C-14 labelled

phosphamidon in the vinyl ( $\gamma\text{C} = \text{C}\alpha$ ) position, were uptake, movement and accumulation within the spruce tree when the material was painted on the foliage and on the basal bark and after injection into the tree trunks. Also, the persistence, degradation and/or possible metabolism of the two isomers *cis* (or  $\beta$ ) and *trans* (or  $\alpha$ ) existing in the ratio of 73:27 in the mixture were of interest. The present study did not include the characterization of any of the possible degradation products formed. The investigation took advantage of the gas-liquid chromatographic (GLC) analytical methodology developed at this Institute (Sundaram 1976) to quantitate phosphamidon isomers in conifer needles coupled with a radiotracer method [liquid scintillation counting (LSC)] and a gross autoradiographic technique to elucidate the systemic behaviour of phosphamidon in conifers.

## MATERIALS AND METHODS

### Chemicals and Solvents

C-14 phosphamidon labelled in the vinyl portion with specific activity (S.A.) 3.62 millicurie (mCi) per millimole (nmole) and the analytical grade nonradioactive phosphamidon used in the study as a primary standard were supplied by courtesy of Ciba-Geigy Ltd., Basle, Switzerland. Purity was confirmed by gas-liquid chromatography (GLC) and liquid scintillation counting (LSC). The solvents used in extraction and column elution procedures and dimethyl sulphoxide (DMSO) used for preparing the phosphamidon solution were distilled in glass. The purity of other chemicals such as anhydrous sodium sulphate, Celite, animal charcoal etc. used in the study corresponded to the specifications given in a previous publication (Sundaram 1976).

### Insecticide Application and Sampling

As described recently (Sundaram *et al* 1977) a tree farm near Shawville, P.Q. was selected as the study site because of easy access and ready availability of uniform size and shape trees ( $\approx$  4m in height and 9 cm in diameter at the base of the trunk) with abundant foliage. Trees labelled P1, P2 and P3 were selected for the insecticide treatment and tree P4 served as the untreated check.

A solution of phosphamidon in DMSO was prepared for application because the latter is not only a versatile solvent for many pesticides but also has favourable attributes in uptake studies due to its ready adherence and penetration of plant cuticle by defatting the contact site and carrying the solute moieties by absorption into the body fluid of the plant through stonata and cuticles. The formulation contained 24.8 mg (0.083 nmole) of

labelled and 435.2 mg (1.453 mmole) of unlabelled phosphamidon respectively in 15 ml of DMSO solution. Each tree (P1, P2 and P3) received 5 ml of the solution containing 0.512 mmole of phosphamidon with S.A. 0.195 mCi/mole.

As previously described (Sundaram *et al* 1977), three modes of application were employed on May 26, 1976 between 0940 to 1120 hours. The tree P1 was treated by the trunk implantation technique (TTI), P2 by basal bark painting (BBP) and P3 by foliar painting (FP). Reference should be made to Sundaram *et al* (1977) for details of the application techniques.

In FP, a rough estimation conducted by weighing an equal amount of unbrushed foliage showed that the initial concentration of phosphamidon on the painted needles would be about 500 ppm.

Foliage samples (50 g) were collected according to the established procedure (Sundaram *et al* 1977) on day 0 (prespray) and thereafter at 1, 3, 5, 8, 12, 16, 21, 27, 34, 41, 50, 64 and 89 days post-spray. Pieces of bark, branch stem, newly flushed and old foliage, budworms feeding on them, and root samples were also collected from different parts of the trees at 21 days post-treatment to study the distribution pattern of the insecticide within the spruce trees under normal weathering conditions. Each sample was processed and stored as described earlier (Sundaram 1974) prior to extraction and analysis.

#### Extraction and GLC Analysis

Recent publications (Sundaram and Davis 1974, Sundaram 1975, Sundaram 1976) describe in detail the extraction and GLC analysis of phosphamidon isomers from forest environmental samples. For brevity and to avoid repetition, the procedure is not described here in detail but is given as an outline in Fig. 1. Reference should be made to those

publications for details of the analytical method developed for conifer materials including instrument parameters. In essence the method consists of Sorvall homogenization of the spruce foliage using ethyl acetate as solvent, filtration under reduced pressure, dehydration of the extract by anhydrous sodium sulphate, flash-evaporation, hexane-acetonitrile partition, concentration followed by Celite charcoal column cleanup, elution by benzene-ethyl acetate solvent mixture and finally quantitation by flame photometric GLC in phosphorus mode. The method was convenient and gave recoveries above 85% from the substrates analysed for both isomers of phosphamidon, with acceptably low background interference for GLC analysis.

Table I  
Concentrations and Radioactivities of Phosphamidon Isomers  
in Spruce Foliage After Trunk Injection Treatment\*

Days After Application	Phosphamidon Concent. (ppm)			Sp. Activity ( $\mu\text{Ci/g}$ )
	Trans-	Cis-	Total	
1	0.22	0.60	0.82	0.52
3	0.96	2.02	2.98	1.98
5	1.54	2.10	3.64	2.44
8	2.63	2.69	5.32	3.56
12	2.04	1.63	3.67	2.64
16	1.14	0.66	1.80	1.96
21	1.29	0.60	1.89	1.77
27	0.81	0.42	1.23	0.95
34	0.06	N.D.	0.06	0.62
41	N.D.	N.D.	N.D.	0.33
50	N.D.	N.D.	N.D.	0.41
64	N.D.	N.D.	N.D.	0.24
89	N.D.	N.D.	N.D.	0.11
				0.05

\* Date of application: May 26, 1976.

N.D. Not detected

Minimum detection limit 0.03 ppm.

Table II  
Concentrations and Radioactivities of Phosphamidon Isomers  
in Spruce Foliage After Basal Bark Painting

Days After Application	Phosphamidon Concent. (ppm)			Sp. Activity (nCi/g) Raw Extract	Sp. Activity (nCi/g) Cleanedup Extract
	Trans-	Cis-	Total		
1	0.02	0.04	0.06	0.04	0.04
3	0.08	0.14	0.22	0.15	0.13
5	0.16	0.25	0.41	0.30	0.27
8	0.05	0.07	0.12	0.12	0.09
12	0.06	0.08	0.14	0.14	0.10
16	0.11	0.11	0.22	0.16	0.11
21	0.10	0.03	0.13	0.13	0.11
27	0.03	N.D.	0.03	0.08	0.06
34	N.D.	N.D.	N.D.	0.06	0.04
41	N.D.	N.D.	N.D.	0.06	0.05
50	N.D.	N.D.	N.D.	0.04	0.02
64	N.D.	N.D.	N.D.	0.04	0.02
89	N.D.	N.D.	N.D.	0.03	0.02

See the footnotes in Table I.

Table III  
Concentrations and Radioactivities of Phosphamidon Isomers  
in Spruce Foliage After Foliar Painting

Days After Application	Phosphamidon Concn. (ppm)			Sp. Activity (mCi/g)
	Trans-	Cis-	Total	
1	0.02	0.04	0.06	0.05
3	0.02	0.06	0.08	0.06
5	0.04	0.06	0.10	0.12
8	0.03	0.07	0.10	0.14
12	0.05	0.08	0.13	0.17
16	0.05	0.08	0.13	0.16
21	0.04	0.05	0.09	0.11
27	0.03	N.D.	0.03	0.12
34	N.D.	N.D.	N.D.	0.08
41	N.D.	N.D.	N.D.	0.04
50	N.D.	N.D.	N.D.	0.05
64	N.D.	N.D.	N.D.	0.04
89	N.D.	N.D.	N.D.	0.03

See the footnotes in Table I.

Table IV  
Longitudinal Translocation of Phosphamidon in Spruce Tree\*  
After 21-Day Trunk Injection Treatment

Sample	Phosphamidon Concn. (ppm)			Sp. Activity Raw Extract (mCi/g)	Cleannedup Extract
	Trans-	Cis-	Total		
New Foliage	1.44	0.81	2.25	1.89	1.60
Old Foliage	1.06	0.44	1.50	1.07	0.99
Branch**	1.28	0.91	2.19	1.76	1.59
Roots	N.D.	N.D.	N.D.	0.02	0.02
Budworms†	0.05	0.03	0.08	0.06	0.05

See the footnotes in Table I.

\* The data represent the average of two replication. Variability of the values did not exceed  $\pm 12\%$ .

\*\* 75 cm samples from midcrown excluding foliage.

† Collected from midcrown twigs.

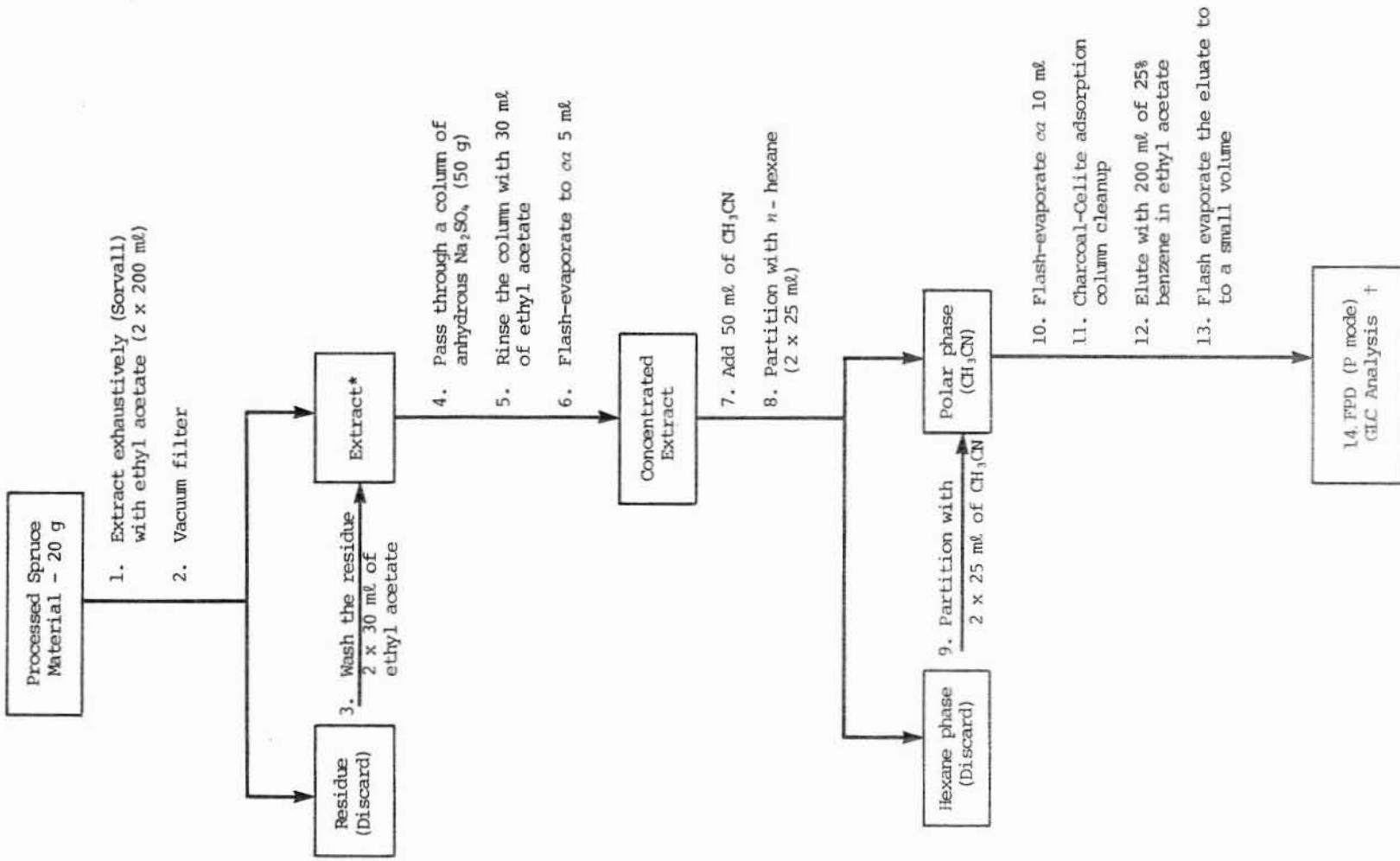


Fig. 1. Scheme of extraction, cleanup and quantitation of phosphamidon isomers from spruce materials (foliage, stem, roots etc). Fractions marked with asterisk (raw extract) and dagger (cleanedup extract) were analysed for radioactivity by LSC. Method described by Sundaram (1976).

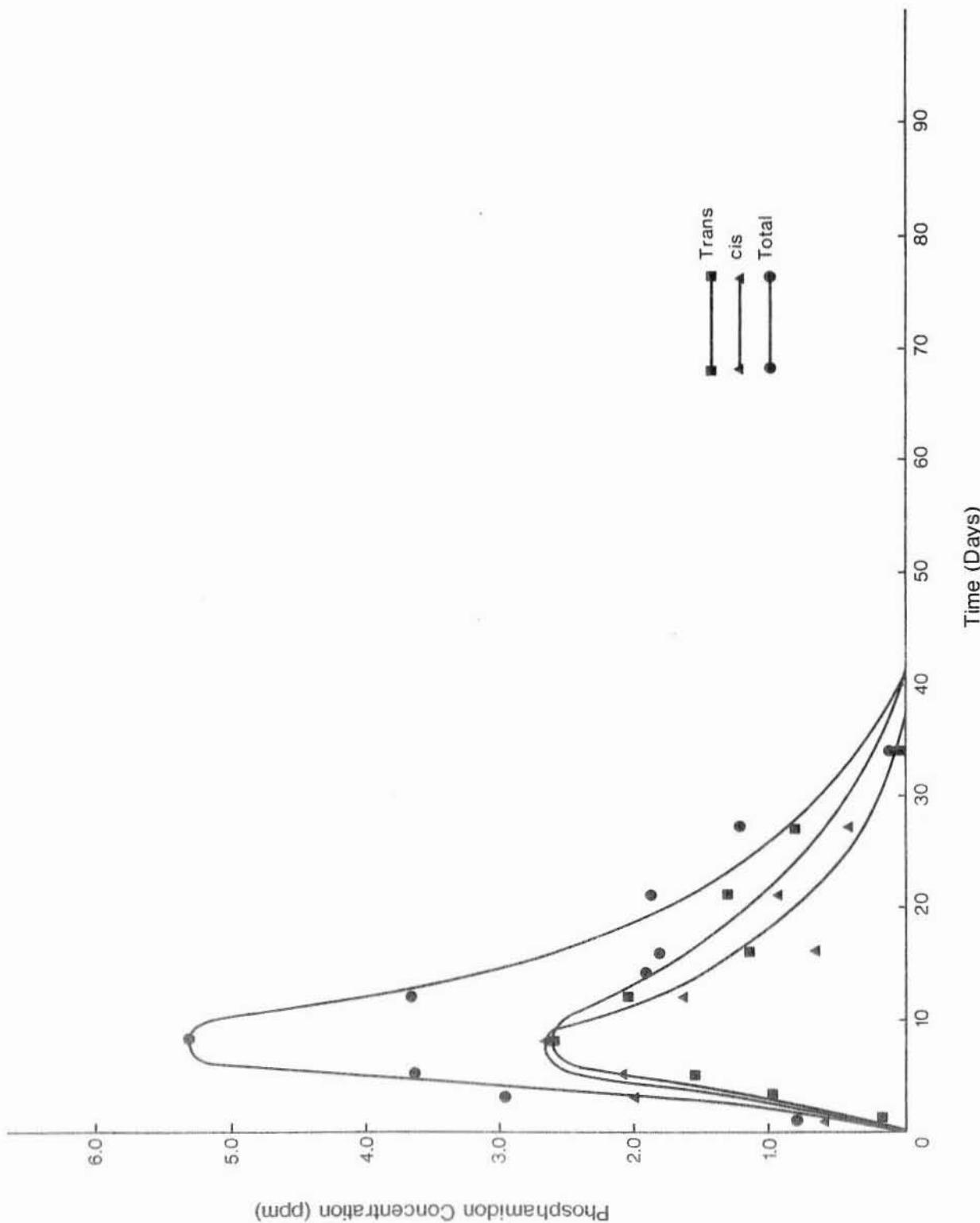


Fig. 2. Rate of decrease of phosphamidon concentration in foliar extracts of spruce tree after trunk injection treatment.

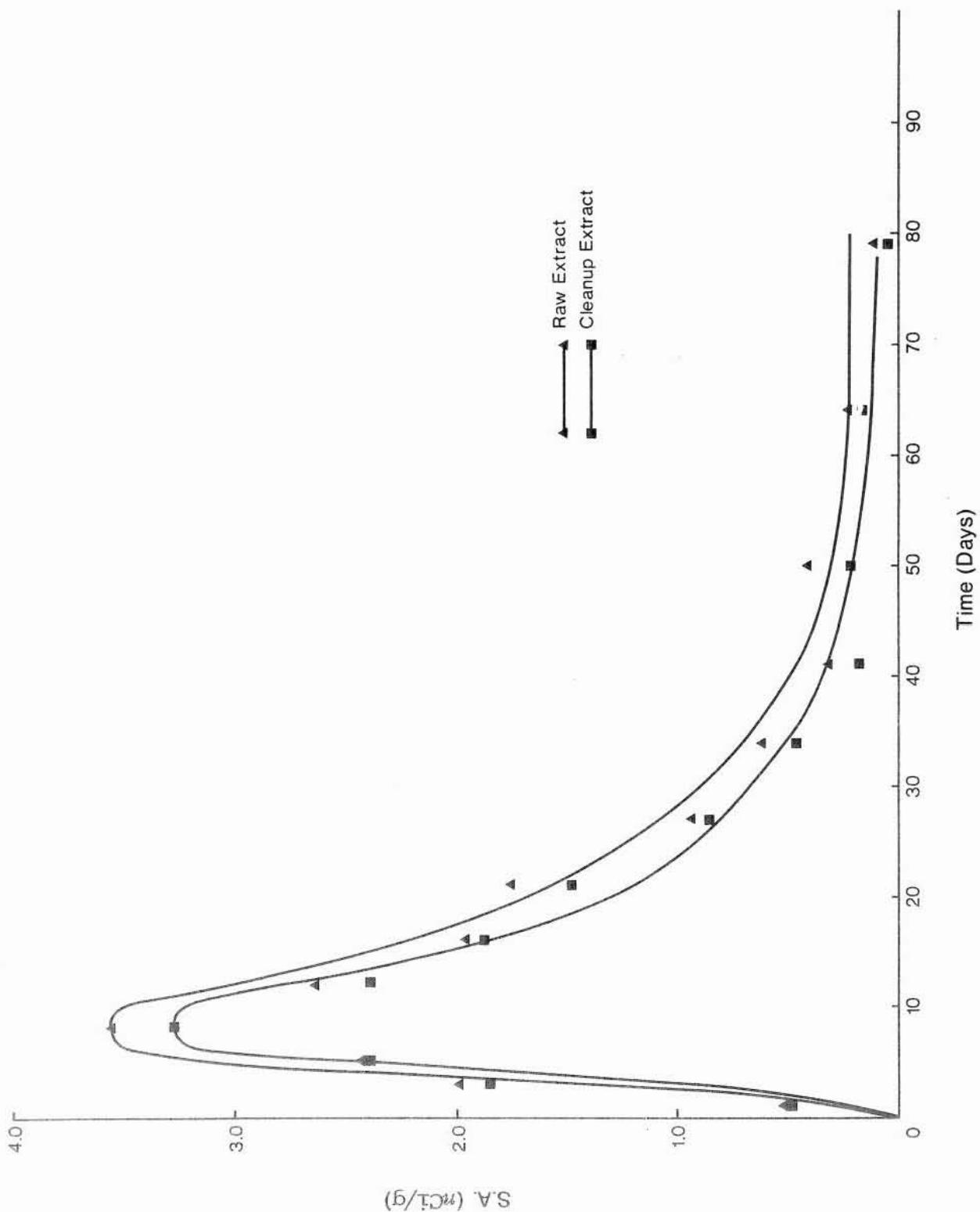


Fig. 3. Distribution and rate of loss of specific activity in raw and cleanup foliar extracts of spruce tree after TIT.

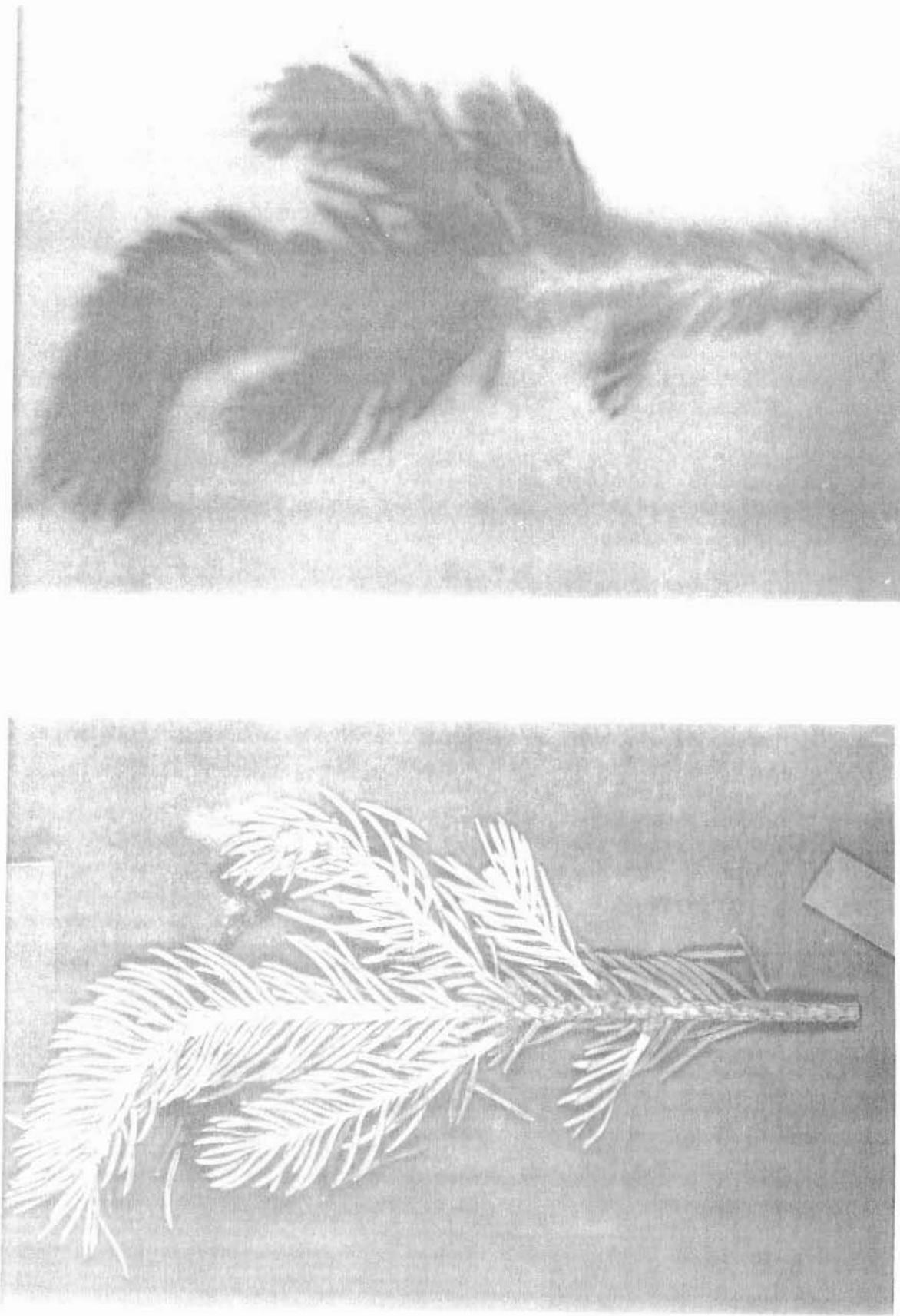


Fig. 4. Autoradiograph of spruce foliage sampled 21-days after treatment with C-14 phosphamidon by TIT.  
Pressed foliage on the left and its autoradiograph on the right.

Fig. 5. Autoradiograph of spruce foliage sampled 21-days after treatment with C-14 phosphamidon by BBP. Pressed foliage on the left and its autoradiograph on the right.



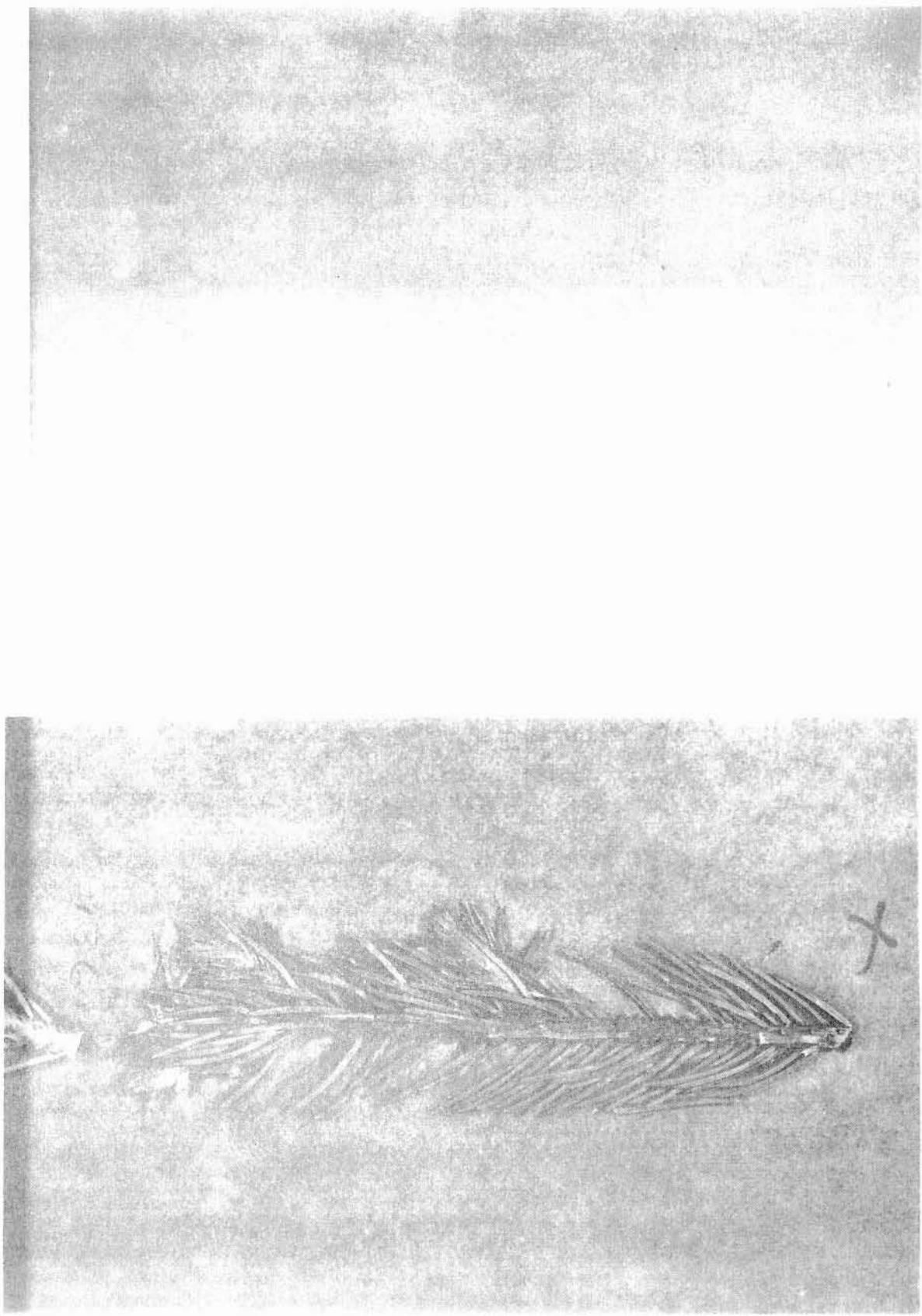


Fig. 6. Autoradiograph of 21-day untreated spruce foliage sampled from the tree after foliar painting.  
Note the feeble acropetal translocation.

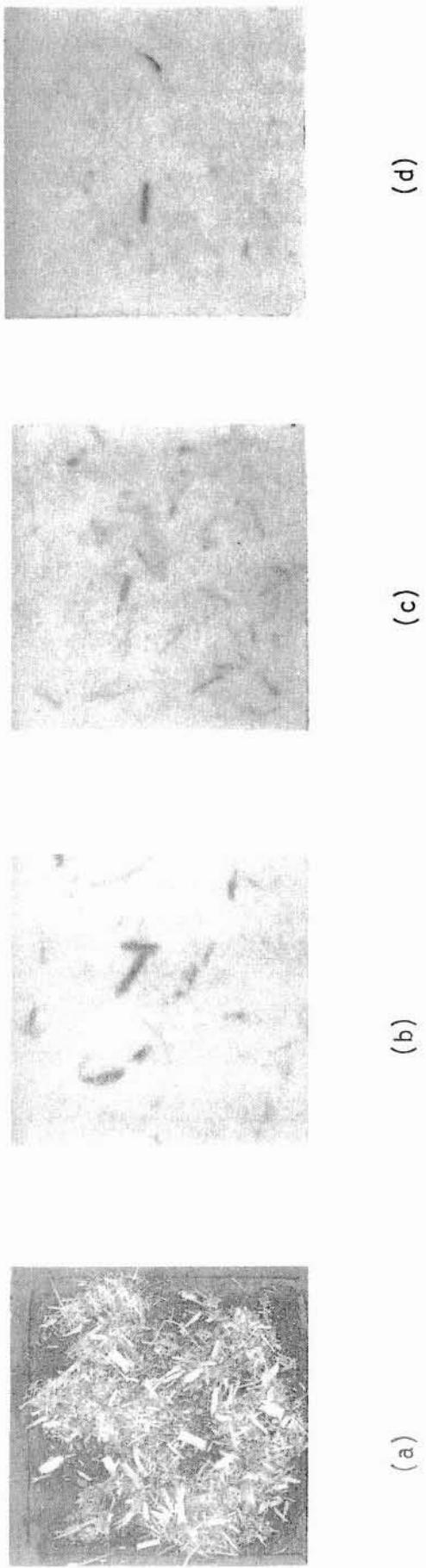


Fig. 7. Autoradiograph of foliar residues by TIR. (a) Pressed residue, (b) 21-day sample, (c) 34-day sample and (d) 50-day sample.

## RESULTS AND DISCUSSION

The results of uptake, penetration and translocation of phosphamidon in the spruce trees are given in Tables I to IV. It was apparent from the results that the insecticide readily penetrated the tissues around the treated areas and accumulated in the foliage. The residue concentrations are expressed in parts per million (ppm) of fresh foliage analysed and the minimum detection limit under the experimental conditions was found to be 0.03 ppm for both isomers. The foliage sample from the check tree did not contain detectable levels of phosphamidon and are not recorded.

### Uptake, Translocation and Persistence of Phosphamidon

Results in Table I show that absorption and upward translocation of both isomers is very high and rapid after trunk injection compared to basal bark (Table II) and foliar painting (Table III) treatments. From 0.82 ppm on day 1, the residue concentration rapidly increased to a maximum of 5.32 ppm after eight days and gradually decreased below the detection limit within 41 days. Such a rapid uptake is confirmed by the maximum radioactivity (3.56 mCi/g) observed in the raw ethyl acetate extract of foliage on day 8. Similarly, the ppm values of total phosphamidon calculated from the observed radioactivity by LSC technique, using the specific activity (3.62 mCi/m mole) of the applied insecticide [conversion factor: 1 ppm =  $0.654 \text{ nCi} = 1.44 \times 10^3 \text{ dpm}$ ] showed reasonably good agreement, at least in the earlier stages, with the concentration levels obtained by the GLC measurement. Plots of total phosphamidon concentration versus time (Fig. 2) and specific activity (S.A.) of raw extract against time (Fig. 3) showed

similar maxima, confirming the relative concentrations of the insecticide in the foliar extracts after TIT. This type of translocation occurs usually in the xylem vessels of the tree and increased with transpiration rate as observed earlier with acephate (Sundaram *et al* 1977) and aminocarb (Sundaram and Hopewell 1977). Although the translocated intact phosphamidon insecticide dissipated after 34 days, the extracts showed considerable levels of radioactivity probably due to the presence of non-extractable labelled moieties, formed during the degradation of the insecticide. Significant differences in specific activities between the raw extract (ethyl acetate) and the cleanedup extract (benzene) were observed especially during the later part of the experiment probably due to the absorption of some of the polar metabolites formed on the charcoal-Celite column used in the cleanup technique. It is also significant to note from the translocated phosphamidon residue data in foliage (Table I) that although the percent ratio of isomers in the applied analytical grade was *cis:trans* 73:27, the accumulated *cis*-isomer dissipated more rapidly than the *trans*-form which is in agreement with earlier observations (Bull *et al* 1967, Weestlake *et al* 1973, Sundaram 1975, Varty and Yule 1976).

In BBP, a considerably diminished translocation pattern was observed (Table II) probably due to poor penetration of the toxicant molecules through the thick cortex layers of bark and their subsequent occlusion in the resin ducts found in them. The concentration of translocated phosphamidon reached a peak in the foliage on day 5 at 0.41 ppm nearly 13 times less than occurred by TIT, and the little that was translocated, dissipated within 27 days. The measured specific activities of the extracts showed similar magnitudes of maxima patterns confirming the

observations made with the aid of GLC.

Somewhat similar translocation and dissipation of phosphamidon was observed in foliar painting showing a low peak concentration of 0.13 ppm (nearly 3 and 41 times lower than the BBP and TIT maxima respectively) and sp. activity ( $\mu\text{Ci/g}$ ) of 0.17 and 0.12 respectively for raw and cleanedup extracts on Day 12. However, the amount translocated was comparatively small considering the high concentration ( $\approx 500$  ppm) of phosphamidon applied to the treated foliage. Either the thick cuticle and waxy ridged needle surface acted as major barriers to the absorption and migration of the insecticide or it rapidly dissipated and/or was degraded on the leaf surface before entering stomata itself.

The GLC and LSC studies showed that once phosphamidon molecules entered spruce trees, they readily moved from the point of absorption to foliage and rate of translocation and the amount of material migrated varied with the method of application. In the current study, the rate of translocation decreased in the following order TIT > BBP > FP. Obviously the amount of phosphamidon translocated in FP was so small (0.14 ppm) compared to the amount applied (500 ppm) that it could be inferred that used in an aerial application for budworm control at the normal operational dosage of 0.140 kg/ha, the possibility of the toxicant being translocated from needle surface to other tree parts in effective amounts to control foliage-eating insects would be remote. Although Randall (1962) reported mortality in budworm larvae feeding on translocated phosphamidon, his experiments were on 2-year seedlings under laboratory conditions and thus much different from practical application. The material may be accumulated and stored indefinitely in cuticular waxes as observed with fenitrothion (Yule and Duffy 1972, Sundaram 1974), by repeated applications. This

extrapolative speculation should be verified in future by experimentation.

#### Longitudinal Distribution of Phosphamidon

Once phosphamidon has entered the spruce tree by TTT, it readily moved upward from the point of application probably due to its hydrophilic nature, to different aerial parts of the tree through the transpiration stream. It is evident (Table IV), that after 21-days post-treatment, the chemical is translocated primarily in the foliage and branch stem and is preferentially accumulated acropetally in the most active growth region, *i.e.*, the newly flushed foliage due to its upward movement *via* the xylem ducts. The average total insecticide concentration and radioactivity (raw extract) in the new foliage were 50 (note the preponderance of the *trans*-isomer) and 77 percent higher, respectively, than the values found in the old foliage, showing its outward migration. Similarly the residue concentration and radiolabel in the branch tissues were higher (46 and 65% respectively) than that in the old foliage. Downward translocation through the assimilate stream *via* phloem to the underground parts of the tree was not evident since the root samples analysed did not contain measurable amounts of phosphamidon. These results were in agreement with the observations made recently with two other insecticides (Sundaram *et al* 1977, Sundaram and Hopewell 1977).

Residue levels of phosphamidon in various parts of the spruce trees after 21-days of BBP and FP treatments, were too low for any definite conclusions and are not recorded here. This again confirms that the rate and amount of phosphamidon translocated vary primarily with the method of treatment. Experiments performed under greenhouse conditions is essential to evaluate the translocation rate and to understand fully the residual, degradational and metabolic fate of this insecticide in conifers.

The finding that phoshamidon is systemic and is translocated acropetally in spruce foliage would increase its usefulness in forest pest control programs provided that the translocated insecticide could be transported in a biologically active state in sufficient quantities from the foliage to budworm larvae while feeding. If this happens, then the material would have considerable practical importance. The residue levels of phoshamidon found (0.08 ppm) in samples of spruce budworm collected while feeding on conifer needles from tree P1, showed that the chemical is translocated intact from the foliar tissues to the target insect in small quantities in a biologically toxic state. However the amount translocated from the substrate to the budworm is comparatively small with a ratio of foliage (old + new) to insect as 47:1 and whether such a low concentration (0.08 ppm) in the insect is sufficient to control the pest is still obscure and necessitates further investigation. Under the present experimental conditions, no translocation of the intact chemical, at measurable levels, had occurred in budworm in the FP treatment even though ca 500 ppm of phoshamidon in DMSO had been painted on the needles, thus discounting the usefulness of the chemical in practical field applications for controlling forest insect pests, based solely on its systemic properties.

#### Autoradiographic Studies

The autoradiograms of 21 day post-treatment branch tips presented in figures 4 to 6 demonstrate the ready uptake and translocation of C-14 labelled phoshamidon. The behaviour of this chemical in spruce corresponds to that of acephate (Sundaram *et al* 1977) which also exhibited systemic properties. Radioactive phoshamidon was readily absorbed after the <sup>3</sup>H and migrated upward through xylem tissues and translocated acropetally in the growing leaves. The movement and preponderance of C-14 moieties

toward the flushed foliage was visible in the autoradiogram (Fig. 4) probably due to the accelerated transpiration rate coupled with increased metabolic activity (Gunther and Gunther 1971) in the new foliage compared to the old needles. Unlike the TIT sample, the autoradiograms of the needles from BBP and FP treatments (Figs. 5 and 6) were light because the concentrations of the radiolabels were low due to decreased translocation for reasons given earlier in this report. Unlike the foliage, the root samples from the treated trees (P1 to P3) did not respond positively to the X-ray films showing that the downward movement of the toxicant moieties through phloem tissues did not readily occur in spruce trees. Likewise the foliage samples from the check tree also showed negative response.

#### Metabolism of Phosphamidon in Spruce Trees

The present investigation was concerned primarily with the rate of uptake, translocation and persistence of phosphamidon in spruce trees when the material is applied to the trees in different ways. Possible breakdown products present in the foliar extracts have not been studied to elucidate quantitatively the metabolism of the insecticide in spruce. It is generally observed that the more toxic *cis*-or  $\beta$  isomer of phosphamidon, is more labile than the *trans*-or  $\alpha$  form. In addition, the mode of treatment had a marked influence on the amount of chemical translocated. Studies also showed that the translocated material in all three treatments disappeared after an interval of 34 days thus indicating little cause for concern about its persistence in conifers.

From the results presented in this paper, it could be predicted, tentatively at least, that the major metabolic pathway for the translocated phosphamidon in spruce foliage was enzymatic degradation at the P-0 vinyl

links and other sites of the molecule, as suggested by Gunther and Gunther (1971) forming polar metabolites (*e.g.* dimethylphosphate and  $\alpha$ -chlor-acetoacetic acid diethylamide, etc.) as hydrolytic products whose concentrations increased with time. This is indicated by the increasingly high residual activity observed in the raw and cleanup foliar extracts from TIT (Table I) after an 8-day interval, even though the residue concentrations of the insecticide observed by the GLC method rapidly diminished after this period. It is also evident from the S.A. of the extracts, that the acetic acid derivative or similar hydrolytic product formed as a metabolite, was not fully eluted from the charcoal-Celite adsorbent column as shown by the difference in radioactivity observed for the raw and cleaned-up extracts obtained from the same foliage sample. No attempts were made in this study to characterize these metabolites except that an autoradiographic study of the residues of 21-day foliage from the TIT, after two solvent extractions, exhibited some activity (Fig. 7) increasing with time, showing that the unextractable radioactivity was due to some of these polar moieties which are strongly adsorbed onto or absorbed into cellular structures of the needles and are not extractable by normal homogenization procedures in the presence of organic solvents.

The level of phosphamidon residue on the brushed foliage (tree P3) was examined by harvesting the painted needles and analysing them on the last day *i.e.* day 89, of the experiment. Only 40 ppm (12 ppm *cis* and 28 ppm *trans*) *i.e.* ca 8% of the initial deposit level (ca 500 ppm) was found in the foliar tissues and with a preponderance of the *trans* - isomer as expected. The rapid loss of the chemical from the leaf surface could be primarily due to physical factors such as weathering, volatilization, photolysis and hydrolysis although physicochemical and enzymatic (biochemical) degradations, absorption, translocation and growth dilution could have

played a minimal part. The more persistent residues probably formed a solid solution with cuticular waxes and oils of the foliage, translocated and eventually stored at some subcuticular level thereby retarding the loss by physical means such as volatilization, leaching and photolysis (see also Sundaram *et al* 1977). Similar dissipation mechanism could be extended to phosphamidon painted on the basal bark of tree P2.

#### Conclusion

The present work has shown the uptake and translocation of phosphamidon in spruce trees in a forest environment. However, further research is needed for the complete understanding of the dynamics and metabolic fate of this insecticide not only in conifers but in different components of the forest environment because of the recent increase in the use of this insecticide in Canadian aerial spray programs. Some attempt should also be made to determine its possible absorption and cumulative build-up in conifers due to repeated large scale applications at increasing dose levels because this insecticide is cause for some concern to ecologists (Fowle 1965).

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